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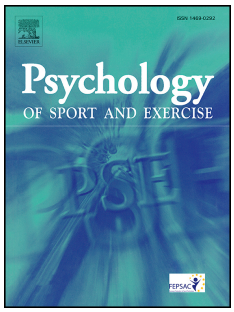

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Martin S. Hagger

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Habit and Physical Activity: Theoretical Advances, Practical Implications, and Agenda for Future Research

Martin S. Hagger

Curtin University and University of Jyväskylä

Author note

Martin S. Hagger, Health Psychology and Behavioral Medicine Research Group, School of Psychology, Faculty of Health Sciences, Curtin University, Perth, Australia, and Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland.

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Correspondence regarding this article should be addressed to Martin S. Hagger, Health Psychology and Behavioral Medicine Research Group, School of Psychology, Faculty of

Health Sciences, Curtin University, GPO Box U1987, Perth, WA 6845, Australia, email:

martin.hagger@curtin.edu.au

Abstract

Objective: Understanding habits may inform intervention development aimed at promoting physical activity maintenance for long-term health. In the present article, I review theory and research on habits applied to physical activity. I provide an overview of contemporary conceptualizations of habit and habit theory; address whether or not physical activity can be habitual; review perspectives on how physical activity habits develop; summarize research on effects of physical activity habits; identify intervention strategies effective in promoting physical activity habits; and propose an agenda for future research on physical activity habits.

Design and Methods: Conceptual and narrative review.

Discussion and Conclusion: My overview begins with the definition and conceptualization of habit. Habits are defined as specific behavioral responses co-occuring with environmental cues or contextual features. Habitual behaviors such as physical activity are represented in associative memory, and experienced as low effort, automatic, and independent of goals and intentions. Habits are developed through repeated experience of the activity in stable contexts. The activity is initially controlled by goals and rewards, but control shifts to non-conscious, automatic processes as habits develop. Interventions to develop habits require promotion of self-regulatory skills that enable repeated experience of the activity in conjunction with stable cues or contexts. I propose a number of strategies based on habit research that may inform interventions to promote physical activity habits. I also propose an agenda for future research on habit in physical activity, which includes developing an integrated theory of habit, adopting innovative measures and designs, and testing interventions to develop habits.

Keywords: automaticity; past behavior; routine; self-regulation; behavioral intervention; behavior change

1. Introduction

A substantive proportion of people's daily actions are accounted for by habits (Bamberg, Ajzen, & Schmidt, 2003; Danner, Aarts, & de Vries, 2008; Rhodes & Rebar, 2018; Wood & Neal, 2007). However, while there is considerable research examining habits as 'low level' motor patterns and routine sequential actions in areas such as learning, conditioning, reinforcement, and goal-means relations (Balleine & Dickinson, 1998; Botvinick & Plaut, 2006), and research examining other types of 'automatic', non-conscious processes such as priming and non-conscious activation of goals (Bargh, 1997; Custers & Aarts, 2005), there has been relatively little research dedicated to understanding habits in everyday contexts (Wood, 2017). Given the pervasiveness of habits in daily life, a complete theoretical account of human behavior necessitates an understanding of habits. In the context of physical activity, understanding habits will provide insight into the extent to which physical activity can become 'habitual' and the processes that may lead to the development of physical activity habits. Knowledge on habits may have utility for organizations interested in developing interventions to increase physical activity participation for health promotion and chronic disease prevention.

In the current article, I review current definitions and theoretical perspectives on physical activity habits; respond to key questions such as whether or not physical activity can truly become 'habitual'; provide an overview of how physical activity habits are developed; summarize research on key issues relating to physical activity habits such as the inclusion of habit in theories of self-regulation and social cognition, habit measurement issues, and the role of past behavior; outline how habit research can inform interventions to promote physical activity behavior; identify the means interventionists can employ to promote physical activity habits; and propose an agenda for future research that may further knowledge and understanding of habits in physical activity[1].

[1]The current review examines physical activity habits from an applied social psychological perspective, with a focus on the inter- and intra-personal and contextual factors that give rise to habits.

In the context of the current article I adhere to a definition of physical activity as any form of physical activity that has potential to promote health. This may encompass moderate-to-vigorous physical activities such as formal exercise (e.g., going for a run, attending a 'cross fit' class), informal exercise (e.g., going for a walk), and incidental physical activities (e.g., cycling to work, using stairs in the workplace). Physical activity is, therefore, considered a 'behavioral category', encompassing a number of different behaviors. While I make reference to physical activity as a set of behaviors in general discussions of theory on habit, I also provide examples in which I refer to some of the specific types of physical activity such as forms of formal exercise or use of active transport.

2. What is a Habit? Definition and Conceptualization

Theory and research on habit has distinguished between habit as a behavior and habit as a process or psychological construct (Aarts & Dijksterhuis, 2000; Gardner, 2015; Mazar & Wood, 2018; Wood, 2017). Many theories view habits as certain kinds of behaviors. For example, some theorists have conceptualized and measured habit as past behavior frequency (e.g., Sutton, 1994; Trafimow & Borrie, 1999; Triandis, 1977). This is based on the assumption that repeated performance of a behavior tends to lead to the development of habitual action. However, this perspective has substantial limitations (Verplanken, 2006). Behaviors performed frequently do not necessarily become habits. Furthermore, mere observation of behavior does not provide information on the conditions or processes within the individual that have given rise to the behavior. For example, observing that your neighbour goes jogging at 7am every morning may lead you to infer that she jogs habitually. However, your observation provides no information on the conditions that determine her jogging. You would, for example, fail to see that her mother provides her with a hefty financial reward for doing so, a reinforcing contingency that controls her behavior, and in its absence her jogging behavior may desist. Recognizing the basic limitations of behavioral observation as a means to infer habits, other perspectives have been promulgated, with many defining habits as a psychological construct

(Aarts & Dijksterhuis, 2000; Gardner, 2015; Mazar & Wood, 2018; Verplanken & Orbell, 2003; Wood, 2017; Wood & Runger, 2016). Such approaches recognize that habitual behaviors are inextricably linked to the cues or contextual features that give rise to them. They also specify the specific features of the behavior and its experience, and identify processes and factors that lead to their development and maintenance, and lead to their extinction.

Contemporary theory defines habit as a specific action or behavioral tendency that is enacted with little conscious awareness or reflection, in response to a specific set of associated conditions or contextual cues (Mazar & Wood, 2018; Neal, Wood, & Quinn, 2006; Verplanken, 2006; Wood, 2017). Theorists and researchers have identified a series of key defining characteristics of habits. Automaticity is considered a key characteristic; habits tend to be enacted with little conscious awareness and, as a consequence, occur rapidly and efficiently, with little effort (Aarts & Dijksterhuis, 2000; Bargh & Ferguson, 2000; Gardner, Abraham, Lally, & de Bruijn, 2012; Verplanken & Orbell, 2003). Habits may have an adaptive function, enabling complex, cognitively costly actions to be enacted with little deliberation thereby 'freeing up' processing capability for higher-order strategic processing (Förster & Jostmann, 2012; Wood, 2017). Habits differ from other forms of 'automatic' processes such as classical conditioning and reinforcement strategies (McHose & Moore, 1976; Skinner, 1953), priming and the non-conscious activation of behaviors and goals (Custers & Aarts, 2005; Dijksterhuis, van Knippenberg, & Holland, 2014), and behavioral scripts (Abelson, 1981). These types of automatic behaviors focus on goal-directed actions and engender broader behavioral responses. Instead, habits relate to specific behaviors or patterns of action, and are enacted in the absence of goals (Wood, 2017).

