An Integrated Behavior-Change Model for Physical Activity

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ABSTRACT

We present the Integrated Behavior-Change Model; a comprehensive multi-theory model outlining the psychological factors and processes that impact physical activity behavior. The model integrates hypotheses from social-cognitive, motivational, dual-phase, and dual-systems theories. We provide the theoretical basis for the model and demonstrate its utility in driving future research and developing effective interventions to promote physical activity.

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The Integrated Behavior-Change Model is a comprehensive multi-theory model that outlines the psychological factors and processes that determine physical activity.

Key Words: social-cognitive theory; self-determination theory; autonomous motivation; action planning; implicit processes; dual-systems theories; behavior-change intervention

INTRODUCTION

Research examining the psychological influences on health-related physical activity behavior has typically adopted a single theoretical approach from an array theories and models developed in the field of social psychology (13). The purpose of adopting any theory or model is to effectively and parsimoniously identify the important psychological factors associated with physical activity behavior and the processes by which these factors affect physical activity (14,30). Although many psychological theories applied in physical activity contexts have been shown to be effective in predicting behavior, numerous limitations have been cited including problems with falsifiability (17), weak relations between key constructs, such as the relationship between intention and behavior (33), and identifying the origins of constructs in the theories (13). These limitations have catalyzed the development of integrated models that draw from a number of different theories that directly address these limitations and aim to arrive at more effective explanations of the psychological influences on physical activity (13,18).

In the present review, we seek to synthesize our recent theoretical and empirical work on the development of integrated theories of health behavior, and draw further on recent and past social psychological theories, to derive an Integrated Behavior-Change (IBC) model that incorporates the very latest thinking on the psychological influences on behavior change and apply it to physical activity behavior. Our review will begin with outlining social-cognitive and motivational theories that conceptualize behavior as a function of deliberative, conscious processes. Many theories and models applied to physical activity behavior subscribe to this approach and have intention or motivation as the focal construct. The integration of these models will provide the starting point for our IBC model. Our integration capitalizes on the flexibility outlined by Ajzen (1) and others that motivational theories are “open to the inclusion of additional predictors if it can be shown that they capture a significant proportion of the variance in intention or behavior after the theory’s current variables have been taken into

account" (p. 199). We would go a step further in our current analysis and propose that additional components integrated into a model should either predict a key dependent variable in the nomological network of relations between variables or serve an explanatory purpose of process or mechanism. Following this principle, we will outline the conceptual basis for incorporating a volitional phase into the integrated model to more effectively account for the process by which intentions are converted into behavior. Volitional processes such as planning have received considerable attention in recent dual-process models of behavior which recognize that motivation may be a necessary but insufficient condition for action. The final link in our model will be to incorporate non-conscious, implicit processes linked to behavioral engagement. We propose that the heavy focus on deliberative, planned action in previous models of physical activity behavior needs revision given the proliferation of evidence demonstrating that behavior is frequently guided by impulsive, automatic factors that operate at an implicit level beyond the conscious awareness of individuals. We draw from dual-systems theories and research on implicit processes to incorporate an impulsive route to behavioral engagement that operates in parallel with the more conscious, deliberative pathways posited in intentional models.

In developing the IBC model, we will make reference to a diagrammatic representation of its propositions and hypotheses (Figure 1) and identify the key empirical and theoretical work that supports the proposed effects from our own and others' research groups (Appendix A, SDC 1, supportive evidence for key effects in integrated behavior change model). Most importantly, we will also outline how the model will serve as a basis of future research on the factors and processes that underpin physical activity behavior and, importantly, inform the design of efficacious interventions that will promote increased physical activity participation.

