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Theories of physical activity behaviour change: A history and synthesis of approaches

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ABSTRACT

Background: Most people in developed countries are not physically active enough to reap optimal health benefits so effective promotion strategies are warranted. Theories of behaviour change are essential to understand physical activity and provide an organizing framework for effective intervention. The purpose of this paper was to provide a narrative historical overview of four key theoretical frameworks (social cognitive, humanistic, dual process, socioecological) that have been applied to understand and change physical activity over the last three decades.

Methods: Our synthesis of research included the brief history, basic efficacy, strengths, and potential weaknesses of these approaches when applied to physical activity.

Results: The dominant framework for understanding physical activity has been in the social cognitive tradition, and it has provided valuable information on key constructs linked to physical activity. The humanistic framework for understanding physical activity has seen a surge in research in the last decade and has demonstrated initial effectiveness in both explaining and intervening on behaviour. The most recent and understudied framework for understanding physical activity is dual process models, which may have promise to provide a broader perspective of motivation by considering non-conscious and hedonic determinants of physical activity. Finally, the individual-level focus of all three of these approaches is contrasted by the socioecological framework, which has seen considerable research attention in the last 15 years and has been instrumental in understanding the role of the built environment in physical activity behaviour and critical to shaping public health policy in government.

Conclusions: Despite the strengths of all four frameworks, we noted several weaknesses of each approach at present and highlight several newer applications of integrated models and dynamic models that may serve to improve our understanding and promotion of physical activity over the next decade.

Evidence continues to accumulate on the health benefits of regular physical activity (Lee et al., 2012; Rebar et al., 2015; Rhodes, Bredin, Janssen, Warburton, & Bauman, 2017; Warburton & Bredin, 2016). Despite this accrual of evidence and best practice recommendations, population physical activity rates are modest (Hallal et al., 2012). As a result, physical activity promotion has been of paramount importance for at least over a quarter of a century (Bouchard, Shephard, & Stephens, 1994; Pate et al., 1995), although duly noted as critical to population health much earlier (American College of Sports Medicine, 1978; Karvonen, Kentala, & Mustala, 1957). In response to this call, research attempting to predict, explain, and intervene upon physical activity has followed suit for over 30 years.

Early physical activity psychology research was largely atheoretical. Investigators utilized available measures in secondary data analysis, often at hand from physiological trial and epidemiological cohort data, to predict and explain physical activity participation and adherence (see Dishman, 1988 for an overview). This first-wave of research created great breadth in the use of potential determinants of physical activity but rendered a list of variables that lacked cohesiveness and offered little depth to these variables under study (Courneya, 2004). Further, it became apparent that simply providing physical activity guidelines wherein the message was “get this much physical activity” or “exercise more” was not sufficient to produce behaviour change. Rather, to enhance individuals’ physical activity, we needed to consider a range of behavioural influences, both internal (e.g., beliefs, cognitions) and external (e.g., social needs, contextual factors). As a consequence,

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the application of theoretical frameworks marked a critical transitional point for the study of physical activity in the late 1980s and early 1990s. Theoretical frameworks create a context for understanding, explaining, and ultimately intervening upon physical activity (Michie, West, Campbell, Brown, & Gainforth, 2014; Rothman, 2004). They define the variables under study, provide structure among variables, overview assumptions for how the variables should operate, allow for study replication and generalization, and enable a dialog for the testing and falsification of hypotheses. Thus, theoretical frameworks are generally considered an essential feature in physical activity science (Rhodes & Nigg, 2011).

The purpose of this paper is to overview the main theoretical frameworks that have been applied to understand and change physical activity over the last three decades. As the discipline of physical activity psychology has matured, so too have the frameworks employed and the scrutiny applied to these frameworks. Thus, we highlight four main frameworks: social cognitive approaches, humanistic/organismic approaches, socio ecological approaches, and dual process approaches with their historical application to physical activity from the 1980s until present day. Our intent in the paper is not to provide a systematic review or meta-analytic approach to the efficacy of these frameworks, as this is already readily available in the published literature (e.g., Bauman et al., 2012; Rebar et al., 2016; Teixeira, Carraça, Markland, Silva, & Ryan, 2012; Young, Plotnikoff, Collins, Callister, & Morgan, 2014). Instead, we provide our historical interpretation and assessment of how and why each of these frameworks became dominant in the psychology of physical activity discipline over a 30-year span. We overview the strengths of each approach and their potential drawbacks. We conclude by highlighting newer applications of integrated theoretical approaches and advancing technology that may serve to further improve our understanding and promotion of physical activity.

1. The social cognitive framework and physical activity

The social cognitive framework evolved from a growing desire by social psychology and developmental psychology researchers to expand beyond behaviourism to a cognitive paradigm that involved social learning and mental representations of motivation (Atkinson, 1957; Kerlinger, 1973; Locke, 1968). This approach was applied to health behaviours soon thereafter (Rosenstock, 1974). The framework is based on the premise that people form, and subsequently act upon, expectancies of behavioural events and outcomes. In particular, valued outcomes and expectancies that carry the most weight of importance are considered critical to subsequent action, which gave rise to the terms expectancy value or reasoned action approaches within theories that employ the social cognitive framework (Ajzen & Fishbein, 1977; Head & Noar, 2014). Expectancies are often given different labels in various social cognitive theories but generally involve expectancies focused on behavioural outcomes (pros/cons, benefits/barriers, attitudes, outcome expectations) or on one's capability to perform the behaviour in order to derive an outcome (self-efficacy, competence, perceived behavioural control), which subsequently are hypothesized to form an intention to act that determines actual behavioural action (Rhodes, 2017). In other words, individuals will intend to be physically active if they believe that (a) physical activity is important, and (b) they are truly capable of enacting activity. Intervening upon physical activity using the social cognitive approach is therefore assumed to follow a rational and value-based approach to appealing to one's values and beliefs and/or building an expectation of capability via factors such as personal/observational accomplishments, and social encouragement (Biddle & Nigg, 2000; Conner & Norman, 2015).

The social cognitive framework is the dominant approach to understanding physical activity with hundreds of observational and experimental applications (Cardinal, 2014; Rhodes & Nasuti, 2011) (see also Beauchamp & Jackson this issue). For example, the theory of planned behaviour (Ajzen, 1991) has been applied to predict physical activity in over 100 studies (Hagger, Chatzisarantis, & Biddle, 2002; McEachan, Conner, Taylor, & Lawton, 2011; Symons Downs & Hausenblas, 2005). The theory of planned behaviour suggests that attitude (evaluation of a behaviour), subjective norm (perceived social pressure to perform the behaviour) and perceived behavioural control (ability to perform the behaviour) predicate the formation of an intention which subsequently determines behaviour. In support of the theory, observational research shows that attitude ($\beta = 0.40$) and perceived behavioural control ($\beta = 0.33$) have medium effects upon intention, and intention ($\beta = 0.42$) has a medium-sized effect upon future physical activity (McEachan et al., 2011). Prediction of physical activity from social cognitive models has shown results of similar magnitude in applications of other variants of the social cognitive approach such as Roger's (1983) protection motivation theory (Plotnikoff & Trinh, 2010), Prochaska and DiClemente's (1982) transtheoretical model (Nigg et al., 2011), or Bandura's (1998) social cognitive theory (Young et al., 2014).

Intervention upon physical activity, however, has not been as successful as mere prediction of physical activity using the social cognitive paradigm (Conn, Hafdahl, & Mehr, 2011; Prestwich et al., 2014). It may be that social cognitive constructs require greater targeted focus or active manipulation in future intervention research but results have been modest thus far. For example, interventions targeting people's expectancies about the value of physical activity outcomes have often not shown significant subsequent behaviour change compared to control groups in systematic reviews (Rhodes & Pfaeffli, 2010; D. M.; Williams, Anderson, & Winett, 2005) or meta-analysis (effect size $d = -0.02$; Conn et al., 2011). Interventions targeting expectations of one's own physical activity capability have shown small-trivial ($d = 0.14$ to 0.21) changes in behaviour (French, Olander, Chisholm, & Sharry, 2014; S.; Williams & French, 2011), and a similar outcome ($d = 0.17$) has been shown for the effect of changes in intention on physical activity (Rhodes & Dickau, 2012). Given the overlap among specific theories using this approach, it should come as no surprise that no particular social cognitive theory has been more effective in producing physical activity behaviour change than any other (Gourlan et al., 2016).