The proposal that habits reflect automaticity is consistent with some forms of dual process theories of behavior (Evans & Stanovich, 2013; Hofmann, Friese, & Wiers, 2011; Strack & Deutsch, 2004). The theories propose that behavior is function of two processes: an automatic, impulsive process in which behavior is determined by implicit cognitions,

behavioral scripts, or habitual responses stored in associative memory (often referred to as a 'system 1' process; Kahneman & Frederick, 2007), and a reasoned, reflective process in which behavior is determined by effortful deliberation over the value and costs of outcomes (referred to as 'system 2' process). The former is considered low-effort, rapid and efficient, while the latter is effortful, slower, and less efficient by comparison. Habit may be considered a specific form of a system 1 process (Hall & Fong, 2007; Verplanken & Aarts, 1999; Wood, 2017; Wood, Labrecque, Lin, & Ruenger, 2014), in which behavior is non-consciously, automatically enacted in response to the presentation of associated cues or contextual features. Dual process theories also provide an explanation for habit-related processes. Just as dual process theories predict that behaviors can be controlled by both reasoned and automatic processes, so behaviors can vary in the extent to which they are habitual. For example, many researchers conceptualize habit strength as a continuum and indicate that individuals differ in the extent to which they experience their behavior as habitual (e.g., Lally, van Jaarsveld, Potts, & Wardle, 2010).

Another defining characteristic of habits is that they tend to relate to specific actions triggered by specific cues or contextual contingencies. The links between these cues or contextual contingencies are held in associative memory (Squire & Zola-Morgan, 1991), and are thought to be developed through repeated experience the behavior in the presence of cues or contextual features (Seger & Spiering, 2011). This makes habits distinct from other implicit social psychological constructs such as implicit attitudes and motives (Greenwald et al., 2002). These constructs reflect non-conscious representations of actions as means to obtain desired goals or rewarding outcomes. Such constructs are goal- or outcome-directed and may entail enactment of multiple behaviour responses to fulfil the goal (Fishbach & Shah, 2006). Habits on the other hand tend to be specific behaviors or closely-related sets of actions linked with particular cues or contextual contingencies (Wood, 2017). For example, the goal of 'losing weight' could be fulfilled through making modifications to one's diet, and increasing

participation physical activity. Of course diet modification and physical activity, as previously suggested, can encompass a number of specific behaviors. However, from the perspective of habits, any one of these behaviors could be acquired as a habit if it were, for example, repeated with sufficient frequency and in response to a specific set of cues.

Although the process that leads behaviors to develop into habits is likely to involve the pursuit of goals or rewards, once acquired, habits are themselves are said to enacted without the necessity of goals or rewards. Therefore, as an action becomes habitual it is enacted with less reliance on the goals that the behavior was originally intended to service (Wood & Runger, 2016). A habitual behavior likely begins as one that services a specific goal, but, as it becomes habituated, the relevance of the goal in activating the behavior wanes. For example, an individual may join a gym and start working out regularly to get fit or lose weight, but, as the gym attendance becomes habitual, the goal of losing weight itself becomes less relevant in instigating the behavior. Analogously, habits are also proposed to be distinct from other implicit constructs like beliefs and attitudes, which reflect individuals' cognitive representation of some future desired outcome or goal (Wood & Neal, 2007). The goal-independence of habits has been corroborated in studies that demonstrate that individuals perform habitual acts regardless of whether or not a goal fulfilled by the action is active or salient (Ji & Wood, 2007; Wood & Neal, 2007). For example, research in physical activity has indicated that individuals' with strong exercise habits follow-through with their behavior even if they do not hold intentions to do so (Gardner, de Bruijn, & Lally, 2011). In another example, habitual runners responded more quickly to word stimuli representing their habitual behavior (e.g., "jogging", "running") when the contexts in which they normally performed the behavior (e.g., "gym", "forest") were primed, whereas priming their running goals (e.g., "control weight", "for relaxation") did not (Neal, Wood, Labrecque, & Lally, 2012). As habits develop, individuals become less sensitive to the goals and rewards that may have led to the development of the habit. However, it is important to note that habits may remain functional in that they service

adaptive goals, but their enactment does not require an individual to recall or represent the goal. Any adaptive goal serviced by the habit is, therefore, incidental to the habit itself. However, that habits once started out as goal directed indicates that habits may serve as an important mechanism by which people attain long-term goals.

3. Can Physical Activity Be 'A Habit'?

Defining habit as a specific behavior or action is an oversimplification. Just as individual actions can be broken down into specific sets of motor patterns, habits themselves comprise sets of sub-actions, which need to be enacted in sequence or parallel to fulfil the overall behavior (Gardner, Phillips, & Judah, 2016). Therefore, when referring to habits, researchers often consider the behavior observed at the macro level, but seldom account for the sets of co-ordinated sub-actions that comprise those actions. Physical activity is a salient example because it comprises multiple behaviors, and each physical activity comprises a series of coordinated actions that give rise to the behavior. For example, swimming laps in the local swimming pool is not only about coordinating limbs to propel one through the water, but about the specific sets of actions that lead the individual to get to the pool in the first place: identifying the appropriate time and location, packing relevant equipment, arranging transport, ensuring one has sufficient money to pay for the pool use, and so on.

Theorists have, therefore, questioned whether complex series of actions, like those involved in performing a given physical activity, can truly become 'habitual'. Some have argued that truly habitual behaviors should be confined to 'low level' motor patterns executed with high precision, without any conscious or perceptual input, such as operating the pedals or gear lever of a car, or the footwork and arm swing required for a tennis serve. Habits from this perspective are viewed as organized sets or groups of actions executed in a sequential, coordinated pattern to produce the overall observed behavior. Such perspectives are epitomized by research on the acquisition of controlled motor movements in skill acquisition (Egbert &

Barandiaran, 2014; Graybiel, 2008) and reinforcement paradigms in learning (Balleine & Dickinson, 1998).