INTENTIONAL AND MOTIVATIONAL PROCESSES

The majority of theories and models that have been applied to understand physical activity behavior have adopted an information processing or social-cognitive approach. Social-

cognitive models assume that physical activity is an intentional behavior and individuals engage in active deliberation of the attributes of the behavior and their beliefs stored in memory regarding its potential value prior to forming an intention to engage in the behavior (2,3). The role of intention, a motivational construct that reflects the extent to which participants will invest effort to pursue an action, is ubiquitous among the theories based on the assumption that intention is the most proximal predictor of behavior. Intention, for example, is a key construct in a number of leading theories of behavior including protection motivation theory and social cognitive theory (3). Most prominent of these theories, however, is the theory of planned behavior (1), which identifies intention as the key mediator of the effects of individuals' personal, social, and control-related beliefs regarding the behavior on actual behavioral engagement. According to the theory, intentions are a function of individuals' beliefs that the behavior will lead to desired outcomes (attitudes), will be consistent with the desires of significant others (subjective norms), and can be enacted through sufficient personal resources and little hindrance from barriers (perceived behavioral control). In fact, the theory is an integration of the theory of reasoned action, which makes the distinction between personal and social antecedents of intention in the attitude and subjective norm constructs, and elements from Bandura's (4) social cognitive theory, with perceived behavioral control closely aligned with self-efficacy. The theory is one of the most frequently applied and tested in health behavior research and numerous meta-analyses have supported its predictive efficacy in health domains (26), particularly physical activity (20). The theory of planned behavior forms the starting point of the proposed IBC model, such that intentions form the most proximal predictor of behavior and mediates the effects of attitudes, subjective norms, and perceived behavioral control on behavior (see Figure 1 and Appendix A, effects 1-4). Meta-analytic reviews of the large number of studies adopting the theory have demonstrated the important contribution it has made to the prediction of health behaviors like physical activity (20,26).

A noted limitation of the theory of planned behavior is that the theory is relatively silent on the origins and drivers of the belief-based antecedents of physical activity intentions (9,18,19). In his original theorizing, Ajzen (1) noted that attitudes, subjective norms, and perceived behavioral control were developed over time through experiences with behaviors, or similar actions, that provided scripts or schema regarding the behavior and served as a basis for evaluating whether or not to engage in the behavior, or similar behaviors, on future occasions. A recent line of research has integrated hypotheses from another leading motivational theory, self-determination theory (9,10), as a means to provide a basis for the antecedent beliefs in the theory of planned behavior (18,20). Specifically, motivational orientations from self-determination theory are proposed to lead to individuals forming the belief-based components on the theory of planned behavior, namely, attitudes, subjective norms, and perceived behavioral control consistent with these motives (see Figure 1 and Appendix A, effects 6-8).

Self-determination theory is a needs-based, organismic theory of motivation that makes the broad distinction between autonomous and controlled forms of motivation. Individuals who are autonomously motivated with respect to a particular behavior experience a sense of personal choice and autonomy when acting and feel that their actions represent their true self. Autonomously-motivated individuals are also more likely to persist with the behavior without any external reinforcement or contingency. Individuals experiencing their behavior as control motivated, on the other hand, act out of a sense of external pressure and obligation. Control-motivated individuals engage in the behavior only as long as the controlling contingencies are present, and once removed behavior will desist. From a physical activity perspective, autonomous motivation is adaptive because it means participants are more likely to persist with behaviors without any external incentive or reinforcement. This means that fostering autonomous motivation toward physical activity may be an important endeavour in health promotion interventions that aim to increase population activity levels.

The proposed links between autonomous motivation and the belief-based antecedents of intentions in the theory of planned behavior in our integrated model are wholly consistent with the original conceptualization of self-determination theory (9). Deci and Ryan proposed that autonomous motivation toward a given behavior or activity will lead to approach-oriented beliefs toward performing the behavior and intentions to engage in the behavior in future. Although the specific processes linking autonomous motivation with beliefs regarding action were proposed in the original conceptualization of the theory, no formal hypotheses were outlined. The integration of hypotheses from both theories addresses this gap by adopting constructs representing the behavioral, normative, and control-related beliefs from the theory of planned behavior in an integrated motivational model.