2. How and why has the social cognitive approach endured?

Adoption and application of the social cognitive framework in physical activity science followed the rise of this approach in psychology, education, business and public health. The social cognitive framework also links perfectly to the central rationale for studying physical activity in a public health context. Specifically, physical activity promotion is founded on its health benefits, so theories that assume a behaviour is performed for such expected outcomes aligns with the exact rationale for the discipline and the scientists/clinicians who pursue the discipline. The continued use of the social cognitive framework in physical activity science, however, is likely a result of many factors. First, social cognitive variables such as intention and self-efficacy represent reliable correlates of physical activity (Bauman et al., 2012; Rhodes et al., 2017). Thus, certain variables within the framework have earned their utility in predicting physical activity. Second, the assumptions of the social cognitive framework are sensible and intuitive. As much of the study of physical activity features exercise, which is defined as "physical activity that is planned, structured, and repetitive and has a final … objective of the improvement or maintenance of physical fitness (Caspersen, Powell, & Christenson, 1985)," it stands to reason that social cognitive models that propose purposeful and planned action based on an expected outcome would fit for the study of the behaviour.

There are also pragmatic factors that may have contributed to the dominance of the social cognitive framework, that are not entirely based on its scientific merit as much as market forces in research. For example, as the first framework to establish itself in physical activity

psychology, it had the benefit of collateral networks and cross-generation transmission/learning across supervisors to their trainees. As research training is founded on a mentorship model, the social cognitive framework would have been taught, applied, and then re-taught to perpetuate its practice and research within the discipline. Further, from an efficiency standpoint, the social cognitive framework was easy to proliferate in early research. It relies on questionnaire-based assessment at an individual-level and most of these social cognitive models lend themselves to path analyses that can be performed with cross-sectional designs or short-term prospective designs. Thus, research accumulation is cost-effective and relatively simple in comparison to other means of measurement (e.g., environmental scans, detailed interviews, lab-based observations) and design (longitudinal cohorts, experimental designs, etc.).

The social cognitive framework is still the dominant research approach in physical activity, but the premise that physical activity solely a result of deliberation about values and expectancies is now under debate (Conroy & Berry, 2017; Ekkekakis & Zenko, 2016; Rebar et al., 2016; Rhodes, 2017; Sallis et al., 2006; Sniehotta, Presseau, & Araújo-Soares, 2014). Some of the reasons for the shift from a complete social cognitive explanation for physical activity again parrots the shifts in other disciplines such as social psychology, education and public health, where complementary or competitive frameworks are now developed and receiving research attention. Other reasons for this shift include the growing concerns over the modest and short-lived effects of social cognitive interventions (Conn et al., 2011; Foster, Hillsdon, & Thorogood, 2009), the large disconnect between population knowledge of physical activity's benefits (Martin, Morrow, Jackson, & Dunn, 2000; O'Donovan & Shave, 2007) and population prevalence of physical activity, the discordance between intention and behaviour that underpins this framework (Rhodes & de Bruijn, 2013), the over-reliance on the individual as the agent of change (Sallis et al., 2016), and the efficacy of frameworks that also highlight fast, non-conscious factors in determining physical activity (Rebar et al., 2016). The shift has been slow. Indeed in a recent debate, the lead author of this paper jokingly compared the social cognitive framework to the undead (i.e., zombie apocalypse), because of its resilience under continued evidence for its inadequacies (Rhodes, 2016). Nevertheless, other key frameworks have now begun to receive research attention and form the basis of the remainder of this review.

3. Humanistic/organismic framework and physical activity

Much like social cognitive theorists, early organismic and humanistic theorists also sought to move beyond the mechanistic view of human behaviour that was held by behaviourists, such as Pavlov (1849–1936), Watson (1878–1958), and Skinner (1904–1990). Contrary to behaviourism, these perspectives propose that humans have inherent needs and that behaviour is not merely a response to reinforcement or punishment. Rather, human action is thought to be motivated by an innate drive to grow, develop, and realize one's potential—a concept often referred to as *self-actualization* (Goldstein, 1995/1934; Maslow, 1943; C. R. Rogers, 1995/1961).

The most common theory borne out of these organismic/humanistic perspectives of growth and development that has been applied to understanding physical activity is *self-determination theory* (SDT) (Deci & Ryan, 1985, 2000). The basis of SDT is that humans are active, growth-oriented organisms who are naturally inclined to form a unified sense of self and to integrate themselves into their larger social structures (Deci & Ryan, 2000). SDT is comprised of five mini-theories, including *causality orientations theory*, *goal contents theory*, *cognitive evaluation theory*, *basic psychological needs theory*, and *organismic integration theory* (Deci & Ryan, 2002). Together, these mini-theories inform our understanding of motivation by considering: (1) individual differences in one's tendencies towards motivation (causality orientations theory); (2) the type of goals that individuals strive to attain (goal contents theory); (3) the conditions in one's environment that can impact one's motivation (cognitive evaluation theory); (4) the psychological needs that each individual has in relation to motivation (basic psychological needs theory); and (5) individuals' innate tendencies to engage in interesting activities and to refine their inner representation of themselves (organismic integration theory) (Deci & Ryan, 2000; 2002).

Two commonly employed mini-theories that have been used to examine physical activity behaviour include basic psychological needs theory (BPNT) and organismic integration theory (OIT). The central tenet of BPNT is that humans have an innate drive to fulfill three basic, universal needs. These include experiencing meaningful connections with other individuals in one's environment (i.e., relatedness), having a sense of choice and control over one's behaviour (i.e., autonomy), and feeling capable and effective when completing a task (i.e., competence). OIT posits that motivation is considered as a continuum of self-determination, with *amotivation*—the absence of motivation to perform a behaviour (e.g., having no desire or drive to exercise)—falling on the lowest end of the continuum, and *intrinsic motivation*—performing an activity for its own sake (e.g., exercising because it is enjoyable)—at the other end of the continuum. A third general form of motivation, *extrinsic motivation,* falls between these two ends of the continuum and involves engaging in an activity in order to obtain some outcome that is separate from the activity itself (Ryan, Williams, Patrick, & Deci, 2009). Four types of behavioural regulation comprise extrinsic motivation. The least self-determined form of extrinsic motivation is *external regulation*, wherein behaviour is controlled by some external contingency. Next, *introjected regulation* involves behaviour that is partially internalized and controlled by emotions or self-perceptions. A more self-determined form of extrinsic regulation is *identified regulation* whereby a behaviour is valued and deemed important. Finally, the most self-determined form of extrinsic regulation is *integrated regulation* in which a behaviour is part of one's sense of self. It is hypothesized that individuals can experience a higher level of self-determination by fulfilling their needs of relatedness, autonomy, and competence (Deci & Ryan, 2000, 2002). In turn, individuals whose motivation is self-determined are more likely to then experience better levels of physical activity, health, and overall well-being compared to those whose motivation is extrinsically controlled or altogether absent.

The hypothesized relationships between physical activity with psychological need satisfaction as well as self-determined motivation has been evident across a range of populations (Teixeira et al., 2012). With regard to the specific types of motivational regulation, a systematic review by Teixeira et al. (2012) demonstrated that more autonomous forms of motivation were consistently related to physical activity behaviour, while controlled forms of regulation were not. Interestingly, the researchers also found that identified regulation predicted short-term adoption of physical activity more strongly than intrinsic motivation, while intrinsic motivation was more predictive of long-term exercise adherence. With regard to the three psychological needs, competence was found to be the most commonly-examined and consistent positive predictor of physical activity (Teixeira et al., 2012). More mixed findings were shown in the relationships between physical activity and autonomy, while there was often an absence of an association between physical activity and relatedness. It should be recognized that the latter finding may have emerged due to the fact that physical activity is a solitary behaviour for many individuals. As such, relatedness may be more relevant within group exercise settings—indeed, many primary studies within these group contexts have shown positive relationships between relatedness and physical activity-related outcomes (e.g., engagement during PE class, intentions to be physically active outside of class; Standage, Duda, & Ntoumanis, 2001).

Experimental studies have also found that SDT-based interventions can enhance physical activity (e.g., Fortier, Sweet, O'Sullivan, & Williams, 2007; Silva et al., 2010). For example, Fortier et al. (2007) found that physical activity behaviour was greater among individuals who received autonomy-supportive physical activity counselling over

the course of three months compared to individuals who only received a brief counselling session at the beginning of that timeline. Moreover, it has been demonstrated that leaders of group exercise can be trained effectively in need-supportive communication styles, which can subsequently enhance a range of group member outcomes (Cheon, Reeve, & Moon, 2012; Ntoumanis, Thøgersen-Ntoumani, Quested, & Hancox, 2017). For example, Cheon et al. (2012) examined the effect of an SDT-based intervention delivered to PE teachers on an array of student outcomes. They found that, in comparison to students whose teachers did not receive the intervention, students within the experimental condition showed greater levels of self-determined motivation, classroom engagement, skill development, intentions towards future activity, and academic achievement; moreover, the effect of the intervention on these outcomes were mediated by increases in psychological need satisfaction. Taken together, this collection of research suggests that SDT not only provides a viable framework for explaining physical activity behaviour, but can also be used to guide exercise intervention programs.