An alternative perspective defines habitual behaviors as "any action, or sequence of actions, that is controlled by habit" (Gardner, 2015, p. 282), implying that behaviors can be initiated habitually, performed habitually, or a combination of the two. According to this approach, some behaviors can be initiated or instigated habitually, but their performance may require more reasoned, deliberative input, while others may be executed habitually, regardless of whether they have been instigated through a habitual impulse (Gardner, 2015; Gardner et al., 2016). This perspective allows for the initiation of complex behaviors, such as performing a sport skill or physical activity, including all the necessary preparatory behaviors, as a non-conscious, automatic response to an associated cue, but the sets of actions themselves require considerable deliberation or cognitive input to be performed. It also allows for execution of sets of motor sequences, such as those involved in executing a swimming stroke in the previous example, to occur habitually. For such behaviors, individuals may 'chunk' sequences of actions together to form the co-ordinated sets of actions observed in the higher-order behavior, and the execution habit, therefore, is reflected in the experience of mastering a specific skill, similar to the swimming example provided earlier. The distinction between instigation and execution habitual control may not be necessary to describing simple, 'low level' behaviors, such as such as operating the foot pedals of a car. However, making the distinction may have utility in describing the habitual control of behaviors like physical activity that involve complex sequences of behaviors to enact.

4. Habit Development

Habits are developed through repeated execution of behaviors in the presence of salient cues or contextual features (Gardner, 2015; Gardner & Lally, 2018; Wood, 2017; Wood & Runger, 2016). Before a behavior develops into one that is controlled habitually, it is likely to be determined by deliberative processes. In the case of performing complex behaviors like

physical activities, which comprise multiple sets of coordinated sub-actions, habitual control over the behavior most likely relates to its instigation rather than execution. Initiation of the behavior at this initial stage is determined by intentional processes guided by reflection on the merits and detriments of acting and anticipated outcomes. With repeated instigation of the behavior in stable contexts, behavioral control shifts toward automatic, non-conscious processes, and the instigation of the behavior acquires the features of a habit: fast, efficient, non-conscious, and non-intentional.

Repeated exposure to the behavior in the presence of the cues during habit development strengthens links between salient cues and the instigation of the behavior in associative memory. This increases the strength and accessibility of cue-action associations and makes the behavior the most likely and readily-enacted alternative on presentation of the cue (Aarts & Dijksterhuis, 2000; Danner et al., 2008). The high accessibility of cues to action, the speed and efficiency with which they cue-up the associated action, makes the habitual response the most likely 'winner' relative to alternatives for which the cues and associated response are weaker and less routinized. Habits, therefore, and proposed to override competing intended behaviors in given contexts (Gardner, de Bruijn, & Lally, 2011; Triandis, 1977), and are considered to have a 'cognitive advantage' over behavioral alternatives (Adriaanse, Gollwitzer, De Ridder, de Wit, & Kroese, 2011). However, there is also evidence to suggest that habits facilitate acting on intentions (de Bruijn, Rhodes, & van Osch, 2012; Galla & Duckworth, 2015). This implies that habits may enable behavioral instigation in situations where intentions to engage in the habituated behavior are weak, which suggests habits may have an adaptive function with respect to goal pursuit. Correlational research designs in which measures of habits, intentions, and behaviors are aligned may be sub-optimal in exploring these effects, and research further is needed to test effects of habits in the presence of competing, counter-habitual intentions for physical activity and competing alternatives.

How long does it take for individuals to develop a 'habit' for physical activity? Research using computerized tasks suggests that individuals can develop strong links between contextual cues and novel behavioral responses relatively quickly, and that such links in associative memory interfered with subsequent efforts to alter the response (Wood, 2017). However, research on the development of habits for more complex behaviors like physical activity in 'real world' contexts suggests that rates of habit development are highly variable, and dependent on the presence or absence of number of key factors during development. For example, Lally and colleagues (2010) asked participants asked to perform a self-nominated health behavior (physical activity participation, healthy eating, drinking water) in the same context every day and log in a daily diary whether or not they had performed the behavior, and the extent to which they experienced it as 'automatic' or habitual. Results indicated that habit development, indicated by degree of self-reported automaticity experienced over time, followed a non-linear, 'asymptotic' development curve. Data indicated relatively rapid early gains in reported behavioral as automaticity, which tailed off over time. Further, although the median time taken for participants to reach the 'peak' of their personal habit development curve was approximately nine weeks, there was substantive variability both in the time taken to reach the peak and the absolute level of the peak. This indicates individual differences in the speed at which people acquire habits, and that some individuals' habit curves never reach levels indicating the behavior is habitual. The data also demonstrated that individuals performing the behavior with greater consistency were more likely to follow the habit development curve more closely.

A number of potential factors in the formation stage may determine how quickly an individual comes to experience a behavior as habitual, such as intention strength, perceived behavioral complexity, and use of self-regulatory skills. For example, Kaushal and Rhodes' (2015) longitudinal study of first-time gym attendees' over a period of 12 weeks revealed that participants were more likely to report forming a physical activity habit if they participated in

at least four physical activity sessions over a six-week period. Similarly, Armitage (2005) analysed attendance lapses in first-time gym attendees over a period of 12 weeks. Participants' attendance to the gym in the first five weeks of the trial predicted subsequent attendance across the 12 weeks, while attendance from week six onwards did not. Armitage contends that these data indicate that attendance in the first five weeks is critical for habit formation. However, it is important to note the data from which this conclusion is drawn focuses solely on the frequency of past behavior. The presence of conditions that facilitate habit acquisition such as stability of context, and changes in experiences of automaticity by the participants, are inferred rather than measured directly. These data indicate that physical activity habits can develop over a period of weeks, and that there is considerable inter-individual variability in how quickly habits can be acquired. However, there are relatively few long-term studies examining habit development and further research is needed, especially on factors that may facilitate or impede the developmental process.

5. Habit and Self-Regulation

Habits may have an important function in the effective self-regulation of behaviors. Individuals with strong tendencies toward effective self-control over their behavior, such as those high in conscientiousness, trait self-control, and grit, demonstrate good capacity to engage in behaviors that lead to adaptive outcomes. For example, individuals with high conscientiousness or trait self-control are more likely to form intentions to participate in physical activity in the future (Chatzisarantis & Hagger, 2008; Conner & Abraham, 2001), and report participation in health behaviors including physical activity (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; Hagger, Hankonen, et al., 2018). Individuals high on these traits have better self-regulatory skills such as capacity to organize and structure their behaviors to attain goals, recognize deviations from goal pursuit and correct them, and inhibit or effectively manage barriers and contingencies that may derail their goal directed

behaviors (de Ridder & Gillebaart, 2017; Gottfredson & Hirschi, 1990; Hofmann, Friese, & Strack, 2009).

Such research seems to indicate that the superior regulatory capacity exhibited by individuals high in these traits is attributable to a generalized capacity to engage in effortful, deliberative control over behavior. However, recent research suggests that self-controlled, conscientious individuals develop habits as an strategic means to effectively regulate their behavior. For example, research has shown that individuals with high trait self-control have strong habits to engage in health-promoting behaviors including physical activity (Galla & Duckworth, 2015), and weak habits for unhealthy behaviors (Adriaanse, Kroese, Gillebaart, & De Ridder, 2014). It seems, therefore, that formation of adaptive habits may be an effective regulatory strategy that individuals adopt to obtain goals, and minimize potential for cues to competing behaviors and temptations to derail their actions. Once habituated, the habits are less dependent on goals for their initiation or enactment, but their development is adaptive and people high on traits such as conscientiousness are more likely to form them. Such strategies suggests that individuals may perform 'upstream' operations, such as developing habits for desired behaviors, in order to prevent or minimize unnecessary or problematic regulation of behavioral alternatives or impulses 'downstream' (Wood, 2017).