In terms of the mechanisms underpinning these proposed effects, autonomous motivation reflects the extent to which individuals perceive a behavior, like physical activity, fulfils basic psychological needs, particularly the need for autonomy. The presence of psychological needs is an important unifying premise within self-determination theory. The theory proposes that people need to feel as if they are the origin of their own behavior, that is, to be autonomous, and actively seek out behaviors that satisfy this need for autonomy (10). An individual who is autonomously motivated toward physical activity will, therefore, will be motivated to fulfil this need in the future by bringing their systems of beliefs that underpin intentions in line with those motives and forming intentions to pursue the physical activity in the future. We focus on autonomous motivation in the IBC model for three reasons: (a) autonomous motivation is a key determinant of adaptive behavioural outcomes, while controlled forms of motivation have been shown to have a relatively limited role; (b) differentiation between the various forms of autonomous motivation is relatively superfluous as many of these forms of regulation share considerable variance (19) and are promoted through autonomy-support techniques rendering

fine-grained distinction redundant; and (c) a single autonomous motivation construct maximizes model parsimony.

Our research has suggested that that individuals can and do make the distinction between beliefs that are autonomous and controlled in nature (28,29), and those beliefs significantly predict behavior (29). The addition of autonomous motivation from self-determination theory, therefore, provides a basis for the origin of the psychological antecedents of future behavior. Furthermore, the inclusion of the theory of planned behavior also has a reciprocal explanatory role in self-determination theory. It provides an explanation as to how autonomous motivation is implicated in the decision-making processes and converted into future action. This is consistent with the complementarity goal of theoretical integration (13).

A key hypothesis of the IBC model is that the belief-based constructs from the theory of planned behavior and intentions will mediate the effects of autonomous motivation from self-determination theory on actual physical activity behavior. Our research has provided support for the proposed mediation relationships in numerous behavioral domains, including physical activity (19,21). In addition, a meta-analytic path analysis of 34 the studies that have integrated the theory of planned behavior and self-determination theory since our initial tests has provided support for the proposed pattern of effects and established that the effects remain after controlling for past behavior (18). The effect of autonomous motivation as a distal predictor of intentions mediated by the belief-based constructs from the theory of planned behavior, forms the ‘motivational sequence’ at the core of our proposed model.

VOLITIONAL PROCESSES AND DUAL-PHASE MODELS

A prominent critique of the theory of planned behavior is the consistently imperfect link between intentions and actual behavioral engagement (33) and the relatively poor performance of interventions aimed at changing intentions in affecting a concomitant change in behavior (35). This means that while many people may have positive intentions to engage in physical

activity in the future, they fail to carry out or enact their intentions. This shortfall in the link between intentions and action has been labelled the intention-behavior 'gap'. Researchers have indicated that a substantial number of participants report positive intentions toward health behavior but fail to act (31,33). This has presented researchers with a considerable challenge: how to foster a more effective enactment of intentions among the substantial proportion of 'inclined abstainers'?

One approach has been to integrate the theory with dual-phase models of action which propose an additional 'volitional' phase between the formation of an intention to act and actual behavioral enactment. Heckhausen and Gollwitzer (23) recognized that having an intention was frequently insufficient for behavioral engagement because people either forgot to carry out their intention or failed to identify and recall cues to initiate the intention. In their action-control model, they proposed a volitional phase in which individuals formed a plan to act after they had settled upon an intended course of action. The plan comprised the identification of a cue in the environment that would be linked to the initiation of the behavior (e.g., "If my alarm clock chimes at 12 noon, I will collect my gym bag and go for a workout at my local fitness center"). According to the model, the plan would stimulate the efficient recall and enactment of the intention and was referred to as an action plan or 'implementation intention'. As action plans are formed after the formation of intentions, they act in a post-decisional manner in a separate 'volitional' phase. Action plans have been shown in laboratory and field experiments to promote effective behavioral enactment, and, therefore a stronger intention-behavior relationship, by facilitating efficient recall of the intention (22). The volitional phase and action planning construct has been the subject of a considerable body of research and meta-analyses in numerous behavioral domains (12), including physical activity (5), have demonstrated that furnishing intentions with action plans is effective in promoting better behavioral enactment. Following this evidence, we propose a volitional 'phase' to our model with action planning

forming an important moderator of intention-behavior relationship to account for the insufficiency of intentions (see Figure 1 and Appendix A, effect 5).