4. How and why has the humanistic approach endured?

A systematic review conducted in 2012 on the relationships between SDT and physical activity found that 53 of the included 66 papers had been published within the previous five years of that review (Teixeira et al., 2012). This review has since been cited nearly 1000 times (according to Google Scholar), which highlights the continued expansion of research examining physical activity from a humanistic perspective. Why has there been such growth in this area over the past decade? Perhaps the most obvious answer to this question—as it pertains to physical activity—lies in the empirical support (noted above) that has been demonstrated in using humanistic-based approaches to both explain and promote physical activity. Moreover, compared to other theories that have an extensive number of components, the concept of self-determined motivation (from OIT) and the three psychological needs (from BPNT) is arguably easier to teach. Indeed, as previously mentioned, research has provided support for the efficacy of teaching key stakeholders (e.g., group exercise leaders, PE teachers) strategies that they can utilize to help foster autonomy, competence, relatedness, and, in turn, intrinsic motivation (Cheon et al., 2012; Ntoumanis, Thøgersen-Ntoumani, Quested, & Hancox, 2017).

As with the other theories described in this paper, SDT is not without its critics. Perhaps the most common query is whether there truly are only three psychological needs or if other needs should be identified (Sheldon, Elliot, Kim, & Kasser, 2001). For example, although autonomy, competence, and relatedness have emerged as the most dominant needs, Sheldon (2011) argued that other positive psychological experiences (e.g., self-esteem, pleasure, security) explain variability in behaviour and well-being. The impact of one such experience on exercise behaviour that has recently been tested within the SDT framework is the concept of *variety*, which involves the provision or experience of diverse opportunities, activities, and behaviour (Sheldon & Lyubomirsky, 2012; Sylvester et al., 2016). Specifically, Sylvester and colleagues have found that variety is a unique predictor (that is, independent of autonomy, relatedness, and competence) of exercise behaviour and exercise-related well-being. This research underscores the question of whether autonomy, relatedness, and competence truly cover the gamut of individuals' psychological needs. Ryan, Patrick, Deci, and Williams (2008, p. 659) posit that the "criterion for distinguishing a need from a motive, again, pertains to its necessity for growth, integrity, and wellness". Might there be other universal needs that promote these necessities that have not yet been uncovered? As with any psychological theory, SDT could evolve over time if there is an accumulation of evidence supporting the integration of additional needs.

There may also be similar critiques for the motivational regulations embedded within SDT—specifically, the four extrinsic regulations identified under OIT. That is, do the four types of extrinsic regulation encompass all forms of behaviour that is externally controlled or only partially internalized, or might there be others? Furthermore, self-determined motivation is said to consist of a continuum from controlled to autonomous regulation. If motivation indeed consists of a single continuum, then individual's motivation should fall at one point on this spectrum. However, individuals may have more than one reason for being physically active and, as such, self-determined motivation might be better conceptualized as involving six separate continuums rather than one general spectrum. Indeed, participants are typically scored corresponding to the six behavioural regulations as opposed to one score of self-determined motivation (Markland & Tobin, 2004). Moreover, whereas some researchers have examined the independent effects of each regulation on physical activity, others have examined the combination of these regulations by creating "motivational profiles" for each participant (Gourlan et al., 2016). These inconsistencies in conceptualization and measurement can create challenges in understanding how exactly motivation relates to physical activity behaviour—improving this consistency in future SDT studies remains a challenge for researchers. Finally, with regard to the organismic/humanistic perspective more broadly, a question arises as to whether humans truly act on an innate drive to grow, develop, and realize one's potential. Individuals could likely think of many actions that they perform each day that do not contribute to self-actualization and flourishing but, rather, are a result of other forces of behaviour regulation, such as those that have been learned through operant conditioning or through hedonic motivation (Rhodes, Williams, & Conner, 2018). While physical activity is one possible behaviour through which individuals could seek self-actualization, there are, of course, many others. In future studies, researchers could consider physical activity in concert with other behaviours and examine how these behaviours interact to contribute to individual flourishing.

5. Dual process framework and physical activity

In their most basic application, dual process frameworks are the mapping of individual level behavioural determinants onto one of two different types of influence – *reflective* processes which are deliberative, effortful, and intentional effects, and *non-conscious* or *automatic* processes, which are spontaneous, harder to notice, and more difficult to control (Chaiken & Trope, 1999; Evans & Frankish, 2009; Strack & Deutsch, 2004). Dual process frameworks put forth that reflective processes include the conventional social-cognitive approach variables (e.g., intentions, values, expectations), and non-conscious processes include the comparatively less understood and less tested determinants of physical activity such as habits, automatic evaluations, automatic self-schemas, and automatic motivation (Rebar et al., 2016; D. M.; Williams & Evans, 2014). Recently, dual process frameworks have been integrated with hedonic motivational premises (Brand & Ekkekakis, 2018; Rhodes & Kates, 2015; D. M.; Williams & Evans, 2014) (see also Ekkekakis this issue), providing insight into the reflective and non-conscious processes through which the feelings people have during (but not following) physical activity impacts their future physical activity behaviour (Rhodes & Kates, 2015).

Underpinning most theories of non-conscious regulation of physical activity are notions of associative learning and connectionist models of memory. The basic premise being that memory can be conceived as a network of associated concepts, which are activated when cues (i.e., experienced or perceived representations of a concept) are processed, and that the activation of these mental networks of associations manifest into behavioural influences through the elicitation of urges to approach or avoid circumstances – cognitive adaptations of humans' fight-or-flight autonomic responses. Conroy and Berry (2017) operationalized the influence of automatic evaluations as the manifestations of learned associations between pleasant affective experiences and physical activity. They go on to articulate how cues activate these

associations in memory and influence the quantity and quality of a person's physical activity behaviour. Similarly, Rebar (2017) lays out a foundation for understanding how non-conscious processes may be distinct but interconnected, in that they all form an interwoven network of mental associations, such that the same cue may activate different (coinciding or opposing) non-conscious influences on behaviour through approach or avoidance tendencies. Most dual process theories take on a default-interventionist architecture – a preface that people tend to act in line with their non-conscious processes (like a default setting), unless they have sufficient motivation, opportunity, and self-control resources to inhibit them (Evans & Stanovich, 2013; Strack & Deutsch, 2004). The premise that people tend to 'default' to their more efficient non-conscious motivational processes describes the psychological mechanism of action for the effectiveness of *nudge* choice architecture interventions, in which subtle environmental or system-level changes are made to indirectly influence decision making or behaviour (Thaler & Sunstein, 2008).

Most physical activity studies apply dual process frameworks by simultaneously testing non-conscious and reflective processes in the prediction of behaviour, although much of the research has been correlational (Rebar et al., 2016) (see also Hagger, this issue). Aggregate work has shown evidence of positive associations of physical activity behaviour with habit and automatic evaluations (Rebar et al., 2016). Self-reported habit tends to be associated with physical activity behaviour with medium-to-strong effects (fixed effects $r = 0.43$, random effects: $r = 0.44$; (Gardner, de Bruijn, & Lally, 2011); whereas automatic evaluations tend to be associated with physical activity behaviour to a more modest degree (r = 0.11; Chevance, Bernard, Chamberland, & Rebar, 2018). Most evidence demonstrates that the associations between these non-conscious factors and behaviour remain significant when statistically controlling for reflective motivation. For example, in 13 of the 15 studies reviewed of self-reported habit and in 8 of the 9 studies reviewed of automatic evaluations, the non-conscious factors remained significantly associated with physical activity behaviour after accounting for reflective processes (Rebar et al., 2016). Although there is comparatively less evidence, research is also suggestive of positive associations of physical activity behaviour with automatic self-schemas (Banting, Dimmock, & Lay, 2009), automatic motivation (Williams, Rhodes, & Conner, 2018), and approach/avoidance tendencies (Cheval, Sarrazin, Pelletier, & Friese, 2016).

Non-conscious influences were initially applied in physical activity science as a single-variable supplement to social-cognitive approaches. Since then, however, more developed theoretical conceptions with more straightforward translation into behaviour change efforts have emerged. For example, Williams and Evans (2014) put forth a dual process framework (the Affect and Health Behaviour Framework) for conceiving the effects of affect processing on behaviour, suggesting that people's future behaviour is influenced both through learned automatic associations (e.g., automatic evaluations, affective associations) and through reflective motivational processes such as affective judgments (e.g., affective forecasting, affective attitudes). This framework proposes that automatic affective processing is biased toward more immediate affective responses (e.g., pain and discomfort during exercise); whereas reflective processes are biased toward more distal ones (e.g., pride of accomplishment after exercising). Should non-conscious and reflective influences conflict, the person will experience affectively charged motivational states such as craving, desire or dread. Williams and Evans (2014) also note that these processes and the impact they will have on behaviour will be influenced by other simultaneous motivational processes for competing behaviours (such as sedentary behaviour) and incidental affect (such as current mood).