6. Past Behavior, Habit Measurement, and Theories of Social Cognition

Effects of habit on health behaviors like physical activity have often been investigated in the context of social cognitive theories. Many theories in this tradition are based on the underlying assumption that behavior is determined by a reasoned, intentional process in which individuals evaluate the benefits and detriments of future actions and outcomes. The theory of planned behavior (Ajzen, 1991) is a prototypical social cognition theory that has been applied to predict health-related behavior (McEachan, Conner, Taylor, & Lawton, 2011; Rich, Brandes, Mullan, & Hagger, 2015), including physical activity (Hagger, Chatzisarantis, & Biddle, 2002). According to the theory, sets of personal, social, and control-related beliefs are

proposed as determinants of intentions – individuals' cognitive representations of future decisions to act. Intentions are the most proximal antecedent of subsequent behavior and mediate effects of the beliefs on behavior. Researchers have used the theory to study effects of habits on behavior by measuring habit concurrent with measures of the theory constructs (e.g., Bamberg et al., 2003; Trafimow & Borrie, 1999; van Bree et al., 2015).

One approach to testing habitual effects within the theory of planned behavior has been to include the effects of past behavioral frequency as an additional predictor of behavior (c.f., Ajzen, 2002; Triandis, 1977). This is consistent with the notion that repeating the behavior frequently would increase opportunities for it to become routinized and habitual, resulting in a switch from intentional to habitual control. Studies (e.g., Albarracín, Johnson, Fishbein, & Muellerleile, 2001; Hagger, Chan, Protogerou, & Chatzisarantis, 2016; Hagger, Polet, & Lintunen, 2018; McEachan et al., 2011), including those in the physical activity domain (Hagger et al., 2002), have demonstrated that inclusion of past behavior in the theory results in a direct effect of past behavior on subsequent behavior, independent of intentions. In addition, inclusion of past behavior attenuates effects of intentions on behavior. These residual effects independent of intention are proposed to model habits (Albarracín et al., 2001; Hagger, Chatzisarantis, & Biddle, 2001; Sutton, 1994).

The use of past behavior as a proxy for habit has been criticized as it is not a construct per se and may account for other processes not related to habit (Ajzen, 2002). However, Ouellette and Wood (1998) argued that effects of past behavior in social cognitive models may provide important information on habits. They proposed two pathways by which past behavior acts on subsequent behavior. The first is the direct effect on behavior independent of intentions. By inference, this effect models the automatic, spontaneous processes to behavioral enactment proposed in dual process theories (Strack & Deutsch, 2004), and likely captures the automaticity component of habit. The second is the indirect effect of past behavior on behavior mediated by the social cognitive constructs (attitudes, subjective norms, perceived behavioral

control) and intentions. This pathway is proposed to model how previous behavior, and associated decision making, informs the subsequent decision making process, intention formation, and future action. Such a pathway also provides indication of the extent to which the theory accounts for behavioral stability – a test of its sufficiency (Ajzen, 1991). Both direct and indirect pathways have been supported in empirical research (Hagger, Chan, et al., 2016; Hagger et al., 2001; Hagger, Polet, et al., 2018; Ouellette & Wood, 1998).

An important question arising from this research is what conditions or circumstances determine which 'route' for past behavior, direct or indirect, prevails in determining behavior. Ouellette and Wood conducted moderator analyses and demonstrated that the direct effect of past behavior was larger in groups of studies on behaviors that tend to be conducted in stable contexts (e.g., class attendance, physician appointments) and for which people are likely to have greater opportunity to perform regularly in their everyday lives (e.g., physical activity, seat belt use). In contrast, the direct effect of past behavior was smaller and intentions were the predominant predictor of behavior for behaviors performed in less stable contexts (e.g., condom use with a casual partner, attending a protest march) and those unlikely to be performed with high regularity (e.g., blood donation, vaccinations). As both context stability and opportunity to perform the behavior regularly are defining characteristics of habit, this pattern of effects for past behavior were viewed as modeling habits. This finding has been corroborated elsewhere. For example, Danner et al. (2008), demonstrated in the domain of active travel that both stability and frequency of past behavior determined the extent to which commuters' intentions predicted cycling to work. Analogously, studies have demonstrated that the stability of intentions, as a proxy measure of intention strength, moderates effects past behavior on behavior (Conner, Sheeran, Norman, & Armitage, 2000; Sheeran, Orbell, & Trafimow, 1999). When intentions are more stable, effects of past behavior tend to be weaker compared to effects when intentions are less stable. Taken together, these findings suggest that past behavior does have some validity as an indicator of habit effects in social cognitive

theories, as well as indicating the contextual factors that likely determine when behavior is controlled by automatic or deliberative processes.

However, past behavior is a mere proxy for habit and fails to capture many of its defining features. Researchers have, therefore, sought alternative approaches to represent habits in social cognitive theories (Rebar, Gardner, Rhodes, & Verplanken, 2018; Verplanken, Aarts, van Knippenberg, & van Knippenberg, 1994; Verplanken & Orbell, 2003; Wood & Neal, 2007). The available measures encompass different components of habits, but considerable overlap has also been noted (c.f., Hagger, 2014). Recognizing the co-occurrence of frequency of performance and stable contexts as a key characteristic of habit, Wood and Neal (2009) proposed a measure capturing both frequency with which the behavior is performed, and consistency with which it is performed in the presence of the same contextual features or situational cues. A response-frequency measure of physical activity, for example, would involve asking individuals to report the frequency with which they had performed a particular physical activity in the past (e.g., "how often in the past week did you perform [physical activity]"), and to report stability of the contexts in which the activity was performed (e.g., "always in the same place" vs. "never in the same place"). The habit measure is the product of participants' scores on the frequency and stability questions. The measure has demonstrated good predictive validity. For example, frequency x stability measures of exercise habits are strongly related to the experience of exercise as 'automatic' (Galla & Duckworth, 2015), and subsequent exercise behavior (Wood, Tam, & Witt, 2005).

In contrast, Verplanken and colleagues (1994) proposed a measure based on the assumption that as behaviors come more habitual, they become the most accessible and, therefore, the most likely behavioral response in minimum information situations where there is little opportunity to deliberate over possible alternatives. Individuals are presented with a list of alternatives relating to the behavior of interest and asked to indicate as quickly as possible the option they would select in response to a number of hypothetical scenarios. The lack of

information provided in the scenarios and the time pressure elicits the most readily accessible option. The extent to which the selected option across scenarios relates to the behavior of interest indicates the extent to which it is habitual. For example, in the case of 'active travel', an individual may be presented with a list of behaviors, some of which are physically active choices such as "walking" or "riding a bicycle", and then presented with a list of hypothetical situations, and the following instruction: "Listed below are a few activities you may often perform. Assuming you spontaneously decide to do one of these activities, which mode of transportation would you most likely use? Please respond quickly without thinking too much about each activity". Employment of the response-frequency measures has demonstrated predictive validity in research on travel mode choice (Bamberg et al., 2003; Thøgersen & Møller, 2008), but has rarely been applied in physical activity contexts.