IMPLICIT PROCESSES AND DUAL-SYSTEMS THEORY

The development of our integrated model so far has focused on factors and processes that require cognitive processing and deliberation prior to forming an intention to engage in physical activity. This is consistent with the premise from social-cognitive and motivational theories, like the theory of planned behavior and self-determination theory, that physical activity tends to be a behavior that requires forethought and planning to be enacted (2,10). However, researchers are increasingly recognizing that health behavior, including physical activity, is influenced by non-conscious, impulsive factors that have their effects on action beyond the awareness of the individual (6,24,29). Such processes mean that individuals may engage in physical activity spontaneously with little conscious involvement or protracted deliberation. A typical example might be a student who is passing by some people in the park playing a ball game and chooses to join in without prior planning or deliberation over the merits or detriments of the decision, and without being aware of the factors that have driven his behavior. Theoretically, there is recognition that many behaviors are likely to be enacted via either a deliberative route, mediated by the intentional and motivational factors delineated in our model thus far, or a spontaneous route which directly effects behavior unmediated by intentions. It is also possible that behaviors may be controlled by both routes, with the relative contribution of each determined by the characteristics of the behavior and the context in which it is being conducted. In the IBC model, we propose to incorporate implicit constructs that affect physical activity alongside the integrated components from social-cognitive and needs-based theories in order to account for both routes.

We draw from dual-systems theories of motivation to build implicit processes into our integrated model, particularly Strack and Deutch's (34) influential reflective-impulsive model.

Drawing from previously-developed attitude models that proposed dual routes to behavior, the reflective-impulsive model recognizes that role that deliberative or *reflective* and spontaneous or *impulsive* systems have on behavior, and proposed that behavior is a function of both systems. The reflective route requires the utilization of stored knowledge about a behavior (e.g., beliefs) and available social information to arrive at a decision to act. The impulsive system affects behavior through the activation of behavioral or motivational schema, stored 'ways of behaving' based on previous experience, usually through cues or elements in the environment that trigger nodal information linked to the schema. Behaviors likely to be determined by the impulsive system tend to be those that are relatively simple, have been performed repeatedly in the past, conform to the features of 'habitual action', and for which individuals tend to have well-learned or ingrained schema that is highly accessible to the individual when cued. Behaviors determined by the impulsive system may be behaviors like tooth-brushing and operating the pedals in an automobile. Behaviors largely controlled by the reflective system include those that are more complex, have not been performed as frequently in the past, and for which individuals do not have an elaborate or well-learned schema.

As assumed in many social-cognitive models, physical activity is likely a behavior that is largely under the control of the reflective system given the number of considerations that one needs to give in order to engage in physical activity. Generally speaking, physical activity, particularly formal types of exercise that involve equipment, transport, venue, costs and other considerations, require considerable planning. Nevertheless, there is evidence to suggest that some forms of physical activity may be affected by implicit motivational factors beyond the awareness of the individual. For example, research has shown that implicit attitudes toward physical activity are significantly related to physical activity participation when controlling for explicit attitudes measured by self-report (6).

The close link between implicit attitudes and habitual action has been proposed as a mechanism underlying the effects of implicit attitudes on physical activity. According to Calitri

et al. (6), frequency of performance is likely to make the decision-making process that precedes action less dependent on explicit deliberation. Instead, repeated experience will have resulted in individuals' storing a strong mental representation or schema of the action in memory and the presentation of cues that activate the schema will lead to efficient behavioral enactment by-passing deliberative routes to action. This means that implicit attitudes toward physical activity impact physical activity participation directly, independent of explicit attitudes and intentions. Consistent with this research and dual-systems theories, we have incorporated implicit attitudes into the IBC model as a direct effect on actual behavior (see Figure 1 and Appendix A, effect 9).

Recently, we have investigated the effects of implicit motives based on self-determination theory and their effects on health behavior, including physical activity (24). We proposed, based on previous research and propositions from the reflective-impulsive model, that autonomous and controlled forms of motivation may operate at both explicit and implicit levels. In particular, we subscribed to the proposals of Levesque and Pelletier (25) who found that implicit forms of motivation from self-determination theory reflected more trait-like, dispositional individual differences in generalized self-determined motivation, referred to as chronic motivational orientations. We were interested whether these generalized motivational orientations, which were not tied to a particular behavioral domain, predicted multiple health-related behaviors including physical activity alongside more explicit measures of motivation from self-determination theory. Results indicated that both implicit and explicit forms of autonomous motivation had significant unique effects on physical activity behavior. Consistent with dual-systems theory, the effect of explicit motivation on physical activity participation was mediated by intentions while the effect of implicit motivation was direct and unmediated, supporting the notion that this variable reflects spontaneous and impulsive influences on physical activity behavior. Although the effect sizes of the implicit autonomous motivation were relatively modest, it likely implies that for some individuals dispositional motivational