6. How and why has the dual process approach endured?

In early research, dual process models served as one solution for the revelation that not all physical activity was predicted by intentions. It also allowed for a rationalization of the strong link between past and future physical activity that was powerfully present even after accounting for intentions and self-efficacy (Hagger et al., 2002). However, as evidence emerged showing consistent links between non-conscious processes and physical activity behaviour, theory has evolved. It must be noted that, although it would make researching physical activity motivation easier, unfortunately, the binary distinction of physical activity determinants as being either reflective or non-conscious is likely an oversimplification of the felt experience of interconnected complex, multifaceted cognitive, neurological and physiological processes (Melnikoff & Bargh, 2018). It is probably more accurate to describe influences as being automatic to a certain degree on a continuum somewhere between completely reflective or completely non-conscious. As such, dual process frameworks should be considered a heuristic for conceptualizing the relative efficiency and automaticity of types of influences on physical activity rather than as a defined theory with a specific set of constructs and operational pathways. That physical activity science is now more attuned to the non-conscious influences on behaviour opens up new opportunities for how to intervene with physical activity behaviour.

With the infant state of this area of research comes limitations that have yet to be overcome. For example, the field is awash with a hodgepodge of terminology issues (e.g., the terms 'implicit', 'automatic', 'impulsive', and 'non-conscious' are pretty much used interchangeably; 'habit' continues to be used as a synonym for frequent behaviour). The most rigorously disputed weakness of the field surrounds measurement issues. Measurement of non-conscious constructs requires making inferences about processes that people may not have full awareness. As a result, these constructs are typically assessed implicitly, with measures not requiring subjective reporting of the direct target construct (Gawronksi & De Houwer, 2007). For example, automatic evaluations are primarily assessed through inferences about people's response times and accuracy on two-choice timed response tasks (Greenwald, McGhee, & Schwartz, 1998). There is skepticism and controversy regarding the psychometric soundness of these response-timed measures (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009; Fiedler, Messner, & Bluemke, 2006). In addition, the 'low-hanging fruit' of measurement controversy of non-conscious processes of physical activity is that habit continues to be primarily assessed through self-report (Hagger, Rebar, Mullan, Lipp, & Chatzisarantis, 2015; Sniehotta & Presseau, 2011). Self-report measures of habit could be interpreted as implicit, such that indirect inferences are made about habit strength from people's reported experiential symptoms of habit (Rebar, Gardner, Rhodes, & Verplanken, in press); however, psychometric testing of the automatic nature of self-reported habit is still under developed. Advancements in research of the psychometric properties of measures of non-conscious processes is essential to ensure this area of research progresses with sound rigour.

7. Socioecological framework and physical activity

The socioecological framework is based on this premise that behaviour is the result of direct, indirect and interactive influences from factors of multiple levels that span from the individual to environment and social policy. The original concept for an ecological framework dates to Lewin (1951), who observed that behaviour is a function of persons and their environments. This was expanded by Barker (1968) to include that behaviour was both discriminable at the level of the individual, but also by environmental settings. The grandfather of the contemporary socioecological framework, however, is Bronfenbrenner (1979), whose ecological systems model posited there are multiple levels of influence from the environment that influence a person's behaviour. This has been adapted slightly for health behaviour to include five layers that form concentric rings: an intrapersonal core (e.g., age, sex, cognitive processes), an interpersonal level (persons and groups), an organizational level (clubs, schools, churches, etc.), a community

level (community, environment structure), and a policy level (public policies from local to federal) (McLeroy, Bibeau, Steckler, & Glanz, 1988; Stokols, 1992).

Application of the socioecological model to physical activity has focused heavily on the environmental settings level, perhaps because the social- and individual-level rings of the model have received so much attention in other approaches (e.g., social cognitive, humanistic) in physical activity science (Biddle & Nigg, 2000). It should be noted here that the socioecological framework is entirely complementary with individual-level approaches as they merely place individuals as actors amidst broader systems (Sallis, Owen, & Fisher, 2015; Sniehotta et al., 2017). Overall, there are many reviews of the literature linking physical activity to environmental features of the built environment such as land-mix use, street or pedestrian network connectivity, safety, quality of physical activity infrastructure, and aesthetics (Araujo, Brymer, Withagen, & Davids, in press; e.g.,; Ferdinand, Biasakha, Rahurkar, Engier, & Menachemi, 2012; McCormack & Shiell, 2011; Van Holle, Deforche, & Van Cauwenberg, 2012). The effect sizes for these environment-behaviour relationships are generally small ($r < 0.20$) and sometimes inconsistent across these reviews.

The relative magnitude of association between the different levels of influence in socioecological models on physical activity has not been systematically reviewed, though comparative effect sizes suggest that the individual-level factors provide the largest contribution (approx. $\beta = 0.20$ to 0.50) compared to the social and built environment (approx. $\beta = 0.05$ to 0.30), though all levels can have independent associations as per the tenets of the framework (Giles-Corti & Donovan, 2002; McCormack, Friedenreich, Giles-Corti, Doyle-Baker, & Shiell, 2013; McNeill, Wyrwich, Brownson, Clark, & Kreuter, 2006; Rhodes, Brown, & McIntyre, 2006; Sallis, Saelens, Frank, Conway, & Cain, 2005). The interaction hypothesis among levels of influence upon physical activity has received recent systematic review (Rhodes, Saelens, & Sauvage-Mar, 2018). Overall, there were few examples that the built environment interacted with individual social cognition to explain physical activity. There were two exceptions with interactions in the small effect size range ($R^2 < 0.03$). First, larger intention-behaviour relations were observed under conditions where access to recreation was close compared to far away. Second, those individuals who did not enjoy physical activity were more likely to be active under conditions of better environmental aesthetics compared to those who enjoyed physical activity (who had no such increase). Taken together, the socioecological framework has supportive, though sometimes inconsistent, observational evidence for its assumptions that physical activity is a result of direct, indirect and interactive influences from multiple levels of influence.

8. How and why has the socioecological approach endured?

The dominance of the individualist focus of the social cognitive framework in physical activity science in the 1990s left a vacuum for understanding behaviour through the environment and policy that was filled by the socioecological framework (Sallis & Owen, 1997). This mimicked the rise of this approach in public health and the importance of social determinants of health more generally (Stokols, 1992). Growth trajectory in research interest in the built environment and physical activity was dramatic. Over 30% of all published research in physical activity featured environmental variables during the first decade of the new millennium (Rhodes & Nasuti, 2011). Indeed, a socioecological approach to understanding physical activity has almost become synonymous with the built environment even though this is not an accurate appraisal of the framework. The continued focus on the socioecological approach is likely for several reasons. First, as noted in the previous section, there is evidence to support the central premise of the socioecological framework that physical activity has multiple levels of potential influence. Thus, the socioecological model is slowly refining its research evidence as it moves from exploratory correlational studies to natural experiments and urban redesign across time (Sallis et al., 2015). Second, the socioecological framework offers not only multiple levels of influence on behaviour but also for a broad understanding of physical activity which often occurs within a single individual across several contexts such as occupation/work, transport and leisure (Sallis et al., 2006). This advances beyond the social cognitive framework, which is more inherently aligned with planned physical activities such as exercise and sport (Rebar & Rhodes, in press). There are also pragmatic aspects to why the socioecological model endures in physical activity science. Specifically, the focus on policy and environmental levels of behaviour change provide targets for government to focus on attempting to improve health outcomes. Settings-based interventions such as schools, urban design, parks, and recreation facilities are targets where governments can take action (Heath et al., 2012). These approaches can align with public health policies for a more environmentally friendly urbanization and thus avoid blaming individuals for their roles in unhealthy behaviour. The approach also aligns well with translational efforts to improve community-wide physical activity promotion, rather than a small clinical focus (Estabrooks & Glasgow, 2006). In essence, the socioecological framework is a perfect structure for the current ethos of western society at this time by advocating a shared responsibility for health among all sectors.