An alternative approach is offered in Verplanken and Orbell's (2003) self-reported habit index, a meta-cognitive measure in which individuals report the extent to which behaviors are experienced as routine, automatic, and without thought. Items reflect several defining characteristics of habitual behavior including experiencing it as automatic (e.g., "Working out regularly in the gym is something I do automatically"), the extent to which it is performed without conscious thought (e.g., "Working out regularly in the gym is something I do without thinking"), how it is performed (e.g., "Working out regularly in the gym is something I do frequently"), and whether it is part of their typical routine (e.g., "Working out regularly in the gym is something that belongs to my (daily, weekly, monthly) routine"). The measure has been used extensively in research on physical activity, and a meta-analysis has indicated that the measure accounts for unique variance in behavior, independent of intentions and other social cognitive factors (Gardner et al., 2011). In addition, studies have demonstrated that effects of intention on physical activity wane as self-reported habit strength increases (Chatzisarantis & Hagger, 2007; Gardner et al., 2011; van Bree et al., 2013). This moderating effect was corroborated by a within-participants study demonstrating that the effect of self-

reported habit on physical activity behavior was larger when intentions were weaker (Rebar, Elavsky, Maher, Doerksen, & Conroy, 2014). These findings are consistent with previous research and theory on habit that deliberative control over behavior, represented by effects of intentions on behavior, is attenuated when behavior becomes habitual.

A prominent criticism of the self-reported habit index is that it assesses individuals' experience of behavior as habitual rather than actual behavior. Individuals may not have access to the experience of the behavior in memory, limiting their capacity to recall their experiences and introducing method bias (Hagger, Rebar, Mullan, Lipp, & Chatzisarantis, 2015). The index may also capture individuals' perceived 'fluency' and self-efficacy for the behavior, conflating habit effects with reasoned determinants of action (Wood, 2017). This may be why the index sometimes does not predict behavior independent of cognitive constructs reflecting goal pursuit (Labrecque & Wood, 2015). The measure has also been criticized for encompassing items relating to behavioral frequency, which overlap with behavioral measures (Sniehotta & Presseau, 2012). The index had been modified to exclude the behavioral frequency items and isolate items tapping automaticity (Gardner et al., 2012). However, it is unclear whether exclusive use of automaticity items captures habit with greater precision, and is still likely to be subject to many of the limitations as the full index.

A further limitation of the habit index is that it does not capture other components of the habitual experience, such as the dependency on cues and context stability. Other than Wood and Neal's (2009) measure, which encompasses context stability, there have been some attempts to encompass cues and context stability in self-report measures of habit. For example, Grove, Zillich, and Medic (2014) developed a measure that not only captures the automaticity aspect of physical activity habits, similar to Verplanken and Orbell's scale, but also includes scales to measure patterned action (e.g., "I exercise at the same location each week") and strong stimulus-response bonds (e.g., "Certain surroundings just make me want to exercise"), which capture the context stability and presence of cues components of habits, respectively.

Although initial development of this scale demonstrated its construct validity, and its promise in predicting physical activity participation (Grove et al., 2014), it has yet to be widely applied. However, in the same vein, researchers have incorporated measures of cue presence and consistency alongside habit strength as concurrent predictors of physical activity (Pimm et al., 2016) and dietary behaviors (Verhoeven, Adriaanse, Evers, & de Ridder, 2012). This scale should be adopted in future research on physical activity to establish the relative contribution of these multiple components of habit on physical activity behavior and, more importantly, whether they interact, as suggested by Wood and Neal (2007).

Currently available habit measures move beyond past behavior and seek to capture the defining characteristics of habit, and explore their validity in predicting intentions and behavior within social cognitive theories. However, current have substantive limitations, and more research is needed to develop valid, comprehensive measures of habit that effectively capture the essence of habit as a construct.

7. Using Habits to Change Physical Activity Behavior

Given the importance of sustained participation in physical activity and long-term health benefits (GBD 2015 Collaborators, 2016), developing effective means to promote physical activity habits will have utility for organizations aiming to develop interventions facilitating maintenance of participation in physical activity. Research demonstrating the pervasive impact of habit and past behavior on physical activity adherence suggests that interventions aimed at promoting sustained participation in physical activity should seek to tap into processes linked to habit formation (Hollands, Marteau, & Fletcher, 2016; Kaushal, Rhodes, Spence, & Meldrum, 2017; Marteau, Hollands, & Fletcher, 2012; Verplanken & Wood, 2006). Given that habits likely develop through frequent participation in the behavior concurrent with cues or contextual features, habit-promoting interventions should foster frequent successful practice of the desired behavior in stable contexts. Assuming novel behaviors are likely to be under volitional control from the outset, interventions should initially

focus on fostering motivation to engage in the behavior and identifying clear standards that represent success, both prerequisites for a goal-directed action, using strategies such as goal setting and positive feedback. Repeated successful experience in similar contexts is likely to lead to the development of habits. Interventions should therefore prompt individuals to develop and articulate a planned routine, or set of routines, and follow them regularly (Hagger, Luszczynska, et al., 2016; Kwasnicka et al., 2017), and monitor the routine for consistency in initiating cues such as location and time of day (Harkin et al., 2016; Quinn, Pascoe, Wood, & Neal, 2010). Increased repetition of the behavior concurrent with the relevant contextual cues is expected to lead to a shift in the behavior control from a reasoned process to a more automatic one as the habit develops.

Researchers have applied these techniques to promote increased participation in physical activity and shift control over the behavior to being more routinized and automatic. For example, Fleig et al. (2011) conducted a two phase intervention to promote participation in physical activity among patients in orthopaedic and cardiac rehabilitation programs. Patients received an intervention comprising multiple strategies including setting physical activity goals that were concordant with personal values, forming action plans, recalling positive past experiences, and monitoring their progress toward their goals. These strategies were aimed at increasing motivation to participate in physical activities but also to promote routinization through the planning and self-monitoring strategies. Results indicated that the intervention resulted in increased physical activity participation mediated by planning and self-monitoring and, importantly, greater physical activity habit.

