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Juho Polet

Testing and Extending Predictions of the Trans-Contextual Model for Leisure-Time Physical Activity in Middle School Students

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF SPORT AND
HEALTH SCIENCES

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ABSTRACT

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Social-cognition approaches (e.g., the theory of planned behavior) and motivational theories (e.g., self-determination theory) have been utilized to identify the determinants of health behavior. Research applying these theories is focused on the conscious and deliberative correlates of motivated behavior. The purpose of the current dissertation was to test and develop an integrated theoretical model, known as the trans-contextual model, to identify the determinants of students' leisure-time physical activity and the processes involved (Hagger et al., 2003). Even though there is an expanding body of research broadly supporting the application of the trans-contextual model to the prediction of leisure-time physical activity behavior in school students, the model does not consider the potential effects of constructs that represent non-conscious or automatic processes on physical activity behavior. The dissertation aimed to fill this research gap by including factors proposed to be unique predictors of behavior within the model independent of the intention-mediated effects of the social cognition and motivational constructs from the model. Specifically, past behavior, habit, trait self-control, and attitude were introduced in the model and their effects on behavior were proposed to represent a non-conscious or automatic process (Strack & Deutsch, 2004) alongside the deliberative processes proposed in the original model.

The dissertation research indicates that the trans-contextual model is effective in predicting behavioral intentions, but the question that arises is whether it may predict physical activity behavior, and behavioral change, among middle school students. Amending the model with constructs that represent non-conscious, automatic processes shows promise in the prediction of physical activity within the model, given the importance of both reasoned and non-conscious, automatic processes. Strengths of the dissertation include reliance on advanced methodology and prospective designs accounting also for change over time. Limitations of the thesis include a reliance on correlational designs that limit capacity to infer causality and use of self-reports as a source of information.

Keywords: Trans-contextual model, physical activity, leisure-time, theoretical integration, past behavior, habit, self-control, attitude

TIIVISTELMÄ (ABSTRACT IN FINNISH)

Polet, Juho
Laajennetun transkontekstuaalisen mallin kehittäminen ja testaus yläkouluikäisten vapaa-ajan liikkumisaktiivisuuden selittäjänä
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Sosiaaliskognitiivisia teorioita (kuten suunnitellun käyttäytymisen teoria sekä motivaatioteorioita (kuten itsemääräämisteoria) on hyödynnetty laajasti terveyskäyttäytymiseen liittyvien prosessien tunnistamisessa. Näihin teorioihin perustuva tutkimus on keskittynyt tietoisiin ja harkintaan perustuviin motivoitua käyttäytymistä määrittäviin tekijöihin. Tämän väitöskirjan tarkoituksena oli kehittää ja testata näitä teorioita integroivaa transkontekstuaalista mallia (Hagger ym., 2003) ottamaan huomioon tietoisten ja harkintaan perustuvien terveyskäyttäytymisen determinanttien lisäksi myös ei-tietoisia ja automaattisia terveyskäyttäytymistä määrittäviä tekijöitä (Strack & Deutsch, 2004). Perusmalli ei ota riittävällä tavalla huomioon ei-tietoisten ja automaattisten tekijöiden yhteyksiä liikkumisaktiivisuuteen. Väitöskirja pyrkii täydentämään tätä tutkimusaukkoa sisällyttämällä malliin aiemman tutkimuksen perusteella ehdotettuja liikkumiskäyttäytymisen ei-tietoisia ja automaattisia aikomusvälitteisistä sosiaalisista kognitiosta ja motivaatiokonstruktioista riippumattomia tekijöitä: aikaisempi liikkumiskäyttäytyminen, liikkumistavat ja yleinen itsekontrolli. Laajennetun transkontekstuaalisen mallin avulla pyritään tunnistamaan ja selittämään yläkouluikäisten oppilaiden vapaa-ajan liikkumisaktiivisuutta määrittäviä tekijöitä ja prosesseja.

Väitöskirjan neljän osatutkimuksen perusteella transkontekstuaalinen malli selittää nuorten vapaa-ajan liikkumisaikomuksia, mutta ei vapaa-ajan liikkumisaktiivisuutta tai liikkumisaktiivisuudessa tapahtuvia muutoksia. Mallin täydentäminen ei-tietoisia ja automaattisia prosesseja heijastelevilla konstruktioilla vaikuttaa tutkimuksen perusteella lupaavalta, sillä täydennetyn mallin on mahdollista huomioida sekä vapaa-ajalla tapahtuvaan liikkumisaktiivisuuteen vaikuttavat tietoiset että ei-tietoiset tekijät osana laajennettua mallia. Väitöskirjan vahvuutena ovat kehittynyt metodologia sekä ajan kanssa tapahtuvien muutosten huomioiminen mallin konstruktioissa. Väitöskirjatutkimuksen keskeisimmät rajoitteet ovat tukeutuminen korrelatiivisiin tutkimusasetelmiin ja itsearvioinnit tiedonkeruumenetelmänä.

Avainsanat: Trans-kontekstuaalinen malli, fyysinen aktiivisuus, vapaa-aika, teoreettinen integraatio, aikaisempi käyttäytyminen, liikkumistavat, yleinen itsekontrolli, asenteet

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Juho Polet

LIST OF ORIGINAL PUBLICATIONS

The thesis is based on the following original publications which will be referred to by their Roman numerals:

I Hagger, M. S., Polet, J., & Lintunen, T. (2018). The reasoned action approach applied to health behavior: Role of past behavior and tests of some key moderators using meta-analytic structural equation modeling. *Social Science & Medicine*, 213, 85—94. https://doi.org/10.1016/j.socscimed.2018.07.038

II Polet, J., Lintunen, T., Schneider, J., & Hagger, M. S. (2020). Predicting change in middle school students' leisure-time physical activity participation: A prospective test of the trans-contextual model. *Journal of Applied Social Psychology*, 50, 512—523. https://doi.org/10.1111/jasp.12691

III Polet, J., Hassandra, M., Lintunen, T., Laukkanen, A., Hankonen, N., Hirvensalo, M., Tammelin, T., & Hagger, M. S. (2019). Using physical education to promote out-of school physical activity in lower secondary school students-a randomized controlled trial protocol. *BMC Public Health,* 19, 1—15. https://doi.org/10.1186/s12889-019-6478-x

IV Polet J., Schneider J., Hassandra, M., Lintunen T., Laukkanen, A., Hankonen N., Hirvensalo, M., Tammelin, T., Hamilton, K., & Hagger M. S. (2021) Predictors of school students' leisure-time physical activity: An extended trans-contextual model using Bayesian path analysis. PLoS ONE 16(11): e0258829. https://doi.org/10.1371/journal.pone.0258829

Juho Polet has participated in design, data collection, analysis, and writing up of all the studies I-IV.

FIGURES

TABLES

CONTENTS

1 INTRODUCTION

Low levels of physical activity are related to incidence of a number of non-communicable chronic diseases and health conditions, including cancer, cardiovascular disease, diabetes, and obesity, in adult populations globally (Blair, 2009). In contrast, participation in regular physical activity is related to reduced incidence of chronic disease and numerous health benefits with a dose-response pattern of effects (Janssen & LeBlanc, 2010). Physical activity is also related to health benefits in young people and children, including better mental health (Doré et al., 2020), adaptive health indicators (Hallal et al., 2006), and lower incidence of juvenile obesity (Hills et al., 2011). Importantly, physical activity initiated in the younger years tracks into adulthood, suggesting that active young people may be more likely to lead active lifestyles which may contribute to lower risk of chronic disease and health problems later in life (Lounassalo et al., 2021; Telama et al., 2014). This emphasizes the importance of the promotion of physical activity in the pre-adult years. Adolescence, therefore, is a particularly important time to promote physical activity, particularly in light of research indicating that physical activity tends to decrease during the adolescent years (Kokko & Martin, 2019; Telama & Yang, 2000). Given the imperative of promoting physical activity in this population, public health organizations and advocates have examined optimal means to promote physical activity to do so.

Physical education in school provides a prominent pre-existing context and network that can be potentially exploited to maintain and increase physical activity and works as a means to minimize drop-out from physical activity participation in adolescents. Physical education teachers are in an advantageous position to promote in-school and out-of-school physical activity as they have weekly contact with a diverse and captive audience of young people. Importantly, it is through physical education that young people experience a variety of physical activities, and these experiences may determine future involvement in physical activity during their leisure-time outside of school (Finnish National Agency for Education, 2014; Pate & Dowda, 2019; Pate et al., 1995). As the amount of activity performed during physical education lessons in school is not solely sufficient to confer the health benefits of physical activity, the onus is on teachers to provide

students with the motivation and skills required for them to opt to engage in regular out-of-school forms of physical activity in their leisure-time. Given that an important goal of education is to affect performance and behavior beyond the classroom (Ciani et al., 2010), there is a need for research examining the role of physical educators in affecting student participation in leisure-time physical activity (see Lonsdale et al., 2013). Such research should have sufficient basis in behavioral theory, particularly derived from social and health psychology, to identify the potentially modifiable motivational and decision-making factors that relate to students' participation in physical activities both within the classroom and in their leisure-time. Such factors should incorporate students' perceptions of the merits and detriments of performing the activity, along with their perceptions of the environment in which they perform the activity, the significant others (e.g., teachers, parents, and friends) that may support or undermine the activity, and the interpersonal and intrapersonal processes involved.

1.1 Theoretical background

Research applying theoretical principles from social psychology has aimed to identify the inter-individual and intra-individual factors that relate to individuals' physical activity participation. Much of this research has adopted a social cognition approach in which individuals' beliefs about their future actions are considered instrumental in determining decision-making and intentional behavior, such as physical activity. A prototypical social cognition theory is the theory of planned behavior (Ajzen, 1985), which encompasses the key elements of the social cognition approach and was the key approach adopted in the research reported in the current dissertation (see also Bandura, 1977). In contrast to social cognition theories, other prominent approaches applied to predict physical activity behavior are needs-based theories, which focus on organismic needs, and the quality rather than quantity of motivation, as candidate behavioral determinant. The pre-eminent needs-based approach is self-determination theory (Deci & Ryan, 1985), which was another key approach adopted in the research in the current dissertation.

Common to both the theory of planned behavior and self-determination theory is the consideration that behaviors such as physical activity are determined by motivational factors that involve a deliberative consideration of the merits and detriments of the behavior in future, the value attached to the behavior, and the consideration of the circumstances and internal values placed on the behavior. The research reported in this dissertation adopted an integrated approach in which the theory of planned behavior and self-determination theory were viewed as complementary in explaining physical activity behavior. The integration of these theories forms a key aspect of the trans-contextual model (Hagger, 2014; Hagger et al., 2003), a multi-theory model that aims to explain the processes by which students' perception of autonomy support from their physical education teacher in school relates to motivation, beliefs, and intention

toward physical activity in leisure-time as well as actual participation in physical activity in this context (Figure 1).

However, there is general consensus that the motivational processes outlined in social cognition and psychological needs-based approaches, and therefore in the integrated approach adopted here, do not fully account for the determinants of physical activity participation, and factors that represent non-deliberative, non-conscious, and automatic processes might also function as predictors of these behaviors (Fazio, 2001; Hofmann et al., 2008). The current dissertation drew from the propositions of dual-process models of behaviors, such as the reflective-impulsive model proposed by Strack and Deutsch (2004), which indicates that behavior may be determined by motivational factors such as those implied by the theory of planned behavior and self-determination theory, and more non-deliberative and non-conscious determinants. Recently proposed models, such as the integrated behavior change model (Hagger & Chatzisarantis, 2014), encompass both sets of processes within an integrated framework. However, the contribution of constructs representing non-conscious, automatic processes that lead to behavior have not been investigated broadly in the context of existing integrated models, such as the trans-contextual model. The current dissertation aimed to fill this gap in the literature by examining past behavior, habit, attitude, and self-control (constructs that reflect or represent non-conscious, non-deliberative processes) as predictors of behavior in the trans-contextual model.

1.2 Current research

Self-determination theory states that the motivational ambience in a social environment, such as a physical education lesson, defines the quality of motivation that determines individuals' behavior (Ryan & Deci, 2017). Founded on self-determination theory, the trans-contextual model assumes that significant others with an authority status, such as parents, teachers, and coaches, can support the autonomous motivation of others when they demonstrate behaviors that support individual's basic psychological needs (Hagger, 2014; McLachlan & Hagger, 2010; Ng et al., 2012; Reeve & Jang, 2006). According to the model, physical education teachers can support students' basic needs when teachers exhibit behaviors that contribute to their students' feelings of autonomy (feeling that a person's decisions reflect what the person wants), competence (feeling confident that exercises can be conducted well), and relatedness (feeling close and connected to the teacher and the other students) in a physical education class[1]. Research conducted in the current dissertation relied on students' self-reported perceived autonomy support, a central construct of the trans-contextual model, which is regarded as a proxy for actual autonomy support provided by their physical education teachers. It is important to note that perceived autonomy support also

[1] Definitions of basic needs are derived from those provided by Martela and Ryan (2021).

encompasses competence and relatedness support as the feeling of autonomy is central for the fulfillment of all three basic psychological needs (Ryan & Deci, 2017). Based on these premises, the first hypothesis of this dissertation states that students' perceived autonomy support provided by their teachers toward physical activities performed as part of school physical education will relate to their autonomous motivation toward physical activities performed in physical education. This hypothesis was explicitly tested in studies II and IV of this dissertation.

The trans-contextual model further proposes the transfer of autonomous motivation from the physical education context to the leisure-time context. This proposition is based on Vallerand's (2000) assumption that need satisfaction in one context (e.g., physical activity in physical education) can lead to need satisfaction in another context (e.g., physical activity in leisure-time) when both contexts include similar need-supportive features that enable the rise of autonomous motivation for behavior. The second hypothesis of the dissertation states that students' autonomous motivation toward physical activities performed in physical education will be related to their autonomous motivation toward physical activities performed in the context of leisure-time. This hypothesis of trans-contextual "spillover" of autonomous motivation for physical activity from the physical education context to the leisure-time context was tested in Studies II and IV.

The trans-contextual model integrates the central constructs from self-determination theory and the theory of planned behavior, postulating linkages among autonomous motivation, social cognition constructs, intention, and behavior for leisure-time physical activities. This is based on the proposal that individuals who perceive a given target behavior, such as leisure-time physical activity, as autonomously motivated are inclined to align their beliefs toward this behavior with their motives in order to prepare themselves to engage in this behavior in the future. The third hypothesis states that students' autonomous motivation toward physical activities in a leisure-time context will be related to their leisure-time physical activity participation through social cognition constructs (attitude, subjective norms, and perceived behavioral control) and intentions. Studies II and IV tested the depth and the generalizability of the third hypothesis.

As the standard formulation of the trans-contextual model proposes that autonomous motivation, social cognition, and intention presuppose leisure-time physical activity, research conducted in the current dissertation was extended to include constructs that represent the non-conscious and automatic processes that relate to leisure-time physical activity participation. Consequently, the fourth hypothesis was proposed: constructs representing non-conscious, automatic processes will be directly related to physical activity behavior independent of the other model constructs, and attitude will have a direct effect on behavior independent of the intention-mediated effect. The fourth hypothesis was partially tested in Study I by exploring whether the inclusion of past behavioral frequency in the reasoned action approach, an extended version of the theory of planned behavior, independently predicted behavior without mediation by intentions and other social cognition constructs, and whether the inclusion of the past behavior attenuated the effects of the reasoned action approach constructs on

behavior. Study II also partially tested the fourth hypothesis by including past behavior as an independent predictor of behavior alongside trans-contextual model constructs in a longitudinal test of the model. A broader perspective in testing the fourth hypothesis was taken in Study IV by including effects of multiple constructs representing non-conscious processes on behavior within the trans-contextual model: past behavior, habit, attitude, and self-control. Taken together, these tests were aimed at providing preliminary evidence for the feasibility of incorporating constructs representing non-conscious processes on behavior into the trans-contextual model.

In summary, the main objective of the current dissertation was to further test the key premises of the trans-contextual model and extend the model by including additional determinants that represent non-conscious, automatic processes consistent with dual-process models (e.g., Strack & Deutsch, 2004). This objective was addressed in the four studies by focusing on participation in leisure-time physical activity among school students.

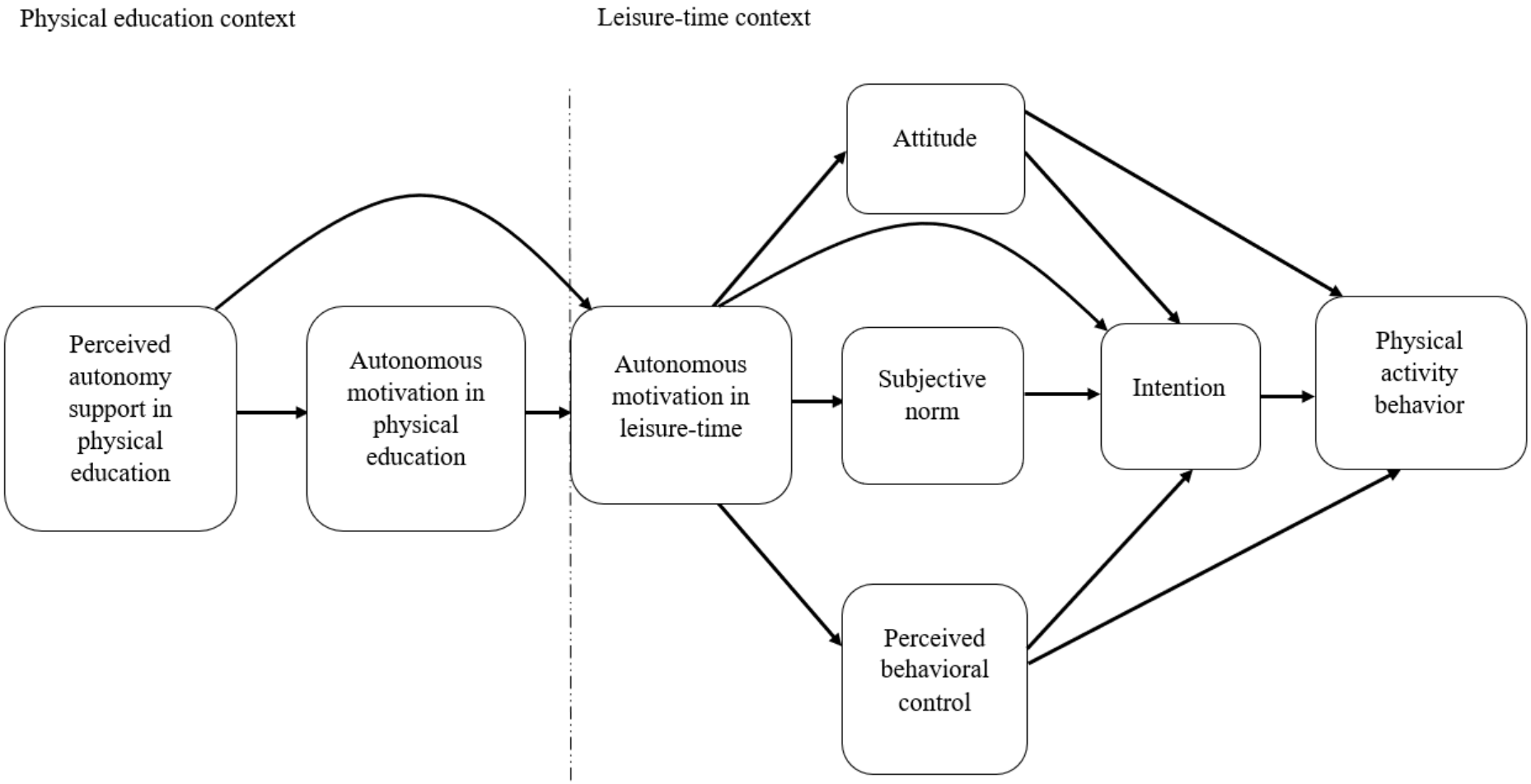

Figure 1 Trans-contextual model. Arrows represent proposed statistically significant effects among model constructs

2 BACKGROUND AND RATIONALE FOR THE TRANS-CONTEXTUAL MODEL AND ITS EXTENSIONS

Given the imperative of promoting increased participation in physical activity, in young people, researchers have applied theories and models derived from social psychology to identify the potentially modifiable determinants of behavior and the associated processes. This is important because it can provide the basis for intervention, particularly constructs that can be targets for a change in interventions based on theory. Many of these theories can be classified as social cognition theories in which individuals' attitudes and beliefs are the key determinants of behavior (Ajzen, 1998; Ajzen & Schmidt, 2020; Bandura, 1998). One of the most prominent theories applied in this regard is the theory of planned behavior (Ajzen, 1985). Recent integrated theoretical approaches aimed at more comprehensive explanations of behavior have extended social cognition theories, such as the theory of planned behavior, to identify the origins of the beliefs related to intentions and behavior. For example, recent approaches have suggested that the belief-based determinants of the theory of planned behavior originate from motivational constructs derived from self-determination theory (Deci & Ryan, 1985). However, social cognition and motivational theories, such as self-determination theory, focus on constructs that reflect largely conscious, deliberative decision-making processes that lead to action. However, dual-process approaches suggest that behavior may also be enacted through automatic, non-conscious processes that determine behavior, or, at least, the decision to act, independent of the more elaborate, intention-mediated processes proposed by social cognition and other motivational theories. Numerous constructs that reflect these non-conscious processes have been proposed (Fazio, 2001; Hofmann, Friese, & Wiers, 2008), and this dissertation examines the effects of several of these, namely, past behavior, habit, attitude, and self-discipline, on behavior in the context of the trans-contextual model.

2.1 Theory of planned behavior and the reasoned action approach

A motivational construct central to the theory of planned behavior is intention, which reflects the degree of effort that an individual is willing to invest in striving for a behavior (Ajzen, 1985, 2012; Ajzen & Schmidt, 2020). Propositions of the theory of planned behavior form integral components of the trans-contextual model, and the theory aims to identify the belief-based determinants of future behavioral engagement. According to the theory, behavioral intention is the most proximal predictor of actual behavior. Intention reflects the strength of effort or motivation that an individual holds with respect to a given target behavior. Intention is determined by three belief-based constructs: attitudes, subjective norms, and perceived behavioral control (Ajzen & Schmidt, 2020).

Attitudes reflect an individual's beliefs that performing the target behavior will lead to a certain outcome, known as instrumental attitudes, or that performing a certain behavior will lead to affective consequences, known as affective or experiential attitudes. In the context of physical activity, instrumental attitude could mean improving physical fitness or losing weight, and affective attitudes could mean anticipated positive feelings or enjoyment following physical activity participation. Subjective norms reflect individuals' beliefs that important referents (e.g., partner, family, friend, or coach) would want them to perform the target behavior (injunctive norm) or are perceived as performing that behavior themselves (descriptive norm). In the context of physical activity, an injunctive norm might mean that the individual believes that their friends or family would want them to be physically active, and a descriptive norm could mean that the individual's friends or family are themselves physically active. Perceived behavioral control reflects individuals' beliefs that facilitating or inhibiting factors may enhance or impede the performance of the target behavior. Perceived behavioral control reflects an individual's perceived ability to perform the target behavior (capacity belief) or an individual's belief that performing the behavior is up to them (autonomy belief). In the context of physical activity, a capacity belief might be an individual's belief that they are capable of going to the gym and performing a scheduled program there, whereas an autonomy belief might reflect an individual's belief regarding whether they have access to the gym and can get transportation and meet the costs of doing so. The elaborated form of the theory of planned behavior in which attitudes are divided into instrumental and experiential attitudes, subjective norms are divided into injunctive and descriptive norms, and perceived behavioral control is divided into capacity and autonomy has become known as the reasoned action approach (Fishbein & Ajzen, 2010).

The theory of planned behavior (Hagger & Chatzisarantis, 2009; Hausenblas et al., 1997; McEachan et al., 2011) and the reasoned action approach (McEachan et al., 2016) have been supported by meta-analyses for predicting general health behavior and physical activity. Intention as a motivational construct plays a key role as a mediator of the effects of the belief-based constructs on

behavior. Of the predictors of intentions, attitudes and perceived behavioral control generally have the largest effects on intention, with smaller effects for subjective norms. Noteworthy, although the theory accounts for substantive variance in intention and behavior in many contexts, much of the variance remains unexplained. Lack of intention in accounting for actual behavior (intention-behavior "gap") has been commonly observed in many previous studies (e.g., Sheeran & Webb, 2016; Orbell & Verplanken, 2020).

2.2 Self-determination theory

Self-determination theory is another theoretical framework of motivation that aims to provide a comprehensive explanation of human behavior. However, it differs from social cognition approaches, such as the theory of planned behavior, in that it focuses on a needs-based approach. The theory focuses on innate psychological needs and the quality rather than quantity of motivation as the origins of human behavior (Deci & Ryan, 1985; Hagger et al., 2020; Ryan & Deci, 2000, 2017). A central sub-theory of self-determination theory is the organismic integration theory, which suggests a conceptual separation among the five different forms of motivation (Figure 2). In this sub-theory, a broad distinction is made between the autonomous and controlling forms of motivation. Autonomous motivation is defined as engaging in behavior for *self-determined* reasons that are perceived consistent with an individual's intrinsic subjective goals and that emanate from the self; in contrast, controlled motivation reflects engaging in behaviors for *external* reasons driven by rewards, social approval, guilt, shame, or fear of punishment (Hagger et al., 2014). Autonomous motivation is considered adaptive because individuals experiencing action as autonomously motivated are more likely to have self-determined reasons for acting and act out of a sense of volition, which can be related to behavioral persistence and beneficial, long-lasting, and adaptive outcomes (e.g., Cheon & Reeve, 2013). In particular, the organismic integration theory proposes that human motivation for behavior varies on a continuum of being extremely controlled, stemming from the expectation of a reward or punishment (*external regulation*); or of being genuinely intrinsic stemming from the joy of, pleasure of, or interest in the action at hand (*intrinsic motivation*; Ryan & Deci, 2017). Push-ups as punishment exemplifies the external regulation for physical activity, and feelings of flow and enjoyment stemming from participating in activities exemplifies the intrinsic motivation for exercise.

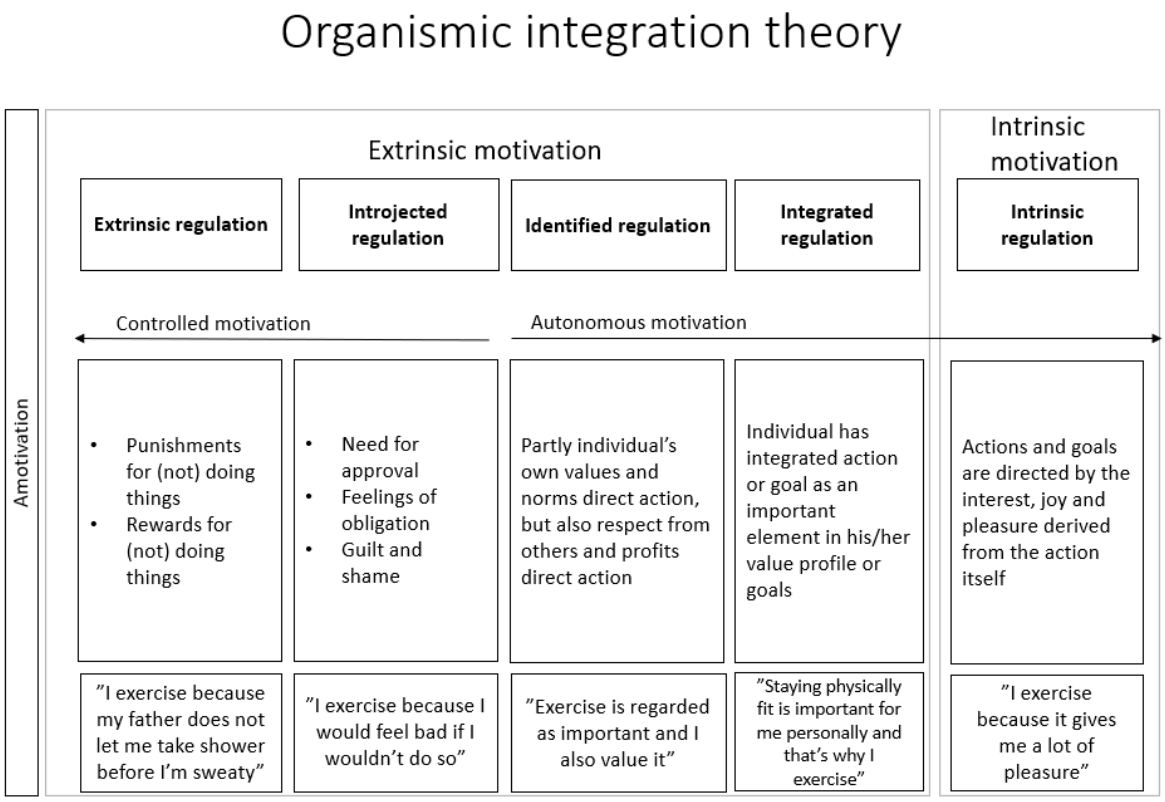

Figure 2 Types of motivational regulations according to the organismic integration theory. Adapted from Ryan and Deci (2017) and Vasalampi (2017).

According to self-determination theory, the source of motivation for behavior can also be derived from less clear-cut contingencies than punishments and rewards. For example, *introjected regulation*, is a form of motivation that is partially *internalized* and reflects acting out for the avoidance of guilt or shame. This type of behavioral regulation reflects a more controlled form of motivation. Introjected regulation may be linked to injunctive norms from the theory of planned behavior because both focus on acting in response to perceived pressurizing social influences.

In contrast, *identified regulation* reflects more internalized forms of motivation. Identified regulation is characterized by acting because the behavior is perceived as personally important or valuable to achieve desired outcomes. In the context of physical activity, identified regulation may reflect exercising for health benefits if health is perceived to be personally important and valuable to the individual. The most autonomous form of extrinsic motivation is *integrated regulation*, characterized by acting because the behavior is congruent with one's genuine sense of self and autonomously-endorsed identity. When it comes to physical activity, integrated regulation reflects acting because the activity itself is considered central to the person's identity and sense of self. Research conducted in current dissertation focus on the degree to which behaviors are autonomously motivated, encompassing identified and integrated regulations, and intrinsic motivation.

Another important sub-theory of self-determination theory is the basic needs theory (Ryan & Deci, 2017). According to this sub-theory, human thriving and well-being are conditional on the fulfilment of three psychological needs: *autonomy*, *competence*, and *relatedness*. Lack of satisfaction of these basic psychological needs is expected to lead to suboptimal functioning or potentially detrimental consequences. The need for autonomy refers to the need to experience volition in one's actions and the perceived psychological discretion to act according to one's will. The need for competence refers to the need to feel effectance and mastery in tasks. Competence reflects not only the experiential features of a given behavior but also human flourishing, a common feeling of "know-how," and well-being in general. The need for relatedness refers to the need to be accepted and connected with. Self-determination theory recognizes that interaction with other human beings (i.e., caring, emotional warmth, social connections, appreciation, and prosocial behavior) is essential for human motivation, functioning, and well-being.

The propositions of the organismic integration theory and the basic needs theory complement each other because individuals that view a behavior as potentially satisfying of their psychological needs are more likely to experience their behavior as autonomously motivated (Ryan & Deci, 2017). The proposed direction of effects between the basic needs theory and the organismic integration theory is that the satisfaction of the basic psychological needs will lead to more autonomous forms of motivation (Ryan & Deci, 2000).

Self-determination theory has been consistently applied to predict behavior in health and well-being contexts, including the physical activity. A meta-analysis by Owen et al. (2014) revealed that autonomous forms of motivation are related to physical activity more strongly than controlled forms of motivation among children and adolescents. Autonomous forms of motivation were related to motivation for physical activity participation in physical education and leisure-time contexts alike. However, the effect sizes observed were small-to-moderate at best. The authors concluded that factors other than motivation, as formulated by self-determination theory, are likely to be important correlates of physical activity. A systematic review by Teixeira et al. (2012) revealed that autonomous forms of motivations are more related to physical activities (exercise) among a predominantly adult population. Similarly, a meta-analysis by Ng et al. (2012), with a broader focus on health behaviors and outcomes, revealed that psychological need satisfaction and autonomous motivation are related to beneficial health behaviors and outcomes. Meta-analyses and systematic reviews on these motivational determinants of behavior rely heavily on cross-sectional or longitudinal studies. However, recent meta-analyses exhibited a small effect of self-determination theory-informed interventions on health indices (Ntoumanis et al., 2021) and health behavior change (Sheeran et al., 2020).

2.2.1 Supporting basic psychological needs in education

Self-determination theory proposes that autonomous motivation is fostered through the fulfillment of the three basic psychological needs of autonomy,

competence, and relatedness (Ryan & Deci, 2017). According to the theory, the motivational environment or climate developed by social agents (e.g., coaches, instructors, and teachers) in leadership or influential roles is key to fostering need support and autonomous motivation (Deci et al., 1994). The motivational environment or climate is fostered by the behaviors that leaders display in such contexts. As an illustration, Haerens et al. (2013) extracted 21 need-supportive techniques in physical education from the extant literature and expert panel interviews and conducted an exploratory factor analysis to identify the underlying emergent domains of the identified techniques and the theory-based constructs to which they pertain. Four factors were found: relatedness support, autonomy support, structure before activity, and structure after activity. Similarly, Jang et al. (2010) found autonomy support and structure to be correlated, and these both predicted students' behavioral engagement individually. In addition, Sarrazin et al.'s (2006) observational study classified organizational communications, technical and tactical hints, and questions used by teachers as being potentially autonomy-supportive, controlling, or neutral depending on their style of delivery. Organizational communication presented in a forceful manner represented a controlling style, asking students to help in organization represented a neutral style, and providing choice as part of the organization of class represented an autonomy-supportive style. Praise, encouragement, and perspective-taking statements were also classified as autonomy-supportive techniques, whereas negative communications related to students' work or social behavior as well as criticism were classified controlling techniques. These studies illustrate the important techniques or behaviors that have been identified in education contexts that support psychological needs, autonomous motivation, and behavioral persistence.

Studies on observed or experienced need support have, thus far, focused on autonomy support from significant others, because the need for autonomy is regarded as the foremost need in the basic needs theory (Ryan & Deci, 2017). In the physical education context, physical education teachers have been educated to use more autonomy-supportive and less controlling techniques in their classes to promote students' autonomous motivation for physical activities (e.g., Reeve et al., 2004). A meta-analysis of studies on intervention programs designed to teach autonomy-supportive techniques and strategies to support the autonomy of others found these interventions to be effective in increasing the perceptions of autonomy support, with a moderate-to-large effect size (Su & Reeve, 2011). The autonomy support programs delivered by teachers had a large effect on autonomous motivation among students. Training teachers to be autonomy supportive in their teaching has also been shown to be beneficial for the teachers themselves, leading to greater teaching motivation and teacher well-being (Cheon et al., 2014).

The types of behaviors that autonomy-supportive teachers and other leaders present provides an indication of the type of content that should be included in autonomy-supportive interventions and how researchers and practitioners can promote autonomous motivation in others. Reeve and Jang (2006) found several instructional behaviors displayed by teachers to be correlated with students'

perception of autonomy; these behaviors included listening, giving time for independent tasks, giving opportunities to talk, praising improvement/mastery, encouraging expressions of effort, offering hints that enable independent progress when stuck, being responsive to questions/comments, and acknowledging students' perspective on the tasks at hand. Instructional behaviors that were negatively correlated with students' perception of autonomy included the hogging of materials, exhibiting answers or solutions before giving time for students to work on the tasks independently, giving directives/commands, using should/got to statements in instructions, and using controlling questions. An observational study by Jang et al. (2010) revealed that higher ratings on autonomy support predicted students' observed and self-reported behavioral engagement. This is an important finding given that engagement in school activities can be affected by the style of delivery of instruction cost-effectively.

Other studies have specifically concentrated on the autonomy-supportive and controlling techniques used by physical education teachers. Edmunds et al. (2008) found that female students taught in the autonomy-supportive manner gained more competence and relatedness support than the students in a control group that did not receive autonomy-supportive education. Tessier et al. (2008) tested the effectiveness of an intervention program based on Sarrazin et al.'s (2006) classification to promote physical education teachers' autonomy support toward their students. Results showed that the teachers of the experimental group expressed more autonomy-supportive and neutral behaviors than the teachers of the control group, but there were no differences between the groups in controlling teacher behaviors.