Still, the socioecological model is not without its criticisms and there are potential weaknesses in the approach. First, while there is no question that physical activity has correlates at multiple levels of influence, these are not equally distributed in their relative contribution (Giles-Corti & Donovan, 2002; McNeill et al., 2006; Rhodes et al., 2006). Social cognitive variables, such as intention, self-efficacy, and enjoyment remain the dominant explanations for physical activity (Bauman et al., 2012; Rhodes et al., 2017). This is not an inherent refutation of the socioecological framework because individual factors are an important feature and interconnected with the environment (Sniehotta et al., 2017). Nevertheless, it dampens the overall unique contribution of the socioecological framework over and above the social cognitive approach, when additional explained variances are small. Thus, in some ways, urban design interventions represent an expensive risk because the formative research has shown such small projected effect sizes for the time, effort and expense required to transform the environment. Second, the socioecological framework has such a minimized theoretical formulation that it becomes difficult to falsify and thus refine, adapt, or refute. Ostensibly, any variable can fit somewhere in this framework so it has no list of specific operational constructs. It is almost a certainty that some relationship will be found with such a high probability of family-wise error. Overall, the socioecological framework would benefit from continued refinement into a series of testable theories.

Finally, policy intervention targets at higher levels than the individual, such as the social and built environment, are laudable because they focus on providing greater opportunities for health behaviours like physical activity (Michie, van Stralen, & West, 2011). Trying to change or understand individual physical activity motivation without consideration for the opportunities afforded to a person within their given circumstances is impractical (Michie, Rothman, & Sheeran, 2007; Rebar & Rhodes, in press; Sniehotta et al., 2017). Nevertheless, individual motivation and subsequent decision-making is still fundamental to physical activity and there is no indication that mere opportunity is enough to determine behaviour (Rhodes, 2017). This dilemma of when people make a free choice against physical activity participation despite being enabled and informed represents a serious ethical temptation within the socioecological paradigm. There is a big difference between providing opportunities to be active (Michie et al., 2011) and modifying choice architecture to make physical activity more likely (Thaler & Sunstein, 2008), compared to removing opportunities to choose otherwise (Duncan & Cribb, 1996; Tannahill, 2008). The balance of making physical activity the sensible choice to making physical activity the only choice is something that requires careful future thought in the

socioecological intervention framework because it is far more likely to straddle over civil liberties, free choice, and conflict with disability access than any other framework in physical activity psychology.

9. Future directions and conclusions

As humans are complex and dynamic, the explanations for many behaviours (including physical activity) are likely to be equally complex. For example, a child may engage in physical activity due to some combination of the positive reinforcement she receives from her parents (i.e., operant conditioning influences), her attitudes toward exercise (i.e., from a social-cognitive perspective), the opportunities within her surrounding environment to be active (i.e., social-ecological influences), and her level of self-determined motivation to be active (i.e., from an organismic/humanistic perspective). Thus, integrated theoretical frameworks across the traditions noted above likely serve physical activity science best. In essence, all of the above noted frameworks have some integration, yet several new models and adapted frameworks continue to serve this purpose. For example, one of the cornerstones of the social cognitive framework is the intention construct as the primary antecedent of behaviour, yet this relationship is modest (McEachan et al., 2011) and asymmetrical (Rhodes & de Bruijn, 2013). Specifically, while nearly all people who engage in physical activity have positive intentions to do so, only half of those with good intentions succeed in actually performing the behaviour (Rhodes & de Bruijn, 2013). The need to bridge intention into behaviour, has thus spawned several recent theoretical models that include the merging of different traditions, such as the health action process approach (Schwarzer, 2008), action phases model (Heckhausen & Gollwitzer, 1987), integrated behaviour change model (Hagger & Chatzisarantis, 2014), multi-process action control framework (Rhodes, 2017), I-Change model (de Vries, Mesters, van de Steeg, & Honing, 2005) and temporal self-regulation theory (Hall & Fong, 2007), among others. All of these approaches have shown some preliminary effectiveness (Rhodes & Yao, 2015) and may be useful for physical activity promotion in the next decade.

In particular, the health action process approach (HAPA; Schwarzer, 2008) has seen considerable application in the physical activity domain over the last several years. HAPA was developed to address the intention-behaviour gap with pre-intentional constructs identical to the traditional social cognitive approach, yet it includes volitional constructs of action (where, when, how) and coping (contingencies when barriers may arise) planning as well as self-efficacy to maintain the behaviour and recover from relapse. Observational and experimental evidence suggests that the volitional constructs of HAPA, in particular, may help augment physical activity intentions as well as maintenance self-efficacy (Carraro & Gaudreau, 2011; Rhodes & Yao, 2015; Zhang, Zhang, Schwarzer, & Hagger, 2018). For example, Carraro and Gaudreau (2013) found that interventions focused on action ($\varphi = 0.43$) and coping ($\varphi = 0.39$) planning amounted to small effect size changes in physical activity compared to control groups who did not receive the intervention.

Theoretical frameworks are also developing by their level of abstraction and the functions they serve for physical activity science. The social cognitive tradition or humanistic tradition, for example are generally micro-theories, focused on critical interrelationships among their key constructs (i.e., all variables defined and paths accounted for, high detail). The socioecological framework, by contrast, is a macro-theory that has breadth at the expense of precision (i.e., amorphous and all-inclusive with few defined paths). As our discipline matures, these approaches differentiate some of the basic and applied science needs required to understand and promote physical activity. For example, micro-theories, with their focus on mediating pathways among constructs to explain the chain of events and conditions for why physical activity occurs, are often not a critical focus for health promoters, who merely want to know how and what to use to change the behaviour. In our observations, this has often created a derision toward theory among the community of applied health promoters. On the other hand, macro-level theoretical approaches, in our observations, are derided by basic scientists as being too simplistic or invalid due to a lack of mechanistic (internal) validity. The most noteworthy example of this case in physical activity science has been the transtheoretical model (Prochaska & DiClemente, 1982), which has arguably been the most successful framework to upscale to the applied sector of physical activity promotion but has seen due criticism among basic scientists (Nigg et al., 2011).

A recognition of the level of scale and purpose of the theoretical framework in physical activity may alleviate these previous critiques. Indeed, what may be most useful to bridge the basic and applied sectors of physical activity are meso-level theoretical frameworks (Rebar & Rhodes, in press; Rhodes, 2017). Meso-level theoretical approaches contain constructs with a strong evidence base and some operational paths for understanding behaviour change but they are built for applied science and health promoters more than basic scientists. The behaviour change wheel is an example of this approach (Michie et al., 2011), as it includes key constructs thought to determine behaviour (ability, motivation, opportunity) that can be subdivided to particular intervention techniques. The theoretical domains framework is another example of a meso-level approach to using theory for implementation science (Cane, O'Connor, & Michie, 2012). Relatedly, Lubans et al. (2017) presents a model of evidence-based principles and aligned teaching strategies targeted toward practitioners for simple delivery of effective physical activity interventions. These types of frameworks represent important future approaches to theory in physical activity because they may service implementation while still remaining accountable to scientific scrutiny and revision.

Finally, the most critical future impact on physical activity theory design, testing, and refinement may come from technological developments applied to research. The theories noted above have largely been created by theorists using deductive processes and designed for face-to-face clinical or education-based (small group) intervention with a limited series of assessments. Analyses that utilize big data and real-time data may assist to develop dynamic theoretical models, create unique insights into theory development via inductive approaches, as well as lead to intervention design that can more effectively capture the momentary idiographic needs of people who are attempting to increase physical activity. Dynamic models explore how psychological processes unfold over time and occur within or across contexts and individuals (Wright & Hopwood, 2016). They are particularly well-suited for the study of physical activity because of the shifts from decision, to adoption, and then to behavioural maintenance (Rhodes, 2017). In addition to the dynamic nature of physical activity itself, predictors of physical activity may vary through time and context, which is not captured through static assessments (Dunton, 2017, 2018). These models also allow for the examination of idiographic behaviour changes (i.e., a person's change over time) that may be more accurate for testing the tenets of a theory and precision in intervention compared to group (nomothetic) behaviour changes (Dunton, 2017). Specifically, there has been a growing body of work using dynamic models by leveraging mobile technology to develop Just-In-Time Adaptive Interventions (Dunton, 2017, 2018; Nahum-Shani et al., 2016; Spruijt-Metz et al., 2015). Exploring the effectiveness of this approach to further develop and refine current theories and interventions has considerable promise.

In summary, the health benefits of physical activity are well recognized but many people in developed countries are not physically active enough to reap optimal health benefits. Theories of physical activity are essential to understand behaviour change and provide an organizing framework for effective intervention. The purpose of this paper was to overview the main theoretical frameworks that have been applied to understand and change physical activity over the last three decades. The dominant framework for understanding physical activity has been in the social cognitive tradition, and it has provided valuable information on key constructs linked to physical activity such as self-efficacy and intention as well as demonstrating changes to behaviour

when applied in intervention. The humanistic framework for understanding physical activity has seen a surge in research in the last decade and has demonstrated initial effectiveness in both explaining and intervening on behaviour through autonomous motivation and meeting basic human needs. The most recent and understudied framework for understanding physical activity is through dual process models. These have promise by complementing the prior frameworks with better understanding of non-conscious and hedonic determinants of physical activity and alternate approaches to intervention. Finally, the individual-level focus of all three of these approaches is contrasted by the socioecological framework, which has seen considerable research attention in the last 15 years and focuses on the interplay between multiple levels of influence (from individual to organizational and environmental policy). The socioecological model has been instrumental in understanding the role of the built environment in physical activity behaviour and critical to shaping public health policy in government. Despite the strengths of all four frameworks, we noted several weaknesses of each approach at present and highlighted several newer applications of integrated models and dynamic models that may serve to improve our understanding and promotion of physical activity.