Strategies aimed at breaking habits require the actor to engage in effortful, conscious, and deliberative actions that run counter to the typical response, which is likely to be efficient, well-learned, automatic, and low in effort. Individuals must, therefore, have sufficient awareness and motivation to engage in an alternative course of action, and attach sufficient value to that action, from the outset. They must also have a clear intention or goal to participate

in the alternative behavior in the future. Means to increase awareness and motivation include persuasive communications to highlight desirable outcomes and negate difficulties (Johnson, Wolf, & Maio, 2017), guidance on how to engage in the behavior , provision of experiences of success with the behavior (Prestwich et al., 2014; Williams & French, 2011), and prompts to remind individuals of their intended goals to enact a counter-habitual behavior like point-of-choice prompts (Naab & Schnauber, 2016). However, motivation alone is often not enough to counteract unwanted habits, particularly when cues and prompts to the undesired behavior are omnipresent in the social environment. Research has consistently shown that strong habits are relatively impervious to persuasive communications aimed at changing attitudes and intentions (Itzchakov, Uziel, & Wood, 2018). In addition to motivation, individuals also need to be able to recognize the cues and contexts that prompt their undesired habit, and set in place strategies to manage or proactively avoid those cues or contexts. Cue identification and self-monitoring have been promulgated as important strategies to assist in effective management of situations that may derail efforts to break 'bad' habits (Hagger & Luszczynska, 2014; Harkin et al., 2016; Quinn et al., 2010). For example, office workers wanting to reduce sitting time in favour of more activity should be prompted to identify situations in which they would typically sit but could feasibly stand, and develop a set of associated active alternatives, or avoid the situations altogether. Recruiting significant others in the social environment that share the same goal or support the behavior change may also be important. They can assist in prompting the desired behavior and help recognize and manage cues and situations that may derail efforts to change.

Changing habitual behaviors that are regularly reinforced by highly-prevalent cues is difficult and likely requires long-term, intensive interventions to alter the course of ingrained actions. An alternative approach is the application of environmental restructuring, often referred to as 'nudging' or 'choice architecture' (Kelly & Barker, 2016; Marchiori, Adriaanse, & De Ridder, 2017; Marteau, 2018). Environmental restructuring involves setting up the physical or social environment so as to make the desired behavior the most effective course of

action by removing barriers or impediments, or making undesired behavioral alternatives, that are, perhaps, more rewarding, more difficult or effortful (Kremers, Eves, & Andersen, 2012; Kurz, Gardner, Verplanken, & Abraham, 2015). These interventions may involve changing the properties of the physical environment such as altering their appearance or adapting their function, changing the placement of objects or other stimuli in the environment such as their proximity or availability, or both (Hollands et al., 2017). For example, participation in incidental physical activity can be promoted by increasing the attractiveness of using stairs rather than elevators by making staircases more prominent and attractive (Naab & Schnauber, 2016). Similarly, arranging the order or prominence of healthy items on a supermarket shelf or restaurant menu (Bucher et al., 2016; Dayan & Bar-Hillel, 2011), changing packaging or portion size of unhealthy food, alcohol, or tobacco products (Hollands et al., 2015), or setting 'standing' workstations to the standing position as the default to reduce sitting time (Venema, Kroese, & De Ridder, 2017).

Given that individuals with 'good' self-control and high conscientiousness tend to form adaptive habits to manage temptations and derailing contingencies (Galla & Duckworth, 2015; Wood, 2017), providing individuals with training on these skills may be useful in assisting them to develop healthy habits. These skills may include identifying and setting appropriate goals, identifying and monitoring for cues and contingencies that may 'line up' the desired behavior and those that may hinder or derail the behavior, and monitoring for cues to undesired competing behaviors, identifying opportunities to put in place situational strategies that cue up the desired behavior and make undesired behavior more difficult, and planning to implement them. Taken together, these key skills are likely to facilitate repeated cue-behavior responses and the formation of adaptive habits. By intervening to foster these skills, organizations may facilitate individuals to self-enact of some of the techniques used in choice architecture to change their behavior, akin to motivating individuals to put in place a series of 'self-nudges' to move them toward adaptive habits and counteract unwanted habits. Verplanken and Wood

(2006) suggest that in doing so such individuals make changes prior to acting that negate subsequent the need for regulation of temptations and impulse control.

The approach to developing adaptive habits is contingent on individuals acquiring and implementing sufficient self-regulatory skills necessary increase the automaticity of the behavior in the long run. As outlined in the previous sections, many behaviors including physical activities start out as goal-directed behaviors controlled by reasoned, deliberative processes, and will only develop as habits under the requisite conditions i.e. performance with sufficient regularity in stable contexts. The path to habit development, therefore, necessitates the use of techniques that motivate individuals to perform the behavior under those conditions. These techniques include goal setting, planning, cue identification and monitoring, and environmental restructuring.

Goal setting is a key skill essential to individuals setting appropriate goals to attain the desired outcome (Locke, 1996). As habits are usually developed through repetition in the presence of stable sets of cues to service some salient goal, setting appropriate, achievable goals that are personally endorsed and can be monitored for progress is essential (Epton, Currie, & Armitage, 2017). However, having goals and forming intentions may not be sufficient to enact behavior: research has demonstrated that individuals often do not follow through on their intentions (Orbell & Sheeran, 1998). Research in physical activity has revealed that this ‘gap’ in intention-behavior relations is substantial (Rhodes & de Bruijn, 2013). Planning is an important skill that facilitates enactment of intentions. Implementation intentions are specific types of planning in which individuals associate a context or contingency that they encounter regularly with the desired behavior (Gollwitzer, 2014; Hagger, Luszczynska, et al., 2016). Research on physical activity have demonstrated that implementation intentions are effective in promoting greater physical activity participation, particularly in those with high intentions (Bélanger-Gravel, Godin, & Amireault, 2013). As such plans are aimed at unifying contexts with actions it is unsurprising that prompting

individuals to form such plans facilitates formation of habits in the long run (Judah, Gardner, & Aunger, 2013).

Alongside planning, identifying and recognizing the appropriate situational cues that may be useful in lining up a desired behavior, and cues to undesired, impulse-driven behaviors likely to derail the desired behavior, are important to facilitate appropriate planning (Adriaanse, de Ridder, & de Wit, 2009; Verhoeven, Adriaanse, de Vet, Fennis, & de Ridder, 2014). Plans are more likely to be effective if individuals can identify appropriate environmental contingencies that they can associate with the desired behavior, and form plans to do so. Further, appropriate monitoring for those contingencies will facilitate plan enactment (Harkin et al., 2016; Verhoeven et al., 2014). Similarly, identifying the contingencies associated with undesired behaviors and planning an alternative course of action may assist in managing cues to competing actions that may derail actions. Finally, individuals can use environmental restructuring as a self-regulatory skill to change their own behavior. This strategy involves individuals using 'choice architecture' methods to alter their environment to facilitate enactment of a desired behavior, or to subvert the enactment of undesired behaviors, I call this 'self-nudging', a hitherto untapped strategy for behavior change. Taken together, this set of strategies with its focus on behavioral performance and environmental contingencies will likely facilitate the initiation of desired behavior, and impede the enactment of undesired behaviors, and, over time, facilitate the development of adaptive habits.