Autonomy support is related to increased autonomous motivation toward behaviors and to the outcomes related to optimal functioning. For example, research in educational contexts has demonstrated that autonomy support provision by teachers leads to life satisfaction (Ferguson et al., 2011), perceived competence (Guay et al., 2001), course value (Patall et al., 2013), and engagement (Reeve et al., 2004) among students. Therefore, teachers are in the optimal position to foster autonomous motivation when they adopt autonomy-supportive behaviors in their instruction. More importantly, autonomy-supportive teacher behaviors focus on the style of instruction and creation of an autonomy-supportive motivational environment, rather than on the specific content of the lesson *per se*, making it possible to apply these techniques in multiple educational contexts. The delivery of autonomy-supportive techniques has been shown to have long-term effects on behavior in academic settings (Cheon & Reeve, 2013). Most studies aiming to foster teachers' autonomy-supportive behavior in class are restricted to an examination of the effects of these practices in students in a school environment.

There have been fewer studies investigating whether the observed provision of autonomy support or students' perception of autonomy support in educational settings has an effect on students' behavior in their leisure-time, such as participation in sports clubs or other voluntary physical activities. According to Vallerand (2000), motivation can transfer across contexts, such that the type of

motivation experienced for a behavior in one context can be related to the same type of motivation experienced for similar behaviors in other contexts. For example, students' motivation experienced toward behaviors performed in an educational context (e.g., in class) can relate to similar behaviors in a leisure-time context (e.g., at home). Similarly, need satisfaction for actions in one context can be related to need satisfaction toward similar behaviors in another context when the same or similar need-supportive elements of the context are present. This proposition forms the central premise of the trans-contextual model, a key model that is central to the research reported in the current dissertation (Hagger & Chatzisarantis, 2016).

2.3 Past behavior, habit, and future behavior

The theory of planned behavior presumes that the proposed intention and belief-based constructs of attitude, subjective norm, and perceived behavioral control are sufficient for accounting for intentional behavior. The theory proposes that the potential effects of numerous background factors (e.g., individual differences and socio-structural variables) on behavior will be fully mediated by the belief-based constructs of the theory (Ajzen, 1991). Such factors are considered distal predictors and serve as sources of information on which people make assessments of their beliefs about future behavioral enactment. However, it is quite typical for past behavior to have a considerable direct effect on future behavior within the context of social cognition theories, such as the theory of planned behavior (Ouellette & Wood, 1998). This implies that individuals are highly consistent in their behaviors and that social cognition constructs do not fully account for this stability. This has been supported in empirical research in which past behavior has been included as an additional predictor in tests of the model predictions. Including past behavior as an independent predictor of behavior in tests of the theory often leads to a significant increase in the explained variance in behavior that the model is capable of explaining (Ajzen, 2002; Brown et al., 2018; Protogerou et al., 2018). It also often leads to an attenuation of the effects of other constructs on behavior in the theory, (Hagger et al., 2016), although it often does not entirely negate their effects. Ajzen (2002) called this a test of the "sufficiency" of the theory in accounting for behavior independent of prior behavioral effects.

Therefore, what does the effect of past behavior on future behavior in the context of the theory of planned behavior represent? It has been argued that the effect of past behavior on future behavior might be a proxy for the effects of the other unmeasured variables that the theory proposes (Fishbein & Ajzen, 2011). A relatively common interpretation is that past behavior represents the effect of habits on behavior (Ouellette & Wood, 1998). This is because a key component of habits is that they represent behaviors that are performed with high frequency. However, this view has been criticized because the frequency of past behavior is not a social cognition construct, so it lacks content that reflects the features and characteristics of habitual behavior; it is also problematic because measures of

past behavior share significant common method variance with behavioral measures (Ajzen, 2011; Fishbein & Ajzen, 2011).

In response, scholars have elaborated habits within social cognition theories, developing them as a psychological construct that reflects the history of repetition (behavioral frequency), automaticity (lack of control/awareness and controllability), and identity (sense of self or personal style) (Verplanken & Orbell, 2003). Habit as a construct has been contrasted with the deliberative decision-making preceding the behavior that is the focal point of interest in the theory of planned behavior; instead, it has been argued that habits reflect spontaneously enacted cue-response links and less-attentive information processing that is not deliberative or conscious (Verplanken & Aarts, 1999). The authors propose that habits are characterized by individuals responding to cue-related information and enacting concomitant responses, while they do not attend to novel information or behavioral alternatives, and thus, the habitual behavior is maintained. Current theory on habit describes habits as behavioral responses cued or initiated by the presentation of environmental or situational circumstances that have been paired with the behavior through repeated experience in stable contexts. Therefore, they are experienced as effortless, automatic, and without thought or elaborate processing (Gardner, 2015; Wood, 2017). The automaticity component of habit has gained attention, and it has been argued that automaticity is a core component of habit and measuring the self-reported experience of behaviors as automatic yields an accurate evaluation of habit strength. More importantly, the self-reported measures of habits in multiple health behaviors, including physical activity, have been shown to be the independent predictors of behavior (Gardner et al., 2011).

Nevertheless, past behavior effects within social cognition models can still be informative of potential habitual control over behavior. For example, Ouellette and Wood (1998) proposed that past behavior can influence future behaviors via a deliberative process (e.g., through formation of intention) or directly and "automatically" without deliberation or reflection, which implies a more habitual process.

In the current dissertation, habitual influences on intentional behavior in the context of social cognition models, such as the theory of planned behavior, were examined both in terms of the implied effects of past behavior and as a construct, which reflected the automatic processes that reflected habit.

2.4 Trait self-control

In addition to motivational and social cognition factors, personality traits are considered to relate to health-related behaviors, such as physical activity. Personality traits include constructs from the "big five" model of personality: extroversion, neuroticism, conscientiousness, openness to experience, and agreeableness (Goldberg, 1993). These factors have been shown to have modest effects on behavior and outcomes across multiple domains, contexts, and populations (e.g., Chiaburu et al., 2011, Raynor & Levine, 2009), including the contexts of physical

activity (Rhodes & Smith, 2006) and physical inactivity (Sutin et al., 2016). In social cognition theories, such as the theory of planned behavior, personality traits are considered distal predictors of intentional behavior and serve as underlying sources of information that individuals draw from when ultimately responding to prompts to report their beliefs and intentions to perform subsequent behaviors. Consequently, the immediate determinants of behavior in the theory are expected to mediate the effects of personality traits on behavior. However, there is research demonstrating that personality constructs predict behavior independent of intentions and other social cognition constructs (Wilson & Rhodes, 2021). In the context of physical activity, conscientiousness and its sub-facets have been shown to be pervasive predictors of the beliefs in the theory of planned behavior and of behavior directly. The direct effects of personality traits on physical activity have been interpreted as potentially representing cognitive biases that predispose people to forming characteristic decisions and performing behavioral patterns beyond their awareness. Therefore, direct behavioral effects may reflect deep-rooted beliefs with concomitant behavioral responses that lead to behavior without the need to form intentions.

One of the prominent personality traits that is likely to influence health behavior is a facet of conscientiousness, known as self-discipline, which is closely aligned with trait self-control (Tangney et al., 2004). This trait is defined to reflect individuals' dispositional and enduring capacity to engage in goal-directed behavior and to manage or overcome potentially derailing impulse-driven alternatives and temptations (Baumeister & Heatherton, 1996; Hofmann et al., 2009). Therefore, high self-control is linked to sustained effortful behavior to reach long-term goals (Gottfredson & Hirschi, 1990; Inzlicht & Schmeichel, 2012). Meta-analytic findings have indicated that trait self-control is consistently linked with multiple health behaviors, including physical activity (de Ridder et al., 2012). Interestingly, one of the strongest connections found in this meta-analysis was the correlation between self-control and forming or breaking habits. Congruent with habit, trait self-control might have a direct effect on behavior, irrespective of the mediating role of behavioral intention, and there is evidence to support this (Hagger, Gucciardi et al., 2019; Hagger, Hankonen et al., 2019). This direct effect of trait self-control on behavior is hypothesized to reflect propensities to attend, or refrain from attending, to behaviors independent of a deliberative process that would require the formation of beliefs or intentions. There is also evidence that self-control predicts behavior mediated by social cognition constructs (Hagger, Hankonen et al., 2019). This may reflect occasions where self-control informs individuals' decision-making, as outlined earlier. Nevertheless, data on these different pathways are limited. In the current dissertation, both the direct and the indirect effects of trait self-control on physical activity intention and behavior were tested.

2.5 Attitude as a direct predictor of behavior

The reasoned action approach proposes that attitude can be divided into affective beliefs (beliefs that a certain behavior will lead to affective consequences) and instrumental beliefs (beliefs that the target behavior will lead to a certain outcome) (Ajzen & Schmidt, 2020; Fishbein & Ajzen, 2011). The reasoned action approach predicts the effect of both types of attitudes on behavior through behavioral intentions, and meta-analytic data support this hypothesis (McEachan et al., 2011). Nevertheless, research has shown a direct effect of affective attitude on behavior, and this effect has been interpreted to represent a more non-conscious and automatic "route" to behavior as opposed to the conscious and deliberative intention-mediated "route" of the instrumental attitude (Conner et al., 2015; Lawton et al., 2009). In the current dissertation, the direct effect of attitude on behavior was examined alongside the intention-mediated effect and the former was interpreted to reflect non-conscious and automatic affective processes that guide judgments that are related to health behaviors in general and physical activity in particular (see also Zajonc, 1980).

2.6 Theoretical integration

While the theory of planned behavior has had demonstrable success in accounting for the variance in multiple health behaviors, contexts, and populations (McEachan et al., 2011), including the physical activity domain, it is not without limitations. It does not account for all variance in behavior (Sheeran & Webb, 2016); it does not explicitly contain constructs that explain the origin or determinants of its predictors (Hagger, & Chatzisarantis, 2007); it does not account for the consistent past-future behavior relations (Ajzen, 1991; Sommer, 2011); and it does not account for non-conscious, automatic influences on behavior (e.g., Hagger, Hankonen et al., 2019). Therefore, authors have sought to modify the theory to increase its predictive validity. This has included research that has added additional constructs that account for additional variance in intentions and behavior, including constructs that represent non-conscious and automatic processes, such as personality and habit.

One key modification has been to identify constructs that might explain the origins of the belief-based constructs in the theory and serve as sources of information for their formation. For example, research has integrated the theory of planned behavior with self-determination theory. This integration has been based on the assumption that motivational constructs of self-determination theory are background factors affecting the social cognition constructs of the theory of planned behavior (Hagger & Chatzisarantis, 2009). Hagger and Chatzisarantis' meta-analysis of studies that have integrated constructs from the theory of planned behavior and self-determination theory revealed that autonomous motivation from self-determination theory predicted attitudes and perceived

behavioral control from the theory of planned behavior across multiple health behaviors, including physical activity. More importantly, autonomous motivation predicted behavior mediated by the social cognition constructs and intention, corroborating the necessity of including variables from the theory of planned behavior as mediators between autonomous motivation and health behavior.

2.7 Trans-contextual model and its hypotheses

A more elaborated form of the integration of the theory of planned behavior and self-determination theory is presented in the trans-contextual model (Hagger, 2014; Hagger et al., 2003; Hagger & Chatzisarantis, 2016). This model is an integrated model with a specific purpose: to propose and test relations between forms of motivation for tasks and behaviors across educational and out-of-school contexts, and relations between these forms of motivation and the immediate social cognition constructs implicated in decisions to participate in similar tasks and behavior outside of school. It also proposes a process by which the perceived motivational environment or climate fostered by the behaviors displayed by educators and teachers relates to forms of motivation toward tasks and behaviors in the educational context and forms of motivation for similar tasks and behaviors outside of school in the leisure-time context. The model has been developed specifically to examine the relationships between these constructs in school students for physical activity in physical education and leisure-time contexts and has mainly been tested in this domain. In addition to integrating the central constructs from the theory of planned behavior and self-determination theory, the trans-contextual model draws from Vallerand's (2000) hierarchical model of intrinsic and extrinsic motivation (see also Vallerand & Ratelle, 2002). This integration provides the basis for the relationships between autonomous motivation for physical activity in a physical education context and autonomous motivation, social cognition constructs, and intentional behavior in a leisure-time context.

The first hypothesis (1) of the trans-contextual model, derived from self-determination theory, is that students' perceived autonomy support from their physical education teacher is positively related to their autonomous motivation for activities performed during physical education in school. Significant others and social agents in a position of authority, such as teachers, are capable of promoting autonomous forms of motivation for in-class physical activities by displaying autonomy-supportive behaviors in their lessons. Provision of autonomy support has been found to be related to increased autonomous motivation (Black & Deci, 2000), engagement (Reeve et al., 2004), and behavioral persistence (Pelletier et al., 2001). Perceived autonomy support in physical education has been found to be consistently related to autonomous motivation for physical activities in physical education (Hagger & Chatzisarantis, 2016), consistent with the first hypothesis derived from the model.

The second hypothesis (2) of the trans-contextual model addresses the trans-contextual association between motivation in the physical education and

leisure-time contexts. The trans-contextual model assumes that the forms of motivation toward physical activities performed in a physical education context are directly related to forms of motivation toward physical activities performed in a leisure-time context. This hypothesis is based on Vallerand's (2000) assumption that motivation for a behavior in a given context such as physical activity can transfer to similar behaviors performed in other contexts. In addition, given that the perceived motivational environment or *climate* in physical education fostered by physical education teachers is considered instrumental in developing autonomous motivation toward physical activity in physical education, the trans-contextual model predicts an indirect effect of the perceived autonomy support for activities in physical education on autonomous motivation toward the leisure-time physical activity mediated by autonomous motivation toward physical activities in physical education.

The third hypothesis (3) of the trans-contextual model predicts that autonomous motivation toward activities in a leisure-time context is directly and positively related to the belief-based constructs (attitudes, subjective norms, and perceived behavioral control), intentions, and actual participation in the leisure-time physical activity. In particular, autonomous motivation in leisure-time physical activity is proposed to have an indirect effect on intention via each belief-based construct, and on behavior via each belief-based construct and intention. The hypotheses of the trans-contextual model are summarized in Figure 3.

Previous meta-analytic research on the trans-contextual model encompassing mainly correlational studies supports model predictions (Hagger & Chatzisarantis, 2016). The model has also been utilized as a theoretical framework for behavioral change intervention to promote school students' leisure-time physical activity (Barkoukis et al., 2021). In the latter study, no intervention effects on the changes in intentions and leisure-time physical activity were observed even though perceived autonomy support in physical education was successfully changed in the intervention group. Nevertheless, the application of the trans-contextual model as a framework for interventions is still in its infancy and more studies are required to determine the effect of interventions on the different components of the model to promote school students' leisure-time physical activity. Research on the trans-contextual model also calls for more longitudinal research as a majority of the studies apply a relatively short timeframe in their design (Cheon & Reeve, 2013). Moreover, more studies modeling change in model constructs over time within the trans-contextual model are needed (e.g., Kalajas-Tilga et al., 2021), as a majority of studies drawing from the trans-contextual model do not consider intra-individual change in its constructs over time (Sniehotta et al., 2014).

In the research reported in the current dissertation, the key hypotheses of the trans-contextual model were replicated and extended to account for some of the prior limitations outlined in previous research, including the long-term prediction and modeling of change. Moreover, the model was extended to incorporate constructs related to non-conscious, automatic processes. This addressed some of the limitations inherent in the component theories that have informed

the model, particularly the exclusive focus on constructs that represent motivational processes. These extensions will be introduced next.

2.8 Extending the trans-contextual model

The trans-contextual model focuses on the forms of motivation from two contexts, and social cognition constructs, as the determinants of students' leisure-time physical activity. These constructs mainly reflect reasoned processes that lead to action. The model does not account for constructs that model the non-conscious processes that may lead to behavior, and it is possible that the unexplained variance in physical activity might be due to the insufficiency of the model in accounting for other processes. As mentioned previously, multiple theories suggest that behavior may be determined by non-conscious, automatic processes that take place largely outside of individuals' awareness (Fazio, 2001; Hofmann, Friese, & Wiers, 2008). For example, Strack and Deutsch (2004) developed a reflective-impulsive model that outlines how constructs representing both types of processes relate to behavior and the conditions that might determine when they do so. Behavior resulting from a reflective system reflects reasoned decision-making based on consideration, knowledge, facts, and values. This type of process is determined by higher-order control resources. The predictions of the trans-contextual model focus predominantly on constructs that represent this reflective process. In contrast, the impulsive system reflects the initiation of behavioral patterns, action patterns, or schemas activated in response to the presentation of the associated environmental cues.

Therefore, the trans-contextual model can be amended to include additional constructs that reflect these impulsive influences in order to broaden its predictive capacity. There is precedent for doing so in other research on integrated theories derived from the component theories of the trans-contextual model. For example, Hamilton et al. (2017) integrated the theories of planned behavior and self-determination theory in the context of parents' sun-protective behaviors for their children. They included a self-reported habit as an independent predictor of a health behavior to represent a non-conscious process. They found that habit predicted the behavior independent of the intentions and the self-determined motivation. There are many other examples of these effects on different behaviors (e.g., de Bruijn et al., 2009; de Bruijn & van den Putte, 2009; Norman & Cooper, 2011), including physical activity (Thomas & Upton, 2014). A key aim of the current dissertation was to amend the trans-contextual model to include additional determinants of students' physical activity behavior that reflect non-conscious, automatic processes that lead to behavior. In particular, past behavior, habit, and self-control were considered the predictors of behavior within the model. The goal was to arrive at a more comprehensive explanation of the variance in leisure-time physical activity behavior, particularly among middle school students.

2.9 Summary of the studies conducted as part of the dissertation

Even though there is a growing body of research lending support to the predictions of the trans-contextual model with respect to health behavior in general, and physical activity in particular, no study to date has extended the model to account for the effect of constructs representing non-conscious, automatic processes that lead to behavior. The current dissertation aimed to fill this gap in the literature by augmenting the model to include past behavior, self-reported habit, and trait self-control as the predictors of physical activity behavior, representing the impulsive processes outlined in the reflective-impulsive model (Strack & Deutsch, 2004). In addition, the model was augmented to include the direct effects of (affective) attitude on the physical activity behavior, which further encompassed a non-conscious process within the model. The ultimate aim of the current thesis, in addition to testing the standard model predictions, was to examine the effects of these constructs as representative of non-conscious, automatic processes within the trans-contextual model in order to arrive at a more comprehensive explanation of students' leisure-time physical activity, as well as health behavior more generally. A further aim of the dissertation was to address some of the limitations of the trans-contextual model, particularly the need to model change in its constructs over time. These aims were fulfilled through four separate but interrelated studies. Study I used a meta-analysis to test the effects of past behavior on future health behaviors, including physical activity, with a generalized social cognition approach, the reasoned action approach. This provided the initial basis for the direct and indirect effects of past behavior as a proxy for one type of non-conscious process, habit, in the context of a social cognition model that was integral to the trans-contextual model. In the Study II, the predictive validity of the trans-contextual model was tested in a sample of school students by using the data collected at three follow-up time points. Study II examined the capacity of the model to account for the change in its psychological constructs and physical activity behavior over time and tested the effects of past behavior on the change in behavior over time. Study III outlined a protocol for an intervention based on the trans-contextual model and identified how the model might be used to change behavior. It also set out the basis for accounting for non-conscious, automatic processes, such as habit, in the model and potential model-based intervention strategies that might promote the increase in physical activity among school students. Study IV provided a fuller test of an augmented version of the trans-contextual model that incorporated additional constructs other than past behavior and accounted for non-conscious processes: self-reported habit and trait self-control. It also tested the direct effect of attitude on behavior, a further effect that was indicative of the effects of non-conscious processes on behavior (Conner et al., 2015; Lawton et al., 2009). The next section outlines the formal aims and hypotheses related to the current dissertation.

3 PURPOSE OF RESEARCH AND HYPOTHESES

The research reported in the current dissertation aimed to provide additional evidence to support the trans-contextual model predictions beyond currently available data, and to extend the model to include variables and constructs that represent non-conscious, automatic processes related to physical activity behavior, namely past behavior, self-reported habit, and trait self-control, and the direct effect of attitude on behavior. The aims were derived from the trans-contextual model and from theories that propose non-conscious, automatic processes related to health behavior, such as the reflective-impulsive model. These aims were addressed in a series of related studies, each testing one or more hypotheses that addressed the aims.

3.1 Aims and hypotheses

The overall aim of the current doctoral research was to provide further tests of the hypotheses of the trans-contextual model and to test hypotheses related to an extended version of the model that incorporated constructs representing non-conscious, automatic processes related to behavior. These predictions were tested in a series of studies predicting, primarily, middle school students' leisure-time physical activity participation. The proposed effects and the corresponding hypotheses are summarized in Figure 3. The specific hypotheses derived from the trans-contextual model (Hypotheses 1-3) and from the theories implying the non-conscious, automatic predictors of behavior (Hypothesis 4) tested in this dissertation are as follows:

1) School students' perceived autonomy support for in-school activities from their physical education teacher will be related to their autonomous motivation toward activities in a physical education context *(this hypothesis was tested in Studies II and IV)*.

2) School students' autonomous motivation in a physical education context will be related to autonomous motivation toward physical activity in a leisure-time context *(this hypothesis was tested in Studies II and IV)*.
3) Autonomous motivation for physical activity in a leisure-time context will be related to leisure-time physical activity intentions and behavior and constructs from the theory of planned behavior (attitudes, norms, perceived behavioral control, and intentions) will mediate these relations *(this hypothesis was tested in Studies II and IV*).
4) Variables and constructs that represent non-conscious, automatic processes (past behavior, habit, trait self-control, and the direct effect of attitude on behavior) will relate to the physical activity behavior independent of the constructs representing reasoned, deliberative processes *(this hypothesis was tested in Studies I, II, and IV)*.

3.2 Context of hypotheses tested in individual studies

Study I presented a meta-analytic structural equation model of studies testing the predictions of the reasoned action approach[2] for health behaviors. This study tested the efficacy of social cognition constructs in predicting intentions for health behavior and the actual health behavior, including physical activity. The purpose of this study was to test the effects of past behavior, a variable that might shed light on the habitual influences on behavior and, therefore, provide important evidence of the non-conscious, automatic processes that lead to health behavior. The study is relevant to the trans-contextual model because it represents an important part of the model: the proximal social cognition determinants of intentional behavior. Therefore, it provides an important preliminary test of the potential role that past behavior, as a proxy for non-conscious processes, may play in the broader model set out in Hypothesis 4. The study also extends a previous meta-analysis by McEachan et al. (2016) by incorporating past behavior. It was also assumed that including past behavior in the model would attenuate the other model effects.

Study II tested the hypotheses of the trans-contextual model and extended them to account for the change over time, i.e., whether the change over time in students' perception of autonomy support from their physical education teacher was related to the change in students' leisure-time physical activity via the change in the motivational constructs of the model in the physical education and leisure-time contexts, and in the social cognition constructs of the model with respect to

[2] The reasoned action approach is a social cognition model that outlines the determinants of intentional behavior. The reasoned action approach is an extended version of the theory of planned behavior in which attitudes are divided into experiential and instrumental attitudes, norms are divided into injunctive and descriptive norms, and perceived behavioral control is divided into capacity and autonomy beliefs (Fishbein & Ajzen, 2011).

the leisure-time physical activity. Hypotheses 1-3 of the current doctoral research were tested in Study II. Modeling the change over time in physical activity provided a more stringent approach to testing the predictive validity of the trans-contextual model. The value of accounting for the change over time is that it increases the relevance of the model in guiding interventions that manipulate perceived autonomy support to change the leisure-time physical activity intentions and behavior. This study also included the effect of the past physical activity behavior on the prospective physical activity, thus providing an additional test of one of the key variables representing the non-conscious processes leading to behavior as set out in Hypothesis 4.

Study III (protocol article) presented a protocol for the procedure, measures, and participants for a randomized controlled trial based on the trans-contextual model, and also the data to be used in Study IV. The protocol identified how the model could be applied to promote leisure-time physical activity behavior among middle school students by educating the physical education teachers on the autonomy-supportive training techniques. It also presented the foundation for accounting for automatic, non-conscious processes, such as habit, in the model. Potentials for the model-based interventions to promote not only physical activity but also other health behaviors were set out in Study III. The realized study presented in the protocol allowed the testing of Hypotheses 1-4 (see Schneider et al., 2020).

Study IV provided a further test of the predictions of the trans-contextual model as set out in Hypotheses 1-3 but, more importantly, extended the model to include variables and constructs that represented the non-conscious, automatic processes leading to behavior: past physical activity behavior, physical activity habit, trait self-control, and the direct effect of attitude on behavior, as set out in Hypothesis 4. The study also used Bayesian structural equation modeling, which enabled the inclusion of the informative prior knowledge from the previous studies on the trans-contextual model to determine whether the data could further inform the relationships among the constructs. An overview of Studies I-IV is presented in Table 1, and a diagram summary of Hypotheses 1-4 is presented in Figure 3.

Table 1 Original studies conducted as part of this dissertation from which Hypotheses 1—4 were derived

Study number and aim	Participants	Design and methods
I. To extend McEachan et al.'s (2016) meta-analysis on the reasoned action approach by including past behavior as predictor in a test of the model across multiple studies.	Original studies included in McEachan et al.'s (2016) meta-analysis, including 74 individual articles and 86 datasets (total N = 21,245).	Meta-analytic structural equation modeling was applied to synthesized data from studies testing the reasoned action approach in health behaviors including physical activity. Past behavior was included as an independent predictor of behavior and other constructs in the model.
II. To test the trans-contextual model predictions and model change in model constructs over time and including past behavior as an additional predictor of behavior and other model constructs.	Sample of middle school students (N = 292) recruited from two schools in the city of Kouvola, Finland.	A three-wave prospective correlational design applying a single-indicator structural equation model to predict change in model constructs over time, including past behavior.
III. To report the protocol of a randomized controlled trial based on the trans-contextual model aimed at promoting participation in leisure-time physical activity and to provide a rationale for applying constructs representing non-conscious processes (e.g., habit).	Proposed sample of middle school students (N = 502) from the city of Jyväskylä, Finland.	A six-wave waitlist-controlled design was proposed with cluster randomization by school. Physical education teachers assigned to the intervention condition were proposed to receive a two-week 12-h training program on strategies to promote students' motivation toward physical activity. Results of the trial are presented in Schneider et al. (2020).
IV. To extend the trans-contextual model to include variables and constructs representing non-conscious processes, including past behavior, habit, and self-control, as predictors of leisure-time physical activity within the model.	Sample of middle school students (N = 298) from the city of Jyväskylä, Finland. The sample is a sub-sample of participants who followed the protocol described in Study III.	A two-wave prospective correlational design applying the Bayesian path analysis using informative priors to test model predictions in leisure-time physical activity.

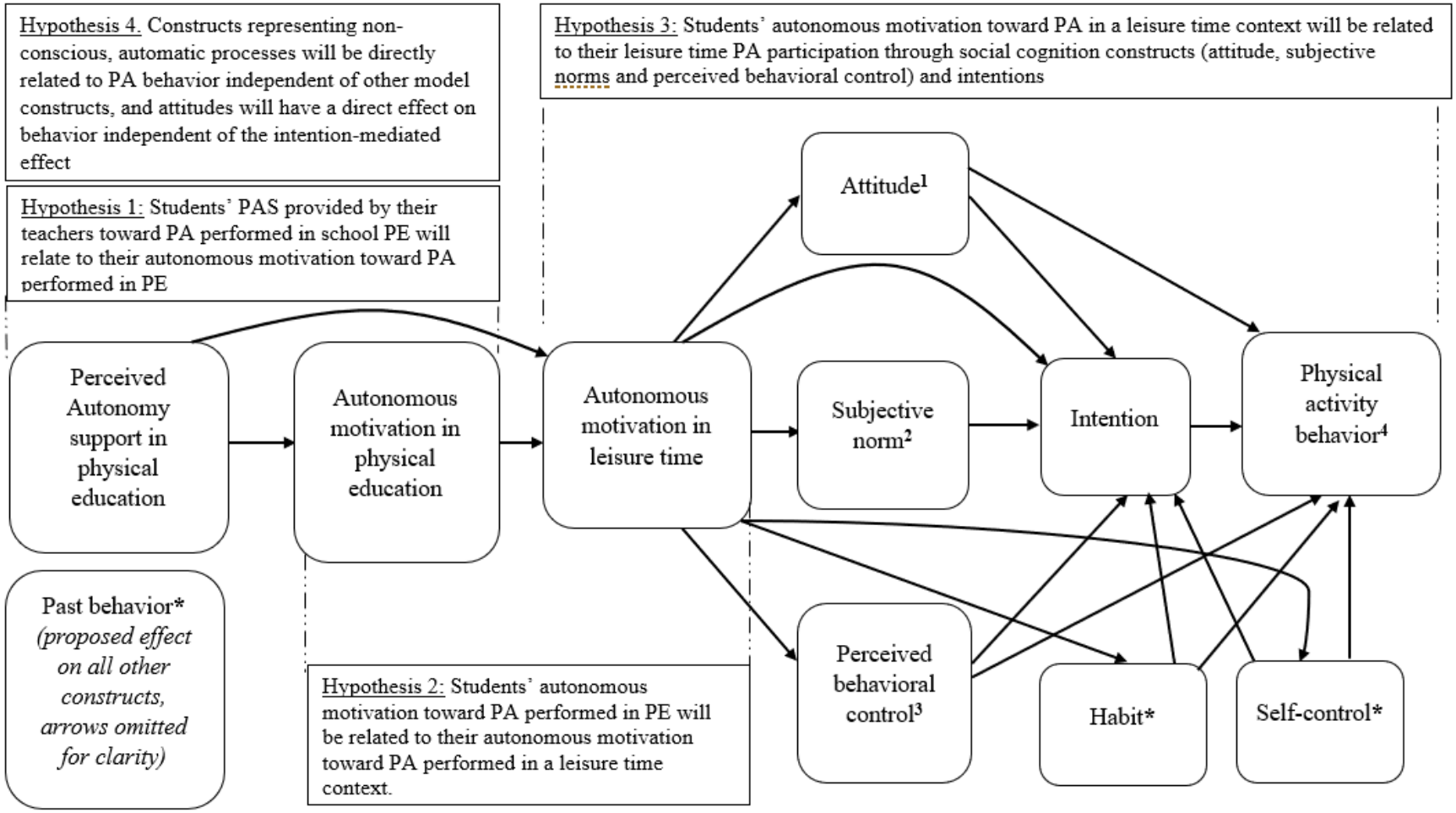

Figure 3 Constructs and hypotheses of the augmented trans-contextual model. Arrows represent proposed statistically significant effects between model constructs. [1]Study I divides attitude into experiental and instrumental components [2]Study I divides subjective norm into injunctive and descriptive component [3]Study I divides perceived behavioral control into autonomy beliefs and capacity beliefs [4]Physical activity is the most common health behavior type examined in study I but also other behaviors are involved in this study. Constructs reflecting non-conscious, automatic processes are marked with *. PAS = perceived automatic support, PE = physical education, PA = physical activity.

4 METHODS

4.1 Study designs and analyses

This dissertation included a meta-analysis in which the predictions of an extended version of the theory of planned behavior, known as the reasoned action approach, was tested in studies testing the model in a health behavior context. The study examined the independent effects of past behavior in the model as a proxy for non-conscious, automatic processes (Study I). Constructs from the model tested in Study I formed an important aspect of the trans-contextual model, the central theoretical approach in the current dissertation. Study II was a longitudinal test of the trans-contextual model using a correlational design in a sample of middle school students and extended previous research by explaining the change in model constructs over time while including the effects of past behavior. Study III described a protocol for an autonomy-supportive intervention based on the trans-contextual model (see Schneider et al., 2020, for the results of the intervention) and set out a rationale for including and changing constructs representing non-conscious, automatic processes leading to behavior: habit and self-control. Study IV was a longitudinal test of the trans-contextual model using a correlational design in another sample of middle school students and extended the model by incorporating additional predictors that represented non-conscious, automatic processes leading to physical activity enactment.

4.1.1 Study I. Reasoned action approach applied to health behavior: Role of past behavior and tests of some key moderators using meta-analytic structural equation modeling

Study I was a meta-analytic review of primary studies applying the reasoned action approach in health behavior. The study extended McEachan et al.'s (2016)

meta-analysis on the same topic by including the effects of past behavior on behavior and the other constructs in the model. The analysis also tested the effects of candidate moderators on model predictions: behavioral frequency (high-frequency behaviors, such as physical activity and healthy eating, versus low-frequency behaviors, such as blood donation and health screenings), behavior type (protective behaviors, such as physical activity and healthy eating, versus risk behaviors, such as smoking and drinking alcohol), and the lag between the measurement of psychological constructs and behavior (short measurement lag of four weeks or fewer, versus long measurement lag of more than four weeks). A matrix of correlations derived from McEachan et al.'s meta-analysis was augmented with correlations between model constructs and past behavior from the same sample of studies. The proposed model of the augmented reasoned action approach was tested using meta-analytic structural equation modeling with the meta-analyzed correlations as an input for the analysis. For the moderator analyses, separate models were estimated in sets of studies on high- and low-frequency behaviors, studies on different types of behavior, and studies with longer and shorter measurement lag between psychological constructs and behavior.

Data for the meta-analytic structural equation modeling consisted of the original studies included in McEachan et al.'s (2016) meta-analysis of the reasoned action approach for health behaviors. McEachan et al. identified 74 articles reporting 86 separate datasets (total N = 21,245) on the reasoned action approach applied to health behaviors defined as those likely to affect health outcomes, including health-promoting behaviors (e.g., physical activity, safer sex, and screening attendance) and health-compromising behaviors (e.g., drug use). The first task was to fill gaps in McEachan et al.'s correlation matrices among the reasoned action approach constructs variables in each study, particularly the relationships among these constructs and past behavior. Original studies identified in McEachan et al.'s analysis were sourced, and the authors' procedures for the extraction and coding of the study data were replicated. The reasoned action approach constructs in each study were exclusively measured using standardized measures derived from published guidelines (Fishbein & Ajzen, 2009). Effect sizes (Pearson's correlation coefficients; r) and the associated sample sizes for the relationships among the reasoned action approach constructs were extracted from the zero-order intercorrelation matrices of the source studies. Correlations among the reasoned action approach measures and past behavior measures (when available; k = 33) were also extracted. Next, the relationships among the reasoned action approach constructs were tested using meta-analytic structural equation modeling (MASEM) with the metaSEM package (Cheung, 2015) in R (R development core team, 2017). MASEM was conducted in two stages. In the first stage, correlation matrices from individual studies were pooled to form a common correlation matrix using random-effects meta-analysis. The analysis produced a pooled correlation matrix representing the average correlation matrix among the study variables in the population, with a sampling variance-covariance matrix that represented the known precision estimates of each correlation in the pooled matrix. The first stage yielded zero-order correlations corrected for

bias by using a random-effects meta-analytic model among the study constructs across studies with 95% confidence intervals.

In the second stage of the analysis, the pooled correlation matrix was used to estimate the proposed model. Two models were tested: a model testing the hypothesized pattern of effects among the study constructs consistent with the hypotheses from the reasoned action approach and a model augmented to include the past behavior. The fit of the proposed model with the data from the meta-analysis was evaluated using multiple goodness-of-fit indices. The effects among the model constructs were evaluated on the basis of the likelihood-based confidence intervals of the model parameter estimates. Whether the inclusion of past behavior in the model-attenuated effects of the reasoned action approach constructs on intentions, and of the intentions on behavior, was evaluated by computing the confidence interval of the difference in the parameter estimates across the models (Schenker & Gentleman, 2001). To the extent that the interval did not include zero, there was confirmation of a statistically significant difference in the parameter estimates across models. The effects of the behavior type and the time lag moderators on the reasoned action approach model effects were evaluated by estimating the models separately in groups of studies on behaviors classified as high and low frequency, studies on specific behaviors that had been tested with high regularity, studies on health risk and health protection behaviors, and studies with longer and shorter time lag between social cognition and behavioral measures. Heterogeneity statistics from the first stage of the MASEM analysis were used to evaluate whether the moderator had resolved the heterogeneity in the correlations among the variables. The differences in the relationships among model constructs at the moderator levels were tested using the confidence intervals of the difference in the model parameter estimates (Schenker & Gentleman, 2001).

The potential effect of the selective reporting bias was evaluated in the relationships among the reasoned action approach model constructs across the included studies using regression analyses based on "funnel" plots of the effect size on the precision estimates.