Conflicts of interest

None.

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References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179–211. https://doi.org/10.1016/0749-5978(91)90020-T.

Ajzen, I., & Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological Bulletin, 84*, 888–918.

American College of Sports Medicine (1978). Position statement on the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults. *Medicine & Science in Sports & Exercise, 10*, 7–10.

Araujo, D., Brymer, E., Withagen, R., & Davids, K. Affordances of green exercise environments demand agency. *Psychology of Sport & Exercise* (in press).

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review, 64*, 359–372.

Bandura, A. (1998). Health promotion from the perspective of social cognitive theory. *Psychology and Health, 13*, 623–649.

Banting, L. K., Dimmock, J. A., & Lay, B. S. (2009). The role of implicit and explicit components of exerciser self-schema in the prediction of exercise behaviour. *Psychology of Sport and Exercise, 10*, 80–86.

Barker, R. (1968). *Ecological psychology: Concepts and methods for studying the environment of human behavior.* Stanford, CA: Stanford University Press.

Bauman, A., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., Martin, B. W., & Lancet Physical Activity Series Working Group (2012). Correlates of physical activity: Why are some people physically active and others not? *Lancet, 380*, 258–271.

Biddle, S. J. H., & Nigg, C. R. (2000). Theories of exercise behavior. *International Journal of Sport Psychology, 31*, 290–304.

Bouchard, C., Shephard, R. J., & Stephens, T. (1994). The consensus statement. In C. Bouchard, R. J. Shephard, & T. Stephens (Eds.). *Physical activity fitness and health: International proceedings and consensus statement* (pp. 9–76). Champaign, IL: Human Kinetics.

Brand, R., & Ekkekakis, P. (2018). Affective-reflective theory of physical inactivity and exercise: Foundations and preliminary evidence. *German Journal of Sport Research, 48* 58-58.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design.* Cambridge, MA: Harvard University Press.

Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science, 7*, 37.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports, 100*, 126–131.

Cardinal, B. J. (2014). Physical activity psychology research: Where have we been? Where are we going? *Kinesiology Review, 3*, 44–52.

Carraro, N., & Gaudreau, P. (2011). Implementation planning as a pathway between goal motivation and goal progress for academic and physical activity goals. *Journal of Applied Social Psychology, 41*, 1835–1856.

Carraro, N., & Gaudreau, P. (2013). Spontaneous and experimentally induced action planning and coping planning for physical activity: A meta-analysis. *Psychology of Sport and Exercise, 14*, 228–248.

Chaiken, S., & Trope, Y. (1999). *Dual-process theories in social psychology.* Guilford Press.

Cheon, S. H., Reeve, J., & Moon, I. S. (2012). Experimentally based, longitudinally designed, teacher-focused intervention to help physical education teachers be more autonomy supportive toward their students. *Journal of Sport & Exercise Psychology, 34*, 365–396.

Cheval, B., Sarrazin, P., Pelletier, L., & Friese, M. (2016). Effect of retraining approach-avoidance tendencies on an exercise task: A randomized controlled trial. *Journal of Physical Activity and Health, 13*, 1396–1403.

Chevance, G., Bernard, P., Chamberland, P.-E., & Rebar, A. L.. The association between implicit attitudes toward physical activity and physical activity behavior: A systematic review and correlational meta-analysis. (2015). https://osf.io/mgv82 2018 All materials available at:.

Conner, M., & Norman, P. (2015). *Predicting health behaviour: Research and practice with social cognition models.* Berkshire, U.K: Open University Press.

Conn, V. S., Hafdahl, A. R., & Mehr, D. R. (2011). Interventions to increase physical activity among healthy adults: Meta-analysis of outcomes. *American Journal of Public Health, 101*, 751–758.

Conroy, D. E., & Berry, T. R. (2017). Automatic affective evaluations of physical activity. *Exercise and Sport Sciences Reviews, 45*, 230–237.

Courneya, K. S. (2004). Antecedent correlates and theories of exercise behaviour. In T. Morris, & J. Summers (Eds.). *Sport psychology: Theories, applications, and issues* (pp. 492–512). (2nd ed.). Sydney: John Wiley and Sons.

De Houwer, J., Teige-Mocigemba, S., Spruyt, A., & Moors, A. (2009). Implicit measures: A normative analysis and review. *Psychological Bulletin, 135*, 347–368.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum Press.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behaviour. *Psychological Inquiry, 11*, 227–268.

Deci, E. L., & Ryan, R. M. (2002). *Handbook of self-determination research.* Rochester, NY: University of Rochester Press.

Dishman, R. K. (1988). *Exercise adherence: Its impact on public health.* Champaign, IL: Human Kinetics.

Duncan, P., & Cribb, A. (1996). Helping people change: An ethical approach? *Health Education Research, 11*, 333–348.

Dunton, G. F. (2017). Ecological momentary assessment in physical activity research. *Exercise and Sport Sciences Reviews, 45*, 48–54.

Dunton, G. F. (2018). Sustaining health-protective behaviors such as physical activity and healthy eating. *JAMA, Advanced online publication.* https://doi.org/10.1249/mss.

Ekkekakis, P., & Zenko, Z. (2016). Escape from cognitivism: Exercise as hedonic experience. In M. Raab, P. Wylleman, R. Seiler, A. M. Elbe, & A. Hatzigeorgiadis (Eds.). *Sport and exercise psychology research from theory to practice* (pp. 389–414). London: Academic.

Estabrooks, P. A., & Glasgow, R. E. (2006). Translating effective clinic-based physical activity interventions into practice. *American Journal of Preventive Medicine, 31*, 45–56.

Evans, J. S. B., & Frankish, K. E. (2009). *Two minds: Dual processes and beyond.* Oxford University Press.

Evans, J. S. B., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science, 8*, 223–241.

Ferdinand, A., Biasakha, S., Rahurkar, S., Engier, S., & Menachemi, N. (2012). The relationship between built environments and physical activity: A systematic review. *American Journal of Public Health, 102*, 7–13.

Fiedler, K., Messner, C., & Bluemke, M. (2006). Unresolved problems with the "I", the "a", and the "t": A logical and psychometric critique of the implicit association test (iat). *European Review of Social Psychology, 17*, 74–147.

Fortier, M. S., Sweet, S. N., O'Sullivan, T. L., & Williams, G. C. (2007). A self-determination process model of physical activity adoption in the context of a randomized controlled trial. *Psychology of Sport and Exercise, 8*, 741–757.

Foster, C., Hillsdon, M., & Thorogood, M. (2009). Interventions for promoting physical activity. *Cochrane Database of Systematic Reviews, 1*, 1–86.

French, D. P., Olander, E. K., Chisholm, A., & Sharry, J. (2014). Which behaviour change techniques are most effective at increasing older adults' self-efficacy and physical activity behaviour? A systematic review. *Annals of Behavioral Medicine, 48*(2), 225–234.

Gardner, B., de Bruijn, G. J., & Lally, P. (2011). A systematic review and meta-analysis of applications of the Self-Report Habit Index to nutrition and physical activity behaviors. *Annals of Behavioral Medicine, 42*, 174–187.

Gawronksi, B., & De Houwer, J. (2007). Implicit measures in social and personality psychology. In H. T. Reis, & C. M. Judd (Eds.). *Handbook of research methods in social and personality psychology*(2nd ed.). New York: Cambridge University Press.

Giles-Corti, B., & Donovan, R. J. (2002). The relative influence of individual, social and physical environment determinants of physical activity. *Social Science & Medicine, 54*, 1793–1812.

Goldstein, K. (1995/1934). *The organism: A holistic approach to biology derived from pathological data in man.* New York: Zone Books.