How might these sets of be applied to promote physical activity habits? Intervention designers should provide individuals with knowledge and practice on setting appropriate goals for physical activity – goals that are appropriate and realistic, valued, able to be monitored, and sufficiently flexible to be modified according to progress (Epton et al., 2017). In addition, individuals should be prompted to identify appropriate contexts and conditions that may cue up their regular physical activity, such as using an alarm or a visual reminder such as leaving their exercise clothing or equipment in a notable place (Harkin et al., 2016; Kaushal, Rhodes,

Spence, et al., 2017; Webb & Sheeran, 2004). They should also prompt individuals to identify cues and contextual contingencies that are linked to actions that may derail their selected physical activity, such as invitations from other people to join them in doing something sedentary such as going for lunch or sitting down and watching television (Conroy, Maher, Elavsky, Hyde, & Doerksen, 2008). Individuals should then be prompted to form implementation intentions and action plans to pair up their selected physical activity with the identified cues or contingencies (Hagger, Luszczynska, et al., 2016). This may involve exercises where the individual formally states the plan, for example using an if-then format, which requires individuals to explicitly identify both cue and associated action, and writes it down or verbally rehearses it (Chapman, Armitage, & Norman, 2009).

Individuals should also be prompted to structure their environment to facilitate regular participation in physical activity in stable contexts, and to avoid potential derailing contingencies. Individuals are encouraged to harness the principles used in choice architecture or 'nudging' interventions facilitate this routinization of behavior. For example, an individual may lock their car in their garage or give their keys to a supportive family member or friend so that they cannot be tempted to use it and must use active transport instead. Or they may only take sufficient money for a one-way trip on public transport so that walking home is the only option. These 'self-nudges' are self-administered strategies that leverage the principles of choice architecture to change behavior. Innovative instances of traditional forms of environmental restructuring abound, such as Venema et al.'s (2017) 'default nudge'. In similar vein, individuals may seek to make the cues or environmental contingencies that initiate preparation for physical activity behavior habitual. Kaushal et al. (2015) demonstrated that gym members who reported having cues in their environment that reminded them to prepare to participate in physical activity (e.g., having their gym bag visible in their car trunk, or a water bottle on their work desk) were more likely to report having a preparatory habit. The focus,

therefore, is on making the preparatory actions that facilitate physical activity habitual rather the activity itself.

Kaushal et al.'s (2017) recent intervention is a useful case study for the use of these strategies to promote a physical activity habit. Individuals were provided with a prompt to set up cues to prepare for the behavior to 'switch on' the behavior (e.g., "During the morning, select your favourite gym clothes from your closet and place them on your bed before you leave for work. When you return home, the clothes remain on the bed and will continue to cue you until you use them for your workout."). Findings indicated an increase in physical activity eight weeks post-intervention, although it must be stressed that the intervention included additional components such as action planning so the effects could not be attributed solely to the cues to preparatory behaviors for physical activity. Furthermore, the intervention prompted the use of the cues for preparatory behaviors. This could be augmented to that individuals are trained to use self-directed strategies to restructure their own environment to facilitate development of physical activity habits.

8. Avenues for Future Research

This far, I have highlighted advances in theory and research on habits in physical activity. The research has also generated new directions of enquiry to promote further knowledge and understanding of habits in this context. In this section I outline some priority avenues for future research that will advance theory and measurement of habit, and contribute to informing future intervention strategies that assist in promoting physical activity habits. These directions include: development of integrated models and theories of habit that draw from perspectives from different disciplines and provide comprehensive explanations of habit; development of better measures of habit and methods and study design to more effectively study habits, particularly habit development over time; conducting research examining the role of habit in maintaining physical activity participation over time; and conducting research examining the intervention strategies that are optimally effective in developing physical

activity habits and the conditions in the environment and individual that may impede or facilitate habit development.

Considerable advances have been made in the understanding of physical activity habits. Theories of habit have drawn from a number of domains including social and health psychology, cognition and learning, and neuroscience (Ashby, Turner, & Horvitz, 2010; Gardner, 2015; Verplanken, 2006; Wood, 2017; Yin & Knowlton, 2006). The theories have provided insight on salient aspects of habit including definition and conceptualization, development and extinction, relations with other constructs like inhibition and self-regulation, and strategies that promote acquisition and breaking of habits. However, there is currently no integrated theory of habit that draws from multiple disciplines and provides a comprehensive explanation of habit processes and effects. Thus far, theory on habit has focused on incorporating habit into existing theories and frameworks, such as social cognitive models, or interpreting habit processes from existing overarching explanatory frameworks (e.g., Gardner, 2015; Neal et al., 2006; Wood & Neal, 2007). These frameworks have been useful in explaining specific components and effects of habit, such as how habits are acquired or developed, or how habits affect behavior relative to other processes such as reasoned, deliberative processes. They also function to provide sets of testable hypotheses that guide empirical research to give insight into the specific habit processes. However, unlike other phenomena in psychology such as motivation (Dweck, 2017; Ryan & Deci, 2017), memory (Baddeley, 2003), agency (Bandura, 1989), and dual processing (Evans & Stanovich, 2013; Strack & Deutsch, 2004), there is no comprehensive, unified theory of habit. For example, theory on habit has yet to integrate approaches from social and health psychology, with other perspectives on habit like those from associative learning and cognitive priming (Watson & de Wit, 2018). Thus, there is a need to develop a comprehensive theory of habit that draws together the hitherto relatively disparate theoretical literature on habits, summarizes and extends current knowledge, provides sets of hypotheses that could be tested to verify

predictions such integrated perspectives, and sets an agenda for future research on habits in applied contexts, including physical activity.

Advances have also been made in the area of habit measurement. Research on habits has moved beyond focus on past behavior as a proxy for habit toward new measures that aim to capture the defining characteristics of habits. These include measures that capture the link between performance frequency and context stability (Wood & Neal, 2009), the role of accessibility such as the response frequency measure (Aarts, Verplanken, & van Knippenberg, 1998), and felt routinization and automatic control such the self-reports of habit (Grove et al., 2014; Verplanken & Orbell, 2003). However, many of these measures have limitations in that they do not capture all components of habit. Furthermore, some such as the self-reported habit index may be subject to methodological artifacts and reporting bias (Hagger et al., 2015; Labrecque & Wood, 2015). There is also little research examining the convergent validity of existing measures of habit such as behavioral frequency x context stability, response frequency, and self-reports of habit, particularly in the context of physical activity. Future research should seek to measure relations among these measures for physical activity and examine their concurrent prediction of future participation in physical activity. Research is needed to further refine these measures or develop new measures that capture the defining components of habits more effectively. These measures may capitalize on decision-making tasks that measure implicit links between cues and behavioral responses or advances in GPS technology that enables tracking of the co-occurrence of individuals' physical activity behaviors and the contexts in which they perform them over time.

In addition, a large proportion of the research on habits has generally adopted correlational designs with measures taken on few occasions, short-term follow up measures of behavior, and an over-reliance on self-report measures. Given the importance of context consistency and frequency in the conceptualization and development of habits, there is a need for better research designs that adequately capture these key components. Research adopting

daily diaries have already yielded important data on habit development and effects (e.g., Neal et al., 2006; Wood, Quinn, & Kashy, 2002). Future research adopting more sophisticated experience sampling and ecological momentary assessment methods (e.g., Conroy et al., 2008) may extend this research further by providing large numbers of data points over a long period allowing researchers to track physical activity habits and cue-response pairings over time. Developments in handheld technology many provide unique opportunities for frequent sampling of physical activity participants' experiences. For example, ubiquitous use of smartphones enables researchers to prompt individuals to complete experiential measures on a regular basis, and in-device technology such as GPS enables frequent sampling of real-time objective data on physical activity participation that incorporates context. In addition, the devices may serve as a unique means to intervene to promote adaptive habits, or break unwanted habits. For example, recent research has used smartphone GPS to identify when individuals approach a location where they might typically perform an unwanted behavior (e.g., smoking a cigarette) and send them text or social media messages to prompt them to execute pre-planned actions to manage or evade the upcoming cue to performing the unwanted behavior (Naughton, 2017). These technologies have yet to be fully leveraged to provide valuable data on habits, and may enable future researchers to collect extensive, fine-grained data on habits permit better tests of hypotheses of habit theories.