4.1.2 Study II. Predicting change in middle school students' leisure-time physical activity participation: A prospective test of the trans-contextual model

In Study II, the trans-contextual model was applied to examine the effects of students' perceived autonomy support from their physical education teachers on autonomous motivation toward physical education, and autonomous motivation, social cognition beliefs, and intentions toward, and actual participation in, leisure-time physical activity. A three-wave prospective design was adopted enabling the modeling of change in the model constructs over time. Middle school students (N = 248) completed the self-report measures of the trans-contextual model constructs at two first-time points five weeks apart. At the third time point, five weeks after the second time point, the participants self-reported their leisure-time physical activity.

Study hypotheses were estimated using single-indicator structural equation models with scale reliabilities to provide estimates of the measurement errors of the latent variables, as advocated by Savalei (2019). Models were estimated using the Mplus software version 8.0 (Muthén & Muthén, 2002). Given the number of variables and the complexity of the model, it was not optimal to use an autoregressive path analytic model. Instead, the change in the model constructs was estimated using residualized change scores, which is a useful means to control for change while minimizing parameterization (Castro-Schilo & Grimm, 2018). Standardized residualized change scores for psychological constructs were computed by regressing scores for each variable taken at the first follow-up occasion (T1) on its score at the baseline data collection occasion (T0). Scores for leisure-time physical activity taken at T0 were included as an independent predictor of each psychological construct, which effectively controlled for the past behavior. The same process was used to compute the residualized change scores for leisure-time physical activity, but because physical activity measures were taken on three occasions, T0, T1, and T2, the final physical activity scores at T2 were regressed on the physical activity scores at both T0 and T1. The residualized change scores were used to indicate the latent variables in a single-indicator structural equation model to test the hypothesized predictions of the trans-contextual model. Latent variables were estimated using the change scores as single indicators with McDonald's omega (ω; Dunn et al., 2014) reliability coefficient used to estimate fixed values for the error variances of the single-indicator latent variables based on Bollen's (1989) formula. The single-indicator structural equation model was chosen over the more traditional multiple-indicator model because of the difficulty of fitting models containing constructs indicated by large numbers of items with data, particularly on relatively small sample sizes (Hsiao, Kwok, & Lai, 2018; Savalei, 2019). The model fit was evaluated using multiple goodness-of-fit indices.

4.1.3 Study III. Using physical education to promote out-of-school physical activity in lower secondary school students: A randomized controlled trial protocol

The objective of Study III was to report on a protocol for a physical education teacher-delivered randomized controlled trial based on the trans-contextual model to promote middle school students' participation in physical activity in leisure-time contexts (PETALS study; Fidiproimpact, 2021). The protocol was important because it not only outlined the methods and materials used to change the physical activity behavior among middle school students on the basis of the trans-contextual model but also outlined the importance of including additional methods to change behavior by taking into account constructs representing nonconscious, automatic processes within the model and the measures to evaluate such a change, including self-reported habit and measures of self-discipline. Data collected from the trial proposed in Study III were used in Study IV to test the trans-contextual model predictions proposed in Hypotheses 1-4. The results of

the randomized controlled trial described in Study III are presented in Schneider et al. (2020).

4.1.4 Study IV. Predictors of school students' leisure-time physical activity: An extended trans-contextual model using Bayesian path analysis.

The objective of Study IV was to apply an extended version of the trans-contextual model that incorporated constructs representing non-conscious, automatic processes in predicting middle school students' leisure-time physical activity behavior. The study adopted survey methods and a five-week prospective design with measures of motivational and social cognition constructs, self-reported habit, trait self-control, and past physical activity participation taken on an initial occasion, and the self-reported leisure-time physical activity participation taken at follow-up, five weeks later. In addition to testing the effects of the motivational and social cognition determinants from the trans-contextual model on students' intentions toward, and actual participation in, leisure-time physical activity, the model tested the direct effects of constructs reflecting non-conscious, automatic processes as determinants of leisure-time physical activity participation: self-reported self-control and habit. Habit and self-control were also examined as the mediators of autonomous motivation in leisure-time physical activity on intention and behavior. In addition, the direct effects of attitudes on behavior were tested, which reflected another non-conscious, automatic process related to physical activity behavior.

Bayesian structural equation modeling was used to analyze these data. The superiority of the Bayesian approach over the standard structural equation modeling is that it allows the use of prior information on model parameters, resulting in improved parameter estimates, latent variable estimates, and model comparison (Lee, 2007). This approach is particularly suitable when extra parameters are added to conventional models (Muthén & Asparouhov, 2012), such as in the trans-contextual model. The fit of the Bayesian structural equation models with the data was assessed using posterior predictive checking with the recommended criteria based on the goodness-of-fit chi-square comparing the proposed model with the observed data across the replications in the Bayesian simulation (Muthén & Asparouhov, 2012). With respect to the model parameters, the Bayesian analysis computed the point estimate and a 95% credibility interval for each of the proposed model path. The hypothesized effect was considered to be supported if the posterior credibility interval of the parameter coefficient for the effect did not include zero. In addition, the estimates and the credibility of the indirect effects of the Bayesian models were estimated using Yuan and MacKinnon's (2009) method. The Bayesian approach that included informative priors for the key relations in the model was expected to improve the precision of the estimates. Comparisons of the models with non-informative priors and the model that included informative priors for the key model relationships were carried out using the reduction in the variance of the parameter estimates as a result of the inclusion of the informative priors for the key model relationships. Therefore, the

extent to which the width of the credibility interval of the parameter estimates decreased in the Bayesian model was computed.

4.2 Contribution of author in Studies I-IV

As the creator of the current dissertation, I am the first author for Studies I-IV included in the thesis (Study I is jointly first-authored). I participated in the conceptualization, planning, data collection, analysis, and writing of the results of all the articles included in the dissertation. My duties in Study I also included sourcing the original articles for the analyses. I read the original articles, searched for the information required, and contacted authors for further details in case certain essential information was missing. The data I gathered formed the basis for the meta-analytic structural equation modeling. I took a leading role in the creation of the study materials and data-analysis in Study II. Data were collected on three consecutive time points in two middle schools in the city of Kouvola, Finland. I actively participated in the development and implementation of the randomized controlled trial described in the protocol article (Study III). In addition, my duties involved contacting middle schools (n = 11), physical education teachers (n = 29), and their students (n = 502) who participated in the study in the city of Jyväskylä, Finland. I led the practical implementation of the study procedures that included six consecutive data collection points and supervised five technical assistants during the implementation of the study. I also collaborated with the city of Jyväskylä to organize the teacher education program described in Study III as physical education teachers' in-service training. Finally, I utilized the data collected from the study described in Study III to test the trans-contextual model predictions in Study IV. Results of the randomized controlled trial described in Study III are presented in Schneider et al. (2020), an additional article, which I also coauthored.

4.3 Ethics, data protection, and availability of data and materials

The studies included in the current dissertation followed the principles of the Declaration of Helsinki (World Medical Association, 2021). Individual studies included in the current dissertation were reviewed by the ethical committee of the affiliate institution, as required. Study I did not require an ethical evaluation because it was based on a secondary analysis of previous studies to test original hypotheses, so no human participants were directly involved. The protocol for Study II was approved by the research ethics committee of the University of Jyväskylä. The protocol for Study III and Study IV were approved by the research ethics committee of the University of Jyväskylä (ref no. 2017/12/13). Students' participation in Studies II and IV was voluntary, and students were permitted to withdraw their participation at any point without consequences or questioning.

Parents or legal guardians of the eligible students were given a chance to complete informed consent or refusal prior to their child's participation in a study using an opt-out[3] strategy. Accelerometer measures as scheduled to be used in protocol for a randomized controlled trial (Study III) required opt-in[4] informed consent from the guardian(s) of the child. The data used in the analysis of the research data were pseudonymized with ID codes representing individual study subjects. The key for the identification of study subjects was held in a separate electronic location with availability only by password access from the core research team who were permitted to access the "cloud" data storage system of the University of Jyväskylä. The data collected as part of the current dissertation will be stored at the Finnish Social Science Data Archive without potential identifiers. Primary and supplemental materials for the studies used in this dissertation are available on the Open Science Framework (see original studies for further details). Teacher training materials developed as part of Study III are available in Finnish and in English on the project website (Fidiproimpact, 2021).

4.4 Measures in Study I

Measures of constructs in Study I were from the original studies included in the meta-analysis. Most studies used standardized measures of the reasoned action approach constructs: *experiential* and *instrumental attitude* (e.g., Lawton et al., 2009), *injunctive* and *descriptive* norms (e.g., Sheeran & Orbell, 1999a), and *autonomy* and *capacity* beliefs (e.g., Terry & O'Leary, 1995). Measures for *intention* and actual *behavior* related to health behaviors were also derived from the original studies. *Past behavior*, when available, was derived from the original studies as the past behavioral frequency of health behavior.

4.5 Measures in Studies II and IV

Measures relevant to the current dissertation used in Studies II and VI are presented next. Standard back-translation procedures were used to adapt the scales into the Finnish language. No major changes in the items were needed. McDonald's omega (ω; Dunn et al., 2014) reliability coefficient for the first measurement is reported for each measure.

4.5.1 Perceived autonomy support in physical education

The perceived autonomy support from physical education teachers was measured using items from the perceived autonomy support scale for the exercise

[3] Participants were given the option to decline to participate in the study.
[4] Active consent from participants was also required to enable their participation.

settings (Hagger et al., 2007). The scale consists of 18 items (e.g., "I feel that my physical education teacher provides me with choices and options to …"), and responses were provided on seven-point scales (1 = *strongly disagree* and 7 = *strongly agree*). The scale has demonstrated adequate construct validity and reliability statistics in previous research (Hagger et al., 2007; Hagger et al., 2009). McDonald's omega (ω) reliability coefficient for the measure was 0.71 in Study II and 0.91 in Study IV.

4.5.2 Autonomous motivation in physical education and leisure-time

Autonomous motivation for in-school and leisure-time physical activities was measured using a modified version of the perceived locus of the causality questionnaire (Ryan & Connell, 1989). Two items measured identified regulation (e.g., "I do physical education/physical activity because it is important to me to do well in physical education/physical activity"), and two-item intrinsic regulation (e.g., "I do physical education/physical activity because it is fun"). Responses were provided on a seven-point scale (1 = *not true for me* and 7 = *very true for me*). For each of the physical education and leisure-time contexts, autonomous motivation scores were computed as the average of the scores on the identified regulation and intrinsic regulation items. The measure for autonomous motivation has demonstrated satisfactory construct validity and internal consistency statistics in previous studies (Hagger et al., 2007). McDonald's omega (ω) reliability coefficient for the measure in the physical education context was 0.90 in Study II and 0.89 in Study IV. The respective coefficients were 0.92 and 0.92 in the leisure-time context.

4.5.3 Attitudes, subjective norms, perceived behavioral control, and intentions

Students' attitudes, subjective norms, perceived behavioral control, and intentions with respect to their future participation in leisure-time physical activity were measured using scales developed according to the reported guidelines (Ajzen, 2002). Attitudes were measured on three items in response to a common stem: "Participating in physical activity in the next month will be…" with responses provided on seven-point scales with bipolar adjectives (e.g., 1 = *unenjoyable* and 7 = *enjoyable*). Subjective norms (e.g., "Most people who are important to me think I should do active sports and/or vigorous physical activities during my leisure-time in the next month"), perceived behavioral control ("I am in complete control over participating in physical activity in the next month"), and intentions ("I intend to participate in active sports and/or vigorous physical activities during my leisure-time in the next month") were measured on two items, each with responses provided on seven-point scales (1 = *strongly disagree* and 7 = *strongly agree*). Previous research supports the construct validity and internal consistency of these measures in the context of the trans-contextual model (Hagger et al., 2009). McDonald's omega (ω) reliability coefficient for attitude was 0.83 in Study II and 0.81 in Study IV. The respective coefficients for subjective norm were 0.82

and 0.82; for perceived behavioral control, 0.68 and 0.76; and for intentions, 0.94 and 0.89.

4.5.4 Leisure-time physical activity

Leisure-time physical activity behavior in Study II was measured using a modified version of the leisure-time exercise questionnaire (Godin & Shephard, 1985). The measure consisted of two items: "In the course of the past five weeks, how often, on average, have you participated in vigorous physical activities during your leisure-time for at least 20 min at a time" and "How frequently did you participate in vigorous physical activities during your leisure-time in the course of the past five weeks for at least 20 min at a time)" with responses provided on six-point scales (1 = *never* and 6 = *all of the time*). This version of the questionnaire has exhibited adequate inter-item correlations in previous studies (Hagger et al., 2009). McDonald's omega (ω) reliability coefficient for leisure-time physical activity in Study II was 0.94.

Leisure-time physical activity participation in Study IV was evaluated using the short form of the International Physical Activity Questionnaire (IPAQ; IPAQ Research Committee, 2005), which was modified to make an explicit reference to leisure-time physical activity participation. The IPAQ consists of four items recording the frequency (number of days) and duration (hours) of participation in moderate and vigorous physical activity, walking, and sitting over the past seven days. The physical activity score for moderate and vigorous physical activity and walking is calculated on the basis of the norms and expressed in metabolic equivalent of task (MET) minutes per week. A score for the total physical activity in the leisure-time context is provided by the sum of the duration and frequency of vigorous, moderate, and light physical activity scores. The IPAQ has acceptable concurrent validity and reliability indices (Craig et al., 2003). McDonald's omega (ω) reliability coefficient for leisure-time physical activity in Study IV is not applicable because the score for IPAQ is a composite score for the frequencies and durations of physical activity (see Appendix B in Study IV for further details).

4.5.5 Habit for physical activity participation

Habit for general physical activity participation in Study IV was evaluated using the four-item self-report behavioral automaticity index (Gardner et al., 2012), e.g., "Physical activity is something I do without thinking", with responses provided on five-point scales (1 = *completely disagree* to 5 = *completely agree*). The scale has demonstrated satisfactory reliability and validity in previous research (Gardner et al., 2012). McDonald's omega (ω) reliability coefficient for habit in Study IV was 0.85.

4.5.6 Self-discipline

Students' self-discipline in Study IV was measured using the ten-item self-discipline scale (e.g., "I tend to carry out my plans") from the IPIP-HEXACO scales (Ashton et al., 2007). Responses were provided on four-point scales (1 = *not like me at all* and 4 = *very much like me*). Research has demonstrated the reliability and predictive validity of this scale in school contexts (Hagger & Hamilton, 2019). McDonald's omega (ω) reliability coefficient for self-control in Study IV was 0.88.

Table 2 Overview of measures used in Studies I, II, and IV

Measure	Study	Source
Perceived autonomy support	II, IV	Hagger et al., 2007
Autonomous motivation in PE	II, IV	Ryan & Connell, 1989
Autonomous motivation in LT	II, IV	Ryan & Connell, 1989
Attitude[1]	I, II, IV	Ajzen, 2002
Subjective norm[2]	I, II, IV	Ajzen, 2002
Perceived behavioral control[3]	I, II, IV	Ajzen, 2002
Intention	I, II, IV	Ajzen, 2002
Behavior[4]	I, II, IV	Godin & Shephard, 1988; IPAQ, 2012
Past behavior[4]	I, II, IV	-
Habit	IV	Gardner et al., 2012
Self-control	IV	Ashton et al., 2007

Note. PE = physical education, LT = Leisure-time. [1] Attitude was divided into experiential attitude and instrumental attitude in Study I. [2] Subjective norm was divided into injunctive norms and descriptive norm in Study I. [3] Perceived behavioral control was divided into capacity and autonomy in Study I. [4] Behavior (or past behavior) as a primary dependent variable was general health behavior in Study I and leisure-time physical activity in Studies II and IV.

5 RESULTS

An overview of the direct and indirect effects (β) in Studies I, II, and IV is presented in Table 3. A visual description of the direct effects in these studies is presented in Figure 4. The effect (β) or correlation (r) of the past behavior on/with the trans-contextual model constructs in Studies I, II, and IV is presented in Table 4.

5.1 Study I

Study I applied the reasoned action approach, which is essentially the theory of planned behavior in which attitudes have been divided into experiential and instrumental attitudes, norms are divided into injunctive and descriptive norms, and perceived behavioral control is divided into capacity and autonomy beliefs. Results of the meta-analytic structural equation model based on data from multiple studies testing the reasoned action approach revealed statistically significant positive direct effects of experiential attitudes, instrumental attitudes, injunctive norms, descriptive norms, and capacity on intentions. There were also statically significant positive direct effects of experiential attitudes, capacity, and intentions on behavior. There were statistically significant and positive indirect effects of experiential attitudes, instrumental attitudes, injunctive norms, descriptive norms, and capacity on health behavior through intentions. Overall, the reasoned action approach constructs accounted for 47.51% and 24.07% of the variance in the intentions and the behavior, respectively.

Including the past behavior as a predictor of all variables in the model caused a statistically significant attenuation of some model relationships: The direct effect of intention on behavior and the indirect effects of experiential attitudes, descriptive norms, and capacity on behavior through intentions were all attenuated. Despite the attenuation of the key model relationships, the inclusion of past behavior as a predictor in the model did not lead to a rejection of the reasoned action approach, because the pattern of effects of the model was still

supported supporting Ajzen's (1991) sufficiency hypothesis. However, the inclusion of past behavior resulted in a significant increase in the proportion of variance explained in the intentions (53.17%) and the behavior (34.41%). This suggested a pervasive effect of the past behavior in the model. Past behavior also had a significant positive indirect effect on behavior via intentions and via the other social cognition constructs and intentions. Study I supported Hypothesis 4, demonstrating that past behavior was a significant direct predictor of all model constructs and, more importantly, a direct predictor of the behavior independent of the other constructs in the model. The frequency of behavioral performance, behavior type, or measurement lag did not moderate the model effects on health behavior. The results of Study I should be interpreted with some caution because of the moderate-to-high heterogeneity and significant publication bias identified in the model coefficients.

5.2 Study II

Study II used a single-indicator structural equation model using residualized change scores to represent the change over time in the model constructs, including the effects of past behavior on each construct. The proposed model exhibited an adequate fit with the data. The results showed that perceived autonomy support had a statistically significant effect on autonomous motivation in physical education, supporting Hypothesis 1. A significant trans-contextual effect of autonomous motivation in physical education on autonomous motivation in leisure-time was also supported—a finding that supported Hypothesis 2. Autonomous motivation in leisure-time had a positive statistically significant effect on attitudes, subjective norms, and perceived behavioral control. Attitudes and subjective norms exhibited a statistically significant effect on the intentions, but the effect of perceived behavioral control on intention was insignificant. Intention had a statistically significant effect on behavior, albeit with a small effect size. The indirect effect of perceived autonomy support on autonomous motivation in leisure-time through autonomous motivation in physical education was significant—a finding that supported the sequence of effects proposed by Hypotheses 1 and 2. The indirect effect of autonomous motivation in leisure-time on intention via attitude was significant, but the indirect effects of autonomous motivation in leisure-time on intention via subjective norms or perceived behavioral control were not statistically significant. The indirect effects of autonomous motivation on behavior via the social cognition constructs and intention were also not significant. The social cognition constructs did not have any indirect effects on behavior via intentions. These results did not support Hypothesis 3, which proposed the effect of autonomous motivation for leisure-time physical activities on behavior through social cognition constructs and intention. Past behavior exhibited small to medium-sized correlations with all other model constructs, supporting Hypothesis 4.

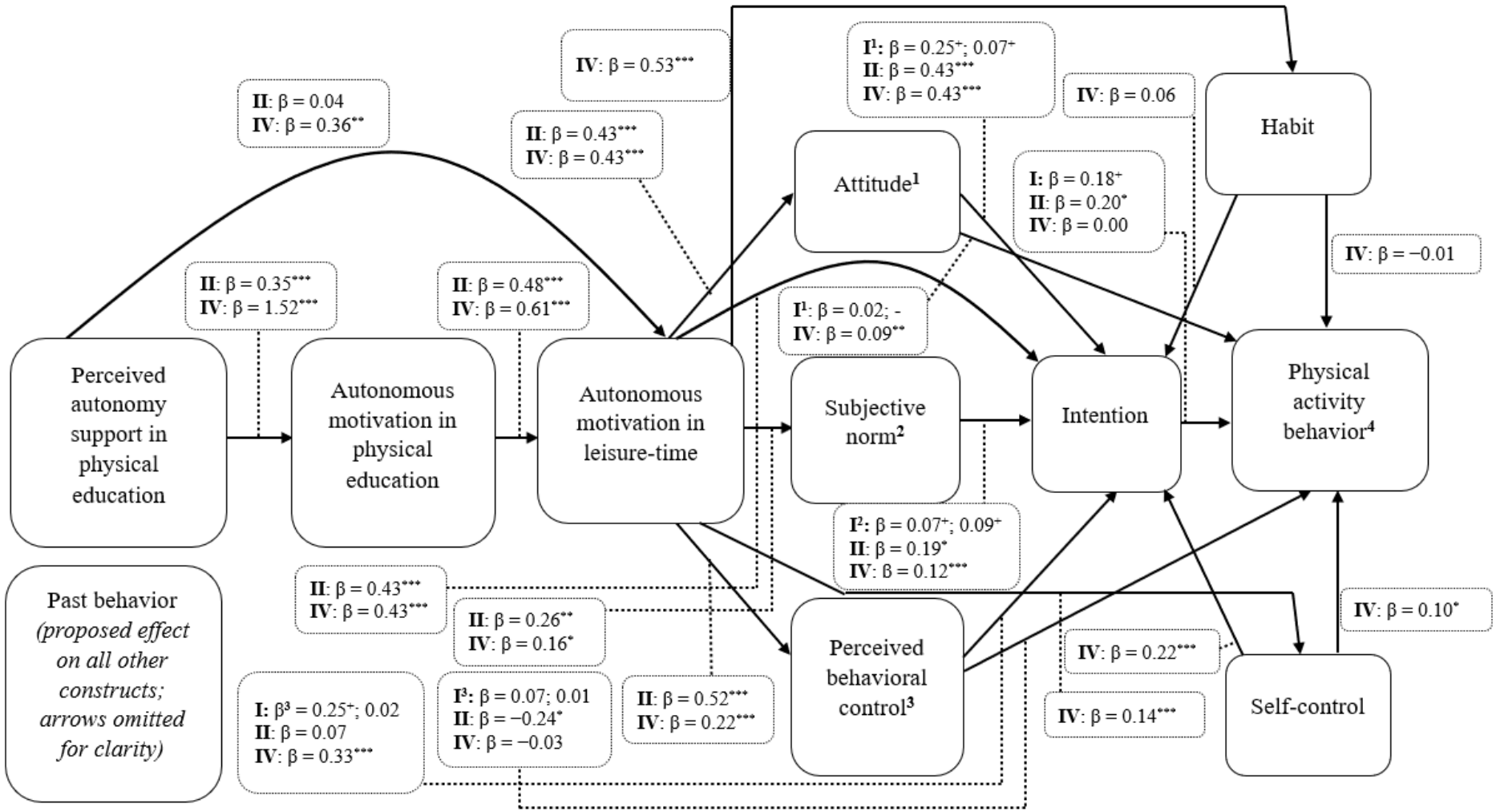

Figure 4 Results for the proposed direct effects (β) of the augmented trans-contextual model constructs (Roman numerals present study number). Direct solid arrows represent proposed statistically significant effects among model constructs. [1] Study I divides attitude into experiental (first β) and instrumental (second β) components. [2] Study I divides subjective norm into injunctive (first β) and descriptive (second β) components. [3] Study I divides perceived behavioral control into autonomy (first β) and capacity (second β). [4] Physical activity is the most common health behavior type examined in Study I, but other behaviors are also involved. *$p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. * Lower limit for 95% confidence interval exceeds 0, indicating the statistically significant path. Effect of past behavior on the other models constructs in each study is presented in Table 4.

5.3 Study III

Study III presented a protocol for a trans-contextual model-based randomized controlled trial to promote secondary school students' participation in leisure-time physical activity by educating physical education teachers to be more autonomy supportive toward their students in class. The results of the trial are presented by Schneider et al. (2020) but are not part of this dissertation. The methods, measures, and participants used in the protocol presented in Study III were used to test the dissertation hypotheses in Study IV.

5.4 Study IV

Study IV provided a test of an extended version of the trans-contextual model that included variables and constructs reflecting non-conscious, automatic processes related to physical activity participation: past behavior, self-reported habit, and trait self-control. These constructs were proposed to mediate the effect of autonomous motivation in leisure-time physical activities on intention and on behavior through intention. The direct effect of attitude on leisure-time physical activity, which also modeled a non-conscious process leading to behavior, was also included in the model, along with attitude being the predictor for intentions. The study used a Bayesian path analysis with informative priors obtained from a meta-analysis of the trans-contextual model, which was compared to an analysis using non-informative priors. We estimated that the former would yield greater precision in the model parameter estimates. Some parameters were more precise for the model using informative priors, and we elected to evaluate our hypotheses on the basis of the model using informative priors. The selected model exhibited adequate goodness-of-fit with the data. As allocation to the intervention or the wait-list control group did not affect most model constructs (Schneider et al., 2020), results related to allocation are not presented in the current dissertation.

The Bayesian path analysis revealed a non-zero effect of the perceived autonomy support in physical education on the autonomous motivation in physical education, a finding that supported Hypothesis 1. There was also a non-zero trans-contextual effect of the autonomous motivation in physical education on the autonomous motivation in leisure-time, a finding that supported Hypothesis 2. Perceived autonomy support in physical education had also a non-zero indirect effect on the autonomous motivation for leisure-time physical activity through autonomous motivation in physical education, a finding that supported Hypotheses 1 and 2. Perceived autonomy support in physical education had a non-zero effect on the autonomous motivation in leisure-time, a finding that was contrary to the prediction, as autonomous motivation in physical education was expected to fully mediate this effect. Autonomous motivation in leisure-time had non-zero effects on attitudes, subjective norms, and perceived behavioral control.

Furthermore, these social cognition constructs had direct effects on intention. Autonomous motivation in leisure-time physical activity and trait self-control had direct non-zero effects on intention, but the effect of habit on intention was not different from zero. Attitude, trait self-control, and past physical activity participation had direct non-zero effects on the physical activity behavior. However, the effects of intentions, perceived behavioral control, habit, and autonomous motivation on the leisure-time physical activity were not different from zero. Hypothesis 3 was not supported as autonomous motivation in leisure-time did not have any direct, indirect, or total effect on behavior. Hypothesis 4 was partly supported as indicated by the non-zero direct effects of past behavior and self-control on behavior. Self-control also mediated the effect of autonomous motivation in leisure-time on intention, but habit did not, which was contrary to our expectations. Habit did not have a direct effect on behavior either.

Table 3 Direct and indirect effects of the trans-contextual model constructs in Studies I, II, and IV

	Study I[1,2,3,4]	Study II	Study IV
Direct effects			
PAS→Aut. Mot PE	-	0.345***	1.520***
PAS→Aut. Mot LT	-	0.039	0.363***
PAS→Beh	-	0.126	-
PAS→Intention	-	0.106	-
Aut. Mot PE→Aut. Mot LT	-	0.484***	0.609***
Aut. Mot PE→Intention	-	−0.040	-
Aut. Mot LT→Attitude	-	0.425***	0.434***
Aut. Mot LT→Sub. Norm	-	0.264**	0.166*
Aut. Mot LT→PBC	-	0.517***	0.222***
Aut. Mot LT→Intention	-	0.376***	0.403***
Aut. Mot LT→Beh	-	0.094	−0.019
Attitude→Intention	0.245+ 0.072+	0.231**	0.182***
Sub. Norm→Intention	0.071+ 0.090+	0.185*	0.118***
PBC→Intention	0.267+ 0.014	0.069	0.323***
Intention→Beh	0.175+	0.198*	0.000
PBC→Beh	0.074 0.014	−0.243*	−0.029

Table 3 continues

Indirect effects			
PAS→Aut. Mot PE→Aut. Mot LT	-	0.167***	0.922***
Aut. Mot LT→Attitude→Intention	-	0.098**	0.078***
Aut. Mot LT→PBC→Intention	-	0.036	0.071***
Aut. Mot PE→Aut. Mot LT→Attitude→Intention	-	0.048*	0.047***
Aut. Mot PE→Aut. Mot LT→Sub. Norm→Intention	-	0.024	0.011*
Aut. Mot PE→Aut. Mot LT→PBC→Intention	-	0.017	0.043***
Aut. Mot PE→Aut. Mot LT→Attitude→Intention→Beh	-	0.009	0.000
Aut. Mot PE→Aut. Mot LT→Sub. Norm→Intention→Beh	-	0.005	0.000
Aut. Mot PE→Aut. Mot LT→PBC→Intention→Beh	-	0.003	0.000
Aut. Mot LT→Intention→Beh	-	0.074	-
Aut. Mot LT→Attitude→Intention→Beh	-	0.019	0.000
Aut. Mot LT→Sub. Norm→Intention→Beh	-	0.010	0.000
Aut. Mot LT→PBC→Intention→Beh	-	0.007	0.000
Autmot LT→Habit→Intention			0.030
Autmot LT→Self-control→Intention			0.028*
Autmot LT→Habit →Beh			−0.002
Autmot LT→Self-control→Beh			0.014*
Attitude→Intention→Beh	0.043^{+} 0.013^{+}	0.046	-
Sub. Norm→Intention→Beh	0.012^{+} 0.016^{+}	0.037	-
PBC[3]→Intention→Beh	0.047^{+} 0.004	0.014	-
Sums of indirect effects			
Aut. Mot LT→Mediators[a]→Intention	-	0.183***	-
Aut. Mot LT→Mediators[b]→Beh	-	−0.015	-
PAS→Mediators[c]→Beh	-	0.035	-

Table 3 continues

Total effects			
PAS→Mediators[d]→Aut. Mot LT	-	0.206**	-
PAS→Mediators[e]→Intention	-	0.207**	-
PAS→Mediators[f]→Beh	-	0.161*	-
Aut. Mot LT→Mediators[g]→ Intention	-	0.559***	-
Aut. Mot LT→Mediators[h]→Beh	-	0.079	-

Note. All values presented are standardized Betas *(β)*. Direct effects of past behavior on other model constructs in Studies I, II, and IV is presented in Table 4. PAS = perceived autonomy support from physical education teachers. Aut. Mot PE = autonomous motivation for physical education. Aut. Mot LT = autonomous motivation for leisure-time physical activity. Beh = Behavior (exclusive leisure-time physical activity in Studies II and IV). Sub. Norm = Subjective norm. [1]Study I divided attitude into experiential (first β) instrumental (second β) components. [2]Study I divided subjective norm into injunctive (first β) and descriptive (second β) components. [3]Study I divided perceived behavioral control into autonomy (first β) and capacity (second β). [4]Physical activity is the most common health behavior type examined in Study I, but other behaviors are involved. [a]Attitude, Sub. Norm, and PBC; [b]Attitude, Sub. Norm, PBC and intention; [c]Aut. Mot PE, Aut. Mot LT, Attitude, Sub. Norm, PBC, and intention; [d]Aut. Mot PE; [e]Aut. Mot PE, Aut. Mot LT, Attitude, Sub. Norm, and PBC; [f]Aut. Mot PE, Aut. Mot LT, Attitude, Sub. Norm, PBC and intention; [g] Attitude, Sub. Norm, and PBC; [h]Attitude, Sub. Norm, PBC and intention. [+]Lower limit for 95% confidence interval exceeds 0, indicating a statistically significant path. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 4 Effect (β) or correlation (r) of past behavior on/with the trans-contextual model constructs in Studies I, II, and IV

	Study I (β)	Study II (r)	Study IV (r)
Perceived autonomy support	-	0.290**	0.388**
Autonomous motivation in PE	-	0.489**	0.243
Autonomous motivation in leisure-time	-	0.609**	1.164***
Attitudes[1]	0.401+ 0.290+	0.608**	0.199
Subjective norms[2]	0.265+ 0.338+	0.408**	0.338
Perceived behavioral control[3]	0.398+ 0.224+	0.421**	0.599***
Intention	0.272+	0.742**	0.293*
Behavior[4]	0.412+	0.712**	0.673***
Habit	-	-	1.765***
Self-control	-	-	0.404***

Note. [1]Study I divides attitude into experiential (first β) instrumental (second β) components. [2] Study I divides subjective norm into injunctive (first β) and descriptive (second β) components. [3]Study I divides perceived behavioral control into autonomy beliefs (first β) and capacity beliefs (second β). [4]Physical activity is the most common health behavior type examined in Study I, but other behaviors are involved. +Lower limit for 95% confidence interval exceeds 0, indicating a statistically significant path. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

5.5 Summary of the results

Hypothesis 1, stating that students' perceived autonomy support provided by their teachers toward physical activities performed as part of school physical education will relate to their autonomous motivation toward physical activities performed in physical education was supported in both Studies II and IV. Hypothesis 2, stating that students' autonomous motivation toward physical activities performed in physical education will be related to their autonomous motivation toward physical activities performed in a leisure-time context, was likewise supported in Studies II and IV. The indirect effect from perceived autonomy support to autonomous motivation for leisure-time physical activity through

autonomous motivation in physical education was also observed in Studies II and IV, which provided further support for Hypotheses 1 and 2.

Hypothesis 3 stating that students' autonomous motivation toward physical activities in a leisure-time context will be related to their leisure-time physical activity participation through social cognition constructs (attitude, subjective norms, and perceived behavioral control) and intention was not supported by Studies II and IV that enabled the full empirical test of this hypothesis. Autonomous motivation for leisure-time physical activities was related to attitudes, subjective norms, and perceived behavioral control in both Studies II and IV that tested these effects explicitly. Autonomous motivation in leisure-time physical activity, attitudes, and subjective norms were related to intention in Studies II and IV. However, only Study IV found a direct effect of the perceived behavioral control on intention. The direct effect of the perceived behavioral control on behavior was inconsistent: Study II found a negative effect of the perceived behavioral control on behavior, whereas Study IV did not find a statistically significant effect of the perceived behavioral control on behavior. The direct effect of intention on behavior was also inconclusive: Study I found meta-analytic support for the effect, which was relatively modest, Study II found a significant but modest effect, and Study IV did not find a statistically significant effect.

Hypothesis 4 stating that constructs representing non-conscious, automatic processes will be directly related to physical activity behavior independent of other model constructs and that attitudes will have a direct effect on behavior independent of the intention-mediated effect was partly supported. Study I exhibited a prominent effect of past health behavior on prospective health behavior, and attenuation of all reasoned action approach effects when past behavior was included in the model. Study II did not explicitly test the effect of past behavior on future behavior or other model constructs, as the study controlled for the effect of past behavior on the extraction of the residualized change scores used in the analyses. Nevertheless, the moderate-to-high correlations between leisure-time physical activity measures suggested a prominent association between the levels of physical activity measured at three consecutive time points. Study IV indicated the effects of past behavior on multiple constructs of the extended trans-contextual model: perceived autonomy support, autonomous motivation in leisure-time, perceived behavioral control, intention, habit, self-control, and prospective physical activity behavior. Contrary to our assumptions, habit had neither a direct nor a mediated effect on intentions or behavior. In contrast, self-control had both a direct and a mediated effect on both intentions and behavior. Study IV also found a positive direct effect of attitude on behavior.

6 DISCUSSION

The purpose of the current dissertation was to develop and apply a theoretical model to better account for the effects of constructs representing reasoned and non-conscious, automatic processes on middle school students' leisure-time physical activity. The aims of the dissertation were derived from the trans-contextual model (Hagger et al., 2003) and from theories that propose non-conscious, automatic processes related to health behavior, such as the reflective-impulsive model (Strack & Deutsch, 2004). In particular, the aim was to provide further tests of the hypotheses of the trans-contextual model and to test hypotheses related to an extended version of the model that incorporated constructs representing non-conscious, automatic processes related to behavior.

The trans-contextual model (Hagger, 2014; Hagger et al., 2003; Hagger & Chatzisarantis, 2016) is an integrated theoretical model consisting of premises derived from the theory of planned behavior (Ajzen, 1985), self-determination theory (Deci & Ryan, 1985), and Vallerand's (2000) hierarchical model of intrinsic and extrinsic motivation. In the current dissertation, this model was extended to include additional constructs that represented non-conscious and automatic processes as the predictors of leisure-time physical activity: past behavior, habit, and self-control. In addition, a direct effect of attitude on behavior unmediated by behavioral intentions was proposed as an additional effect that represented a non-conscious process leading to physical activity behavior.