Gourlan, M., Bernard, P., Bortolon, C., Romain, A. J., Lareyre, O., Carayol, M., ... Boiché, J. (2016). Efficacy of theory-based interventions to promote physical activity. A

meta-analysis of randomised controlled trials. *Health Psychology Review, 10*, 50–66.
Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology, 74*, 1464.
Hagger, M. S., & Chatzisarantis, N. L. D. (2014). An integrated behavior-change model for physical activity. *Exercise and Sport Sciences Reviews, 42*, 62–69.
Hagger, M. S., Chatzisarantis, N. L. D., & Biddle, S. J. H. (2002). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. *Journal of Sport & Exercise Psychology, 24*, 1–12.
Hagger, M. S., Rebar, A., Mullan, B., Lipp, O. V., & Chatzisarantis, N. L. D. (2015). The subjective experience of habit captured by self-report indexes may lead to inaccuracies in the measurement of habitual action. *Health Psychology Review, 9*, 296–302.
Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U., & Wells, J. C. (2012). Global physical activity levels: Surveillance progress, pitfalls, and prospects. *The Lancet, 380*, 247–257.
Hall, P. A., & Fong, G. T. (2007). Temporal self-regulation theory: A model for individual health behavior. *Health Psychology Review, 1*, 6–52.
Head, K. J., & Noar, S. M. (2014). Facilitating progress in health behaviour theory development and modification: The reasoned action approach as a case study. *Health Psychology Review, 8*, 34–52.
Heath, G. W., Brownson, R. C., Kruger, J., Miles, R., Powell, K. E., & Ramsey, L. T. (2012). The effectiveness of urban design and land use and transport policies and practices to increase physical activity: A systematic review. *Journal of Physical Activity and Health, 3*, 55–76.
Heckhausen, H., & Gollwitzer, P. M. (1987). Thought contents and cognitive functioning in motivational and volitional states of mind. *Motivation and Emotion, 11*, 101–120. https://doi.org/10.1007/BF00992338.
Karvonen, M. J., Kentala, E., & Mustala, O. (1957). The effects of training on heart rate: A longitudinal study. *Annales Medicinae Experimentalis et Biologiae Fenniae, 35*, 307–315.
Kerlinger, F. N. (1973). *Foundations of behavioral research* (2nd ed.). New York: Holt, Rinehart & Winston.
Lee, I. M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., & Katzmarzyk, P. T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *Lancet, 380*, 219–229.
Lewin, K. (1951). In D. Cartwright (Ed.). *Field theory in social science: Selected theoretical papers* (pp. 169). New Yourk: Harper Row.
Locke, E. A. (1968). Towards a theory of task motivation and individual performance. *Organizational Behavior & Human Performance, 3*, 157–180.
Lubans, D. R., Lonsdale, C., Cohen, K., Eather, N., Beauchamp, M. R., Morgan, P. J., ... Smith, J. J. (2017). Framework for the design and delivery of organized physical activity sessions for children and adolescents: Rationale and description of the 'SAAFE' teaching principles. *International Journal of Behavioral Nutrition and Physical Activity, 14*, 24.
Markland, D., & Tobin, V. (2004). A modification to the behavioral regulation in exercise questionnaire to include an assessment of amotivation. *Journal of Sport & Exercise Psychology, 26*, 191–196.
Martin, S. B., Morrow, J. R. J., Jackson, A. W., & Dunn, A. L. (2000). Variables related to meeting the CDC/ACSM physical activity guidelines. *Medicine & Science in Sports & Exercise, 32*, 2087–2092.
Maslow, A. H. (1943). A theory of human motivation. *Psychological Review, 50*, 370.
McCormack, G. R., Friedenreich, C. M., Giles-Corti, B., Doyle-Baker, P. K., & Shiell, A. (2013). Do motivation-related cognitions explain the relationship between perceptions of urban form and neighborhood walking? *Journal of Physical Activity and Health, 10*, 961–973.
McCormack, G. R., & Shiell, A. (2011). In search of causality: A systematic review of the relationship between the built environment and physical activity among adults. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 125.
McEachan, R., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviors with the theory of planned behavior: A meta-analysis. *Health Psychology Review, 5*, 97–144. https://doi.org/10.1080/17437199.2010.521684.
McLeroy, K., Bibeau, D., Steckler, A., & Glanz, K. (1988). An ecological perspective on health promotion programs. *Health Education & Behavior, 15*, 351–377.
McNeill, L. H., Wyrwich, K. W., Brownson, R. C., Clark, E. M., & Kreuter, M. (2006). Individual, social environmental, and physical environmental influences on physical activity among blck and white adults: A structural equation analysis. *Annals of Behavioral Medicine, 31*, 36–44.
Melnikoff, D. E., & Bargh, J. A. (2018). The mythical number two. *Trends in Cognitive Sciences, 22*, 280–293.
Michie, S., Rothman, A. J., & Sheeran, P. (2007). Current issues and new direction in psychology and health: Advancing the science of behavior change. *Psychology and Health, 22*, 249–253.
Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science, 6*, 42.
Michie, S., West, R., Campbell, R., Brown, J., & Gainforth, H. (2014). *ABC of theories of behaviour change.* Great Britain: Silverback Publishing.
Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2016). Just-in-Time Adaptive Interventions (JITAIs) in mobile health: Key components and design principles for ongoing health behavior support. *Annals of Behavioral Medicine,* 1–17.
Nigg, C. R., Geller, K. S., Motl, R. W., Horwath, C. C., Wertin, K. K., & Dishman, R. K. (2011). A research agenda to examine the efficacy and relevance of theTranstheoretical Model for physical activity behavior. *Psychology of Sport and Exercise, 12*, 7–12.
Ntoumanis, N., Thøgersen-Ntoumani, C., Quested, E., & Hancox, J. (2017). The effects of training group exercise class instructors to adopt a motivationally adaptive communication style. *Scandinavian Journal of Medicine & Science in Sports, 27*, 1026–1034.
O'Donovan, G., & Shave, R. (2007). British adults' views on the health benefits of moderate and vigorous activity. *Preventive Medicine, 45*, 432–435.
Pate, R. R., Pratt, M., Blair, S., Haskell, W. L., Macera, C. A., & Bouchard, C. (1995). Physical activity and public health: A recommendation from the centers of disease control and prevention and the american College of sports medicine. *Journal of the American Medical Association, 273*, 402–407.
Plotnikoff, R. C., & Trinh, L. (2010). Protection Motivation Theory: Is this a worthwhile theory for physical activity promotion? *Exercise and Sport Sciences Reviews, 38*, 91–98.
Prestwich, A., Sniehotta, F. F., Whittington, C., Dombrowski, S. U., Rogers, L., & Michie, S. (2014). Does theory influence the effectiveness of health behavior interventions? Meta-analysis. *Health Psychology, 33*(5), 465–474.
Prochaska, J. O., & DiClemente, C. C. (1982). Transtheoretical therapy: Toward a more integrative model of change. *Psychotherapy Theory Research and Practice, 19*, 276–288. https://doi.org/10.1037/h0088437.
Rebar, A. (2017). Automatic regulation used in sport and exercise research. In O. Braddick (Ed.). *Oxford research encyclopedia of psychology*. New York: Oxford University Press.
Rebar, A., Dimmock, J. A., Jackson, B., Rhodes, R. E., Kates, A., Starling, J., & Vandelanotte, C. (2016). A systematic review of the effects of non-conscious regulatory processes in physical activity. *Health Psychology Review, 10*, 395–407.
Rebar, A., Gardner, B., Rhodes, R. E., & Verplanken, B. The measurement of habit. In B. Verplanken (Ed.), *The Psychology of Habit*. Cham, Switzerland: Springer (in press).
Rebar, A., & Rhodes, R. E. Progression of motivation models in exercise science: Where we have been and where we are heading. In G. Tenenbaum & R. C. Eklund (Eds.), *Handbook of Sport Psychology* (4th ed.) (in press).
Rebar, A., Stanton, R., Geard, D., Short, C. E., Duncan, M., & Vandelanotte, C. (2015). A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychology Review, 9*, 366–378.
Rhodes, R. E. (2016). Social cognitive approaches to understanding health behavior: The undead of health behavior theories. *Paper presented at the annual meeting of the society of behavioral medicine in Washington, D.C.*
Rhodes, R. E. (2017). The evolving understanding of physical activity behavior: A multiprocess action control approach. In A. J. Elliot (Vol. Ed.), *Advances in motivation science: 4*, (pp. 171–205). Cambridge, MA: Elsevier Academic Press.
Rhodes, R. E., Bredin, S. S. D., Janssen, I., Warburton, D. E. R., & Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates and interventions. *Psychology and Health, 32*, 942–975.
Rhodes, R. E., Brown, S. G., & McIntyre, C. A. (2006). Integrating the perceived neighbourhood environment and the theory of planned behaviour when predicting walking in Canadian adult sample. *American Journal of Health Promotion, 21*, 110–118.
Rhodes, R. E., & de Bruijn, G. J. (2013). How big is the physical activity intention-behaviour gap? A meta-analysis using the action control framework. *British Journal of Health Psychology, 18*, 296–309.
Rhodes, R. E., & Dickau, L. (2012). Meta-analysis of experimental evidence for the intention-behavior relationship in the physical activity domain. *Health Psychology, 31*(6), 724–727.
Rhodes, R. E., & Kates, A. (2015). Can the affective response to exercise predict future motives and physical activity behavior? A systematic review of published evidence. *Annals of Behavioral Medicine, 49*, 715–731.
Rhodes, R. E., & Nasuti, G. (2011). Trends and changes in research on the psychology of physical activity across 20 years. *A quantitative analysis of 10 journals Preventive Medicine, 53*(1–2), 17–23.
Rhodes, R. E., & Nigg, C. R. (2011). Advancing physical activity theory: A review and future directions. *Exercise and Sport Sciences Reviews, 39*, 113–119.
Rhodes, R. E., & Pfaeffli, L. A. (2010). Mediators of physical activity behaviour change among adult non-clinical populations: A review update. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 37.
Rhodes, R. E., Saelens, B. E., & Sauvage-Mar, C. (2018a). Understanding physical activity through interactions between the built environment and social cognition: A systematic review. *Sports Medicine, 48*, 1893–1912.
Rhodes, R. E., Williams, D. M., & Conner, M. T. (2018b). Affective determinants of health behaviour: Common themes, future directions, and implications for health behavior change. In D. W. Williams, R. E. Rhodes, & M. T. Conner (Eds.). *Affective determinants of health behavior* (pp. 485–498). New York, NY: Oxford University Press.
Rhodes, R. E., & Yao, C. (2015). Models accounting for intention-behavior discordance in the physical activity domain: A user's guide, content overview, and review of current evidence. *International Journal of Behavioral Nutrition and Physical Activity, 12*(9), 1–15.
Rogers, R. W. (1983). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In J. T. Cacioppo, & R. E. Petty (Eds.). *Social psychophysiology* (pp. 153–176). New York: Guilford Press.
Rogers, C. R. (1995/1961). *On becoming a person: A therapist's view of psychotherapy.* Boston, MA: Houghton Mifflin Harcourt.
Rosenstock, I. M. (1974). Historical origins of the health belief model. *Health Education Monographs, 2*, 1–9.
Rothman, A. J. (2004). Is there nothing more practical than a good theory? Why innovations and advances in health behavior change will arise if interventions are used to test and refine theory. *International Journal of Behavioral Nutrition and Physical Activity, 1*, 11.
Ryan, R. M., Patrick, H., Deci, E. L., & Williams, G. C. (2008). Facilitating health behaviour change and its maintenance: Interventions based on self-determination theory. *European Health Psychologist, 10*, 2–5.
Ryan, R. M., Williams, G. C., Patrick, H., & Deci, E. L. (2009). Self-determination theory