A further limitation of research on habits in physical activity and other contexts, is the lack of evidence on role of habit in maintaining behavior. Calls for leveraging habit theory and research as a means to promote 'healthy habits' have been largely based on the tacit assumption that habits will lead to sustained participation in behavior over time. This is particularly relevant to physical activity where health benefits have been shown to be maximized with sustained participation. However, evidence that habits maintain behavior over time is relatively limited. Research examining the short-term effects of habits on behavior support to commonly held assumption that habits have utility in maintaining behaviors

(Gardner et al., 2011). However, research on longer-term effects of habits has not tended to corroborate these assumptions. For example, a year-long longitudinal study of commuters provided with a travel pass offering free public transport indicated that habit was a relatively modest predictor of transport use one-year later, with intentions have a far more pervasive effect (Bamberg et al., 2003). Similarly, an exploratory intervention on flossing behavior found that although habit strength increased initially, habit effects declined over the 8-month post-intervention period (Judah et al., 2013). More research is needed examining effects of habit on behavioral maintenance, and associated moderating factors, particularly in physical activity contexts. For example, ability to recognize and manage contingencies that likely disrupt habits may determine whether or not habits are effective in behavioral persistence in the long run.

Finally, development of efficient and effective interventions to promote physical activity habits is an important avenue for future research. Theory and preliminary research has suggested that training individuals to adopt sets of self-regulatory skills may assist in the development of habits (Kaushal & Rhodes, 2015; Kaushal, Rhodes, Spence, et al., 2017; Kliemann et al., 2017). Adoption of motivational strategies such as goal setting combined with planning, cue identification and monitoring, and environmental restructuring may lead individuals to initiate physical activity behaviors and, importantly, perform them regularly in a routine fashion and in consistent contexts, conditions that lead to the development of habits. An additional promising strategy may be developing habits for preparatory actions for physical activity behavior (Kaushal, Rhodes, Meldrum, & Spence, 2017). Such strategies focus on cues to develop preparatory habitual behaviors without explicit focus on developing physical activity as a habit. It would be interesting to see whether use of such strategies facilitate the development of physical activity habits in the long run. However, there are relatively few studies that have tested the efficacy of interventions adopting these habit-promoting techniques in developing physical activity habits (Fleig et al., 2011), and none that track long-term behavioral adherence change to evaluate whether or not the habit has been maintained. What is

needed is randomized controlled trials using clear and accessible protocols that adopt habit-forming strategies and examine their effects on physical activity change longitudinally over an extended time period.

9. Summary and Conclusion

Understanding habits in the domain of physical activity is important considering evidence associating long-term maintenance of physical activity participation with better health and protection from chronic disease (GBD 2015 Collaborators, 2016). In the current review, I have outlined contemporary theoretical perspectives on habit (Aarts & Dijksterhuis, 2000; Gardner, 2015; Verplanken & Orbell, 2003; Wood, 2017; Wood & Runger, 2016), and how these perspectives, and the research literature testing their predictions, have provided insight into the definition and conceptualization, development, and behavioral consequences of habit in physical activity. Contemporary theory on habit defines habit as a specific behavioral response activated automatically to a defined set of cues or contextual features with little conscious awareness or consideration of goals or outcomes (Neal et al., 2006; Verplanken, 2006; Wood, 2017). Physical activities comprise complex sets of inter-related sub-behaviors to enact, and theories of habit make the distinction between the habitual instigation and habitual execution of behaviors, suggesting that complex behaviors like physical activity can be instigated habitually but their execution can be controlled my more deliberative, reasoned processes (Gardner et al., 2016). Measurement of habits has mirrored development of theory and conceptualization of habit and moved beyond the use of past behavior alone to encompass measures reflecting both frequency and context stability (Wood & Neal, 2009), speed of recall and accessibility (Aarts et al., 1998), experience of automaticity and lack of deliberation (Verplanken & Orbell, 2003), and experience of context consistency and cues (Grove et al., 2014). Research on habits are developed through repeated experience of the behavior in the presence of salient cues or contextual features s (Gardner, 2015; Wood, 2017; Wood & Runger, 2016). The developmental process is reflected in shifts from conscious, intentional

control over behavior toward more automatic, non-conscious control (Ashby et al., 2010; Seger & Spiering, 2011). Habits are viewed as a specific form of 'system 1' processing from the perspective of dual process theories (Wood, 2017; Wood et al., 2014), but are separable from other goal-direct automatic processes such as implicit attitudes and actions based on behavioral scripts, which may imply multiple behavioral responses (Fishbach & Shah, 2006). Research has suggested considerable individual differences in the rate and extent of habit development, although rapid early gains in experience of automaticity have been reported (Armitage, 2005; Kaushal & Rhodes, 2015; Lally et al., 2010).

Knowledge of how physical activity habits develop provides valuable guidance for organizations and interventionists interested in developing behavior change interventions that are effective in fostering long-term participation in physical activity. Promotion of physical activity habits requires individuals to frequently practice the target activity in stable contexts, or in response to consistent cues (Gardner, 2015; Wood, 2017; Wood & Runger, 2016). Fostering self-regulatory skills that motivate individuals to perform the behavior regularly in stable contexts, assist in linking contextual cues with the behavior, recognizing contingencies or competing behaviors that might derail the physical activity, and manage the environment to facilitate the behavior and negate competing behaviors will assist in habit development. Behavioral skills such as goal setting (Epton et al., 2017), action planning or implementation intentions (Gollwitzer, 2014), self-monitoring (Harkin et al., 2016), and environmental restructuring (Venema et al., 2017) are all strategies that may assist individuals in acquiring a physical activity habit. While research on habits has led to significant gains in knowledge of habits in physical activity, future research is needed to address important outstanding questions. This includes developing comprehensive theories of habit that integrate multiple perspectives, producing measures and research designs that are optimal in capturing physical activity habits such as behavioral measures and experience sampling, and evaluating the

effectiveness of interventions that foster behavioral skills aimed at promoting routinization of behaviors in stable contexts toward habit formation.

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Highlights

- Definitions, conceptualizations and theory of habit in physical activity are reviewed
- Habits are specific behavioral responses that covary with cues or contextual features
- Physical activity habits are experienced as low effort, automatic, and lacking in awareness
- Habits are developed through repeated experience of physical activity in stable contexts
- Interventions should promote self-regulatory skills that foster physical activity habits