The dissertation formulated four hypotheses based on the extended trans-contextual model: (1) Students' perceived autonomy support provided by their teachers toward physical activities performed as part of school physical education will relate to their autonomous motivation toward physical activities performed in physical education. (2) Students' autonomous motivation toward physical activities performed in physical education will be related to their autonomous motivation toward physical activities performed in a leisure-time context. (3) Students' autonomous motivation toward physical activities in a leisure-time context will be related to their leisure-time physical activity participation through social cognition constructs (attitude, subjective norms, and perceived behavioral control) and intentions. (4) Constructs representing non-conscious, automatic

processes will be directly related to physical activity behavior independent of other model constructs, and attitudes will have a direct effect on behavior independent of the intention-mediated effect. These hypotheses will be discussed next in detail in relation to the findings of the studies included in this dissertation.

6.1 Hypothesis 1

The first hypothesis of the dissertation was tested in Studies II and IV. An extension on previous research was also provided by examining the effects in the context of the change in the constructs over time. Effect sizes for the relations proposed by Hypothesis 1 were medium according to Cohen's (1992) guidelines, particularly in Study IV. This finding supported the proposition from the model if social agents, such as physical education teachers, are perceived by their students as displaying behaviors that support autonomy and satisfy psychological needs, they are more likely to experience actions, such as physical activities in physical education, as autonomous (Deci & Ryan, 1985; Hagger, 2014; Ryan & Deci, 2017). This finding was also consistent with meta-analytic and primary research findings (e.g., Hagger & Chatzisarantis, 2016; Kalajas-Tilga et al., 2021) on the trans-contextual model using comparable designs. This relationship implied that the trans-contextual model could be used to foster autonomous motivation and promote behavioral engagement in educational contexts by adopting intervention techniques that target change in autonomy support. For example, Reeve and Jang (2006) found that certain teacher behaviors (e.g., encouraging student effort and listening to students) are typically experienced as autonomy supportive, whereas other teacher behaviors (e.g., answering a student before they have independently found the solution to a task) controlling. So, training physical education teachers to adopt autonomy supportive behaviors and display them regularly in their classes may promote students' autonomous motivation toward activities in physical education classes.

However, because of the focus on the perceived rather than the observed autonomy support, the current dissertation does not provide definitive evidence that adoption of autonomy-supportive strategies by teachers will foster students' perceived autonomy support and autonomous motivation for physical activity in a school physical education context. Preliminary analyses on the development of a tool for observing autonomy-supportive physical education teacher behaviors have suggested that Finnish physical education teachers typically display autonomy-supportive behaviors such as unconditional praise and encouragement when delivering their lessons and their display of controlling behaviors (e.g., when teacher praises student compliance) is rare (Polet et al., 2020). Students also reported that their teachers provided support for their leisure-time physical activities as well as for physical activities conducted as part of school physical education. The indirect trans-contextual effects of the perceived autonomy support on autonomous motivation in leisure-time through autonomous motivation in physical education in Studies II and IV supported this finding.

However, despite the observed effect of the perceived autonomy support on autonomous motivation in different contexts, the current dissertation relied heavily on the students' subjective ratings. Further studies are needed to examine whether students' perceived autonomy support aligns with the actual autonomy support displayed by teachers, by using observation tools such as the tool described in Study III.

6.2 Hypothesis 2

The second hypothesis of this dissertation was related to another key premise of the trans-contextual model: the effect of autonomous motivation toward physical activities in physical education on autonomous motivation for physical activities performed in a leisure-time context. This was supported in Studies II and IV with medium-sized effects. This finding supported the key prediction of the trans-contextual model and that of self-determination theory. Moreover, Vallerand's hierarchical model (i.e., forms of motivation for a behavior in one context are likely to relate to the same form of motivation across contexts) was supported. This finding was consistent with previous research on the trans-contextual model (e.g., Hagger & Chatzisarantis, 2016; Kalajas-Tilga et al., 2021). Coupled with the effect of students' perceived autonomy support from teachers in physical education on the autonomous motivation for activities in physical education, the trans-contextual effect has important implications for practice. It suggested that teachers might have important effects on students' motivation toward activities both in and out of school, such that physical education lessons might be an important context for intervention to promote motivation toward physical activities outside of school. Of course, this would need corroboration from intervention studies, such as the one proposed in Study III. There is preliminary research reporting the efficacy of an intervention that provides autonomy-supportive training for teachers to promote autonomous motivation toward physical activity across contexts (Chatzisarantis & Hagger, 2009). In addition, other than that from teachers, autonomy support from peers and parents might be important in promoting autonomous motivation toward leisure-time physical activity (Hagger et al., 2009; Soos et al., 2019), and it might be fruitful in future studies to look at interventions that train these groups to offer autonomy support to promote autonomous motivation toward physical activity during leisure-time alongside interventions training teachers to be more autonomy supportive in physical education contexts.

6.3 Hypothesis 3

Hypothesis 3 of the current dissertation was related to another important premise of the trans-contextual model: Students' autonomous motivation toward physical activities in a leisure-time context will be related to their leisure-time

physical activity participation through social cognition constructs (attitude, subjective norms, and perceived behavioral control) and intentions. This hypothesis was tested in Studies II and IV. Current data did not provide clear support for this hypothesis, as the effects were not supported in either study. Study II revealed a relatively small effect of intention on behavior, and Study IV revealed a null effect of intention on behavior. This meant that there were no indirect effects of autonomous motivation on behavior mediated by the social cognition constructs and intention, which was contrary to the hypothesis. However, there were indirect effects of autonomous motivation on intention via attitudes (Study II) and all social cognition constructs (Study IV). Overall, it seemed that autonomous motivation for leisure-time physical activity was more effective in predicting intentions than actual behavior. More importantly, there was a substantive intention-behavior "gap" in these studies, which has been commonly observed in many previous studies (e.g., Sheeran & Webb, 2016; Orbell & Verplanken, 2020). Further studies on the trans-contextual model should better tackle this intention-behavior gap when considering the indirect effect of autonomous motivation on physical activity behavior. For example, incorporating potential moderators of the intention-behavior relationship, such as the extent of planning, may shed light on why the relationships vary across studies (e.g., Hagger & Luszczynska, 2014; Sheeran & Orbell, 1999b. This also has ramifications for other hypotheses in the current dissertation. In the absence of clear evidence for an intention-behavior relationship, other unmeasured constructs might account for the variance in behavior within the trans-contextual model. The current dissertation included variables and constructs that represented non-conscious, automatic processes, such as past behavior, habit, and self-discipline, to predict behavior independent of the existing constructs of the trans-contextual model. Identifying these variables and constructs as the direct predictors of behavior may shed light on the constructs that actively account for the variance in physical activity behavior beyond the existing constructs that represent reasoned processes leading to behavior. The implications of these inclusions are discussed in the next section.

6.4 Hypothesis 4

The fourth hypothesis of this dissertation proposed that the constructs representing non-conscious, automatic processes will be directly related to physical activity behavior independent of other model constructs, and that attitudes will have a direct effect on behavior independent of the intention-mediated effect. Specifically, the direct effects of past behavior, habit, self-control, and attitudes on behavior were explored, as constructs that might imply non-conscious, automatic processes.

6.4.1 Past behavior

The effect of past behavior on all trans-contextual model constructs was explored in Studies I, II, and IV. All studies exhibited a prominent effect of past behavior on future behavior. Past behavior also attenuated other model effects and was the single strongest predictor of future behavior. However, although model relations were attenuated, they were not reduced to zero. In addition, Study I demonstrated that the effect of past behavior on future behavior did not vary according to behavior frequency, behavior type, and measurement lag between psychological measures and behavioral measures. Furthermore, there were indirect effects of past behavior on future behavior through the social cognition constructs and intentions from the models in each study. What do these effects of past behavior represent? Given the presence of direct effects, it seems that past behavior may model effects that are not mediated by intentions and, therefore, represent non-conscious, automatic processes. Past behavior might reflect habitual behaviors, which are behavioral responses developed through repeated performance of the behavior in stable, predictable environments. Another possibility is that past behavior reflects unmeasured constructs that may account for behavioral consistency, such as individual differences (e.g., personality traits). These factors may also affect behavior via a non-conscious, automatic process as they represent innate or well-learned characteristics that may bias behavioral responses. This means that there is scope for research examining potential mediators of the past behavior-future behavior relationship, such as self-reported habit and personality. Finally, the mediated effect of past behavior on future behavior through the social cognition constructs and other motivational constructs in the studies of this dissertation likely reflected past decision-making. In this interpretation, the models accounted for behavioral stability and represented individuals' drawing from their past experience with the behavior when responding to prompts to report their beliefs and motives. The potential of other constructs representing non-conscious, automatic processes as predictors of behavior within the studies on the trans-contextual model in the current dissertation is discussed in the next section.

6.4.2 Habit

Self-reported habit was included as a direct predictor of leisure-time physical activity and behavioral intentions in Study IV. However, contrary to predictions, there was no effect of habit on behavior or behavioral intentions. This finding was inconsistent with previous research that has typically identified strong associations between habit and physical activity participation (Gardner et al., 2012; Polet et al., 2019, 2021). A possible reason for this discrepancy was the complexity of the path model in Study IV and the strong correlations between habit and other constructs reflecting non-conscious processes in the model, such as past behavior, self-control, and attitude. For example, habit had small-to-medium-sized zero-order correlations with past behavior, attitude, self-control, and behavior. When behavior was simultaneously regressed on the habit measure and the other measures that represented non-conscious processes, the variance was most likely

shared with habit, these variables, and past behavior, leading to a substantive attenuation of the habit effects. Future studies should examine the overlap between habit, past behavior, and other constructs representing non-conscious processes and test their discriminant validity and unique contribution to the prediction of behavior. In addition, it may be useful to test alternative models in which some of the constructs representing non-conscious processes are mediated by others. For example, researchers have indicated that effects of past behavior on future behavior are mediated by habit (van Bree et al., 2015). In addition, Study IV relied heavily on a measure that focused exclusively on the automaticity component of habit, whereas other components, such as behavioral frequency and self-identity, were omitted and might have accounted for the additional variance in behavior (Gardner et al., 2012).

6.4.3 Trait self-control

In addition to past behavior and habit as variables representing the effects of non-conscious processes related to physical activity behavior within the trans-contextual model, the current dissertation introduced another personality factor, self-discipline, as an additional predictor in the model that represented these processes. This construct was included in the test of the model in Study IV, in which self-discipline was included as a direct predictor of future behavior. The findings revealed a significant direct effect of self-discipline on behavior. Students reporting greater capacity to self-regulate and manage temptations and impulses were more likely to report participating physical activity behavior in the model presented in Study IV. This has important implications for theory and research.

Knowledge that trait self-discipline determines adaptive participation patterns for physical activity in students, suggests that interventions should be tailored for those with low self-discipline by assisting them to deal with situations wherein they might be vulnerable to temptation and impulses. Hofmann et al. (2020) argued against a "one-size-fits-all" approach to interventions to deal with self-control challenges and favored the targeting of the "weak spots" of the target population when planning interventions for enhancing self-discipline. Therefore, adolescents particularly vulnerable to impulses and immediate gratification should be targeted. Intervention strategies that may assist in managing behavioral deficits due to low impulse control and self-control could be found by using cues and choice architecture or nudging (Marteau et al., 2020) to change environments to support physical activity. These types of methods could involve planning students' school environment so that it would be more conducive for them to be physically active (Pasi, 2017). For example, a family-based indirect intervention to support physical activity and avoid other impulses with rapid gratification could be to set restrictions on the use of mobile phones during leisure-time (Ruiter et al., 2020). Such intervention approaches rely on altering the social environment of the individual, and they do not solely rely on the individual to manage their behavior. Further studies would benefit from taking this broader perspective on self-control into account when planning interventions to promote adolescents' physical activity. As self-control was found to predict physical activity,

interventions should not only promote individual techniques to enhance self-control but also create optimally "temptation-free" and supportive environments for enhanced individual self-control for physical activity and other health behaviors.

6.4.4 Attitude as direct predictor of behavior

Finally, the direct effect of attitude on behavior unmediated by intentions was also proposed to represent a non-conscious, automatic process. Study I did not find support for this effect even though it specifically measured the effect of the experiential attitude on behavior (Conner et al., 2015; Lawton et al., 2009). Note that experiential attitude was a significant predictor of health behaviors with a small effect size without the inclusion of past behavior as a control variable, but when past behavior was included in the model, this effect was attenuated and became non-significant. A likely explanation for the finding is that the inclusion of past behavior accounted for the shared variance between experiential attitude and future behavior. Unlike Study I, Study IV found a direct effect of attitude on behavior even though the past behavior effects were included in the model. Moreover, the measure of attitude used in Study IV did not solely measure the experiential component of attitude; it also measured the moral and instrumental components. Despite the inconsistent results, the observed effect of attitude on behavior might represent spontaneous or impulsive decisions to engage in physical activities based on the emotionally rewarding anticipated outcomes. Finding this effect was novel in the context of the trans-contextual model; it has earlier been found in the context of the theory of planned behavior across multiple studies (Conner et al., 2015). The results suggested that changing behavior by changing (affective) attitudes might be an approach to promoting leisure-time physical activity. For example, a physical education teacher could deliver the content of their class as emotionally appealing and enjoyable, which might promote spontaneous participation in physical activities outside of school because of the anticipated positive emotions that the students expect to experience.

6.5 Limitations and considerations for future research

The effects tested in the models reported in this dissertation were, to a large extent, theory-driven and not data-driven. Psychological constructs of the proposed model were set to predict the physical activity behavior over time. Even though these designs implied a temporal order, the tested relations were based on correlational data. Although Study II controlled for the temporal stability of the model constructs and modeled the change over time, this did not resolve the issue because other extraneous, unmeasured variables could have been responsible for the change. One solution would be to adopt an experimental or intervention design in which one or more independent variables in the model can be manipulated and the effects of the manipulation on the physical activity behavior

can be tested. Study III formulated a protocol for a randomized controlled trial to explore the effect of an intervention targeting the change in the effect of autonomy support on leisure-time physical activity. Such an intervention would enable better inference of causality and change.

It may also be useful to examine other mediators of the effects in the trans-contextual model. For example, the effect of the perceived autonomy support by physical education teachers was assumed to be a direct predictor of autonomous motivation toward activities in physical education and an indirect predictor in the leisure-time contexts. However, psychological need satisfaction might be an additional mediator, as shown elsewhere (Barkoukis et al., 2010). It might also be important to consider autonomy and need support from significant others, such as parents and peers, as noted elsewhere (e.g., Hagger et al., 2009).

The research reported in the current dissertation also relied heavily on self-report measures of constructs, which might have introduced an error variance and bias in the model tests. Such measures are likely to be subject to socially desirable responding and common method variance. Future studies should adopt other methods, such as observation and direct measures of model constructs, particularly measures of behavior, such as accelerometers, to measure physical activity.

There is a body of research on the techniques that physical education teachers can adopt to support students' autonomous motivation and serve as important indicators of intervention content to change behavior on the basis of the trans-contextual model reported in the studies included in the current dissertation. A key means is to train these social agents to display autonomy-supportive behaviors through autonomy-supportive training programs. An example of such a program is reported in the protocol for the intervention study reported in Study III. Such interventions have shown efficacy in changing autonomous motivation and intentions toward leisure-time physical activity (e.g., Kalajas-Tilga et al., 2021), and, in some cases, actual physical activity behavior outside of school (e.g., Chatzisarantis & Hagger, 2009).

Further studies should also consider the distinction between organized and non-organized forms of physical activity. The studies of the current dissertation measured leisure-time physical activity, irrespective of its form. The differences between organized and non-organized activities may have affected students' reporting of their beliefs and other constructs with respect to leisure-time physical activity in the surveys in the current study (Reynolds et al., 2020). For example, parental or teacher support or pressure may be influential for organized activities, while peer support or pressure may be important for non-organized activities. As non-organized activities are the most popular form of physical activity among the Finnish students aged 9 to 15 years (Martin et al., 2019), future studies could consider the determinants of these forms of activities, including access to appropriate environments, such as social spaces that support sport and activity participation. Examining the determinants of leisure-time physical activity in the context of access to, and availability of, these social spaces might assist in identifying intervention targets, based on the trans-contextual model, to promote young peoples' physical activity.

SUMMARY

The current dissertation aimed to provide additional evidence for the predictions of an integrated theoretical model known as the trans-contextual model (Hagger et al., 2003), which predicts effects of students' perceived autonomy support from their teacher in physical education on their motivation toward, and actual participation in, physical activity in leisure-time. The trans-contextual model was extended to include variables and constructs that represented the non-conscious, automatic processes related to behavior drawing from the theories such as the reflective-impulsive model (Deutsch & Strack, 2020; Strack & Deutsch, 2004). The research found support for two key hypotheses derived from the trans-contextual model: (1) Students' perceived autonomy support provided by their teachers toward physical activities performed as part of school physical education will relate to their autonomous motivation toward physical activities performed in physical education. (2) Students' autonomous motivation toward physical activities performed in physical education will be related to their autonomous motivation toward physical activities performed in a leisure-time context. However, the third hypothesis of the trans-contextual model did not receive clear support: (3) Students' autonomous motivation toward physical activities in a leisure-time context will be related to their leisure-time physical activity participation through social cognition constructs (attitude, subjective norms, and perceived behavioral control) and intentions. However, autonomous motivation for leisure-time physical activity was found to be associated with intentions toward leisure-time physical activity mediated by the social cognition constructs. The final hypothesis stated that (4) constructs representing non-conscious, automatic processes will be directly related to physical activity behavior independent of other model constructs, and attitudes will have a direct effect on behavior independent of the intention-mediated effect. The results revealed a medium-sized effect of past behavior on future behavior, as predicted, as well as all other model constructs. Trait self-control had a direct effect on behavior and intentions, but the effects of habit on behavior and intentions were not significant. The results for the direct effect of attitude on behavior, also indicative of a non-conscious process, were mixed with one individual study reporting the effect (Study IV), whereas in another study (Study I), this effect was absent.

Results supported trans-contextual model hypotheses consistent with previous studies and extended them by accounting for the change in the model constructs over time. However, the results did not support the full motivational sequence of the model. Specifically, the model worked relatively well in predicting behavioral intentions but not behavior, indicating a substantive intention-behavior "gap," as noted elsewhere (Sheeran & Webb, 2016). Future studies should account for factors that might moderate the effect on intention on behavior and consider the simultaneous effects of autonomy or need support on leisure-time physical activity from other sources (e.g., parents and peers).

The central scientific contribution of the research reported in the current dissertation was the extension of the trans-contextual model to better account for

the non-conscious, automatic processes that led to students' participation in leisure-time physical activity. Future studies should elaborate the role and input of variables and constructs that represent non-conscious, automatic processes that, according to the current thesis, are related to leisure-time physical activity and other health behaviors alongside constructs that represent reasoned, intentional processes. Self-control, in particular, was identified as a predictor of behavioral intentions and actual behavior. Students' capacity to manage "temptations" and impulses seemed to be influential in determining their leisure-time physical activity, so interventions based on cueing and choice architecture to alter students' environment may be a pertinent means to change behavior. The medium-sized effect of past behavior on future behavior within the model should also be considered when testing the determinants of students' leisure-time physical activity, and health behaviors in multiple populations more broadly. It is not only difficult to promote the adoption of new behaviors, but it might also be equally difficult to encourage individuals to quit previous behaviors that may impede the adoption of new behaviors, such as sedentary behaviors in the context of physical activity promotion.

YHTEENVETO (SUMMARY IN FINNISH)

Sosiaaliskognitiivisia teorioita (kuten suunnitellun käyttäytymisen teoria) sekä motivaatioteorioita (kuten itsemääräämisteoria) on hyödynnetty laajasti terveyskäyttäytymiseen liittyvien prosessien tunnistamisessa. Näihin teorioihin perustuva tutkimus on keskittynyt tietoisiin ja harkintaan perustuviin, motivoitua käyttäytymistä määrittäviin tekijöihin. Tämän väitöskirjan tarkoituksena oli kehittää ja testata näitä teorioita integroivaa transkontekstuaalista mallia (Hagger ym., 2003), ottamaan huomioon tietoisten ja harkintaan perustuvien terveyskäyttäytymisen determinanttien lisäksi myös ei-tietoisia ja automaattisia terveyskäyttäytymistä määrittäviä tekijöitä (Strack & Deutsch, 2004).

Perusmalli olettaa, että oppilaan liikunnanopettajalta saama autonomian tuki on yhteydessä oppilaan kokemaan autonomiseen motivaatioon koululiikuntaa kohtaan, mikä puolestaan on (transkontekstuaalisesti) yhteydessä autonomiseen motivaation oppilaan vapaa-ajalla tapahtuvia liikkumisaktiviteetteja kohtaan. Autonominen motivaatio vapaa-ajan liikkumisaktiviteetteja kohtaan on mallin mukaan yhteydessä vapaa-ajalla tapahtuvaan liikkumisaktiivisuuteen tässä kontekstissa harjoitettua liikkumista koskevien asenteiden, normien, koetun hallinnan tunteen ja aikomusten välityksellä. Perusmalli ei kuitenkaan ota riittävällä tavalla huomioon ei-tietoisten ja automaattisten tekijöiden yhteyksiä liikkumisaktiivisuuteen. Tämä väitöskirja pyrkii täydentämään tätä tutkimusaukkoa sisällyttämällä malliin aiemman tutkimuksen perusteella ehdotettuja liikkumiskäyttäytymisen ei-tietoisia ja automaattisia aikomusvälitteisistä sosiaalisista kognitiosta ja motivaatiokonstruktioista riippumattomia tekijöitä: aikaisempi liikkumiskäyttäytyminen (Fishbein & Ajzen, 2011), liikkumistavat (Verplanken & Orbell, 2003) ja yleinen itsekontrolli (Tangney ym., 2004). Väitöskirjassa tämän laajennetun transkontekstuaalisen mallin avulla pyritään tunnistamaan ja selittämään yläkouluikäisten oppilaiden vapaa-ajan liikkumisaktiivisuutta määrittäviä tekijöitä ja prosesseja.

Transkontekstuaalinen malli

Transkontekstuaalisessa mallissa oppilaan kokemalla autonomian tuella viitataan oppilaan kokemuksiin niistä liikunnanopettajan käyttämistä pedagogisista käytänteistä ja strategioista, joilla hän tukee oppilaan kokemuksia itsestään omaehtoisena valintoja, ratkaisuja ja päätöksiä tekevänä yksilönä. Oppilas kokee tällöin, ainakin osittain, toimivan omasta tahdostaan. Autonomian tukemiseen liittyy läheisesti myös muiden niin kutsuttujen psykologisten perustarpeiden tukeminen: Oppilaan pätevyyden kokemukset liittyvät oppilaan kokemukseen itsestään osaavana ja asiansa hallitsevana yksilönä. Opettajan tarjoamat haasteet ja tehtävät, jotka ovat tarpeeksi haastavia, mutta eivät kuitenkaan liian vaikeita, tukevat parhaiten oppilaan kokemusta itsestään osaavana oman toimintansa aloitteellisena ja pätevänä subjektina. Oppilaan yhteenkuuluvuuden kokemuksella viitataan siihen, että oppilas kokee olevansa ”samassa veneessä” arvostettuna, kunnioitettuna ja kuunneltuna yksilönä.

Tutkimusten mukaan liikunnanopettajan on mahdollista tukea oppilaidensa autonomiaa, kyvykkyyttä ja yhteenkuuluvuutta sellaisten ohjeiden avulla, jotka eivät tuota oppilaille pakon tai velvollisuuden tunteita (Reeve ym., 2004). Käskyttäminen ja kehottaminen voivat olla oppilaan autonomian kokemukselle haitallista, vaikkakin ne ovat koulumaailmassa joskus tarpeellisia ja jopa pakollisia. Selkeän struktuurin määrittäminen tunneilla tehtäville harjoitteille tukee oppilaan psykologisia perustarpeita, koska tällöin opetuksen tavoite pysyy keskiössä ja oppilas tietää mitä häneltä odotetaan (Haerens ym., 2013). Myös tunneilla tehtävien harjoitteiden perustelut, positiivinen palaute, kannustus ja toiminnan mielekkyyden linkittäminen oppilaiden vapaa-ajan toimintaan ovat opettajien käyttämiä keinoja oppilaiden autonomian ja muiden psykologisten perustarpeiden tukemiseksi (Polet ym., 2020).

Koetun autonomian tuen oletetaan transkontekstuaalisessa mallissa tukevan oppilaiden autonomista motivaatiota tehtyjä harjoitteita kohtaan. Autonomisesti motivoitunut oppilas kokee kimmokkeen liikuntatunneilla tehtäviin harjoitteisiin juontuvan sisäisistä omaehtoisista motiiveista kuten kiinnostuksesta käsin eikä esimerkiksi halusta olla mieliksi opettajalle. Autonomisen motivaation vastakohta on kontrolloitu motivaatio, jolloin yllyke toimintaan kumpuaa esimerkiksi palkinnoista, rangaistuksesta tai esimerkiksi syyllisyyden ja häpeän tuntemuksista. Transkontekstuaalinen malli olettaa, että autonominen motivaatio siirtyy liikuntatunneilta myös vapaa-ajan kontekstissa tehtäviin fyysisiin harjoitteisiin. Vapaa-ajan liikkumiseen liittyvä autonominen motivaatio on mallin mukaan yhteydessä vapaa-ajalla tapahtuvaan liikkumisaktiivisuuteen ja sitä koskeviin aikomuksiin kolmen sosiaaliskognitiivisen uskomuksiin perustuvan konstruktion kautta. Näitä ovat vapaa ajan liikkumiseen liittyvät asenteet, normit ja hallinnantunne (Fishbein & Ajzen, 2011).

Ajzen ja Shcmidt (2020) esittävät, että asenteiden vaikutus voi juontaa juurensa toimintaa koskevista affektiivista tai instrumentaalisista uskomuksista. Affektiiviset uskomukset liittyvät toimintaan liittyviin tunteisiin. Liikkuminen saattaa näyttäytyä yhdelle positiivisena keinona virkistää mieltä ja saada raitista ilmaa, kun taas toinen näkee liikkumisen pakonomaisena puurtamisena. Instrumentaaliset uskomukset liittyvät arviointeihin toiminnan seurauksista. Toisille vapaa-ajan liikkuminen saattaa näyttäytyä hyvänä keinona ylläpitää ja kehittää kuntoa, kun taas toiselle kaikenlainen liikkuminen vapaa-ajalla näyttäytyy hyödyttömänä ajantuhlauksena. Normien vaikutus voi puolestaan liittyä siihen, miten yksilö uskoo läheistensä suhtautuvan hänen omaan vapaa-ajalla tapahtuvaan liikkumiseen (subjektiviinen normi) tai siihen millaisia uskomuksia yksilö uskoo hänelle läheisten ihmisten itse kohdistavan heidän omaan vapaa-ajan liikkumiseensa, ja miten näiden uskomusten oletetaan ohjaavat heidän liikkumistaan (deskriptiivinen normi). Hallinnantunteen vaikutus liittyy siihen, missä määrin yksilö kokee olevansa kyvykäs ja osaava esimerkiksi toimimaan kuntosalilla (taitojen hallinta) tai missä määrin hän kokee omaavansa mahdollisuuksia, tilaisuuksia ja aikaa menemään kuntosalille (autonomia-uskomus). Nämä transkontekstuaalisen mallin mukaan vapaa-ajan liikkumiseen linkittyvät uskomukset vaikuttavat yhdessä vapaa-ajan liikkumista koskevien aikomusten

muodostamiseen, kun taas aikomukset määrittävät mallin mukaan itse toimintaa eli vapaa-ajalla tapahtuvaa liikkumista.

Tässä väitöskirjatutkimuksessa on uutta se, että transkontekstuaaliseen malliin lisättiin aiemman tutkimuksen perusteella vapaa-ajan liikkumiseen liitettyjä ei-tietoisia ja automaattia prosesseja heijastelevia konstruktioita (aikaisempi liikkumiskäyttäytyminen, liikkumistavat sekä yleinen itsekontrolli). Näiden tekijöiden oletetaan olevan yhteydessä liikkumiskäyttäytymiseen suoraan ilman uskomusten ja aikomusten välittämää tietoiseen prosessointiin liittyvää harkintaa (Strack & Deutsch, 2004). Aikaisempaa liikkumiskäyttäytymistä tarkastellaan tutkimuksessa lähimenneisyyden fyysisenä aktiivisuutena, minkä ajatellaan välillisesti heijastelevan liikkumistapoja. Liikkumistapoja arvioidaan tutkimuksessa myös teoreettisemmin ja tässä arvioinnissa korostuu ennen kaikkea yksilön kokemus siitä, missä määrin liikkumiskäyttäytymisen hahmotetaan olevan automaattista ja ikään kuin itsestään ilman suurempaa harkintaa tapahtuvaa toimintaa. Yleisen itsekontrollin arvioinnissa tukeudutaan yksilön kokemuksiin omista kyvyistä ohjata käyttäytymistään päämäärätietoisesti 'kiusauksista' tai tavoitteiden kannalta epäolennaisista houkutuksista huolimatta. Tutkimus tarkastelee myös erityisesti affektiivisten asenteiden suoraa aikomuksista riippumatonta yhteyttä vapaa-ajan liikkumiskäyttäytymiseen, koska asenteet saattavat vaikuttaa vapaa-ajan liikkumiskäyttäytymiseen myös niihin liittyvien positiivisten ei-tietoisten ja automaattisten mielleyhtymien ja tunteiden kautta (Conner ym., 2015).

Transkontekstuaalisen mallin hypoteesien testaus

Väitöskirjan osatutkimukset tukivat transkontekstuaalisen mallin ensimmäistä hypoteesia: liikuntatunnilla koettu opettajalta saatu autonomian tuki selitti autonomista motivaatiota liikuntatunneilla harjoitettuja liikkumisaktiviteetteja kohtaan. Toinen hypoteesi liikkumisaktiviteetteja koskevan autonomisen motivaation 'läikkymisestä' liikuntatunneilta vapaa-ajalla tapahtuvan liikkumisen kontekstiin sai niin ikään tukea. Kolmas hypoteesi vapaa-ajan liikkumisaktiviteetteihin kohdistuvan autonomisen motivaation yhteydestä vapaa-ajalla tapahtuvaan liikkumisaktiivisuuteen (asenteiden, normien, koetun hallinnantunteen ja aikomusten kautta) ei saanut tukea. Vapaa-aikakontekstin autonominen motivaatio selitti kyllä liikkumista koskevia aikomuksia samassa kontekstissa, mutta aikomukset eivät välittyneet toiminnaksi. Toiminta-aikomusten ja itse toiminnan kohtaamattomuus on tunnettu tosiasia niin tutkimuksen kuin arkikokemuksenkin valossa. Vaikuttaa siltä, että ihmisten toimintaa ohjaajat tietoisten aikomusvälitteisten sekä tavoitteita ja uskomuksia korostavien sosiaaliskognitiivisten tekijöiden ohella myös tiedostamattomat ja automaattiset prosessit (Strack & Deutsch, 2004). Väitöskirjan neljäs hypoteesi oletti näiden tiedostamattomien ja automaattisten prosessien olevan suorassa yhteydessä yläkouluikäisten oppilaiden vapaa-ajalla tapahtuvaan liikkumiseen. Tämä hypoteesi sai osittaista tukea: aikaisempi liikkumiskäyttäytyminen oli selvästi yhteydessä tulevaan liikkumiseen, mutta liikkumistavat eivät olleet. Yleinen itsekontrolli oli yhteydessä vapaa-ajalla tapahtuvaan liikkumiseen, kun taas tulokset asenteiden suorasta vaikutuksesta vapaa-ajan liikkumiseen olivat ristiriitaisia.

Johtopäätökset

Transkontekstuaalisen mallin laajentaminen siten, että siihen lisätään ei-tietoisia, ei-intentionaalisia ja automaattisia prosesseja heijastelevia konstruktioita saa väitöstutkimuksesta tukea. Väitöskirjan osatutkimukset tukivat aikaisemman liikkumiskäyttäytymisen ja yleisen itsekontrollin roolia vapaa-ajan liikkumisaktiivisuutta selittävinä tekijöinä. Myös asenteilla oli suora yhteys vapaa-ajan liikkumisaktiivisuuteen yhdessä osatutkimuksessa. Tutkimuksen vahvuutena ovat kehittyneiden tilastollisten menetelmien käyttö sekä seuranta-aineistojen hyödyntäminen ja niiden myötä ajan kuluessa tapahtuneiden muutosten huomioiminen transkontekstuaalisen mallin kehittämisessä. Tutkimuksen pohjalta tehtävien päätelmien rajoitteisiin kuuluvat korrelaatioasetelmiin perustuvat osatutkimukset, jotka eivät salli oletuksia vahvoista syy-seuraus-suhteista. Väitöstutkimuksessa käytettyjen itsearvioon perustuvien mittareiden käyttö voi myös heikentää etenkin liikkumisaktiivisuutta koskevien arvioiden luotettavuutta, kun vertailukohtana käytetään kiihtyvyysanturilla mitattua fyysistä aktiivisuutta.

Väitöskirjatutkimus osoitti oppilaiden autonomian ja muiden psykologisten perustarpeiden tukemisen liikunnanopetuksessa olevan tärkeää oppilaiden liikkumista koskevan autonomisen motivaation kannalta niin koululiikunnassa kuin myös vapaa-ajan liikkumisessa. Liikunnanopetuksen pedagogiikalla on näin ollen merkityksensä niin koulussa kuin oppilaiden arjessakin. Aikaisemman liikkumiskäyttäytymisen ja itsekontrollin haasteiden huomioiminen tulevan liikkumiskäyttäytymisen ennustajana on väitöskirjatutkimuksen perusteella myös tärkeää huomioida ohjatessa oppilaita liikunnallisesti aktiiviseen elämään.

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ORIGINAL PAPERS

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THE REASONED ACTION APPROACH APPLIED TO HEALTH BEHAVIOR: ROLE OF PAST BEHAVIOR AND TESTS OF SOME KEY MODERATORS USING META-ANALYTIC STRUCTURAL EQUATION MODELING

by

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The reasoned action approach applied to health behavior: Role of past behavior and tests of some key moderators using meta-analytic structural equation modeling

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ABSTRACT

Rationale: The reasoned action approach (RAA) is a social cognitive model that outlines the determinants of intentional behavior. Primary and meta-analytic studies support RAA predictions for multiple health behaviors. However, including past behavior as a predictor in the RAA may attenuate model effects. Direct effects of past behavior on behavior may reflect non-conscious processes whereas indirect effects of past behavior through social cognitive variables may represent reasoned processes.

Objective: The present study extended a previous meta-analysis of the RAA by including effects of past behavior. The analysis also tested effects of candidate moderators of model predictions: behavioral frequency, behavior type, and measurement lag.

Method: We augmented a previous meta-analytic data set with correlations between model constructs and past behavior. We tested RAA models that included and excluded past behavior using meta-analytic structural equation modeling and compared the effects. Separate models were estimated in studies on high and low frequency behaviors, studies on different types of behavior, and studies with longer and shorter measurement lag.

Results: Including past behavior attenuated model effects, particularly the direct effect of intentions on behavior, and indirect effects of experiential attitudes, descriptive norms, and capacity on behavior through intentions. Moderator analyses revealed larger intention-behavior and past behavior-behavior effects in high frequency studies, but the differences were not significant. No other notable moderator effects were observed.

Conclusion: Findings indicate a prominent role for non-conscious processes in determining health behavior and inclusion of past behavior in RAA tests is important to yield precise estimates of model effects.

1. Introduction

Epidemiological research has consistently identified pervasive links between regular participation in health-related behavior (e.g., physical activity, healthy eating, not smoking, drinking alcohol only in moderation) and reduced risk of chronic disease (e.g., cancers, cardiovascular disease, diabetes) and adaptive health outcomes (Ford et al., 2011; Li et al., 2018). The development of an evidence base of the psychological factors associated with participation in health behaviors has been identified as a priority in behavioral medicine (Conner and Norman, 2015; Sheeran et al., 2017b). The evidence may inform practice by identifying the salient constructs to target in behavioral interventions (Kok et al., 2016). Theories of social cognition have been at the forefront of research on psychological correlates of health behavior as they provide a fundamental understanding of behavior and the associated processes. Prominent among these theories is the reasoned action approach (RAA; Fishbein and Ajzen, 2009). The RAA is a generalized, belief-based theory that identifies sets of personal, social, and control-related factors that impact social behavior and the mechanisms involved. McEachan et al.'s (2016) meta-analysis of studies applying the RAA in health behavior contexts provided generalized support for its predictions. In the current article, we extended

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McEachan et al.'s findings by examining the role of past behavior as an indirect predictor of RAA variables in health behavior contexts. In addition, we tested effects of candidate moderators on RAA relations: behavioral frequency, behavior type, and time lag between measures of RAA constructs and behavior. We expected our analysis to advance previous findings by illustrating that inclusion of past behavior in the RAA provides important information on the extent to which health behavior may be subject to non-conscious processes. In addition, we expected studies on target behaviors that are likely to be performed more frequently, therefore offering greater opportunity for habit formation, to have larger effects of past behavior, and smaller effects of intentions, on behavior. We also expected effects of RAA constructs on behavior to be smaller in groups of studies with longer measurement lag.