orientations affect their physical activity participation beyond their awareness and suggests spontaneous engagement in activity in accordance with the impulsive route in dual systems theories. Consistent with dual-systems theory and our preliminary evidence, we have included an independent direct effect of implicit autonomous motivation from self-determination theory on actual physical activity behavior parallel to the explicit motivational factors and implicit attitudes (see Figure 1 and Appendix A, effect 10). This will provide a basis for testing the extent to which physical activity behavior is controlled by explicit and implicit processes.

ADVANCING THE INTEGRATED BEHAVIOR-CHANGE MODEL

The purpose of the IBC model is to provide a comprehensive representation of the important psychological processes that affect physical activity behavior. The model serves as a guide for researchers in developing future studies on the antecedents of physical activity and forms a template for practitioners in the development of effective interventions that will promote health-related physical activity. It is unique as it draws its predictions and hypotheses from multiple theories with different perspectives and integrates them into single model. Furthermore, the model provides a means to identify the relative contribution of different psychological constructs and proposed processes or pathways to physical activity behavior. It also provides the basis for comparative research in which the effects of the model constructs and processes on exercise behavior are contrasted across populations or contexts. In this section we outline means by which the integrated model can be tested, avenues for future research, and the practical value of the model as a guide for the development of interventions to promote physical activity.

Testing the Model

The IBC model has been derived from hypotheses from multiple psychological theories and, while there is evidence to support these hypotheses separately, there is a need for empirical confirmation of the proposed pattern of effects in a full test of the model. The majority of studies adopting the component theories of the model have adopted prospective,

correlational studies. In the tests, researchers tend to administer self-report measures of the key psychological constructs to samples of participants and follow these up with self-report and, preferably, objective measures of physical activity behavior at a subsequent point in time (14,15). These studies are somewhat limited in the sense that they do not permit inferences of causality, but enable researchers to ascertain the fit of the theoretically-determined network of relationships among the proposed constructs with the data (17). This is the case with tests of the component theories of the IBC model such as the theory of planned behavior (16), self-determination theory (19), and dual-systems theory (24) conducted in our lab. Furthermore, we have also provided comprehensive evidence to support one of the key integrated components of the proposed model, the links between autonomous motivation from self-determination theory and constructs from the theory of planned behavior, in a meta-analysis of research incorporating both theories, the majority in physical activity contexts (18). There is, therefore, evidence drawn from our own studies to support some of the hypotheses proposed in the integrated model and we have used this evidence alongside our theoretical proposals to aid its construction.

There is a need, of course, for comprehensive tests of the model in its entirety to provide complete support for the proposed network of relations derived from the multiple theories and models, known as nomological validity. Such tests need to adopt appropriate measures and designs, including psychometrically-sound self-report measures advocated by researchers for the component psychological and behavioral constructs, with appropriate statistical power to test the effects, and the adoption of optimal statistical analytic methods such as path or latent-variable analysis. In tests of the model, data collected from an appropriate sample should fit with a model of the hypothesized effects specified a priori. Action planning, as a proposed moderator of the intention-behavior relationship, should be tested using interaction effects within the model. It is also important that there are multiple high-powered replications of the model in diverse samples. This will provide more robust

evidence for the proposed relationships in the model and also enable researchers to test whether the hypothesized effects generalize to multiple populations such as younger and older samples, males and females, and clinical and non-clinical groups (e.g., patients vs. non-patients, obese vs. normal weight). Given the central role that replication plays in building evidence for effects in psychology, and science in general, such multiple tests are sorely needed.