and physical activity: The dynamics of motivation in development and wellness. *Hellenic Journal of Psychology, 6*, 107–124.
Sallis, J. F., Bull, F., Guthold, R., Heath, G. W., Inoue, S., Kelly, P., ... Hallal, P. C. (2016). Progress in physical activity over the Olympic quadrennium. *The Lancet, 388*, 1325–1336.
Sallis, J. F., Cervero, R. B., Ascher, W., Henderson, K., Kraft, M. K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health, 27*, 297–322.
Sallis, J. F., & Owen, N. (1997). Ecological models. In K. Glanz, F. M. Lewis, & B. K. Rimer (Eds.). *Health behavior and health education* (pp. 403–424). San Francisco: Jossey-Bass.
Sallis, J. F., Owen, N., & Fisher, E. (2015). Ecological models of health behavior. In K. Glanz (Ed.). *Health behavior: Theory, research, and practice* (pp. 43–64). San Francisco: Jossey-Bass.
Sallis, J. F., Saelens, B. E., Frank, L., Conway, T., & Cain, K. (2005). Relative contributions of psychological, social, and environmental variables to explanation of physical activity. *Annals of Behavioral Medicine, 29*, S204.
Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology, 57*, 1–29.
Sheldon, K. M. (2011). Integrating behavioral-motive and experiential-requirement perspectives on psychological needs: A two process model. *Psychological Review, 118*, 552–569.
Sheldon, K. M., Elliot, A. J., Kim, Y., & Kasser, T. (2001). What is satisfying about satisfying events? Testing 10 candidate psychological needs. *Journal of Personality and Social Psychology, 80*, 325–339.
Sheldon, K. M., & Lyubomirsky, S. (2012). The challenge of staying happier: Testing the hedonic adaptation prevention model. *Personality and Social Psychology Bulletin, 38*, 670–680.
Silva, M. N., Vieira, P. N., Coutinho, S. R., Minderico, C. S., Matos, M. G., Sardinha, L. B., & Teixeira, P. J. (2010). Using self-determination theory to promote physical activity and weight control: A randomized controlled trial in women. *Journal of Behavioral Medicine, 33*, 110–122.
Sniehotta, F. F., Araújo-Soares, V., Brown, J., Kelly, M. P., Michie, S., & West, R. (2017). Complex systems and individual-level approaches to population health: A false dichotomy? *The Lancet Public Health, 2*, e396–e397.
Sniehotta, F. F., & Presseau, J. (2011). The habitual use of the self-report habit index. *Annals of Behavioral Medicine, 43*, 139–140.
Sniehotta, F. F., Presseau, J., & Araújo-Soares, V. (2014). Time to retire the theory of planned behavior. *Health Psychology Review, 8*, 1–7.
Spruijt-Metz, D., Hekler, E., Saranummi, N., Intille, S., Korhonen, I., Nilsen, W., ... Pavel, M. (2015). Building new computational models to support health behavior change and maintenance: New opportunities in behavioral research. *Translational Behavioral Medicine, 5*, 335–346. https://doi.org/10.1007/s13142-015-0324-1.
Standage, M., Duda, J., & Ntoumanis, N. (2001). A model of contextual motivation in physical education: Using constructs from self-determination and achievement goal theories to predict physical activity intentions. *Journal of Educational Psychology, 95*, 97–110.
Stokols, D. (1992). Establishing and maintaining healthy environments: Toward a social ecology of helath promotion. *American Psychologist, 47*, 6–22.
Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8*, 220–247.
Sylvester, B. D., Standage, M., McEwan, D., Wolf, S. A., Lubans, D. R., Eather, N., ... Beauchamp, M. (2016). Variety support and exercise adherence behavior: Experimental and mediating effects. *Journal of Behavioral Medicine, 39*, 214–224.
Symons Downs, D., & Hausenblas, H. A. (2005). Exercise behavior and the theories of reasoned action and planned behavior: A meta-analytic update. *Journal of Physical Activity and Health, 2*, 76–97.
Tannahill, A. (2008). Beyond evidence—to ethics: A decision-making framework for health promotion, public health and health improvement. *Health Promotion International, 23*, 380–390.
Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9*, 78.
Thaler, R., & Sunstein, C. (2008). *Nudge.* London, UK: Penguin Books.
Van Holle, V., Deforche, B., & Van Cauwenberg, J. (2012). Relationship between the physical environment and different domains of physical activity in european adults: A systematic review. *BMC Public Health, 12*, 807.
de Vries, H., Mesters, I., van de Steeg, H., & Honing, C. (2005). The general public's information needs and perceptions regarding hereditary cancer: An application of the Integrated Change Model. *Patient Education and Counseling, 56*, 154–165.
Warburton, D. E. R., & Bredin, S. S. D. (2016). Reflections on physical activity and health: What should we recommend? *Canadian Journal of Cardiology, 32*, 495–504.
Williams, D. M., Anderson, E. S., & Winett, R. A. (2005). A review of the outcome expectancy construct in physical activity research. *Annals of Behavioral Medicine, 29*, 70–79.
Williams, D. M., & Evans, D. R. (2014). Current emotion research in health behavior science. *Emotion Review, 6*, 282–292.
Williams, S., & French, D. P. (2011). What are the most effective intervention techniques for changing physical activity self-efficacy and physical activity behaviour-and are they the same? *Health Education Research, 26*, 308–322.
Williams, D. M., Rhodes, R. E., & Conner, M. (2018). Overview of affective determinants of health behavior. In D. M. Williams, M. Conner, & R. E. Rhodes (Eds.). *Affective Determinants of Health Behavior* (pp. 1–18). New York: Oxford Press.
Wright, A. G. C., & Hopwood, C. J. (2016). Advancing the assessment of dynamic psychological processes. *Assessment, 23*, 399–403.
Young, M. D., Plotnikoff, R. C., Collins, C., Callister, R., & Morgan, P. J. (2014). Social cognitive theory and physical activity: A systematic review and meta-analysis. *Obesity Reviews, 12*, 983–995.
Zhang, C. Q., Zhang, R., Schwarzer, R., & Hagger, M. S. (2018). *A meta-analysis of the health action process approach. Open science framework*.