1.1. The reasoned action approach

The RAA is a social cognitive model that has been applied to predict and explain behavior in multiple contexts (Fishbein and Ajzen, 2009). The RAA is a more comprehensive version of its precursor, the theory of planned behavior (TPB; for reviews see Armitage and Conner, 2001; Hagger et al., 2002; Rich et al., 2015), and distinguishes between specific subcomponents of the TPB constructs. Intention is a central construct of the RAA. It reflects the extent to which individuals are motivated to perform a given behavior and is conceptualized as the most proximal antecedent of behavior. Intentions are a function of three sets of belief-based constructs: attitude, subjective norms, and perceived behavioral control (PBC). Attitudes are an individual's overall positive or negative evaluation of a behavior. The attitude construct is differentiated into *experiential* and *instrumental* subcomponents that reflect the affective and utilitarian functions of attitudes, respectively (e.g., Lawton et al., 2009). Subjective norms reflect the individual's beliefs that significant others want them to participate in the behavior. Subjective norms comprise *injunctive* and *descriptive* subcomponents (e.g., Sheeran and Orbell, 1999), which describe social pressures to perform the behavior and beliefs in the extent to which the behavior is typical or normal, respectively. PBC reflects the extent to which the behavior is under the individual's control. PBC is differentiated into *autonomy* and *capacity* subcomponents (e.g., Terry and O'Leary, 1995), which reflect perceptions of control over doing the behavior and perceived confidence in doing it, respectively. Intentions are proposed to mediate relations between the belief-based constructs and behavior.

Predictive validity of the individual subcomponents of the RAA constructs has been supported in primary studies and meta-analytic reviews. Studies distinguishing between instrumental and experiential attitudes indicate that both subcomponents predict intentions directly, but also revealed direct effects of experiential attitudes on behavior. Although not previously hypothesized, the direct effects were interpreted as indicative of more spontaneous, non-conscious effects of affective responses on action (Conner et al., 2015; Lawton et al., 2009). Research has demonstrated significant effects of both normative components on intentions, with effects sizes for descriptive norms tending to be larger than those for injunctive norms (Manning, 2009; Rivis and Sheeran, 2003; Sheeran and Orbell, 1999). Studies examining effects of capacity and autonomy subcomponents of PBC have demonstrated that capacity tends to be more influential as a predictor of intentions and, directly, behavior (Rodgers et al., 2008; Terry and O'Leary, 1995). Together these analyses provide converging evidence for the distinction between the subcomponents of the TPB constructs, consistent with hypotheses of the RAA.

Further support for the RAA has been provided in a meta-analysis of prospective studies on health behavior that included RAA subcomponents (McEachan et al., 2016). Regression analyses based on the meta-analysis revealed significant effects for all RAA subcomponents on intentions, with the exception of autonomy. Experiential attitudes and capacity were the most prominent predictors of intentions with small-to-medium effect sizes, with much smaller effects for instrumental attitude and the two normative constructs. Intention significantly predicted health behavior with a medium effect size, with smaller direct effects for descriptive norms, experiential attitudes, and capacity. The authors noted that the direct effects indicate that individuals may be compelled to act spontaneously on the basis of these beliefs without the need for deliberation. Overall, the analysis provided support for the proposed relations among the study constructs.

1.2. Importance of past behavior

A prominent omission from McEachan et al.'s meta-analysis was an account for the effects of past behavior in the RAA. Considerable theory and empirical research has focused on the role of past behavior in social cognitive models (e.g., Conner et al., 1999; Hennessy et al., 2010; Ouellette and Wood, 1998). Past behavior typically exhibits large effects on future behavior, illustrating that behavior tends to have high temporal stability. In the context of social cognitive models, research has consistently shown that the inclusion of past behavior as a predictor of behavior alongside the theory-determined constructs has four important effects: (a) past behavior predicts behavior; (b) it predicts the other social cognitive variables in the model, including intention; (c) it attenuates effects of the other social cognitive variables on intentions and behavior; and (d) it leads to a significant increase in the amount of variance in behavior accounted for by the model (Ajzen, 2002; Brown et al., 2017; Hagger et al., 2002, 2016; Hamilton et al., 2017; Norman and Cooper, 2011; Protogerou et al., 2018).

Theorists have suggested that direct effects of past behavior on behavior in social cognitive models reflect implicit or non-conscious processes that affect behavior beyond an individual's awareness (Dombrowski and Luszczynska, 2009; Hamilton et al., 2017; Wood et al., 2014). This perspective is consistent with dual process theories of cognition and behavior, which predict that participation in health behaviors is a function of two processes: a reasoned, deliberative processes, that tend to be represented by the belief-based constructs in social cognitive theories like the RAA, and an implicit, impulsive process, that can be represented by past behavior (Hagger, 2016; Sheeran et al., 2013; Strack and Deutsch, 2004). Past behavior effects may model a number of different types of non-conscious processes. For example, Ouellette and Wood (1998) suggest that direct effects of past behavior on behavior independent of effects of other social cognitive constructs may reflect habits. A habit is defined as an action or behavioral tendency that it enacted spontaneously, with little conscious awareness or reflection, in response to a set of associated conditions or contextual cues. Research has indicated that contextual factors implicated in the development of habits, such as opportunity for frequent repetition of the behavior in the presence of a stable environment or facilitating conditions, determine whether behavior is predominantly determined by intentions or past behavior (Ouellette and Wood, 1998; Wood, 2017). Large effects of past behavior on behavior relative to intentions may be indicative of a habitual action, while larger effects of intentions on behavior relative to past behavior may be indicative of an action controlled by reasoned processes.

Inclusion of past behavior in social cognitive models may also attenuate effects of social cognitive constructs on behavior. This likely reflects previous or 'habitual' decision making; that individuals have processed information about the behavior in a similar way previously. Such previous decision making is likely captured by measures of the social cognitive constructs in the RAA, and can be modeled by past behavior. In such cases, variance the social cognitive constructs attributable to previous decision making that is shared with behavior is also shared with past behavior. In the absence of past behavior, effects of these variables may give a misleading indication of the extent to which the behavior is determined by constructs representing reasoned processes that lead to action (Ajzen, 2002). Inclusion of past behavior in social cognitive theories is, therefore, important to provide precise

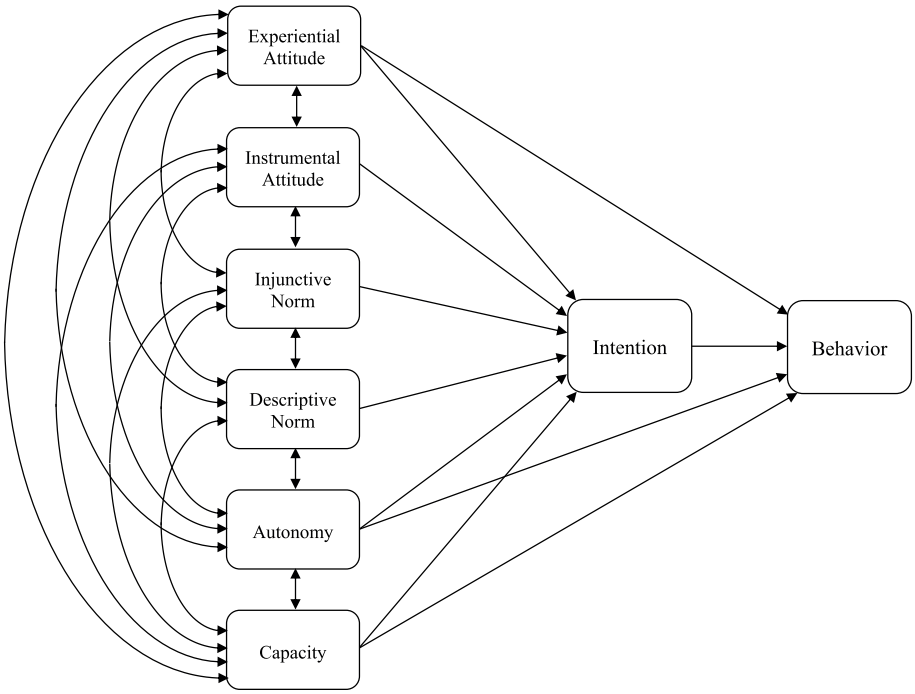

Fig. 1. Proposed model tested in path analysis of meta-analytic correlations of the reasoned action approach for health behavior excluding past behavior.

estimates of the unique effects of theory constructs on behavior.

Effects of past behavior may also reflect effects of other unmeasured constructs on behavior that represent implicit, non-conscious determinants of behavior. For example, direct effects of past behavior may reflect effects of implicit cognitions or behavioral scripts, constructs that represent stored sets of information developed over time that initiate behavior beyond an individual's awareness (Abelson, 1981; Ajzen, 2002). These implicit behavioral determinants have proposed to be separable from habits (Ouellette and Wood, 1998; Wood, 2017). The inclusion of past behavior as a predictor of intentions and behavior in tests of social cognitive models may, therefore, provide important information on the extent to which the behavior is controlled by non-conscious processes.

It is important to note that inclusion of past behavior may diminish the predictive validity of social cognitive models. Constructs in social cognitive models should account for effects of past behavior on subsequent behavior, that is, behavioral stability. However, if past behavior completely accounts for the effects of the social cognitive models on behavior, or renders them relatively trivial by comparison, then model constructs are effectively redundant as a means to explain behavior. It also has serious implications for the effectiveness of the model as a means to inform interventions aimed at changing behavior. If the social cognitive constructs assumed to be manipulable through intervention do not predict behavior, then affecting change in the constructs using intervention techniques will have no concomitant effect on behavior. In cases where past behavior is the dominant predictor and social cognitive constructs account for very little variance in behavior, it may be necessary to look to constructs unaccounted for in traditional social cognitive models, such as habit (van Bree et al., 2015, 2017), implicit attitudes (Gawronski, 2018), implicit motives (Keatley et al., 2012), or behavioral scripts (Abelson, 1981), as candidate mediators of past behavior effects. In such cases, those designing interventions for behavior change might look to identify strategies that target change in these determinants, such as altering the context in which the behavior frequently occurs or avoiding cues that activate implicit cognitions (Hagger, 2016; Hollands et al., 2016). In summary, accounting for past behavior may provide important information on the extent to which behavior is under the control of reasoned and non-conscious processes. It will also permit evaluation of the sufficiency of the model as an effective means to explain behavior.

1.3. The present study

The purpose of the present study was to extend McEachan et al.'s (2016) meta-analysis of the RAA in health behaviors to include past behavior as a precursor of model constructs (Hennessy et al., 2010). Given the pervasive effects that past behavior has on future behavior in tests of social cognitive models, and its attenuating effects of social cognitive constructs on behavior, the omission of past behavior in model tests may lead to the drawing of erroneous conclusions over the size of the effects among the model constructs and, as a consequence, its validity in accounting for variance in behavior. Including past behavior will also provide an indication of the extent to which the behavior is accounted for by non-conscious processes, one of the functions indicated by the past behavior-behavior relation. In addition, the inclusion of past behavior permitted evaluation of the extent to which the social cognitive variables in the RAA account for the effects of past behavior. Confirmation that the RAA variables account for effects of past behavior on future behavior would provide support for the sufficiency of the model in accounting for behavioral stability and the reasoned processes that lead to health behavior. This point has implications for practice as it will indicate which, if any, RAA constructs should be targeted in health behavior change interventions.

Specifically, we aimed to extend McEachan et al.'s meta-analysis by augmenting their original correlation matrix among RAA constructs to include past behavior. Next, we tested the RAA model that excludes past behavior (see Fig. 1) and compare model effects with the augmented model that includes past behavior (see Fig. 2) using meta-analytic structural equation modeling. Overall, we expected our analysis to provide new data on whether RAA effects identified in McEachan et al.'s meta-analysis hold in the presence of past behavior, and provide insight into the process by which past behavior relates to subsequent behavior in health behavior contexts.

We also aimed to test effects of three candidate moderators of RAA model effects within the meta-analysis: behavioral frequency, behavior type, and time lag between social cognitive and behavioral measures.

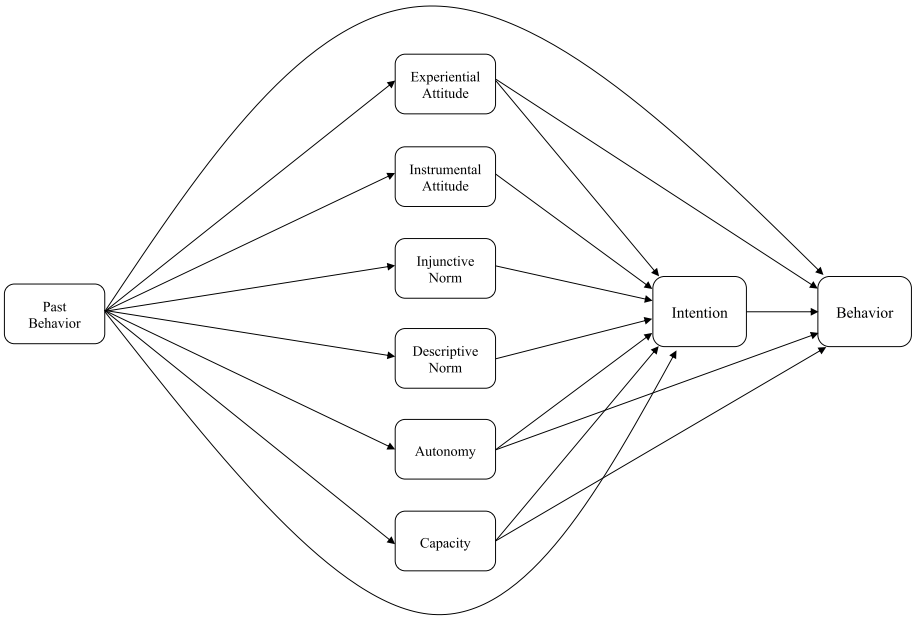

Fig. 2. Proposed model tested in path analysis of meta-analytic correlations of the reasoned action approach for health behavior including past behavior.

Specifically, we aimed to test whether frequency of performance of the target behavior moderated the effects of intentions on behavior, and the effects of past behavior on intentions and the other model constructs. Consistent with previous theory and research on the role of past behavior in social cognitive models (Ouellette and Wood, 1998; Wood, 2017), we hypothesized that behaviors affording greater opportunity to be performed frequently (e.g., physical activity, eating healthily) are more likely to be acquired as habits, and, as a consequence, the behavior is more likely to be controlled by non-conscious, automatic processes. In contrast, behaviors that are likely to be performed less frequently (e.g., blood donation, screening attendance) offer fewer opportunities for habit formation, and actions are, therefore, more likely to be determined by intentional, reasoned processes. We therefore predicted that the effect of intentions on behavior would be smaller, and the effect of past behavior on behavior as a proxy for habit, would be larger, in studies on behaviors that tend to be performed frequently. It is important to note that behaviors are likely to be habitually controlled not only when individuals have high opportunity to perform them frequently, but also when they are performed in stable contexts (Ouellette and Wood, 1998). Although frequency and context stability are often associated, segregating behaviors in terms of their opportunity to be performed frequently without considering context stability is a relatively crude means to identify conditions that influence habitual control over behavior.

We also aimed to test whether model effects varied across different behaviors. Following McEachan et al.'s (2016) original analysis, we tested whether RAA predictions were consistent across studies with target behaviors that offer protection from risks to health (e.g., physical activity, healthy eating) and studies on target behaviors that are risky for health (e.g., smoking, drinking alcohol). Although they did not make specific predictions, McEachan et al. suggested that experiential attitudes were more likely to have larger effects on risk behavior when compared to protection behaviors given that participation in these behaviors might be determined by affective-related beliefs than instrumental beliefs. Their analysis supported this prediction with larger effects for experiential attitudes, but they also found larger effects for instrumental attitudes and descriptive norms. McEachan et al.'s moderator analyses were confined to univariate relations between model constructs. We aimed to extend this analysis by examining moderator effects in a full test of the RAA in which all model paths are estimated simultaneously. In addition, some behaviors, such as physical activity and dietary-related behaviors, were frequently tested in the set of studies used by McEachan et al., so we aimed to test whether or not model effects were consistent across specific behaviors.

McEachan et al. also tested effects of time lag between measures of RAA model constructs and behavior on individual correlations between the constructs. We aimed to conduct a similar analysis, but in the context of the full structural model. Consistent with previous meta-analytic research adopting social cognitive models indicating that behavioral prediction over time tends lead to smaller effects (Hagger et al., 2002; Mankarious and Kothe, 2015; McEachan et al., 2011), we expected effects of social cognitive factors, intentions, and past behavior on behavior to be larger when behavior is measured in close proximity to the social cognitive variables. However, we did not expect the RAA to be entropic, that is, for the proposed model effects to wane over time to zero, partly because temporal correspondence in measures tends to maintain prediction, but also because there are likely other constructs that tend to maintain intentions over time, albeit those that are typically unmeasured, such as implicit motives and attitudes, planning, and self-monitoring.

2. Method

Our analysis used the original studies included in McEachan et al. (2016) meta-analysis of the RAA for health behaviors. McEachan et al. identified 74 articles reporting 86 separate datasets (total $N = 21{,}245$) on the reasoned action approach applied to health behaviors defined as those likely to impact health outcomes including health promoting behaviors (e.g., physical activity, safer sex, and screening attendance) and health compromising behaviors (e.g., drug use). A list of included in the analysis is provided in Appendix A. Our first task was to fill gaps in McEachan et al.'s correlation matrices among RAA constructs variables in each study, particularly relations among RAA constructs and past behavior. We therefore sourced all of the original studies identified in McEachan et al.'s analysis and replicated their procedures for extraction and coding of study data. The RAA constructs in each study were exclusively measured using standardized measures derived from published guidelines (Fishbein and Ajzen, 2009). The homogeneity in measurement and conceptualization of constructs obviated the need to code the measures for equivalence across studies (Hagger, 2014). Effect sizes (Pearson correlation coefficients; r) and associated sample sizes for relations among the RAA constructs were extracted from the zero-order

intercorrelation matrices of the source studies. We extracted correlations among the RAA measures and past behavior measures where available (k = 33). We also extracted correlations among the experiential and instrumental attitude, injunctive and descriptive norms, and autonomy and capacity constructs which were not reported in McEachan et al.'s original analysis. We aggregated effect sizes at the study level in cases where studies included multiple measures of related behavior measures. When a study measured behavior at multiple follow-up timepoints, we used the latest timepoint. We also extracted the time lag between measures of RAA constructs and behavior measures, for each study. Our final sample sizes for each RAA effect was closely matched with McEachan et al.'s original analysis although there were some variations. For example, Blanchard et al. (2008) reported data from four samples defined by ethnicity (Caucasian, African-American) and length of follow-up (two-week, two-month), we included all four samples in our analysis while McEachan et al. included only the two-month samples. Collection of studies and data extraction were conducted between May and August 2017.

Next, we tested relations among RAA constructs using meta-analytic structural equation modeling (MASEM) using the metaSEM package (Cheung, 2015) in R (R Development Core Team, 2017). A typical method used to analyze multiple relations among constructs in social cognitive models is to adopt a univariate approach that involves first correcting correlations among variables in the model across studies using meta-analysis and then using the average bias-corrected correlation matrix as input in a multiple regression or path analysis testing the model. This method has been used in many previous studies (e.g., Hagger et al., 2016; Hagger et al., 2017b; Ng et al., 2012), including McEachan et al. (2016). Yet, this procedure has been identified as problematic because it necessitates finding a common sample size to estimate the standard errors, such as the harmonic mean of the sample size across studies, and assumes that the correlation matrix is a covariance matrix, which likely leads to inaccuracies in the resulting standard errors, confidence intervals, and chi-square values of the model (Cheung, 2015). MASEM offers an alternative that directly addresses the inherent limitations of the univariate approach. The analysis is conducted in two stages. In the first stage, correlation matrices from individual studies are pooled to form a common correlation matrix using random effects meta-analysis. The analysis produces a pooled correlation matrix representing the average correlation matrix among study variables in the population, with a sampling variance-covariance matrix that represents the known precision estimates of each correlation in the pooled matrix. The first stage yields zero-order correlations corrected for bias using a random effects meta-analytic model (r^{+}_{RE}) among study constructs across studies with 95% confidence intervals. In addition, statistics to evaluate heterogeneity in the effect sizes are also provided: the τ^2 statistic, the Q statistic, and the I^2 statistic and its 95% confidence interval. Statistically significant τ^2 and Q values with I^2 values exceeding 25% with wide confidence intervals are considered indicative of substantive heterogeneity. We also computed conventional fixed- and random-effects meta-analytic estimates for each RAA effect using the metafor package in R for comparison.

In the second stage of the analysis, the pooled correlation matrix is used to estimate the proposed model. Two models were tested: a model testing the hypothesized pattern of effects among study constructs consistent with hypotheses from the RAA (see Fig. 1) and a model augmented to include past behavior (see Fig. 2). Fit of the proposed model with data from the meta-analysis was evaluated using multiple goodness-of-fit indices: the model goodness-of-fit chi-square, the comparative fit index (CFI), the Tucker-Lewis index (TLI), the standardized root mean square of the residuals, and the root mean error of approximation (RMSEA). A non-significant χ^2, CFI and TLI values that approach or exceed 0.95, a SRMSR value of less than 0.008, and a RMSEA value of 0.005 or less, indicate good fit of the model with the data (Hu and Bentler, 1999). Effects among model constructs were evaluated based on the likelihood based confidence intervals about model parameter estimates. We evaluated whether inclusion of past behavior in the model attenuated effects of RAA constructs on intentions, and of intentions on behavior, by computing the confidence interval of the difference in the parameter estimates across the models (Schenker and Gentleman, 2001). To the extent that the interval does not include zero, we have confirmation of a statistically significant difference in the parameter estimates across models.

We evaluated effects of behavior type, and time lag moderators on RAA model effects by estimating the models separately in groups of studies on behaviors classified as high and low frequency, studies on specific behaviors that had been tested with high regularity, studies on health risk and health protection behaviors, and studies with longer and shorter time lag between social cognitive and behavioral measures. Classification of studies into high (k = 65) and low (k = 16) frequency was based on Ouellette and Wood's (1998) criterion. Although classification of studies into those targeting behaviors that offered greater opportunity to be performed with high (e.g., physical activity, health eating) or low frequency (e.g., blood donation, health screening) was a relatively straightforward process, there were particular cases that presented some difficulty. For example, for condom use, individuals in a regular, long-term relationship using condom use for contraception are more likely to have greater opportunity for use of condoms than individuals not in a relationship. Similarly, for speeding when driving, opportunity may be dependent on whether or not the individual used a car on a daily basis, such as commuting to work. In these cases we relied on the definition and operationalization of the behavior and the sample description provided by in the original report as a basis for our decision. Coding for this moderator was conducted independently by two raters. Inter-rater analysis indicated strong agreement (κ = .85). Discrepancies were discussed before settling on a final classification. We also identified groups of studies that tested the RAA in the same target behavior. The most frequently occurring target behaviors in the sample of studies were physical activity (k = 38) and dietary behaviors (k = 13), with other behaviors adopted with lower frequency (k < 10). We retained McEachan et al.'s (2016) original coding of studies into health protection (k = 70) and health risk (k = 11) behaviors. Consistent with previous meta-analytic studies (e.g., Hagger et al., 2002) including McEachan et al. (2016), studies were classified as having longer measurement lag if the time gap between measurement of the RAA constructs and behavior was greater than 4 weeks (k = 43), and shorter if the time lag was four weeks or fewer (k = 38). Heterogeneity statistics from the first stage of the MASEM analysis were used to evaluate whether the moderator had resolved the heterogeneity in correlations among variables. Differences in relations among model constructs at the levels of the moderator were tested using the confidence intervals about the difference in model parameter estimates (Schenker and Gentleman, 2001).

We also evaluated the potential effect of selective reporting bias in relations among the RAA model constructs across included studies using regression analyses based on 'funnel' plots of effect size on estimates of precision. The plots are used to estimate the extent to which an averaged effect size derived from a meta-analysis may deviate from the true effect due to selective biases in the sample of studies in the analysis. A principal source of bias may be 'publication bias' caused by a preponderance of studies in the sample with disproportionately large effect sizes relative to the sample size. Regressing effect size on study precision provides an estimate of the extent of bias and an estimate of the effect size corrected for bias. Two methods are used: the precision effect test (PET) and the precision effect estimate with standard error (PEESE). The PET is the linear regression of study effect size on its standard error estimate, weighted by the inverse variance. The intercept of the model provides an unbiased estimate of the true mean effect size. However, the PET may underestimate the true mean effect size when there is evidence of a non-zero effect. The intercept derived from a non-linear (quadratic) regression of study effect size on the square of its standard error, again weighted by the inverse variance, the PEESE,

has been shown to provide a more precise estimate of the true mean effect in cases where there is evidence of a non-zero effect. We computed PET and PEESE estimates, with *t*-test for bias, and statistical significance of the bias-corrected effect from zero to provide an indication of selective bias in each estimate using the PETPEESE function in R (Carter et al., 2017). A full table including study characteristics, extracted data, and moderator coding can be accessed online from the Open Science Framework (OSF) project for this study: https://osf.io/w4hfr.

3. Results

3.1. Zero-order parameter estimates and bias statistics

Zero-order averaged bias-corrected correlations (r^{+}_{RE}) among RAA model constructs including past behavior from the first stage of the MASEM analysis are presented in Appendix B (supplemental materials), with bias-corrected correlations from conventional random- and fixed-effects meta-analysis included for comparison. The bias-corrected correlations from the MASEM analysis were all significantly different from zero and non-trivial in size (r^{+}_{RE} range = 0.158 to 0.564). Heterogeneity statistics revealed moderate-to-high heterogeneity according to the I^2 statistic. Values for the *Q*-statistic across studies also indicated substantial heterogeneity for the models excluding (Q (1244) = 6742.459, $p < .001$) and including (Q (1440) = 7666.848, $p < .001$) past behavior. As correlations from the MASEM analysis and conventional meta-analytic models indicated positive non-zero effects, the PEESE regression test was taken as an estimate of selection bias. The test revealed significant bias in the majority of the effects. However, the bias-corrected PEESE estimates did not alter conclusions with respect to whether effects were different from zero and their overall size. Analysis scripts and output files for the metaSEM analysis, conventional meta-analysis, and PET-PEESE analysis with funnel plots can be accessed online from the study OSF project: https://osf.io/w4hfr.

3.2. Meta-analytic structural equation models

Goodness-of-fit statistics indicated that the second stage MASEM models of the RAA that excluded (Fig. 1) and included (Fig. 2) past behavior exhibited adequate fit with the data (see Appendix C, supplemental materials). Standardized parameter estimates with 95% likelihood-based confidence intervals from the MASEM analyses for both models are presented in Table 1. Patterns of effects for the model excluding past behavior were consistent with those found by McEachan et al. in their regression analyses, albeit with some variation in the magnitude of the effects. Specifically, we found statistically significant, positive direct effects of experiential and instrumental attitudes, injunctive and descriptive norms, and capacity on intentions. We also found significant and positive direct effects of experiential attitudes, capacity, and intentions on behavior. Effect sizes were small (βs < 0.150), with the exception of the effects for experiential attitude, descriptive norms, and capacity on intentions, and intentions on behavior. In addition, experiential and instrumental attitudes, injunctive and descriptive norms, and capacity had significant and positive indirect effects on health behavior through intentions, consistent with hypotheses. Indirect effects for instrumental attitudes, and injunctive and descriptive norms were relatively small and trivial (β < |0.075|) (Seaton et al., 2010), while indirect effects for experiential attitude and capacity were more substantive. Overall, RAA constructs accounted for 47.51% and 24.07% of the variance in intentions and behavior, respectively.

Including past behavior as a predictor of all variables in the model (Fig. 2) revealed statistically significant attenuation of some model relations. Specifically, the direct effect of intention on behavior, and the indirect effects of experiential attitudes, descriptive norms, and capacity on behavior through intentions were significantly smaller. The attenuation of key effects notwithstanding, inclusion of past behavior did not lead to a rejection of the RAA as the overall pattern of effects of the model was supported. Including past behavior as a predictor in the model resulted in a significant increase in the proportion of variance explained in intentions (53.17%) and behavior (34.41%), reflecting the pervasive effect of past behavior in the model. In addition, past behavior also exhibited significant indirect effects on behavior mediated by intentions alone, and mediated by the other social cognitive variables and intentions, on behavior. According to the proportion mediation statistic (P_M; Ditlevsen et al., 2005), the total indirect effect of past behavior through the social cognitive variables from the RAA and intentions accounted for a small proportion of the total effect of past behavior on behavior (P_M = .200). This means that 20% of the total effect of past behavior on behavior was accounted for by the indirect effects, and indicated that the direct effect of past behavior on future behavior was the larger effect.

3.3. Moderator analyses

MASEM analyses of the RAA in moderator groups representing behavior frequency, behavior type, and measurement lag, exhibited adequate fit with the data according to multiple criteria (see Appendix C, supplemental materials). Standardized parameter estimates, confidence intervals, and test statistics for each moderator analysis are presented in supplemental materials (Appendixes D-G). For the behavior frequency moderator (Appendix D), the direct effects of intention on behavior was larger, and the direct effect of past behavior on behavior smaller, in groups of studies with high frequency, compared to studies with low frequency. These effects were contrary to predictions. However, it is important to note that these observed differences were not statistically significant across moderator groups. In addition, we found significantly larger effects of past behavior on experiential attitudes, injunctive norm, and descriptive norm in studies on low frequency behaviors. There were also trends toward larger effects of past behavior on autonomy and capacity in studies on low frequency behaviors.

For the behavior type moderators, the models estimated on dietary behaviors and health risk behaviors did not converge due to small numbers of studies and positive non-definite covariance matrices. The model on health protection behaviors was therefore compared to the full sample, effectively a sensitivity analysis testing whether our conclusions on model effects would change with the exclusion of studies on health risk behaviors. The model estimated on studies on physical activity behaviors was compared to models on other behaviors. We found no differences in model effects for studies on health protection behaviors relative to the overall sample (Appendix E). Effects of past behavior on experiential and instrumental attitudes, and injunctive norms were smaller in studies on physical activity behavior relative to studies on other behaviors. However, there were significant differences or observed trends in the total effects of past behavior and intention on behavior across behavior type (Appendix F). Finally, there were no significant differences or observed trends in model effects across the measurement lag moderator (Appendix G). It seems that model effects were consistent regardless of time gap between measures, indicating that the model effects were consistent in studies with shorter- and longer-term behavioral follow-up.

4. Discussion

The purpose of the present study was to extend McEachan et al.'s (2016) meta-analysis of the RAA for health behaviors by including past behavior as a predictor in the model. The analysis aimed to evaluate the extent to which past behavior predicts prospectively-measured health behavior beyond the RAA constructs – effects that likely model habitual, non-conscious processes on health behavior. We also set out to examine the effects of candidate moderators of RAA model effects: behavior frequency, behavior type, and time lag between measurement

Table 1
Standardized path coefficients for direct and indirect effects for the meta-analytic structural equation model (stage 2) of the reasoned action approach excluding and including past behavior with model comparisons.

Effect	Model excluding past behavior			Model including past behavior			Model comparisons				
	β	*LB CI*$_{95}$		β	*LB CI*$_{95}$		β_{diff}[a]	*CI*$_{95}$		*t*[b]	*p*
		LL	*UL*		*LL*	*UL*		*LL*	*UL*		
Direct effects											
Experiential attitude→Intention	.296	.244	.347	.245	.188	.299	.052	-.024	.127	1.339	.181
Instrumental attitude→Intention	.092	.033	.150	.072	.009	.135	.020	-.066	.106	0.457	.648
Injunctive norm→Intention	.079	.037	.119	.071	.030	.111	.008	-.049	.065	0.267	.790
Descriptive norm→Intention	.151	.099	.202	.090	.034	.144	.061	-.014	.136	1.593	.111
Autonomy→Intention	.032	-.041	.101	.022	-.054	.094	.010	-.092	.112	0.199	.842
Capacity→Intention	.318	.254	.383	.267	.197	.335	.051	-.043	.145	1.056	.291
Autonomy→Behavior	.034	-.031	.098	.014	-.067	.092	.021	-.080	.122	0.401	.689
Capacity→Behavior	.106	.033	.176	.074	-.010	.156	.032	-.076	.140	0.574	.566
Experiential attitude→Behavior	.064	.017	.108	.024	-.032	.077	.040	-.031	.111	1.095	.273
Intention→Behavior	.370	.304	.436	.175	.075	.265	.195	.081	.310	3.316	.001
PB→Experiential attitude	–	–	–	.401	.353	.450	–	–	–	–	–
PB→Instrumental attitude	–	–	–	.290	.229	.350	–	–	–	–	–
PB→Injunctive norm	–	–	–	.265	.230	.300	–	–	–	–	–
PB→Descriptive norm	–	–	–	.338	.285	.391	–	–	–	–	–
PB→Autonomy	–	–	–	.224	.124	.325	–	–	–	–	–
PB→Capacity	–	–	–	.398	.333	.462	–	–	–	–	–
PB→Intention	–	–	–	.272	.197	.344	–	–	–	–	–
PB→Behavior	–	–	–	.412	.317	.509	–	–	–	–	–
Indirect effects											
Experiential attitude→Intention→Behavior	.110	.085	.138	.043	.018	.070	.067	.030	.104	3.516	.000
Instrumental attitude→Intention→Behavior	.034	.012	.057	.013	.001	.029	.022	-.005	.048	1.596	.110
Injunctive norm→Intention→Behavior	.029	.014	.045	.012	.004	.024	.017	-.002	.035	1.762	.078
Descriptive norm→Intention→Behavior	.056	.035	.080	.016	.005	.032	.040	.014	.066	2.972	.003
Autonomy→Intention→Behavior	.012	-.015	.038	.004	-.010	.018	.008	-.021	.037	0.521	.602
Capacity→Intention→Behavior	.118	.088	.154	.047	.020	.077	.067	.030	.104	3.516	.000
PB→Experiential attitude→Intention→Behavior	–	–	–	.017	.007	.028	–	–	–	–	–
PB→Instrumental attitude→Intention→Behavior	–	–	–	.004	.000	.008	–	–	–	–	–
PB→Injunctive norm→Intention→Behavior	–	–	–	.003	.001	.006	–	–	–	–	–
PB→Descriptive norm→Intention→Behavior	–	–	–	.005	.002	.011	–	–	–	–	–
PB→Autonomy→Intention→Behavior	–	–	–	.001	-.003	.004	–	–	–	–	–
PB→Capacity→Intention→Behavior	–	–	–	.019	.008	.032	–	–	–	–	–
PB→Autonomy→Behavior	–	–	–	.003	-.020	.017	–	–	–	–	–
PB→Capacity→Behavior	–	–	–	.029	-.004	.058	–	–	–	–	–
PB→Experiential attitude→Behavior	–	–	–	.010	-.014	.029	–	–	–	–	–
PB→Intention→Behavior[b]	–	–	–	.047	.023	.072	–	–	–	–	–
Total effects											
Autonomy→Behavior[c]	.046	-.017	.107	.017	-.067	.099	.029	-.074	.131	0.548	.584
Capacity→Behavior[c]	.224	.166	.282	.121	.040	.197	.103	.007	.200	2.074	.038
Experiential attitude→Behavior[c]	.173	.134	.211	.067	.011	.117	.107	.042	.172	3.193	.001
PB→Social cognition→Behavior[d]	–	–	–	.138	.098	.177	–	–	–	–	–
PB→Behavior[c]	–	–	–	.551	.488	.613	–	–	–	–	–
Correlations[e]											
Experiential attitude↔Instrumental attitude	.474	.436	.512	.358	.309	.405	.116	.055	.177	3.720	.000
Experiential attitude↔Injunctive norm	.333	.304	.362	.227	.192	.261	.106	.061	.152	4.583	.000
Experiential attitude↔Descriptive norm	.282	.253	.311	.146	.108	.184	.136	.088	.183	5.595	.000
Experiential attitude↔Autonomy	.229	.181	.276	.140	.077	.201	.089	.011	.166	2.232	.026
Experiential attitude↔Capacity	.453	.410	.497	.296	.242	.349	.157	.088	.226	4.456	.000
Instrumental attitude↔Injunctive norm	.382	.350	.415	.306	.268	.343	.076	.026	.126	3.001	.003
Instrumental attitude↔Descriptive norm	.221	.177	.266	.124	.073	.174	.098	.030	.165	2.837	.005
Instrumental attitude↔Autonomy	.229	.182	.276	.164	.105	.220	.065	-.009	.140	1.731	.084
Instrumental attitude↔Capacity	.340	.299	.382	.224	.171	.276	.116	.049	.183	3.391	.001
Injunctive norm↔Descriptive norm	.386	.338	.434	.296	.245	.347	.089	.019	.159	2.499	.012
Injunctive norm↔Autonomy	.178	.140	.216	.118	.071	.165	.060	.000	.120	1.948	.051
Injunctive norm↔Capacity	.292	.256	.329	.186	.142	.229	.107	.050	.163	3.704	.000
Descriptive norm↔Autonomy	.160	.110	.209	.082	.019	.144	.077	-.002	.157	1.903	.057
Descriptive norm↔Capacity	.245	.169	.320	.097	.015	.180	.148	.036	.259	2.589	.010
Autonomy↔Capacity	.390	.320	.460	.303	.221	.383	.087	-.020	.194	1.597	.110

Note. β = Standardized path coefficient; *LB CI*$_{95}$ = Likelihood based 95% confidence interval; *LL* = Lower limit of *CI*$_{95}$; *UL* = Upper limit of *CI*$_{95}$; *CI*$_{95}$ = Conventional 95% confidence interval; β_{diff} = Difference in standardized path coefficient; PB = Past behavior.