While we acknowledge the likelihood that the majority of future tests of the IBC model will be prospective and correlational in design, we recognize the need for experimental and intervention research designs to better enable the inference of causality and provide robust evidence for the model. Specifically, studies that independently manipulate the key psychological constructs antecedent to physical activity in the model and examine their effects on psychological and behavioral outcomes are needed. This would provide much more effective evidence to support the hypothesized pattern of effects of the model. While correlational tests of the model can be relatively comprehensive, it is methodologically challenging to include manipulations of constructs in a model that proposes a complex network of relations among multiple constructs. We therefore recognize that experimental and intervention studies adopting the model will be of hybrid design examining the effects of experimentally-manipulated psychological variables alongside other non-manipulated variables (7,8). A good example of this type of design comes from an intervention study in which we manipulated school children's autonomous motivation toward physical activity by providing autonomy support and examined its effects on salient mediators (autonomous motivation, intentions) and physical activity behavior (8). A combination of experimentally-manipulated variables, represented as dummy-coded predictor variables, and non-manipulated self-reported variables was used to test a network of relationships in a path analytic model. Finally, the effect of action planning as a proposed moderator of the intention-behavior relationship within our integrated model would be most effectively tested using experimental manipulation and

analyzing the effect of the interaction between the manipulation and intentions on physical activity.

Guiding Intervention Design

An important role for psychological models applied to predict physical activity behavior, including the integrated model, is their role in guiding the design of interventions to promote physical activity participation. One of our key intentions in developing the integrated model is that it will not only facilitate the identification of the psychological variables linked to physical activity but to also pinpoint the factors that should be the targets for intervention. A recent advance in psychological theory-based approaches to behavior-change interventions has been the development of taxonomies of unique behavior-change techniques that have been shown empirically to impact on behavior through the mediation of the theoretical construct the technique is purported to change (30). The techniques can then be used as content for interventions to promote health related behavior, such as physical activity, delivered by various means such as print communication (e.g., leaflets, websites), media campaigns (e.g., posters, radio advertisements), and personal communication (e.g., primary-care workers). Our integrated model is expected to be able to provide a comprehensive, evidence-based guide for interventions by identifying the key factors that impact on physical activity in a given population.

Each of the antecedent constructs comprising the integrated model has an associated behavior-change technique. Autonomy support is a behavior-change technique that specifically targets changes in autonomous motivation and involves the provision of choice, rationale, acknowledgement of conflict, and support for personally-valued outcomes (27). Attitudes, subjective norms, and perceived behavioral control can be promoted through communicating information targeting the salient beliefs associated with each construct for the given population. For attitudes, the communication will involve promoting the salient advantages of exercise and dispelling disadvantages, for subjective norms it will involve highlighting the

importance of salient others' beliefs, and for perceived behavioral control it will involve the promotion of facilitating factors and dispelling barriers (7). Action planning can be promoted by prompting the formation of an 'if-then' plan in which the individual identifies an event or critical situation salient for them and link it with a physical activity initiation behavior (12,22). In order to make an evidence-based decision as to which of these techniques will be optimally effective in changing physical activity behavior in an intervention, formative correlational research identifying the constructs that are most effective in predicting physical activity is needed. This will lead intervention designers' to make appropriate decisions as to the techniques to include in their intervention content.

There is also a need for appropriately-designed intervention research in which the identified techniques are independently manipulated using factorial designs and their effects on physical activity behavior and proposed mediators examined in the model. For example an intervention that includes independent manipulations of autonomous motivation, using autonomy support, and constructs from the theory of planned behaviour, using communications to change beliefs, would be appropriate. Results would be expected to demonstrate that the autonomy support manipulation would only affect distal variables such as intention and behavior in the model through autonomous motivation while the effects of manipulation of attitudes or perceived behavioral control would be exclusively through these constructs (8).