[a] Model comparisons made using Schenker and Gentleman's (2001) 'standard method' using confidence intervals about the mean difference derived from Wald standard errors.

[b] Indirect effect of past behavior on behavior through intention only.

[c] Total effect including direct and indirect effects.

[d] Total indirect effect of past behavior on behavior excluding direct effect.

[e] Correlations among residuals of the predictors of intention, decreases in the size of these correlations with the inclusion of past behavior indicates that shared variance in the residuals of the constructs is accounted for by past behavior.

of social cognitive constructs and behavior. We updated McEachan et al.'s database of correlations among the RAA constructs with correlations between these constructs and past behavior, and extracted data on behavioral frequency, behavior type, and measurement lag. MASEM was used to test the proposed RAA models excluding and including past behavior across studies. Results for the model excluding past behavior replicated the pattern of effects reported in McEachan et al.'s original analysis. Inclusion of past behavior resulted in significant attenuation of the direct effect of intentions on behavior, and the indirect effects of experiential attitudes, descriptive norms, and capacity on behavior through intentions. The indirect effects of past behavior through the social cognitive variables in the model and intentions accounted for a relatively modest proportion of the total effect of past behavior on behavior. We found few statistically significant differences or observed trends in model effects when testing the model in studies across levels of the moderator variables.

Current findings point to the pervasive effect of past behavior as a determinant of health behavior, which has two important ramifications for the interpretation of RAA predictions. First, it means that regardless of any variability in effect sizes due to potential moderators (e.g., context, behavior, or population), the observed effects among RAA constructs in health behaviors are likely to be non-zero. Furthermore, the effect of intentions on behavior is likely to be lower when past behavior is included in the model. In other words, researchers testing the model would expect to find these patterns of relations regardless of variations in study characteristics. This conclusion is consistent with previous meta-analytic research examining past behavior effects in social cognitive models (Hagger et al., 2002, 2016), and recent research applying the RAA to health behaviors (Conner et al., 2017). Second, an important implication of these findings is that tests of the RAA in the absence of past behavior are likely to yield inflated estimates of the averaged effects of intention on health behavior, and indirect effects of RAA constructs acting through intentions, and may lead to misleading conclusions regarding the size of the effects. This has important ramifications for the RAA given that the intention-behavior relationship is central to the model and fundamental to its validity (Hagger et al., 2017a; Trafimow, 2009). At the aggregate level, our analysis has important implications for interpreting the pattern of effects in the RAA and for future research. Researchers should be encouraged to consider the effects of past behavior in future tests of the RAA, and consider past behavior when interpreting model effects.

However, it is important to note that while the size of these effects among RAA model variables was substantially reduced with the inclusion of past behavior, the effects were not extinguished. Taken together with results from primary studies indicating pervasive effects for past behavior in social cognitive models (e.g., Brown et al., 2017; Hamilton et al., 2017; Norman and Cooper, 2011), our findings are consistent with explanations offered by dual process theories in which two pathways to action are proposed: a reasoned route, modeled by the effects of the belief-based constructs from the RAA mediated by intentions, and a non-conscious, habitual route, represented by the effects of past behavior (Hagger, 2016; Sheeran et al., 2013; Strack and Deutsch, 2004). Rather than both processes operating simultaneously, a likely interpretation of the coexistence of these two pathways is that health behavior may be predominantly controlled by one of the processes, determined by moderator variables such as type of population or behavior.

A possible explanation for the past behavior effects in the current synthesis of the RAA is that they model implicit, non-conscious processes on health behavior. To speculate, past behavior effects may reflect the influence of habits. However, Ouellette and Wood's (1998) contention that habitual behaviors tend to be those that individuals have high opportunity to perform in stable contexts, was not supported in our behavior frequency moderator analysis. In fact, we found non-significant trends of smaller effects of past behavior, and larger effects of intentions, on behavior in studies on high frequency behaviors, findings which deviate from our predictions. An explanation may lie in a recent analysis demonstrating that the intention-behavior relationship is curvilinear under the moderating effects of past behavior (Sheeran et al., 2017a). Sheeran et al.'s findings suggest that past behavior has a stabilizing effect on the intention-behavior relationship at moderate levels of behavioral frequency. However, as behavioral frequency increases, individuals are more likely to form habits and the role of intentions is diminished. Our results may, therefore, be indicative of the stabilizing effect. We stress that this is a speculative interpretation, and current data did not permit us to verify whether the intention-behavior relation follows a quadratic relation with past behavioral frequency. It is also important to note that these interpretations are based on the strength of the effects alone and must be interpreted in light of a lack of formal differences.

Alternatively, the effects for past behavior effects in the RAA observed in the present study may reflect the influence of behavioral 'scripts'; organized sets of information stored schematically linking the action with cues and contexts built up through repeated past experience (Abelson, 1981). Implicit measures of social cognitive constructs, such as implicit association tests and tasks measuring accessibility of constructs, may provide a means to directly tap beliefs representing this 'scripted' information (Gawronski, 2018; van Bree et al., 2015). Testing whether implicit measures mediate effects of past behavior on prospectively-measured health behavior would provide evidence to corroborate the contention that past behavior effects reflect automatic, non-conscious processes, and is an important avenue for future research.

4.1. Study limitations and implications for practice

A number of limitations that affect inferences and generalizability of current findings should be noted. Studies included in the current analysis were exclusively correlational in design. Such designs do not permit the inference of causal relations among variables in the model. Such inferences are based on theory alone and alternative models that are plausible empirically, if not theoretically, could be proposed (Hagger and Chatzisarantis, 2016; Hagger et al., 2017a). Studies that test premises of the RAA using cross-lagged panel designs, in which study constructs including behavior are measured at multiple time points, are needed. Panel designs would permit prediction of variable change over time and provide tests of directional and reciprocal relations among constructs, particularly prediction of future behavior from intentions and past behavior. Of course such designs are also correlational, so a further alternative would be experimental and correlational designs which manipulate key variables in the RAA and test effects of subsequent intentions and behavior while controlling for past behavior. Another alternative would be to use a quasi-experimental design in which previous experience with the behavior is varied, for example by testing the RAA in novice and experienced participants enroled in a fitness center or exercise program. A further limitation was that most studies relied on self-report measures of past and prospective behavior. This is likely to introduce additional error variance into the relations in the current synthesis due to limits on individuals' ability to recall their behavior, as well as a potential for selective reporting and socially-desirable responding. In addition, self-report measures of past and future behavior usually adopt the same format, and this similarity in measurement is likely to inflate relations due to common-method variance. Research that adopts objective direct or proxy measures for behavior should be advocated to minimize bias. Another limitation was the potential for a lack of correspondence between the RAA measures and behavioral measures. RAA measures frequently tap beliefs with respect to behavioral engagement as a goal or endpoint, while behavior is often measured using frequency measures. This lack of correspondence may introduce method variance to the effects (Ajzen, 1991). We recommend research testing the moderation of model effects by the degree of correspondence between RAA constructs and frequency behavioral

measures, and tests that compare model effects using frequency behavioral measures with other behavioral measures such as recency and frequency in context. Finally, effects among RAA constructs in the present analysis were highly variable with wide confidence intervals and substantive heterogeneity. Caution should be taken when drawing conclusions on patterns of effects in the RAA in the presence of high levels of heterogeneity.

Current findings have important implications for interventions to promote and change health behavior. One of the reported advantages of the RAA is that it allows greater precision in identifying the factors most influential in predicting health behavior. Greater precision means greater specificity in identifying salient targets for intervention and the behavior change methods to modify them. Differentiation of constructs in the RAA seems to be important given that some factors (e.g., experiential attitudes, capacity) have larger effects on behavior. These factors make viable targets for intervention. However, attenuation of the effects of these variables on behavior through intentions when past behavior was included in the model meant that the potential impact of interventions targeting RAA constructs might be muted. However, knowledge of the pervasive effects of past behavior may also inform interventions. While the effects of past behavior do not highlight a specific target for intervention, it indicates the need for self-regulatory skills which may minimize or circumvent habitual or non-conscious enactment of behaviors. Such skills may include cue identification and management, and depending on the behavior, self-monitoring to manage potential opportunities to act or minimize the threat of lapsing (Kleinjan et al., 2012; Marteau et al., 2012; Miller and Thayer, 1988).

5. Conclusion

Extending McEachan et al.'s (2016) meta-analytic test of the RAA to include past behavior has provided evidence that the RAA may not provide a comprehensive account of health behavior beyond previous experience. Our findings indicate that past behavior predicts prospective health behavior directly, and indirectly, through the social cognitive constructs in the model, and attenuates the effects of intention and social cognitive factors on health behavior. The current evidence seems to point for a substantive role for habitual, automatic processes, represented by the direct effects of past behavior on health behavior. Current results do not, however, invalidate the RAA, the social cognitive constructs in the model remain statistically significant albeit more modest predictors. Although current research indicates a possible role of behavioral frequency as a moderator of intention and past behavior effects in the RAA, testing the moderating effects of other variables that likely determine whether behaviors are controlled by habitual or reasoned processes (e.g., behavioral recency, self-reported habit) on past behavior-behavior and intention-behavior relations should be a priority for future research.

Data statement

All raw data files, analysis scripts for R, output files, and plots for this manuscripts can be accessed online from the following Open Science Framework project: https://osf.io/w4hfr.

Acknowledgements and Conflict of Interest Statement

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Appendixes A-G. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.socscimed.2018.07.038.

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II

PREDICTING CHANGE IN MIDDLE SCHOOL STUDENTS' LEISURE-TIME PHYSICAL ACTIVITY PARTICIPATION: A PROSPECTIVE TEST OF THE TRANS-CONTEXTUAL MODEL

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ORIGINAL ARTICLE

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Predicting change in middle school students' leisure-time physical activity participation: A prospective test of the trans-contextual model

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Abstract

We applied the trans-contextual model (TCM) to examine the effects of middle school students' perceived autonomy support from their physical education (PE) teachers on autonomous motivation toward PE in school and, critically, autonomous motivation toward, and actual participation in, leisure-time physical activity (PA). The research adopted a three-wave prospective design enabling the modeling of change in the TCM constructs over time. Middle school students (N = 248) aged from 12 to 16 years reported their perceived autonomy support, autonomous motivation in PE, autonomous motivation toward leisure-time PA, attitudes, subjective norms, perceived behavioral control (PBC), intentions for PA in leisure-time, and leisure-time PA participation. The psychological constructs and leisure-time PA were measured at baseline (T0) and at a first follow-up occasion (T1) 5 weeks later. Another measure of PA was taken at a second follow-up occasion (T2) a further 5 weeks later. A single-indicator structural equation model using residualized change scores revealed that perceived autonomy support predicted autonomous motivation in PE (β = .345), and autonomous motivation in PE predicted autonomous motivation for leisure-time PA (β = .484). Autonomous motivation toward leisure-time PA predicted attitudes (β = .425), subjective norms (β = .264), and PBC (β = .517). Autonomous motivation toward leisure-time PA (β = .376), attitude (β = .231), and subjective norms (β = .185) predicted intentions toward leisure-time PA, and intentions predicted PA (β = .198). Findings extend research on the TCM by demonstrating its efficacy in predicting change in middle school students' autonomous motivation across PE and leisure-time contexts, and accounting for change in intentions toward, and actual participation in, leisure-time PA.

1 | INTRODUCTION

Regular participation in physical activity (PA) in young people is associated with reduced risk of chronic disease risk factors and positive mental health outcomes (Haskell, Blair, & Hill, 2009; Janssen & LeBlanc, 2010; Warburton, Nicol, & Bredin, 2006). In addition, there is evidence that PA in young people tracks into adulthood and may be a gateway to lifelong PA participation (Tammelin et al., 2014).

Despite these benefits, research has shown that young people do not participate in sufficient PA to confer health benefits (Guthold, Stevens, Riley, & Bull, 2020).

Given the insufficient levels of PA observed in young people (e.g., Kokko et al., 2016), development of effective campaigns, and interventions to promote increased PA participation in young people has been identified as a priority (Messing et al., 2019). Researchers in behavioral science and applied psychology have, consequently, adopted psychological theories and models to predict and understand PA participation in young people, with the view of identifying the potential targets for intervention (Hagger, Cameron, Hamilton, Hankonen, & Lintunen, 2020; Hagger, Moyers, McAnally, & McKinley, 2020; Sheeran, Klein, & Rothman, 2017). In addition to identifying these targets, researchers have also been mindful of the key contexts, in which interventions to promote PA will have maximum benefit and reach (Messing et al., 2019). Physical education (PE), for example, has been noted as a potentially viable existing network on which interventionists can capitalize to deliver PA interventions to a broad, and captive audience of young people (Finnish National Board of Education, 2014; Hagger & Chatzisarantis, 2016).

Considering the imperative of identifying factors that determine PA participation and the potential for the school context to intervene and motivate young people to participate in PA in their leisure-time, researchers have sought to identify the factors linked to young people's motivation toward PA both within (Standage, Duda, & Ntoumanis, 2003) and outside of school (Plotnikoff, Costigan, Karunamuni, & Lubans, 2013). Theories of motivation and belief-based decision-making have been identified as important in this regard. Prominent among these is the trans-contextual model (TCM), an integrated model of motivation that outlines the psychological factors that likely influence the children's motivation toward, and actual participation in, PA outside of school (Hagger, Chatzisarantis, Culverhouse, & Biddle, 2003). The model outlines how the quality of motivation toward PA in school relates to motivation toward, and actual participation in, out-of-school PA. The model has been shown to be effective in identifying the predictors of motivation and PA participation in multiple samples in many countries, and these findings have been supported in a meta-analysis of studies (Hagger & Chatzisarantis, 2016). However, to date, research applying the TCM has not modeled change in its constructs over time. The current study aimed to advance knowledge on the TCM by testing its effectiveness in accounting for change in its constructs over time, particularly the target outcomes of leisure-time autonomous motivation, intentions, and PA behavior.

1.1 | The TCM

The TCM is a multi-theory integrated model that specifies how students' perception of their PE teacher's support for their motivation toward physical activities relates to their in school motivation toward PA and, importantly, their motivation, intentions, and actual PA behavior outside of school in their leisure-time (Hagger et al., 2003). The model draws its hypotheses from three motivational theories: self-determination theory (SDT; Deci & Ryan, 1985), the theory of planned behavior (TPB; Ajzen, 1991), and the hierarchical model of intrinsic and extrinsic motivation (Vallerand & Ratelle, 2002). Next, we outline the predictions of the model derived from the premises of the component theories.

Central to the model is autonomous motivation. Consistent with the predictions of SDT, autonomous motivation reflects engaging in activities and tasks out of a sense of volition, choice, and interest, and to attain self-endorsed goals. Autonomous motivation is important because it has been consistently shown to relate to behavioral persistence in multiple populations, behaviors, and contexts, and in the absence of external contingencies and reinforcement (Hagger et al., 2014; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). It is, therefore, important for fostering self-regulation of behaviors, as individuals who are autonomously motivated are more likely to persist with behaviors without the need for consistent, intensive prompts and interventions. According to the theory, social agents in the environment, such as teachers in school contexts, have the capacity to foster autonomous motivation by displaying autonomy-supportive behaviors. Research in educational contexts has demonstrated that the students of teachers displaying autonomy supportive behaviors in school contexts are more likely to report autonomous motivation and display greater engagement and persistence on tasks (Reeve & Cheon, 2020; Reeve, Jang, Carrell, Jeon, & Barch, 2004). Furthermore, students that perceive their teachers as autonomy supportive are more likely to report autonomous motivation in class (Hagger, Chatzisarantis, Barkoukis, Wang, & Baranowski, 2005). This forms the first premise of the TCM: Students perceiving that their teacher supports their autonomy in their PE classes will report autonomous motivation toward physical activities in class.

A key prediction of the TCM is that students' autonomous motivation toward PA in school will transfer to autonomous motivation toward physical activities outside of school in their leisure-time. This prediction is based on Vallerand and Ratelle's (2002) hierarchical model of intrinsic and extrinsic motivation. The hierarchical model proposes interplay between types of motivation across contexts. The rationale behind this "transfer" of motivation is that individuals who view activities as autonomously motivating in a given context will also seek out further opportunities to experience autonomous motivation in other contexts. The primary drivers behind this process are basic psychological needs. Self-determination theory suggests that satisfaction of three fundamental needs for autonomy, competence, and relatedness is essential for optimal functioning, with the need for autonomy, that is, the need to experience actions as chosen and self-endorsed, the foremost need (Ryan & Deci, 2017). Individuals who experience behaviors as autonomous, are likely to internalize such behaviors as those that satisfy their need for autonomy. Consistent with the hierarchical model, individuals will also be motivated to pursue need-satisfying behaviors elsewhere. This process forms the second premise of the TCM: Students experiencing physical activities in PE as autonomously motivating are more

likely to report autonomous motivation toward PA outside of school in their leisure-time.

Consistent with SDT, individuals experiencing an activity as autonomously motivating are likely to seek out further opportunities to engage in that activity in the future, and will strategically bring their beliefs and intentions toward that activity in line in order to do so (Deci & Ryan, 1985; Hagger et al., 2014). This is because individuals are motivated to seek out behaviors likely to satisfy their psychological needs. The formation of beliefs, therefore, outlines *how* individuals' motives lead to future participation in need-satisfying behavior. In the TCM, this is the process by which autonomous motivation in leisure-time leads to subsequent PA behavior. The TCM utilizes the TPB, a social cognition theory that identifies the belief-based determinants of intentions and behavior, as a means to model these relations (Chan, Zhang, Lee, & Hagger, 2020; Hagger & Chatzisarantis, 2009). The theory suggests that intentions are the most proximal predictor of behavior, a critical relationship in many social cognition theories (Orbell, 2004; Sheeran & Webb, 2016). Intentions are proposed to mediate the effects of three belief-based constructs, attitudes, subjective norms, and perceived behavioral control, on behavior. Research has demonstrated that these beliefs mediate relations between autonomous motivation and leisure-time PA participation (Chan et al., 2020; Hagger & Chatzisarantis, 2009). These findings form the basis of the third premise of the TCM: Autonomous motivation toward leisure-time PA will predict PA participation mediated by attitudes, subjective norms, PBC, and intentions.

Research adopting the TCM has supported its predictions in multiple samples and in different national groups (Chan, Hagger, & Spray, 2011; González-Cutre, Sicilia, Beas-Jiménez, & Hagger, 2014; Hagger & Chatzisarantis, 2016; Hagger, Sultan, Hardcastle, & Chatzisarantis, 2015). Specifically, research has demonstrated that the key premises hold: students' perceived autonomy support predicts their autonomous motivation toward PA in school; students' in school autonomous motivation predicts their autonomous motivation toward PA in leisure-time; autonomous motivation toward leisure-time PA predicts subsequent participation in leisure-time PA mediated by the belief-based constructs and intentions from the TPB. Primary research and meta-analytic findings have indicated small-to-medium sized effects for the direct effects that comprise the three key premises, with a small indirect effect of autonomous motivation on PA participation (Hagger & Chatzisarantis, 2016). In addition, intervention research has also suggested that provision of autonomy support by PE teachers or social agents affects leisure-time PA through the mediation of the model variables (Chatzisarantis & Hagger, 2009; Mavropoulou, Barkoukis, Douka, Alexandris, & Hatzimanouil, 2019; Wallhead, Hagger, & Smith, 2010).

1.2 | Modeling change in the TCM

Despite growing support for the premises of the model, numerous limitations and critiques of the model exist. At the forefront of these critiques has been the "static" approach to test the model (Hagger & Chatzisarantis, 2016). The three-wave prospective design, typically used to test the predictive validity of the model is limited as it does not account for change in the various model components over time. This is problematic because such models do not account for potential changes in both the predictor and predicted variables of the model that occur in the interim between measurements. Such changes may occur for multiple reasons, such as new information becoming available that influences the students' beliefs. For example, the introduction of a new teacher with a different interpersonal approach in PE lessons, the increased availability of opportunities to perform PA, or a series of positive or negative experiences may all change constructs in the model. A means to account for such change is to measure all model variables at each time point, which permits the explicit modeling of change in variables over time. Such an approach accounts for the relative temporal variability or stability in each construct over time, and allows the researcher to evaluate how well changes in antecedent constructs, such as perceived autonomy support and autonomous motivation in PE, predict changes in dependent constructs, such as autonomous motivation, beliefs, intentions, and behavior in leisure-time. Modeling change provides a more stringent test of the predictive validity of the model; if the model is able to account for change in constructs over time, then it will be more relevant to guiding interventions which focus on manipulating model constructs (e.g., perceived autonomy support) in order to affect change in key outcomes (e.g., leisure-time PA intentions and behavior.

1.3 | The present study

The purpose of the present study was to test the predictive validity of the TCM using change scores for each model construct in a sample of middle school students. Previous applications of the TCM have tested the predictive validity of the model using prospective designs, which use absolute values for model constructs to estimate the hypothesized relations among them. However, no previous study has shown whether the key premises of the model hold when it is used to predict change in its constructs over time. We applied a three-wave design to include measures of all model constructs at two data collection occasions separated by a 5-week interval, with a further follow-up measure of leisure-time PA behavior, 5 weeks after the second occasion. This design enabled modeling of change in study constructs using residualized change scores. In terms of specific predictions, we expected to find support for the three premises of the model in our change-score model: (i) changes in students' perceived autonomy support from teachers in PE were proposed to be positively related to changes in autonomous motivation toward PE; (ii) changes in autonomous motivation in PE were proposed to be positively related to changes in autonomous motivation for leisure-time PA outside of school; and (iii) changes in autonomous motivation for leisure-time PA were proposed to be positively related to changes

in intentions toward, and actual participation in, leisure-time PA through changes in the immediate antecedents of intentions from the TPB.

2 | METHOD

2.1 | Participants and design

A convenience sample of middle-school students (*N* = 292) aged from 12 to 16 years was recruited from two schools in the city of Kouvola, Finland. Schools were identified through PE teachers with established links with the University, and approval from the principals of both schools was secured in advance of data collection. The study protocol was approved by the research ethics committee of the University of Jyväskylä. Students' participation in the study was voluntary. Guardians of the eligible students were required to complete informed consent forms prior to participation via letters sent home with the students using an opt-out strategy. The study employed a three-wave prospective correlational design with measures of all TCM variables and PA behavior collected at two initial data collection occasions and a further follow-up comprising a behavioral measure only. Data were collected during regular school lessons and students who did not participate in the study were provided with an alternative writing task. In the first (T0) and second (T1) data collection occasions, separated by 5 weeks, self-report measures of students' perceived autonomy support by teachers, autonomous motivation for PE, autonomous motivation for leisure-time PA, TPB constructs, and self-reported PA were administered. Five weeks after the second data collection occasion, participants self-reported their PA participation for a third time (T2).

2.2 | Measures

Participants completed questionnaires containing previously validated self-report measures of the TCM constructs and self-report measures of behavior. Details of the measures are provided in the next section, and complete study measures are available in Appendix A (Supporting Information).

2.2.1 | Students' perceived autonomy support from their PE teacher

Perceived autonomy support from the students' PE teacher was measured using items from the perceived autonomy support scale for exercise settings (PASSES; Hagger et al., 2007). The scale comprised 12 items (e.g., "I feel that my PE teacher provides me with choices and options to …") with responses provided on 7-point scales (1 = *strongly disagree* and 7 = *strongly agree*). The scale has demonstrated adequate construct validity and reliability statistics in previous research (Hagger et al., 2007, 2009).

2.2.2 | Autonomous motivation toward in school and out-of-school PA

Autonomous motivation toward in school and out-of-school physical activities was measured using items from the perceived locus of causality questionnaire (Ryan & Connell, 1989). Two items measured identified regulation (e.g., "I do PE/PA because it is important to me to do well in PE/PA") and two items measured intrinsic motivation (e.g., "I do PE/PA because it is fun"). Responses were provided on 7-point scales (1 = *not true for me* and 7 = *very true for me*). For each of the PE and out-of-school contexts, a composite autonomous motivation score was computed by averaging scores on the identified regulation and intrinsic motivation items. Measures of autonomous motivation have demonstrated satisfactory construct validity and internal consistency in previous studies (Hagger et al., 2009).

2.2.3 | Theory of planned behavior constructs

Measures of students' attitudes, subjective norms, PBC, and intentions with respect to their future participation in PA were measured using scales developed according to reported guidelines (Ajzen, 2002). Attitudes were measured on three items in response to a common stem: "Participating in PA in the next five weeks will be…" with responses made on 7-point scales (e.g., 1 = *unenjoyable* and 7 = *enjoyable*). Subjective norms (e.g., "Most people who are important to me think I should do active sports and/or vigorous physical activities during my leisure-time in the next five weeks"), PBC (e.g., "I am confident I could do active sports and/or vigorous physical activities during my leisure-time in the next 5 weeks"), and intentions (e.g., "I intend to do active sports and/or vigorous physical activities during my leisure-time in the next five weeks") were measured using two items each with responses provided on 7-point scales (e.g., 1 = *strongly disagree* and 7 = *strongly agree*). Previous research has supported the construct validity and internal consistency of these measures within the TCM (Hagger et al., 2009).

2.2.4 | Physical activity behavior

PA behavior was measured using a modified version of the leisure-time exercise questionnaire (Godin & Shephard, 1985). The measure comprised two items: "In the course of the past five weeks, how often on average, have you participated in vigorous physical activities during your leisure-time for at least 20 min at a time" and "How frequently did you participate in vigorous physical activities during your leisure-time in the course of the past five weeks for at least 20 min at time)" with responses provided on 6-point scales (e.g., 1 = *never* and 6 = *all of the time*). The reference to a 20-min duration was based on American College of Sports Medicine (ACSM) daily guideline levels for vigorous PA. This version of the questionnaire has exhibited adequate inter-item correlations in previous studies (Hagger et al., 2009).

2.3 | Data analysis

Study hypotheses were estimated using single-indicator structural equation models using scale reliabilities to provide estimates of the measurement errors of the latent variables as advocated by Savalei (2019). Models were estimated using the Mplus software version 8.0 (Muthén & Muthén, 2002). Given the number of variables and the complexity of the model, we opted not to use an autoregressive path analytic model. Instead, change in model constructs was estimated using residualized change scores, which is a useful means to control for change while minimizing parameterization (Castro-Schilo & Grimm, 2018). Standardized residualized change scores for psychological constructs were computed by regressing scores for each variable taken at the first follow-up occasion (T1) on its score at the baseline data collection occasion (T0). We also included scores for leisure-time PA taken at T0 as an independent predictor of each psychological construct, which effectively controlled for past behavior. We used the same process to compute residualized change scores for leisure-time PA, but since PA measures were taken on three occasions, T0, T1, and T2, we regressed final PA scores at T2 on PA scores at both T0 and T1. The proportion of missing data for time 1 and time 2 psychological variables was low (M = 0.57%; range 0% to 3.2%), and data were missing completely at random (Little's MCAR test, $\chi^2(26) = 273$, $p = .058$). Missing data for the model components excluding leisure-time PA were imputed using linear interpolation. The residualized change scores were used to indicate latent variables in a structural equation model to test hypothesized predictions of the TCM presented in Figure 1. Latent variables were estimated using change scores as single indicators with McDonald's Omega (ω) reliability coefficient used to estimate fixed values for the error variances of the single-indicator latent variables based on Bollen's (1989) formula. We opted for a single-indicator structural equation model over the more traditional multiple-indicator model because of the difficulty of fitting models comprising constructs indicated by large numbers of items with data, particularly on relatively small sample sizes (Hsiao, Kwok, & Lai, 2018; Savalei, 2019). Model fit was evaluated using multiple goodness-of-fit indices: the model chi-square, the comparative fit index (CFI), the standardized root mean square of the residuals (SRMR), and the root mean error of approximation (RMSEA). A nonsignificant chi-square, a CFI value that approaches or exceeds .95, a SRMR value of less than .08, and a RMSEA value of .05 or less, are indicative of good fit of the model with the data (Hu & Bentler, 1999). Model effects were expressed as standardized parameter estimates. This makes assessment of effect sizes easy because each effect has the same scale ranging from 0 to 1.00. However, because effect sizes for indirect effects are products of one or more direct effects, effect sizes of standardized coefficients should be interpreted differently. Researchers have suggested that indirect effect sizes of .075 or larger are non-trivial in size while effect sizes < .075 are small or trivial in size (Hagger, Koch, Chatzisarantis, & Orbell, 2017; Seaton, Marsh, & Craven, 2010). The data file, Mplus syntax, and output files for the analyses are available online: https://osf.io/py2g7/.

3 | RESULTS

3.1 | Final sample and preliminary analyses

Forty-four participants dropped out of the study due to absences across the three waves of data collection resulting in a final sample size of 248 participants (boys, n = 118, girls, n = 130; M age = 13.63,

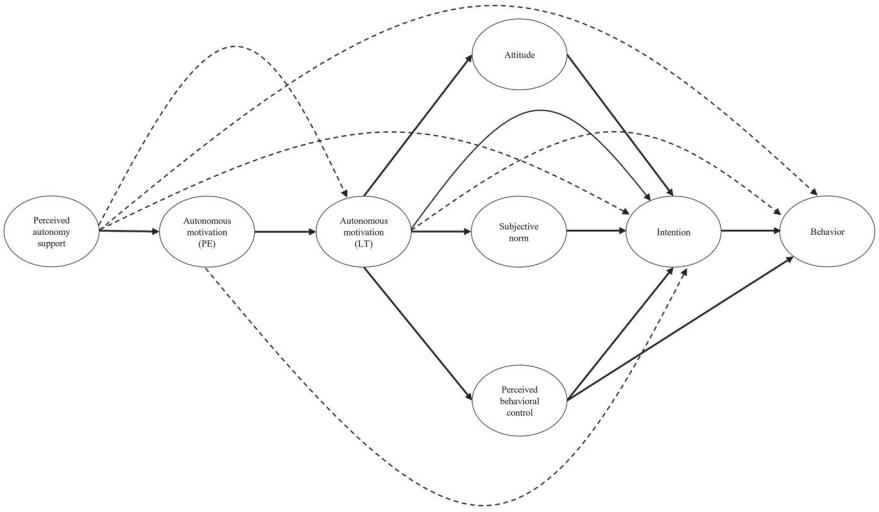

FIGURE 1 The hypothesized trans-contextual model. Broken lines between constructs indicate direct effects proposed to be nonsignificant or unsubstantial. Changes in students' perceived autonomy support from teachers in PE are proposed to be positively related to changes in autonomous motivation toward PE; changes in autonomous motivation in PE are proposed to be positively related to changes in autonomous motivation for leisure-time physical activity outside of school; changes in autonomous motivation for leisure-time physical activity are proposed to be positively related to changes in intentions toward, and actual participation in, subsequent leisure-time physical activity through changes in the immediate antecedents of intentions (i.e., attitude, subjective norm and perceived behavioral control); PE = physical education, LT = leisure-time

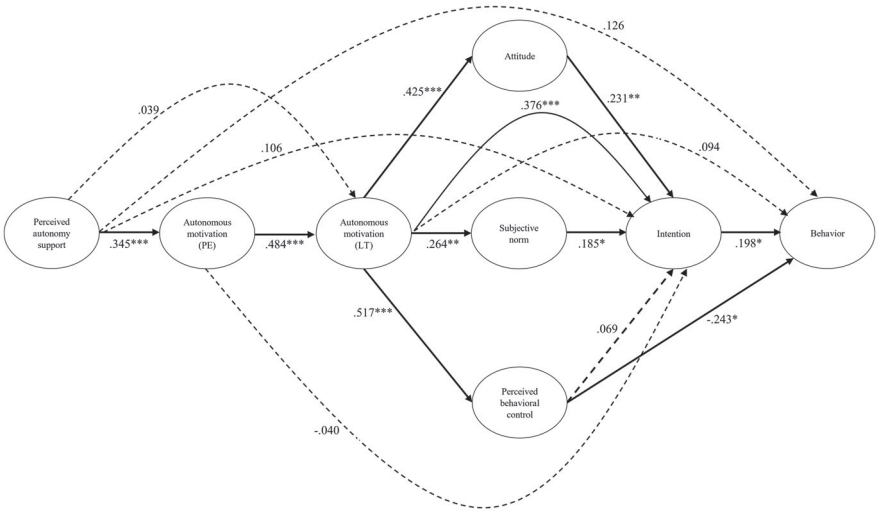

FIGURE 2 Results of the single-indicator structural equation model of the trans-contextual model. Coefficients are standardized parameter estimates. Solid unidirectional arrowed paths represent statistically significant effects among the model variables, broken unidirectional arrowed paths represent nonsignificant effects. Variables depicted are residual change scores for the study variables calculated by regressing variable scores taken at the first follow-up occasion (T1) on scores for the same variable taken on the first data collection occasion (baseline, T0). Physical activity behavior measured at T0 was also included in computing the change score of each variable to control for past behavior. The change score for physical activity was calculated by regressing the physical activity score taken at the second-follow up occasion (T2) on physical activity scores taken at T1 and T0. All parameter estimates of the model and error variances presented in Appendix F. Correlations among study variables omitted for clarity. *p < .05. **p < .01. ***p < .001

SD = 0.92). Attrition analyses indicated that students retained in the study were marginally younger (*M* age = 13.63, *SD* = 0.92) on average than those that dropped out of the study at any stage (*M* age = 14.02, *SD* = 0.73), $t(8) = 3.155$, $p = .002$, $d = .469$. There were no differences between participants that dropped out of the study at any stage and those that were retained in the final analysis on gender distribution, $\chi^2(1) = 1.981$, $p = .159$, Cohen's $w = .082$, psychological variables in the first and second data collection occasions (perceived autonomy support and autonomous forms of motivation in school and leisure-time context, attitudes, subjective norms, PBC, and intention), $F(14, 255) = .884$, $p = .577$; Wilk's $\Lambda = .954$, partial $\eta^2 = .046$, and PA $F(2, 274) = 2.674$, $p = .071$; Wilk's $\Lambda = .981$, partial $\eta^2 = .019$. Descriptive statistics and full correlation matrices among manifest variables prior to residualized change score computation are presented in Appendices B and C (Supporting Information).