It must be noted that means to change implicit factors has been somewhat more contentious than means to change explicit variables in the integrated model. By their nature, implicitly held beliefs should be immune to change or variation from information processed explicitly, which is the case for the majority, if not all, of the behavior-change techniques catalogued in recent taxonomies. Means to change implicit factors may occur through priming, that is, the activation of the implicitly-held information relating to the construct by presenting cue information that is processed implicitly or without conscious awareness of the individual. Priming manipulations have been typically carried out in the laboratory using computer-based

or pen-and-paper tasks in which information related to the primed construct, such as pictures or words, is presented to the individual incidental to the task (e.g., word-search tasks). In practical situations, such information may be presented through posters or advertisements that do not have explicit content but seek to prime a positive activity attitude or motive. There is some research indicating that placing posters encouraging stair use in atria and foyers of public places increases stair use, and, although the authors have provided an explanation based on explicit processes for the effect (11), they have not ruled out the possibility that such posters may exert their effects by priming implicit physical activity attitudes or motives similar to laboratory-based association tasks. This is a new and exciting avenue of research and investigating the role of manipulating implicit attitudes and motives in the context of the integrated model may provide an indication as to how implicit behavior-change techniques, such as messages with content aimed at implicit constructs, may promote physical activity participation alongside more explicit behavior-change techniques.

SUMMARY

In this review we have presented the IBC model; a comprehensive model drawing from multiple theoretical perspectives aimed at examining the psychological factors and processes involved in physical activity participation. The model is unique in that it attempts to bring together perspectives from intentional and motivational, volitional, and dual-systems theories into a unified model that not only identifies the multiple unique psychological factors linked to physical activity behavior, but the mechanisms involved. It also guides the development of interventions to promote physical activity behavior by identifying the variables and, by implication, the behavior-change techniques that will be optimally effective in changing physical activity behavior. Our model begins with the premise that physical activity is a behavior that is largely driven by intentions, and a leading theory of intention, the theory of planned behavior (1), provides the core set of hypotheses about which we have constructed our model. We incorporated an organismic, needs-based theory of motivation, self-determination

theory (9), as a means to explain the origins of the direct belief-based behavioral antecedents in the theory of planned behavior. This is presented in the IBC model as a motivational sequence in which motives from self-determination theory predict physical activity intentions mediated by the belief based antecedents from the theory of planned behavior. We also incorporated hypotheses from Heckhausen and Gollwitzer's (23) dual-phase model to introduce a volitional phase, separate from the intentional phase, in which action planning is key construct in promoting effective and efficient conversion of intentions into behavior. Finally, we have incorporated hypotheses from dual-systems theories (34) to account for implicit processes on physical activity behavior. This is in recognition that behavior is impacted by factors that operate outside individuals' awareness and based on evidence that implicit processes have statistically significant effects on physical activity behavior (6,24).

In the construction of our model we have outlined the theoretical basis for the integration of its component hypotheses supported by evidence from our own work and that of others. We look to future research to develop complete tests of the theory using prospective non-experimental correlational designs. We expect such tests to include appropriate measures, design, samples, and analyses, and we anticipate that multiple replications by different research teams and in multiple populations will assist in supporting the nomological validity of the IBC model. Multiple replications in independent samples using non-experimental designs may form the starting point for future experimental and intervention research, which is also needed to build strong converging evidence for the propositions of the integrated model. We do not expect experimental tests to comprehensively manipulate all of the variables in the proposed model. The required number of experimental cells, and, therefore, sample size, would render such an endeavour impractical (32). We do, however, recognize the need for effective experimental evidence for the proposed effects in the model that is factorial in design including manipulations that target key individual constructs in the model, likely those with the strongest effects identified in non-experimental research, with appropriate control or comparison groups

for each. Experimental tests should therefore seek to test the differential effects of manipulations of multiple constructs in the model. Intervention research should also adopt similar designs in field settings. Furthermore, interventions based on the model should involve the careful mapping of behavior-change techniques identified in taxonomies on to the integrated model constructs in order to arrive at appropriate content.

The IBC model represents our attempt to bring together leading theories, and accompanying evidence, in order to arrive at a comprehensive perspective on the psychological processes involved in physical activity behavior. We recognize that although our model needs to stand up to the rigor of empirical testing, we also acknowledge the need to be fluid and flexible and open to new information and evidence that may assist in its modification and refinement. We encourage researchers to test and challenge our new model and continue the process of theory development to further understanding of the factors and mechanisms that impact physical activity behavior.

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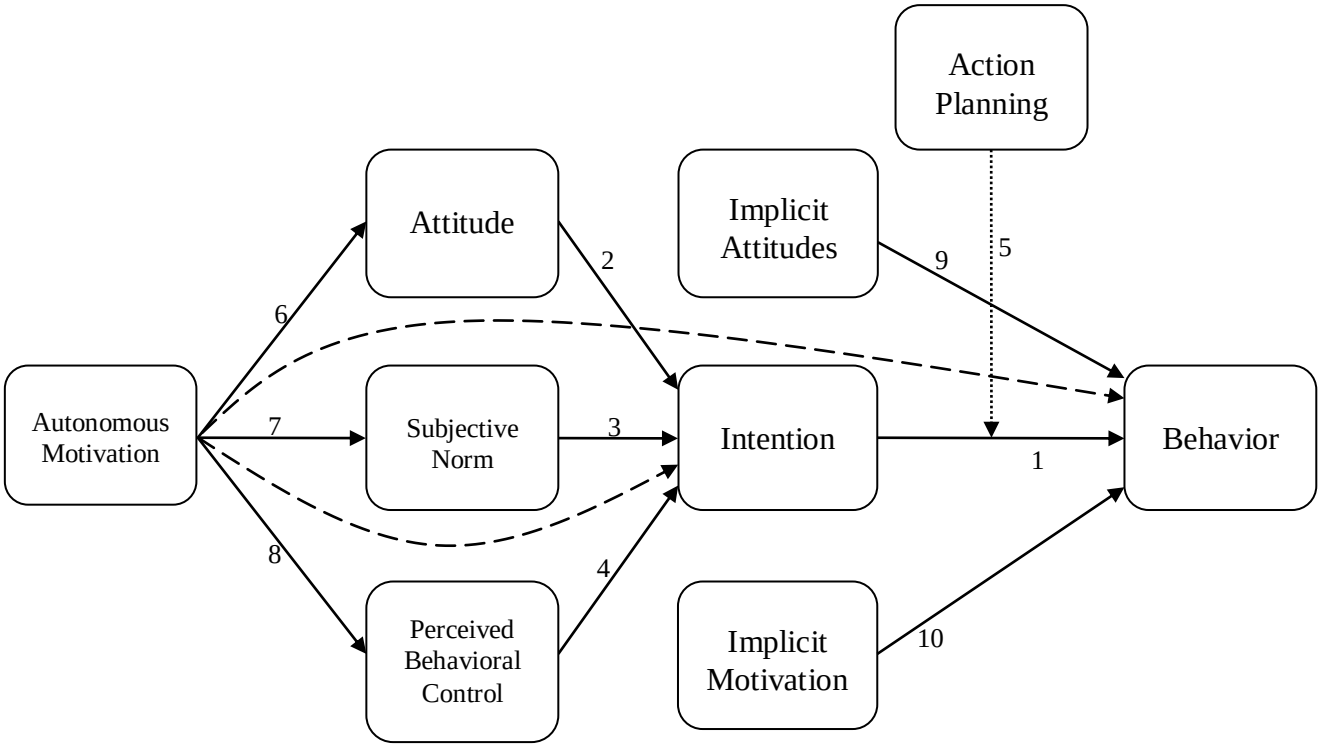
SUPPLEMENTAL DIGITAL CONTENT (SDC1)

Appendix_A.pdf

Figure caption

Figure 1. Schematic diagram of the Integrated Behavior-Change (IBC) Model for physical activity. The model depicts deliberative (reflective) and spontaneous (impulsive) pathways for the effects of motivational and psychological constructs from multiple theories on physical activity participation. The deliberative pathway comprises the distal effects of autonomous motivation from self-determination on physical activity mediated by constructs from the theory of planned behaviour (attitudes, subjective norms, perceived behavioral control, intention). The spontaneous pathway involves the effects of implicit attitudes and motivation on physical activity. The intention-behavior relationship is proposed to be moderated by action planning, depicted as a broken line directed at the path between intention and behavior. Broken lines between constructs indicate direct effects proposed to be non-significant or unsubstantive relative to the indirect effects. Other non-significant direct effects include the effects of attitude, subjective norms, and perceived behavioral control on behavior. Numerals reflect the hypothesized paths in the model.


Action Planning
Attitude
Implicit Attitudes
Autonomous Motivation
Subjective Norm
Intention
Behavior
Perceived Behavioral Control
Implicit Motivation
1
2
3
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5
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