3.2 | Model effects

The proposed model exhibited adequate fit with the data according to the adopted goodness-of-fit indices, χ^2 (9) = 18.543, $p = .029$; CFI = .967; SRMR = .036; RMSEA = .06590% CI [.020, .108]. Measurement-level parameters from the structural equation model including factor loadings and terms used to fix error variances of each latent variable are presented in Appendix D (Supporting Information), and correlations among latent variables from the structural equation model are presented in Appendix E (Supporting Information). Hypothesized paths among the TCM constructs in the proposed model are summarized in Figure 1. Results of the single-indicator structural equation model of the TCM are presented in Figure 2. Full standardized parameter estimates for model effects including direct, indirect, and total effects are presented in Table 1. Although we did not calculate an a priori statistical power analysis, we conducted a posteriori analysis to check whether the study was sufficiently powered to detect effects. The analysis was based on Satorra and Saris' (1985) recommendations based on effect size and model fit. We first calculated an effect size (δ) for the model based on the proposed restricted model relative to the totally free model based on the goodness-of-fit χ^2 value and final sample size (δ = 18.543/(248–1) = 0.075). We provided an estimate for the reproduced power of the model using this effect size with alpha set at 0.05, degrees of freedom of 9, and the final sample size of 248 implemented using the Webpower function in R (Zhang & Yuan, 2018). The model yielded a power estimate of 0.875, which suggests we had sufficient statistical power to detect effects.

Next, we report parameter estimates for the model-implied direct and indirect effects for the structural equation model. It should be noted that each construct referred to in our description represents change score, but for economy of description we do not prefix each construct with "change in…". Focusing first on direct effects, perceived autonomy support had a statistically significant effect on autonomous motivation in PE ($\beta = .345$, CI_{95} [.213, .478], $p < .001$). There was also a significant trans-contextual effect of autonomous motivation in PE on autonomous motivation in leisure-time ($\beta = .484$, CI_{95} [.335, .614], $p < .001$). Autonomous motivation in leisure-time had a statistically significant effect on attitudes ($\beta = .425$, CI_{95} [.298, .552], $p < .001$), subjective norms ($\beta = .264$, CI_{95} [.109, .419], $p = .001$), and PBC ($\beta = .517$, CI_{95} [.389, .644], $p < .001$). All effects were

TABLE 1 Parameter estimates (β) with 95% confidence intervals for hypothesized effects from the single indicator structural equation model of the trans-contextual model

Independent variable	Dependent variable	Mediator	β	95% CI		p
				LL	UL	
Direct effects						
PAS	Aut. mot. (PE)		.345***	.213	.478	.000
PAS	Aut. mot. (LT)		.039	−.103	.180	.593
PAS	Physical activity		.126	−.016	.269	.082
PAS	Intention		.106	−.025	.237	.111
Aut. mot. (PE)	Aut. mot. (LT)		.484***	.355	.614	.000
Aut. mot. (PE)	Intention		−.040	−.197	.117	.618
Aut. mot. (LT)	Attitude		.425***	.298	.552	.000
Aut. mot. (LT)	Sub. norm		.264**	.109	.419	.001
Aut. mot. (LT)	PBC		.517***	.389	.644	.000
Aut. mot. (LT)	Intention		.376***	.210	.542	.000
Aut.mot. (LT)	Physical activity		.094	−.101	.290	.345
Attitude	Intention		.231**	.080	.383	.003
Sub. norm	Intention		.185*	.014	.355	.034
PBC	Intention		.069	−.139	.277	.514
Intention	Physical activity		.198*	.012	.384	.037
PBC	Physical activity		−.243*	−.437	−.048	.015
Indirect effects						
PAS	Aut. mot. (LT)	Aut. mot. (PE)	.167***	.086	.248	.000
Aut. mot. (LT)	Intention	Attitude	.098**	.028	.168	.006
Aut. mot. (LT)	Intention	Sub. norm	.049	−.004	.101	.069
Aut. mot. (LT)	Intention	PBC	.036	−.072	.143	.514
Aut. mot. (PE)	Intention	Aut. mot. (LT) Attitude	.048*	.011	.084	.011
Aut. mot. (PE)	Intention	Aut. mot. (LT) Sub. norm	.024	−.003	.050	.079
Aut. mot. (PE)	Intention	Aut. mot. (LT) BC	.017	−.035	.070	.516
Aut. mot. (PE)	Physical activity	Aut. mot. (LT) Attitude Intention	.009	−.002	.021	.104
Aut. mot. (PE)	Physical activity	Aut. mot. (LT) Sub. norm Intention	.005	−.002	.011	.171
Aut. mot. (PE)	Physical activity	Aut. mot. (LT) PBC Intention	.003	−.008	.015	.548
Aut.mot (LT)	Physical activity	Intention	.074	−.001	.150	.055
Aut. mot. (LT)	Physical activity	Attitude Intention	.019	−.003	.042	.094
Aut. mot. (LT)	Physical activity	Sub. norm Intention	.010	−.004	.023	.162
Aut. mot. (LT)	Physical activity	PBC Intention	.007	−.016	.030	.546

(Continues)

TABLE 1 (Continued)

Independent variable	Dependent variable	Mediator	β	95% CI		p
				LL	UL	
Attitude	Physical activity	Intention	.046	−.006	.098	.084
Sub. norm	Physical activity	Intention	.037	−.010	.083	.126
PBC	Physical activity	Intention	.014	−.031	.058	.546
Sums of indirect effects						
Aut. mot. (LT)	Intention	Multiple[a]	.183***	.084	.281	.000
Aut. mot. (LT)	Physical activity	Multiple[a]	−.015	−.146	.117	.825
PAS	Physical activity	Multiple[a]	.035	−.007	.076	.103
Total effects						
PAS	Aut. mot. (LT)	Multiple[b]	.206**	.068	.344	.003
PAS	Intention	Multiple[b]	.207**	.071	.344	.003
PAS	Physical activity	Multiple[b]	.161*	.023	.299	.022
Aut. mot. (LT)	Intention	Multiple[b]	.559***	.428	.690	.000
Aut. mot. (LT)	Physical activity	Multiple[b]	.079	−.064	.233	.279
Correlations						
Attitude ↔ Subjective norm			.114	−.064	.291	.210
Attitude ↔ PBC			.291**	.119	.463	.001
Subjective norm ↔ PBC			.429***	.253	.605	.000

Abbreviations: 95% CI = 95% confidence interval of path coefficient; Aut. mot. (PE) = Autonomous motivation (physical education); Aut. mot. (LT) = Autonomous motivation (leisure-time); PAS = Perceived autonomy support; PBC = Perceived behavioral control; Physical activity = Self-reported participation in leisure-time physical activity; Sub. norm = Subjective norm; β = Standardized parameter estimate.

[a]Mediators for this effect included effects of the predictor on the outcome through multiple mediators.

[b]Mediators for this effect included effects of the predictor on the outcome through multiple mediators along with the direct effect of the predictor variable on the outcome.

*p < .05; **p < .01; ***p < .001.

small-to-medium in size. Attitudes (β = .231, CI_{95} [.080, .383], p = .003) and subjective norms (β = .185, CI_{95} [.014, .355], p = .034) exhibited statistically significant effects on intention with small effect sizes, but there was no effect of PBC on intention and the effect size was small (β = .069, CI_{95} [−.139, .277], p = .514). The hypothesized effect of intention on leisure-time PA was statistically significant with a small effect size (β = .198, CI_{95} [.012, .384], p = .037). The direct effect of perceived autonomy support on intention was not statistically significant and the effect size was small (β = .106, CI_{95} [−.025, .237], p = .111).

Next, we focus on indirect effects in the model. We found a statistically significant indirect effect of perceived autonomy support on autonomous motivation in leisure-time mediated by autonomous motivation in PE (β = .167, CI_{95} [.086, .248], p < .001), with a non-trivial effect size. The indirect effect of autonomous motivation in leisure-time on intention mediated by attitude was statistically significant with a small effect size (β = .098, CI_{95} [.028, .168], p = .006). Indirect effects of autonomous motivation in leisure-time on intention mediated by subjective norm (β = .049, CI_{95} [−.004, .101], p = .069) and PBC (β = .036, CI_{95} [−.072, .143], p = .514) were not statistically significant and the effect sizes were small. The indirect effects of attitudes (β = .046, CI_{95} [−.006, .098], p = .084), subjective norms (β = .037, CI_{95} [−.010, .083], p = .126), and PBC (β = .014, CI_{95} [-031, .058], p = .546) on PA participation mediated by intention were not statistically significant with small effect sizes. There were statistically significant total effects of perceived autonomy support in PE on intention (β = .207, CI_{95} [.071, .344], p = .003), and PA participation (β = .161, CI_{95} [.023, .299], p = .022), with non-trivial effect sizes.

4 | DISCUSSION

The present study applied the TCM to explain the process by which children's motivation in a school PE context relates to motivation, beliefs, and intentions toward, and actual participation in, leisure-time PA. The model advances previous research applying the model by examining its effectiveness in accounting for change in model constructs over time. The research is expected to provide further formative evidence to inform the development of interventions aimed at promoting leisure-time PA participation delivered in PE context. Current findings provided support for some, but not all, of the key premises of the TCM when accounting for change over time. Specifically, perceived autonomy support predicted autonomous motivation in a PE context directly, and autonomous motivation in a

leisure-time PA context indirectly mediated by autonomous motivation in PE. In addition, we found direct effects of autonomous motivation in leisure-time on attitudes, subjective norms, and PBC. There was also an indirect effect of autonomous motivation in leisure-time on intentions mediated by attitudes, and a direct effect of autonomous motivation in leisure-time on intentions. There were direct effects of intentions and PBC on PA behavior, although the effect of PBC was negative, contrary to predictions. However, we did not find indirect effects of autonomous motivation in leisure-time and the belief-based constructs on PA behavior indirectly mediated by intentions, contrary to predictions. However, we found total effects of perceived autonomy support in leisure-time on PA intentions and behavior through the entire motivational sequence of the TCM.

Current findings support two of the central premises of the TCM: effects of perceived autonomy support on autonomous motivation in PE, and the critical trans-contextual relationship between autonomous motivation in PE and leisure-time PA contexts. Consistent with research testing the model using traditional "static" methods, current findings support these relations when accounting for change over time. Evaluating model effects using the change score model is a more robust test of the TCM and is more faithful to the original proposal of the model as it should be able to account for change in constructs and, in particular, behavior over time. Results provide evidence that students' perceptions that their teachers support their autonomy is related to their autonomous motivation toward the physical activities they do in PE, and also translates to their autonomous motivation toward activities outside of school. These findings have important implications for interventions to promote autonomous motivation among students in both contexts. Research suggests that PE teachers can foster autonomous motivation in PE by displaying key autonomy supportive behaviors (e.g., listening, providing positive feedback, providing choice, providing a clear rationale, assisting setting of autonomous goals), and that such behaviors lead to increased perceptions of autonomy support in students (Cheon, Reeve, & Moon, 2012; Reeve & Cheon, 2020). If such behaviors are effective in changing perceptions of autonomy support, as indicated in the literature, they may lead to changes in school and out-of-school autonomous motivation according to the TCM. While the effects of such interventions need to be empirically verified, these findings may signpost a key strategy that may have utility in promoting positive changes in autonomous motivation and PA across contexts (Ntoumanis et al., 2020).

That changes in autonomous motivation toward PA in leisure-time were also related to the sets of beliefs (attitudes, subjective norms, and PBC) that underpin intentions to participate in PA, also supports a key process in the TCM, as well as previous correlational research demonstrating these relations (Chan et al., 2020). Furthermore, attitudes mediated the effects of autonomous motivation on intentions, as predicted by the model and previous integrative research on the TPB and SDT (Hagger & Chatzisarantis, 2009). Importantly, current findings are consistent with previous research in an adult sample that has also demonstrated that changes in autonomous motivation lead to changes in beliefs and intentions (Jacobs, Hagger, Streukens, De Bourdeaudhuij, & Claes, 2011). What is the value of the inclusion of these beliefs as intermediary constructs between autonomous motivation and intentions? As Deci and Ryan (1985) suggest in their original specification of SDT, individuals holding autonomous motives toward behaviors will likely seek out those behaviors, primarily because they are associated with adaptive, self-referenced outcomes and fulfillment of psychological needs, and, in order to do so, they will strategically align their beliefs and intentions with their motives. The TCM formalizes these proposals and capitalizes on the TPB, a preeminent theory outlining the belief-based determinants of intentions and behavior, as a means to do so. Importantly, current findings provide further evidence to support this process by incorporating change processes. This suggests that these processes hold when accounting for naturally occurring changes in these constructs over time. They also may signpost that changes in autonomous motivation toward PA brought about by contexts that support autonomy may lead to changes in beliefs and intentions. This illustrates one of the additional, often overlooked, advantages of the TCM which is that it provides multiple potential targets for interventions across contexts. For example, significant others like parents and peers may provide support for students' autonomy toward PA in a leisure-time context, and interventions using autonomy support in these groups may be additional means to promote autonomous motivation and intentions toward PA (Teixeira et al., 2020).

However, caution must be exercised when evaluating the effectiveness of the TCM in determining change in PA behavior. Current findings indicate that although intentions toward PA were related to actual participation in PA, the size of the effect was small, much smaller than the effect sizes identified in previous meta-analyses of the TCM (Hagger & Chatzisarantis, 2016) and integrated models of the TPB and SDT (Hagger & Chatzisarantis, 2009). This suggests that intention change may not be very effective in accounting for change in PA participation, and that previous estimates of the size of the intention-behavior relationship based on "static" tests that do not account for change may be inflated, a finding that has been reported elsewhere (Webb & Sheeran, 2006). The small effect size also means that changes in intentions did not transmit effects of changes in beliefs and autonomous motivation to PA behavior. Although the model appears to have efficacy in explaining variance in autonomous motivation and intention change, it seems that it does not account for substantive variance in actual PA change. This raises questions over the effectiveness of the model when it is evaluated taking change into account.

It is important to note that we found a statistically significant small-to-medium sized total effect of perceived autonomy support on PA behavior—this effect comprised the total indirect effect and the direct effect of perceived autonomy support. The direct effect of perceived autonomy support on PA behavior was expected to be zero, and accounted for by the motivational sequence offered by the model. Therefore, although neither the direct nor the indirect effect of perceived autonomy support on behavior was statistically significant, the combined effect was, and was non-trivial in size. There may be a number of reasons for this pattern of effects. One

reason may be limitations in the measures of the TCM constructs. This means that these measures were not sufficient to account for the effect of perceived autonomy support change on PA behavior change. While reliability coefficients of these constructs were reasonable, some researchers have indicated that use of self-report measures reduce the precision of model tests (Fan et al., 2006). Given that all constructs were measured using self-report, such imprecision may have introduced substantive method variance, which may have attenuated relations. Another possibility is that other unmeasured constructs may be responsible for explaining the relationship between perceived autonomy support and PA behavior. For example, the current study did not take into account psychological need satisfaction, another key mediator of perceived autonomy support (Fenner, Straker, Davis, & Hagger, 2013). There is also the possibility that implicit motives that may represent more "automatic" or "non-conscious" effects are important in explaining model relationships (e.g., Hagger, Trost, Keech, Chan, & Hamilton, 2017; Keatley, Clarke, & Hagger, 2012). Nevertheless, the lack of mediation from autonomous motivation raises questions about the proposed process by which perceived autonomy support in PE translates to PA participation in leisure-time.

4.1 | Strengths, limitations, and future directions

Strengths of the current research are the adoption of the TCM, an appropriate integrated model that provides a clear set of predictions on the motivational determinants of PA across contexts, the use of robust, previously validated measures, and the adoption of a three-wave design to account for change in model constructs over time. However, several limitations need to be acknowledged. First, although the TCM includes numerous determinants of PA, the determinants are confined to a relatively narrow set of constructs. For example, the model focused on perceived autonomy support as a determinant of autonomous motivation in PE, and neglected to include student perceptions of other teacher-related behaviors such as controlling behaviors that might have undermined PA participation in school. In addition, the model did not incorporate other environmental factors derived from ecological models of behavior, such as facility availability or neighborhood walkability, which have been shown to be important determinants of PA (e.g., Olson, Ireland, March, Biddle, & Hagger, 2019; Salmon, Hesketh, Arundell, Downing, & Biddle, 2020). Research exploring effects of these additional constructs should be considered in future extensions of the model. Second, while the current data accounted for naturally occurring intra-individual change over time, the data are still correlational. More effective means to explore change would be through manipulation of key model variables experimentally or through interventions, such as an intervention to change autonomy support, and is a key avenue for future research (Chatzisarantis & Hagger, 2009; Hagger, Cameron, et al., 2020). Third, related to the previous point, while the temporal ordering implied directional relations among constructs, causal effects are inferred only by theory and not the data. Again, experimental manipulations are paramount for such inferences. Finally, we also modeled change using two or, in the case of behavior, three time points. Future research should consider adopting multiple measures and assessing change using growth curve models, which has often been cited as the method of choice for effectively modeling change (Rogosa, Brandt, & Zimowski, 1982). However, such analyses involve a large number of parameters, and we had insufficient sample size to estimate such a model. Studies using larger samples and multiple time points are needed for a more fine-grained evaluation of change.

5 | CONCLUSION

The TCM was applied to outline how changes in perceived autonomy support from PE teachers and autonomous motivation in school PE related to changes in autonomous motivation toward PA in a leisure-time context, and changes in beliefs, intentions, and future participation in PA. Although research supported the model in explaining change in autonomous motivation across contexts, including prediction of PA participation and total effects of perceived autonomy support on PA participation, effect sizes were small. Current findings suggest that the TCM does not account for substantial variance in change in PA intentions and behavior. Nevertheless, it should be noted that even small changes in outcomes may translate to substantive changes when translated to the population level.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the Supporting Information section.

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III

USING PHYSIAL EDUCATION TO PROMOTE OUT-OF-SCHOOL PHYSICAL ACTIVITY IN LOWER SECONDARY SCHOOL STUDENTS – A RANDOMIZED CONTROLLED TRIAL PROTOCOL

by

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STUDY PROTOCOL Open Access

Using physical education to promote out-of school physical activity in lower secondary school students – a randomized controlled trial protocol

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Abstract

Background: Given the documented decline in levels of physical activity in early adolescence, promoting physical activity in young people is a priority for health promotion. School physical education (PE) is an important existing network in which participation in physical activity beyond school can be promoted to the captive young people. The objective of current article is to present the protocol for a PE teacher-delivered theory-based trial to promote secondary school students' participation in physical activity out-of-school contexts. The intervention will be guided by the trans-contextual model explaining the processes by which PE teachers' support for autonomous motivation in the classroom promotes students' motivation to engage in out-of-school physical activity. We hypothesize that school students receiving the teacher-delivered intervention to promote autonomous motivation toward physical activity will exhibit greater participation in physical activities outside of school, relative to students receiving a control intervention.

Methods: The trial will adopt a waitlist-control design with cluster-randomization by school. PE teachers assigned to the intervention condition will receive a two-week, 12-h training program comprising basic information on how to promote out-of-school physical activity and theory-based training on strategies to promote students' autonomous motivation toward physical activity. Teachers assigned to the waitlist control condition will receive an alternative training on how to monitor physical functional capacity in children with special needs. PE teachers ($n = 29$) from eleven schools will apply the intervention program to students ($n = 502$) in PE classes for one month. Physical activity participation, the primary outcome variable, and psychological mediators from the trans-contextual model will be measured at pre-trial, post-trial, and at one-, three- and six-months post-trial. We will also assess teachers' autonomy-supportive techniques and behaviours by observation.

Discussion: The study will make a unique contribution to the literature by testing a theory-based intervention delivered by PE teachers to promote school students' participation in out-of-school physical activity. Information will be useful for educators, community stakeholders and policy makers interested in developing programs to promote students' out-of-school physical activity.

Trial registration: ISRCTN39374060. Registered 19.7.2018.

Keywords: Autonomy support, Behavioural intervention, Trans-contextual model, Self-determination theory, Theory of planned behaviour, Intervention development

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Background

Promoting physical activity in school

Epidemiological data consistently indicate that levels of physical activity decline with age [1]. Consistent with these trends, national survey data from Finland indicate a decline in physical activity during adolescent years with only 41% of 11-year olds and 17% of 15-year olds meeting current national guidelines for physical activity [2]. Given that low levels of physical activity are related to increased risk of chronic illness later in life, and increased rates of conditions such as overweight and obesity [3, 4], the promotion of physical activity participation among young people is a public health priority. Physical education (PE) stands in an advantageous position for promoting the benefits of leisure physical activity as it addresses young, diverse and captive audiences [5]. Importantly, it is through PE that young people experience a variety of physical activities, and it is these experiences that may determine future involvement in physical activity during leisure time [6]. One of the primary aims of PE is to provide young people with the necessary motor skills, knowledge and competence to choose and participate in health-related physical activity in their leisure time [7]. Nevertheless, there is relatively little research outlining how PE teachers or PE programs can effectively orient young people toward participation in regular leisure-time physical activity outside of school.

The present article outlines the protocol of a trial in which PE teachers will be trained to support autonomous motivation toward leisure-time physical activity in lower-secondary school students (the PETALS trial). The trial aims to capitalize on school PE as an existing network to promote out-of-school physical activity in secondary school students. The trial will adopt a cluster randomized design and implement an intervention based on psychological theory to train participating teachers in techniques that support school students' motivation to participate in physical activity in their leisure time outside of school. Trial effectiveness will be evaluated in terms of effects on participating school students' post-intervention out-of-school physical activity participation. The theoretical basis for the intervention will be described next, followed by the study objectives.

Theoretical basis for the intervention

The identification of factors that determine physical activity participation, and the processes by which they affect action, is paramount in providing formative evidence on which to base effective behavioural interventions [8]. The application of psychological theory, particularly theories of motivation and attitudes, has been at the forefront of providing an evidence base for the factors that drive participation in physical activity [9, 10]. However, only recently has this evidence has been applied to understand how teachers can promote students' physical activity outside of school [10]. Such evidence is essential as it provides guidance on the content of interventions likely to be effective in promoting physical activity participation.

Self-determination theory is a prominent theory of motivation that has been applied to understand participation in health behaviours like physical activity [11, 12]. Central to the theory is the construct of self-determined or *autonomous* motivation. This form of motivation reflects an individuals' general reflection on the causes of their action. Self-determined or autonomously-motivated individuals engage in actions such as physical activity out of interest, choice, and the sense of personal involvement they feel when engaged in the physical activities. In contrast, individuals who feel that their actions are less self-determined are likely to feel that their actions are controlled by external contingencies and engage in activities because they feel pressured, forced or obliged to do so. Research has indicated that autonomously-motivated individuals are more likely to persist with activities and more likely to gain positive or adaptive outcomes [13]. There is increasing research demonstrating that autonomous motivation is related to uptake and persistence with health behaviours [14] particularly physical activity [15, 16]. The proposed mechanism by which autonomous motivation leads to adaptive outcomes is through greater interest, effort, and involvement in the task [17].

Given that autonomous motivation has been shown to be related to persistence on adaptive behaviours, researchers and interventionists have sought to identify the contexts and conditions that promote and give rise to autonomous motivation. In particular, the focus on motivational 'environment' or 'climate' provided by the actions of significant others with leadership roles (e.g., coaches, teachers, instructors, bosses) has been shown to be influential in developing autonomous motivation. Specifically, leaders' autonomy-supportive behaviours such as provision of choice and support for self-directed action have been shown to promote autonomous motivation and persistence in individuals operating in that environment [18, 19]. In addition, individuals' perception that significant others in their environment are autonomy supportive have been shown to be strongly related to autonomous motivation as well as other adaptive outcomes in multiple contexts [14, 20–22]. In educational contexts, therefore, teachers can take the lead role in fostering autonomous motivation toward learning activities in the classroom by adopting autonomy supportive behaviours. Autonomy support focuses on style and delivery of lesson content rather than the content itself [23]. Interventions that have adopted autonomy support techniques and interactive styles have been found to be effective in multiple contexts in producing positive motivational and behavioural outcomes. Importantly, evidence exists that autonomy-

supportive interventions can produce long-term changes in motivation and behaviour in academic settings [24, 25].

While there is considerable research demonstrating links between the use of autonomy-supportive intervention techniques and student autonomous motivation and adaptive outcomes in class, comparatively less research has focused on the role that autonomy support in educational settings has on students' behaviour outside the class (e.g., participation in sport and physical activities during leisure time). Recent theory has proposed the potential mechanisms by which autonomy support in an educational context like PE may lead to participation in physical activities outside of school. Capitalizing on multiple theories of motivation, particularly self-determination theory [12] and the theory of planned behavior [26] the trans-contextual model (TCM) was developed [6]. The model (Fig. 1) outlines how teachers' autonomy support for in-class activities in PE context transfers to autonomous motivation toward, and future intentions to engage in, leisure-time physical activity in an out-of-school context. According to the model, teachers' promotion of students' autonomous motivation toward physical activities in PE will lead individuals to strategically align their motivation, beliefs, and intentions toward similar activities in related contexts with those motives. A review and meta-analysis of studies adopting the model provided support for model predictions across multiple studies [10]. In particular, the analysis supported links between autonomy support from teachers and autonomous motivation in school, consistent with previous research [27, 28]. In addition, the research supported trans-contextual links between autonomous motivation in school and autonomous motivation, beliefs (attitudes, subjective norms, and perceived behavioural control), and intentions toward participation in physical activity outside of school, and actual participation in physical activity outside of school.

The trans-contextual model provides a theoretical framework for developing interventions in educational contexts such as school PE to promote motivation toward, and actual participation in, related activities such as physical activity outside of school. The model implies that strategies aimed at fostering autonomous motivation will promote in-school and out-of-school autonomous motivation toward physical activity, and promote adaptive beliefs and intentions toward out-of-school physical activity and actual physical activity participation. These proposed effects are supported by research demonstrating the trans-contextual effects and confirming the relevant mechanisms involved [10]. The most effective means to support autonomous motivation in school is for teachers to display autonomy-supportive behaviours during PE lessons. Consistent with the model, effects of interventions aimed at promoting autonomy support in students on out-of-school physical activity is expected to be mediated by autonomous motivation in both contexts, beliefs, and intentions. Together, these mediators provide a demonstration of how the intervention functions in promoting physical activity behaviour. In other words, it provides a framework on *how* the intervention works.

The primary focus of this study is to test the effectiveness of an intervention based on the trans-contextual model in promoting out-of-school physical activity.

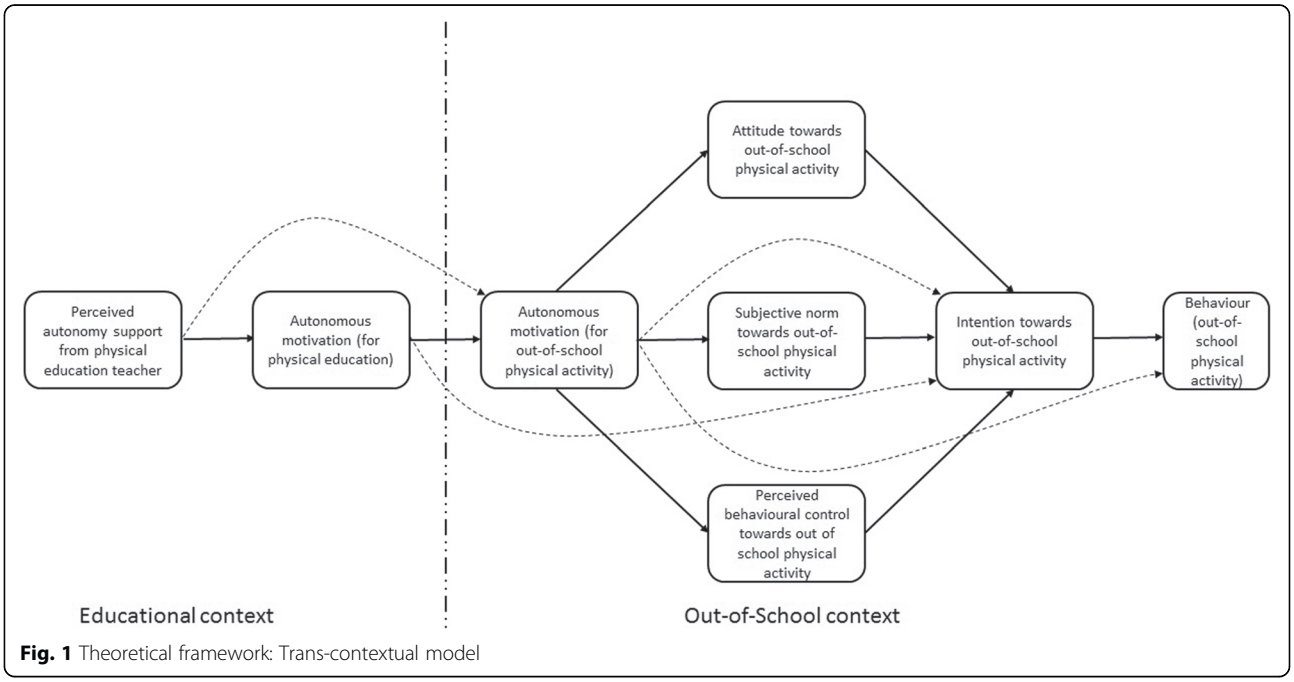

Fig. 1 Theoretical framework: Trans-contextual model

However, we will also control for key demographic, environmental, and psychological variables that may moderate or affect intervention effects. With respect to demographic variables, we will control for effects of student's age, gender, nationality, ethnicity and parental education level, given the potential for these variables to affect levels of physical activity and engagement in school. With respect to environmental variables, the autonomy support offered by parents and peers towards out-of-school physical activity, parental affection, and parental control may affect students' performance and engagement in school [29, 30] and will also be considered covariates in our analysis of intervention effectiveness. Finally, we will also control for individual difference characteristics that have been shown to affect students' motivation in previous research. These variables include grit [31] and self-discipline [32], two factors shown to be related to long-term effort and perseverance on tasks. Finally, we will also control for the extent to which students habitually perform physical activity out-of-school. The intervention may have less effect on students who have strong exercise habits, as they are already likely to exercise regularly and are unlikely to respond to motivational messages.

Objectives

The purpose of the current protocol article is to report the development of a school-based intervention based on the trans-contextual model to promote secondary school students' physical activity participation by fostering autonomous motivation (the PETALS trial). The trial will adopt a cluster-randomized waitlist-control design, and participants will be teachers of lower-secondary school PE classes and their students. The intervention will involve initial training of PE teachers of lower-secondary PE classes on the use of autonomy support strategies in their regular lessons, followed by an implementation period in which teachers apply their training in regular PE classes. Effects of the intervention will be evaluated through changes in subsequent follow-up measures of participating students' physical activity levels and trans-contextual model variables relative to pre-trial baseline measures. We will also evaluate effects of the intervention on PE teachers' autonomy-supportive behavior measured using self-report and observation. We will also control for support for autonomy from parents and peers. Other salient demographic and individual difference variables will be also controlled for. We expect the research will provide formative evidence of an effective, replicable, low-cost behavioural intervention, which will help in developing long-term participation in physical activity in young people. In addition, key deliverables of the research will be a set of training materials and an intervention manual, which will provide step-by-step accessible instructions on how to implement the intervention and can be disseminated to schools with no specialist knowledge and minimal cost.

Methods

Trial design

The study will adopt a cluster-randomized, wait-list control, single-arm intervention design with randomization by school. The trial comprises two phases: a teacher-training phase and an implementation phase. The teacher-training phase will comprise a two-week, 12-h training program in which secondary school teachers will receive the autonomy-support training program developed for the present study. The teacher-training program will be preceded by the pre-trial data collection occasion during which baseline measures of primary and secondary outcome variables will be taken. The training will be delivered by experienced teacher trainers as part of the teachers' regular in-service training. The implementation phase will comprise a one-month period during which teachers will apply their training in their regular PE classes and it is followed by post-trial data collection occurrence. Thereafter, primary and secondary outcome variables will be collected at one-, three-, and six-month follow-up data collection occasions. Teachers allocated to the waitlist control condition receive a 4-h training program in which they will be instructed on how to apply a monitoring system for physical functional capacity in children with special needs [33]. Secondary school teachers ($N = 29$) from 11 secondary schools and their students ($N = 502$) in the city of Jyväskylä in central Finland will be invited to participate in the study.

Participants and eligibility criteria

Qualified full-time PE teachers teaching regular PE lessons in lower secondary schools will be eligible to participate in the study. Participating teachers will be asked to select one of their PE classes to be invited to participate in the study. Students in grades 7–9 (typical ages 13–15 years) in lower secondary schools will be eligible to participate. Students with existing physical or mental health condition that prevents participation in PE lessons, regular physical activity or completing surveys will be excluded. The proposed participant flow diagram through the trial is presented in Fig. 2.

Recruitment process and informed consent

All available lower secondary level school PE teachers in the city will participate in the teacher-training phase of the study, irrespective of their participation, as the city Education Department has accepted the teacher-training phase to be part of PE teachers' regular in-service training. We will recruit PE teachers and their students for the study via established links with schools and with

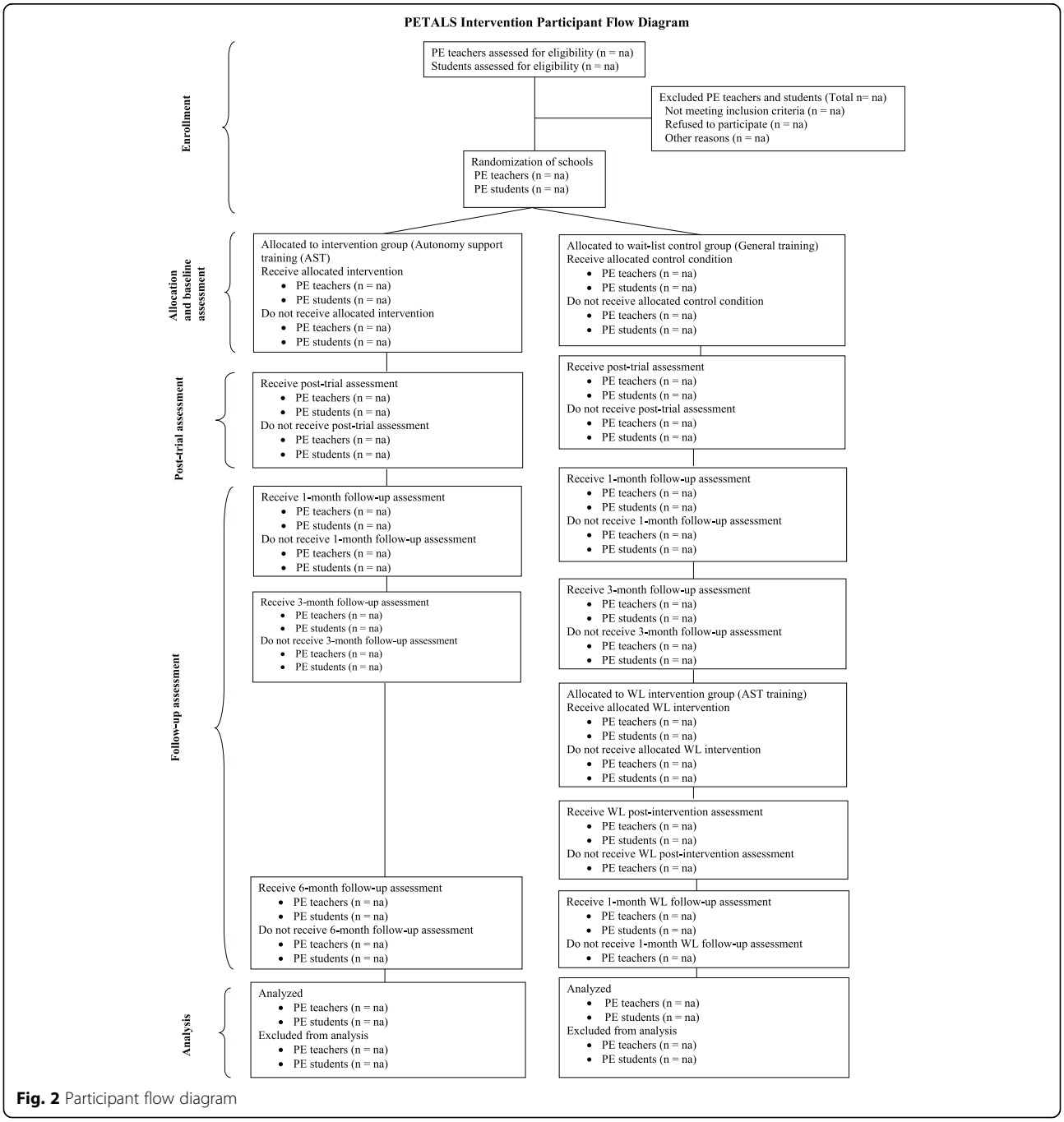

Fig. 2 Participant flow diagram

support from the Education Department. Initial contact will be made with the head teacher of the school provided with details of the study aims and methods and the commitment required by the school. Once head teacher has consented their school to participate in the study, eligible teachers from each school will be invited to participate and provided with information on the study, and the benefits and requirements of participation, and given the opportunity to ask questions. Teachers agreeing to participate to the study will complete an opt-in informed consent form. Students of the PE teachers will be recruited to the study by referral from their teacher. Invitation letters, study information, and opt-out consent forms, with the exception of opt-in consent form for participation in the accelerometry component of the study measures, will be sent to eligible students' parents or legal guardians via the schools' online administration and communication software or via email or post. Students whose parents or guardians decline to give consent for their child to participate in the

study will be exempted, and will be provided with alternative activities while participating students complete study measures at data collection time points.

Procedure and data collection methods

The pre-trial baseline data collection will be scheduled for the third week after the beginning of the 2018–2019 school year. The following data will be collected: questionnaires administered to participating teachers and students comprising self-report measures, a one-week physical activity surveillance for participating students using accelerometers, and audio recordings of a selected PE class of each participating PE teacher. At pre-trial, all consenting teachers and students will complete a questionnaire containing demographic, psychological, and behavioural measures. Audio recordings of participating teachers' classes will also take place during the baseline data collection. Physical activity behaviour will be collected from a subsample of students from the intervention and wait-list control groups using accelerometers for the week after the pre-trial data collection occasion. In addition, parents or legal guardians of participating students will complete self-report measures of demographic information, provision of autonomy support towards out-of-school physical activity, parental affection, and parental control they provide for their children at the baseline data collection.

Pre-trial data collection will be followed, consecutively, by the teacher training and implementation phases of the trial. In the teacher training phase, teachers allocated to the intervention group will receive the autonomy-support training program and teachers allocated to the wait-list control group will receive control education program over the same period. The completion of the training program will be followed by a 1 month implementation phase. In this phase, teachers in the intervention group will apply the techniques they learned in the training program in their regular PE classes.

Following the implementation phase, a post-trial data collection occasion will be scheduled. Data collection will comprise administration of measures identical to those at pre-trial with the exception of the baseline measures of behavioural automaticity, grit, self-discipline, parental affection, parental control, parental autonomy support and demographic measures. Accelerometer data and audio recordings of teachers' lessons will also be collected from the same subsample of students and teachers, respectively. Follow-up data collection occasions are scheduled for one-, three-, and six-months post-trial. Accelerometer data from the subsample of students and audio recordings of teachers' lessons will not be collected on the one-month follow up occasion. All assessments will be completed at the three- and six-month follow up data collection occasions, identical to the post-trial data collection occasion. Immediately after the three-month follow up data collection occasion, the wait-list control group will receive the autonomy-support training program. Post-trial and one-month follow up assessments will be conducted for teachers and students from this group, using identical measures as those administered in the intervention group (Fig. 3). Retention of participants will be maximized through pro-active email and telephone communication with school teachers who will provide access to students. Where collection of data on any given collection occasion is prevented due to unforeseen circumstances, we will negotiate an alternative occasion for the data collection as close as possible to the scheduled occasion.

Intervention

Autonomy support intervention group

Teachers in schools allocated to the intervention condition will receive the twelve-hour interactive autonomy support teacher-training program developed specifically for this study. The program aims to familiarize PE teachers with techniques and strategies aimed at promoting students autonomous motivation toward out-of-school activities. The program focuses on six sets of autonomy-supportive strategies and techniques: Taking students' perspective, using non-controlling and informational language, providing a rationale, displaying patience, providing choices, and accepting negative

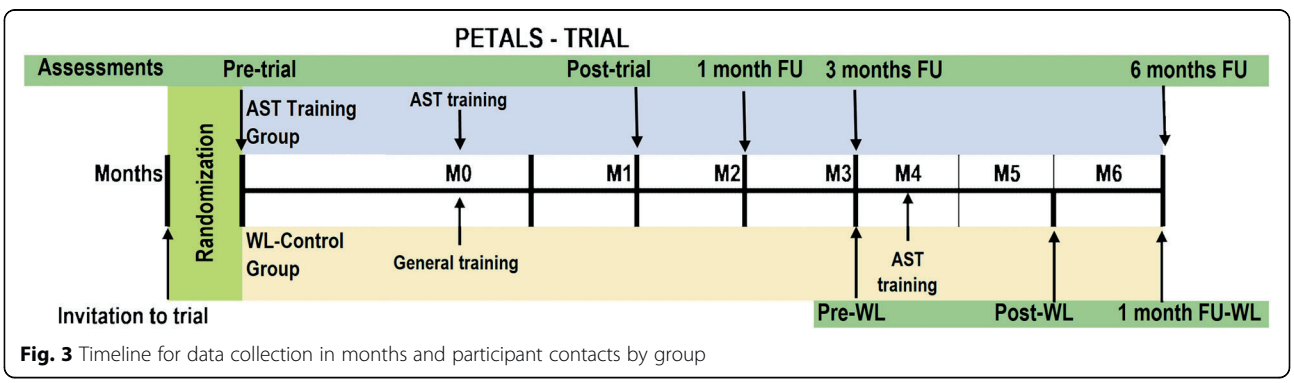

Fig. 3 Timeline for data collection in months and participant contacts by group

emotions and feelings. The techniques are adapted from the strategies identified in previous autonomy support training programs [34–37]. The training will be delivered by two trained teacher trainers with extensive experience of PE and teacher education. The trainers will undergo a familiarization session with the core research team in which they will be introduced to the training material (manual, power point presentations, supportive material) and provided with instruction on how to deliver the program prior to implementation of the training. A summary of session content and related delivery techniques are presented in Table 1.

The teacher training was developed in three stages. In the first stage, we identified the most effective autonomy supportive techniques and means to deliver them to PE teachers based on current evidence. We therefore reviewed the existing literature on autonomy support techniques and training programs. Previous successful applications of autonomy support interventions in general classroom [38] and PE settings [39], as well as feasibility [36] and conceptual articles on autonomy support [34, 40] were identified. In addition, we acquired teacher training material from existing autonomy support training programs used in previous interventions [35, 37].

Table 1 Description of teacher training program: Content and matched behaviour change techniques for each session

Session topic	Content	Behaviour change techniques[a]
1. Introduction and added value of the training to teaching practice	Introduction and warm up activities Information on the added value of the training and expectations Explore current supportive style and reflection Why autonomy support matters Introduction to self-determination theory	Social support (unspecified) Social support (practical) Discrepancy between current behaviour and goal Shaping knowledge Information about social and environmental consequences Imaginary reward
2. Autonomy supportive techniques: Description and benefits for students and teachers	Basics of the autonomy supportive teaching techniques: Definitions and implementation examples Using autonomy supportive techniques: Benefits for students and teachers based on previous research results	Demonstration of the behaviour Shaping knowledge Information about social and environmental consequences Behavioural practice/rehearsal
3. Use of autonomy supportive techniques to provide instructions	How, when, and why to use autonomy supportive techniques when giving instructions (organizational, technical and tactical) Taking students' perspective Using non-controlling and informational language Providing rationale Providing choices Displaying patience	Information about social and environmental consequences Instruction on how to perform a behaviour Behaviour substitution Habit reversal Framing/ reframing Self-monitoring of behaviour Behavioural experiments Behavioural practice/rehearsal Graded tasks
4. Use of autonomy supportive techniques to provide feedback, encouragement, and praise	How, when, and why to use autonomy supportive techniques when providing feedback, encouragement, and praise Using non-controlling and informational language Taking students' perspective Displaying patience	Generalization of a target behaviour Behaviour substitution Habit reversal Framing/ reframing Information about social and environmental consequences Instruction on how to perform a behaviour
5. Use of autonomy supportive techniques to deal with discipline issues and off-task behaviours	How, when, and why to use autonomy supportive techniques when dealing with discipline issues and off task behaviours Taking students perspective Accepting negative affect Providing rationale Using non-controlling and informational language Displaying patience Providing choices	Self-monitoring of behaviour Behavioural experiments Behavioural practice/rehearsal Graded tasks
6. Building personalized action plans	Plan changes in own teaching practice: Specific goals and plans for change when giving instructions, provide feedback, and respond to students with low motivation Identify barriers and problem solving for using the autonomy supportive techniques in every day teaching practice Development of their individualized infographic poster	Generalization of a target behaviour Goal setting Action planning (and implementation intention) Instruction on how to perform a behaviour Prompts/cues Adding objects to the environment Pros and cons Social support unspecified

[a] From behaviour change technique taxonomy (Version 1) [66]

Next, we developed a list of training activities and delivery techniques considered effective and relevant to the proposed intervention. We also conducted a mapping exercise guided by a recent study outlining self-determination theory techniques and constructs [23] to ensure that the training activities and delivery techniques precisely matched the theory-based motivational determinants (e.g., autonomous motivation, psychological need satisfaction) targeted in the intervention.

The second stage involved the development of a detailed draft of the teacher training program. For each session, we developed a detailed description of the program content including aims, learning outcomes, main instructional points, examples, and interactive activities. Accompanying supportive materials (worksheets, printed examples, video demonstrations, presentation slides, and session's summaries) were produced for illustration of the program content. The content and materials were reviewed and revised by the core research team.

The third and final stage involved review and revision of the entire program and materials by external stakeholders and teacher educators. Reviewers were experienced PE teachers and teacher-training experts, and researchers with expertise in the theoretical approaches on which the program was based, the delivery techniques used, and behavioural interventions conducted in school settings. The stakeholders reviewed each session content in detail in an interactive workshop with the research team. They also provided written feedback on the materials separately. Stakeholders identified issues relating to the clarity of the aims and descriptions, relevance of the examples, and overlap and redundancy in the materials. The program content and materials were further revised by the research team resulting in a final autonomy support training program with supporting materials.[1]

Wait-list control group

Participating teachers allocated to the waitlist control group will receive an alternative training program comprising 4-h of education on how to apply a monitoring system for physical functional capacity for children with special needs [33]. The control intervention is delivered in a one-day workshop by two educators experienced in PE teacher training.

Outcome measures

All self-report outcome measures were translated from English into Finnish using a back-translation process by two bilingual researcher [41].

Primary outcome variable

The primary outcome measure is students' post -intervention participation in out-of-school physical activity at the pre-trial, post-trial, one-, three and 6 month follow-up data collection occasions. Physical activity participation will be measured using the short form of the International Physical Activity Questionnaire, IPAQ [42], which will be modified to make explicit reference to out-of-school physical activity. The IPAQ comprises four items recording the frequency (number of days) and duration (hours) of participation in moderate and vigorous physical activity, walking, and sitting over the past 7 days. The physical activity score for moderate and vigorous physical activity and walking is calculated based on norms and expressed in MET-minutes per week. A score for total physical activity in out-of-school contexts is provided by the sum of the duration and frequency of vigorous, moderate and light physical activity scores. The IPAQ has acceptable concurrent validity and reliability indices [43].

Secondary outcome variables

Physical activity behaviour. A subsample of participants (approx. 120) from representative school classes covering grades 7–9 will have their physical activity participation measured using accelerometry. The purpose of this secondary measure is to provide concurrent validity and comparison data to support the IPAQ used as the primary outcome measure.[2] Participants will wear the accelerometers (Hookie AM 20) for seven consecutive days after each data collection occasions at pre-trial, post-trial, and at the three-, and six-month follow up data collection occasions. These accelerometers have been shown to be valid and reliable in as a measure of physical activity in previous research [2]. Participants will be also asked to complete a short diary of their daily in-school and out-of-school physical activities for the period during which they wear the accelerometer. Data will provide duration participants spent in sedentary, light, moderate, and vigorous intensity physical activity per day. Diary data will be used to identify duration of physical activity on in-school and out-of-school contexts. It will also provide a measure of total energy expenditure in each context. For the purposes of the current study, we will compute total time spent in light, moderate, or vigorous physical activity and total energy expenditure in out-of-school contexts as criterion measure to test the concurrent validity of the IPAQ measure in each participant. The accelerometry data will be included only for those participants who have provided valid accelerometer data for a minimum of 3 days.

Mediating variables

All students will complete a battery of self-report measures of psychological variables based on the trans-contextual model. These factors are expected to reflect the mechanisms by which the intervention affects change in the primary outcome consistent with the model.

Students' perceived autonomy support by their PE teacher Perceived autonomy support from PE teacher will be measured using items from the perceived autonomy support scale for exercise settings [44]. The scale consists of 18 items (e.g., "I feel that my PE teacher provides me with choices and options to …") and responses are provided on 7-point scales (1 = *strongly disagree* and 7 = *strongly agree*). The scale has demonstrated adequate construct validity and reliability statistics in previous research [44, 45].

Autonomous motivation, controlled motivation and amotivation toward in school and out-of-school physical activity Autonomous and controlled forms of motivation for in-school and out-of-school activities will be measured using a modified version of the perceived locus of causality questionnaire [46], and amotivation using modified version of amotivation subscale from the sport motivation scale [47]. The total scale consists of ten items with two items measuring each of the external regulation (e.g., "I do PE/ physical activity so that the teacher won't yell at me"), introjected regulation (e.g., "I do PE/physical activity because I would feel bad if the teacher thought that I was not good at PE"), identified regulation (e.g., "I do PE/physical activity because it is important to me to do well in PE/physical activity"), intrinsic regulation (e.g., "I do PE/physical activity because it is fun") and amotivation (e.g., I do PE/ physical activity but I ask myself why I do it) constructs. Responses will be provided on 7-point scales (1 = *not true for me* and 7 = very true for me). For each of the PE and out-of-school contexts, autonomous motivation scores will be computed as an average of scores on the identified regulation and intrinsic regulation items, and controlled motivation scores will be computed as an average of scores on the external regulation and introjected regulation items. Amotivation will be measured with responses provided on the same seven-point scales. Measures for autonomous and controlled motivation have demonstrated satisfactory construct validity and internal consistency statistics in previous studies [45] and measure for amotivation has demonstrated adequate level of internal consistency [47].

Attitudes, subjective norms, perceived behavioural control, and intentions Students' attitudes, subjective norms, perceived behavioural control, and intentions with respect to their future participation in physical activity will be measured using scales developed according to reported guidelines [48]. Attitudes will be measured on three items in response to a common stem: "Participating in physical activity in the next month will be…" with responses made on seven-point scales (1 = *unenjoyable* and 7 = *enjoyable*). Subjective norms (e.g., "Most people who are important to me think I should do active sports and/or vigorous physical activities during my leisure time in the next month"), perceived behavioural control ("I am in complete control over participating in physical activity in the next month"), and intentions ("I intend to do active sports and/or vigorous physical activities during my leisure time in the next month") will be measured on two items each with responses provided on seven-point scales (1 = *strongly disagree* and 7 = *strongly agree*). Previous research has supported the construct validity and internal consistency of these measures in the context of the trans-contextual model [45].

Additional measures

Observation of teacher autonomy supportive behaviours Teacher's use of autonomy-supportive behaviours in their lessons will be assessed using the tool for observing autonomy-supportive behaviours in teachers (TOAST) developed specifically for this study. The tool is a modified and extended version of checklist [49] for rating teachers' autonomy-supportive and controlling behaviours in classroom contexts. The tool was augmented to include additional content based on the list of autonomy supportive and controlling behaviours identified in previous research [18]. The checklist was also developed to closely correspond to the autonomy supportive behaviours and strategies targeted in the autonomy support training program. The tool comprises three main categories of teacher behaviour: providing instructions, praise and encouragement, and dealing with misbehaviour. Each category is coded as autonomy supportive or controlling. Two additional categories, links with out-of-school physical activity and provision of an explanation or rationale, are coded as autonomy supportive only. The tool requires observers to note the frequency of behaviours displayed by the observed teacher in each category. Overall autonomy supportive and controlling behaviours in the first three categories, and autonomy supportive behaviours in the final two categories, are calculated by summing the frequencies of the observed behaviours in each category over the observation period. The open-source BORIS software is used for coding observations [50]. Research assistants blind to the purpose of the study will be trained by project researchers to code of the audio recordings from the lessons of participating teachers' at baseline and at the scheduled follow-up data collection occurrences.

Behavioural automaticity Behavioural automaticity, an important component of habit, will be measured using the four-item self-report behavioural automaticity index [51] (e.g., "Physical activity is something I do without thinking", with responses provided on five-point scales (1 = *completely disagree* to 5 = *completely agree*). This

scale has demonstrated satisfactory reliability and validity in previous research [51].

Grit Student's grit, defined as self-rated trait-level perseverance and passion for long-term goals, will be measured using 12-item grit scale [31] (e.g., "I have overcome setback to conquer an important challenge") with responses provided on four-point scales (1 = *not like me at all* and 4 = *very much like me*). The scale has demonstrated adequate construct and predictive validity in previous research in school contexts [52].

Self-discipline Students' self-discipline will be measured using the 10-item self-discipline scale (e.g., "I tend to carry out my plans") from the IPIP-HEXACO scales [32]. Responses will be provided on four-point scales (1 = *not like me at all* and 4 = *very much like me*). Research has demonstrated the reliability and predictive validity of this scale in school contexts [52].

Perceived parental affection and control from parents Students' self-reports of their parents' or legal guardians' provision of affection, behavioural control and, psychological control will be measured using three scales taken from the modified version [29] of the child rearing practices report (CRPR) [53]: the seven-item parental affection scale (e.g., "My mother/father/legal guardian respects my opinions"), the six-item parent behavioural control scale (e.g., "When my mother/father/legal guardian gets angry, (s)he also shows it"), and the four-item parent psychological control scale (e.g., "My mother/father/legal guardian often reminds me of all the things, (s)he has done for me"). Responses will be provided on seven-point scales (1 = *not at all true* and 7 = *completely true*). Previous research has supported the construct validity and reliability of the scales [54].

Perceived autonomy support by parents (or legal guardians) and peers towards out-of-school physical activity Students' perceptions of autonomy support from their parents (or legal guardians) and peers will be measured using a four-item scale (e.g., "I feel that my parent(s)/guardian(s)/peers offer(s) me with choices, options, and opportunities to do active sports and/or vigorous exercise") based on the PASSES [44]. Responses will be provided on 7-point scales (1 = *strongly disagree* and 7 = *strongly agree*). The measure has demonstrated adequate reliability [45].

Teachers' measures

PE teachers' provision of autononomy support and control Teachers' self-report of their provision of autonomy support to students in PE lessons will be measured on an adapted six-item version of PASSES (e.g. "I feel that I provide choices and options to my physical education students") [44]. We also developed an additional item for autonomy support scale to assess teachers' self-reported provision of autonomy support for student's participation in leisure time physical activity ("I encourage my PE students to think about how physical activity during PE class can be useful to them during their free time physical activity") and provision of a rationale for students' participation in PE ("I feel that I provide choices and options to my physical education students"). Similarly, teachers self-report of their use of controlling behaviours in PE lessons will be measured using an adapted three-item version of the teacher social context questionnaire (e.g., "I always have to tell my PE students what to do") [55]. Satisfactory psychometric properties have been reported for the original versions of both measures [44, 55]. Responses to items from both scales will be provided on seven-point scales (1 = *completely disagree* and 7 = *completely agree*).

Parents' measures

Parental affection, behavioural control, and psychological control Parents' or legal guardians' perceptions of their provision of affection-, behavioural control-, and psychological control towards their child will be measured using three scales [29]: the seven-item parental affection scale (e.g., "I respect my child's opinions"), the six-item parental behavioural control scale (e.g., "When I am angry at my child, I let him/her know about it"), and the four-item parental psychological control scale (e.g., "My child should be aware of how much I sacrifice for him/her"). Responses will be provided on five-point scales (1 = *not like me at all* and 5 = *very much like me*). The scales have exhibited satisfactory psychometric properties in previous research [29].

Parental provision of autonomy support towards out-of-school physical activity Parents' or legal guardians' perception of their provision of autonomy support towards out-of-school physical activity will be measured using a four-item scale (e.g., "I encourage my child to be physically active in free-time") based on the PASSES [44]. Responses will be provided on 7-point scales (1 = *strongly disagree* and 7 = *strongly agree*).

Demographic variables

We will also ask participating PE teachers to self-report the following demographic details: age, gender, education, years of teaching experience, and number of students in their PE class. In addition, we will collect self-reported demographic details from participating students: age, grade, gender, and school. We will also collect the following demographic details from participating parents: gender, nationality of a child, ethnicity of a

child, and highest level of education. A summary of study measures, data collection occasions and methods is provided in Additional file 1.

Sample size

A statistical power analysis was conducted to estimate the required sample size for student data based on a path analysis according to published recommendations [56]. The analysis was based on a model in which the primary outcome variable of student's participation at each post-intervention follow-up occasion was regressed on the intervention condition (dummy coded as 1 = received intervention, 0 = received control) and constructs from the trans-contextual model (perceived autonomy support, autonomous motivation in PE and out-of-school, attitudes, subjective norms, perceived behavioural control, and intentions) as simultaneous predictors. Statistical power (beta) was set at 0.90 and statistical significance level (alpha) was set at 0.05, and confidence intervals of 0.068 and 0.080 for the root mean square error of approximation fit index based on previous trans-contextual models [9]. The analysis indicated that a student sample size of 286 is required to detect the effect size based on model fit. Based on typical attrition rates of 40% reported in the literature in multiple follow-up studies of physical activity [57, 58] we aim to recruit 476 student participants at baseline (n = 238 participants per intervention group).

Randomization

The core research team will enroll PE teachers and their students to the trial. Schools (N = 11) consenting to participate in the trial will be randomized to the intervention or waitlist control conditions. Randomization will be conducted by a researcher independent of the core research team using a random number generator. After generation of the random allocation sequence, the researcher will seal the names of the schools and their allocation in envelopes. Recruitment of teachers and students for the intervention and wait-list control groups will be drawn from the appropriate clusters. The cluster-randomized design precludes potential for contamination of data across conditions caused by the presence of participants from different conditions within schools. The waitlist-control design ensures that the benefits of a potentially effective intervention are not withheld from control group participants.

Blinding

The researcher who will conduct the randomization of schools to intervention conditions, and the research assistants who will code the audio-recordings of PE teachers' lessons at baseline and follow-up time points will be blind to group allocation.

Data analysis

Multilevel structural equation modelling using the Mplus, v. 8.0 software [59] will be used to test our hypotheses. All analyses will be performed using intention-to-treat analysis and supplemented by per-protocol analyses for all planned outcome variables [60]. Where data is missing for the psychological variables, we will impute missing values using linear interpolation if the data is confirmed missing completely at random. We expect to have data on our primary and secondary outcome measures, as well as mediating measures, at pre-trial and at the allotted follow-up occasions after the delivery of the intervention (post-trial, and at the one-, three-, and six-month follow up data collection occasions after the implementation period). We also expect to have self-report data on parenting from students and their parents or guardians at pre-trial. Student data will be nested within school and teacher/class, and therefore variance in outcome variables may be attributable to school-level and class-level variation as well as variation between students attributable to the intervention itself. Effects of the intervention on study outcomes can be interpreted at the student level after controlling for school- and class-level effects. Our longitudinal design enables also the examination of potential trajectories in the development of outcome variables. We will test the model at each of the follow-up time points with students' out-of-school physical activity as the primary dependent variable, the intervention condition as a dummy-coded independent variable (1 = intervention group; 0 = control group), and the psychological variables (perceived autonomy support from teachers, autonomous motivation in PE and out-of-school physical activity, attitudes, subjective norms, perceived behavioural control, intentions), as simultaneous predictors. We will statistically control for each of model variables from the previous time point using the standardized residual scores.

Monitoring and intervention adherence plan

The project is led by the core research team comprising the principal investigators, lead researchers, and a doctoral student. The project team is advised by a steering group comprising the core research team and stakeholders. The core research team holds regular meetings to monitor study progress. During intervention planning and development, two meetings with stakeholders, comprising a school PE teacher, a representative of the teacher union, the head of the in-service PE teacher training program, and the head of the city Education Department, will take place to maximize acceptability and adherence to the trial. In addition, the project team will hold regular meetings with stakeholders to discuss content and administration of the intervention. The PE teacher trainers who will deliver the autonomy support training for teachers in the intervention group will

receive a familiarization session with the research team during which they will receive instruction on the intervention aims and training materials. They will also have the opportunity to discuss the rationale and expected outcomes of the program to maximize quality of delivery. To increase responsiveness and engagement of the PE teachers, we will use several motivational techniques such as facilitating their autonomous goals or outcomes and clarifying expectations. We aim to offer concrete, clear, and relevant feedback during the teacher training sessions. In terms of intervention fidelity [61, 62], the observation of PE teachers' lessons during the course of the intervention will serve as a means to ensure fidelity of the intervention delivery to students during the implementation period. In cases where lower than expected compliance with the intervention is identified indicating problems with fidelity, we will create a dichotomous variable representing compliance with intervention and include it as a control variable in our path analyses to test whether fidelity had a significant effect on changes in out-of-school physical activity and other outcomes. Finally, we will content analyse the teachers self-evaluation forms completed after the teacher training period, and the infographic posters produced by each teacher during training that are designed to summarize their learning. These will serve as means to ensure fidelity of the intervention training delivery to participating PE teachers.

Data management

The University of Jyväskylä will own the research data. Consent forms and paper questionnaires will be stored in locked cabinets in the lead project researcher's office. Digital data will be stored on password-protected centrally-managed cloud-based storage drives of the Information Management Center at the University of Jyväskylä. All datasets will be de-identified with participants allocated a unique code number. Data files will be managed by core research team members appointed to this task. The key used to identify participants' data will be stored separately from data files and will only be accessible to designated members of the core research team members. Results will be reported in articles published in established international scientific journals and presentations in scientific and professional congresses. The researchers will target open access publishing and comply with the University of Jyväskylä recommendation of parallel publishing in the University open access digital repository. Results will also be communicated through traditional and social media for the public.

Discussion

School PE is an existing network with considerable potential for the delivery of interventions to promote physical activity to a captive audience of young people. Such interventions are also consistent with PE curricula to promote lifelong physical activity and health. However, relatively few studies have examined the effectiveness of school-based PE interventions in promoting out-of-school physical activity. The goal of the proposed study outlined in this protocol is to address this gap in the literature by testing the effectiveness of a theory-based intervention delivered in PE to promote lower secondary school students' physical activity outside of school. The intervention will capitalize on the trans-contextual model [6, 10], a motivation model which specifies the processes by which teachers' support for students' self-determined or *autonomous* motivation in school translates to their autonomous motivation, beliefs, and intention toward, and actual participation in, physical activity outside of school.

The intervention will make a unique contribution to knowledge in four areas: (i) it will test the effectiveness of a theory-based in-school intervention delivered by PE teachers in promoting lower secondary school students' physical activity participation outside of school, which has seldom been demonstrated; (ii) it will evaluate how the intervention works in promoting students' out-of-school physical activity participation through effects of intervention on key constructs from the trans-contextual model; (iii) it will outline the development and implementation of a cost-effective, replicable theory-based teacher training program to train teachers to use autonomy-support techniques in their PE lessons and promote out-of-school physical activity; and (iv) it will evaluate the long-term effectiveness of the intervention in promoting physical activity behaviour through one, three, and six-month post-intervention follow-up of behavioural and theory-based outcomes.

Although school PE has been identified as an important existing network in which messages and interventions promoting out-of-school physical activity participation could be promulgated, interventions to promote out-of-school physical activity through school PE are rare and these studies often only have limited follow-up periods of behavioural outcomes. For example, a previous study [63] demonstrated the effectiveness of a PE delivered intervention aimed at promoting physical activity participation in high school students. However, the study adopted a relatively brief intervention, relied exclusively on self-reported physical activity measures, and only adopted a relatively short term follow-up of students' behaviour. Our proposed intervention will advance this research by developing a comprehensive autonomy support training program with an associated set of training materials, use accelerometry to verify self-report measures of physical activity, and conduct a longer-term follow up of intervention effects.

One of the key strengths of the current study is the theoretical basis and the provision to test the mechanisms of effectiveness of the intervention. The current intervention is based on the trans-contextual model [10], which provides a clear basis for the mechanisms of the proposed intervention effects. Specifically, we expect the autonomy-supportive intervention delivered by PE teachers to lead to changes in students' autonomous motivation in school and outside of school, and their beliefs and intentions toward physical activity outside of school. We will test the effects of the proposed intervention on these theory-based constructs as secondary outcomes in the current intervention. Furthermore, because we plan to collect long-term follow up data we will be able to ascertain whether changes in the psychological constructs as a result of the intervention are maintained over time. The current study is the first to specifically design an intervention using this model and to test the theory-based mechanisms of intervention effects.

One of the potential challenges for the study, raised by external stakeholders, is that Finnish PE teachers are likely to be relatively autonomy-supportive at baseline. Autonomy-supportive teaching is currently emphasized both in the Finnish national PE curriculum and in the Finnish PE teacher training curriculum [7]. This raises the possibility that intervention effects will not be as strong as interventions in other contexts where autonomy support is not part of teacher training [24]. However, despite teachers' previous exposure to instruction on how to support students' autonomy, it is unclear to what extent teachers apply these techniques. For example, it is likely that teachers may use these techniques inconsistently, coupled with other, more controlling techniques. Research has demonstrated that even when teachers use autonomy support techniques, if they also use controlling techniques concurrently, it will undermine students motivation and lead to maladaptive outcomes [64]. The potential for previous exposure to autonomy support training notwithstanding, the current program focuses on training teachers' to use these strategies with greater intensity, specificity, and consistency, so we expect to see changes in the relevant indicators of autonomy support in students post-intervention. Another potential challenge, raised by external stakeholders and teacher educators, is resistance by PE teachers towards supporting students' autonomy in PE lessons. A key strategy to deal with this challenge is to convince PE teachers that supporting students' autonomy should not be equated with independence, and autonomy support does not lead to lack of discipline or 'chaos' in the classroom [34].

One of the challenges facing interventionists is difficulty in replicating interventions. This is important given the well-publicized need for high-quality replications of interventions that have demonstrated effects to provide converging evidence for effectiveness across contexts and populations. This endeavor is hampered by poor reporting of intervention protocols and content [65]. A strength of the current study is the provision of complete and detailed intervention materials to maximize transparency and potentials for replication. We will provide open access to the materials for the autonomy support training program including the materials used to train teachers and an accompanying manual providing explicit step-by-step instructions for facilitators to run courses to train teachers in autonomy supportive techniques. In addition, study measures and instruments will also be made available. The materials will be made available on the project website: https://osf.io/s4b2g/.

Endnotes

[1]Full details of the schedule and content of the autonomy support training program with accompanying training materials are available as supplemental materials: https://osf.io/s4b2g/

[2]As collecting physical activity participation using accelerometry is costly, time-intensive, and highly burdensome on participants, we will only have sufficient resources to conduct these measures in a subsample of participating students. The study will therefore, not have sufficient statistical power to conduct main analyses for intervention effectiveness using this outcome measure. The purpose of the measure is to provide concurrent validity data for the self-report measure of physical activity, which will be used as the primary outcome variable in the present study.

Additional file

Additional file 1: PETALS measures. Measures, data collection time points and methods in the PETALS intervention. Overview of measures, data collection time points and methods in the PETALS intervention including main outcome measure, secondary outcome measure, mediating measures, additional measures, teacher measures, parenting measures and demographic measures. (DOCX 17 kb)

Abbreviation

PE: Physical Education

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the study and will have no role in the analyses or interpretation of the data, or decision to submit results.

Availability of data and materials

After completion of the study, data will be stored at the Finnish Social Science Data Archive without potential identifiers (open access) and on the study project site on the Open Science Framework, https://osf.io/s4b2g/. In addition, all supplemental materials including the intervention manual and accompanying resources will be available online at https://osf.io/s4b2g/.

Authors' contributions

The manuscript was drafted by all authors. All authors were responsible for writing part of the manuscript or critically revising the complete manuscript. JP contributed to the concept and design of the study, to the training of the data collection research assistants, to data acquisition, and to quality assurance of data collection; MH contributed to the intervention design and intervention material development; TL contributed to the study design and intervention material; AL contributed to the study design and intervention material, to data acquisition, and to quality assurance of data collection; NH contributed to the concept and design of the study and to quality assurance; MH contributed to the concept and design of the study related to PE teacher training; TT contributed to the concept and design of the study related to measures; MSH is the principal investigator, and contributed to the concept and design of the study as well as quality assurance; All authors read and approved the final manuscript.

Ethics approval and consent to participate

The study follows the principles of the Declaration of Helsinki. The study protocol has been approved by the research ethics committee of the University of Jyväskylä (ref no. 2017/12/13). Written informed consent will be sought from participating teachers, students, and students' parents prior to the commencement of the trial. All participants will be informed that they are allowed to withdraw from the study at any time without prejudice, and have their data deleted. During the study, all travel and activities of research staff and participating teachers will be covered by accident insurance. In case of important protocol changes, a new ethical statement will be requested and new informed consent procedures will be delivered to participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

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IV

PREDICTORS OF LOWER SECONDARY SCHOOL STUDENTS' LEISURE-TIME PHYSICAL ACTIVITY: APPLICATION OF AN EXTENDED TRANS-CONTEXTUAL MODEL USING BAYESIAN PATH ANALYSIS

by

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RESEARCH ARTICLE

Predictors of school students' leisure-time physical activity: An extended trans-contextual model using Bayesian path analysis

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Abstract

The present study aimed to examine effects of motivational and social cognition constructs on children's leisure-time physical activity participation alongside constructs representing implicit processes using an extended trans-contextual model. The study adopted a correlational prospective design. Secondary-school students ($N = 502$) completed self-report measures of perceived autonomy support from physical education (PE) teachers, autonomous motivation in PE and leisure-time contexts, and social cognition constructs (attitudes, subjective norms, perceived behavioral control), intentions, trait self-control, habits, and past behavior in a leisure-time physical activity context. Five weeks later, students ($N = 298$) self-reported their leisure-time physical activity participation. Bayesian path analyses supported two key premises of the model: perceived autonomy support was related to autonomous motivation in PE, and autonomous motivation in PE was related to autonomous motivation in leisure time. Indirect effects indicated that both forms of autonomous motivation were related to social cognition constructs and intentions. However, intention was not related to leisure-time physical activity participation, so model variables reflecting motivational processes did not account for substantive variance in physical activity participation. Self-control, attitudes, and past behavior were direct predictors of intentions and leisure-time physical activity participation. There were indirect effects of autonomous motivation in leisure time on intentions and physical activity participation mediated by self-control. Specifying informative priors for key model relations using Bayesian analysis yielded greater precision for some model effects. Findings raise some questions on the predictive validity of constructs from the original trans-contextual model in the current sample, but highlight the value of extending the model to incorporate additional constructs representing non-conscious processes.

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Introduction

Research indicates that low levels of physical activity have deleterious effects on the health of young people [1]. However, children and adolescents in many nations are not sufficiently active to confer health benefits and reduce disease risk [2]. As a consequence, national and international health organizations have developed guidelines and national strategies aimed at promoting physical activity in this population [3]. Given the imperative for promoting physical activity among young people, public health organizations and educators have sought to identify optimally effective strategies to enhance physical activity in this population, and the contexts in which these strategies will have maximal reach.

Physical education (PE) has been suggested as a potentially useful existing network that can be utilized to deliver interventions promoting physical activity both inside school, and, importantly, outside school, in children and adolescents [4]. Researchers have, therefore, aimed to explore the potentially efficacious strategies delivered in PE to promote increased physical activity outside of school. Such an endeavor necessitates an understanding of the determinants of children and adolescents' physical activity participation in a PE context and, importantly, whether those determinants relate to physical activity participation outside of school in students' leisure time [5]. Understanding how factors linked to engagement in physical activity in school relate to physical activity performed in another context, leisure time, is critical to informing potential strategies delivered in PE that promote physical activity participation in children and adolescents in their leisure time. Such an approach is also consistent with one of the key pedagogical aims of PE to provide young people with the necessary skills to lead an active lifestyle [6].

The trans-contextual model

The trans-contextual model [5] was developed to provide a theoretical explanation of the constructs and associated processes that link engagement in physical activity in school PE with physical activity participation in leisure time. Specifically, the model draws on multiple theories to outline relations between school students' motivation toward physical activity in PE and their motives and beliefs toward, and actual participation in, physical activity in their leisure time. The model integrates core constructs and processes from self-determination theory [7], the hierarchical model of intrinsic and extrinsic motivation [8], and the theory of planned behavior [9]. Next, we outline the key premises of the model relating to the determinants of children and adolescents' leisure-time physical activity and the processes involved.

Based on self-determination theory, the first premise of the trans-contextual model focuses on the origins of school students' motivation toward activities in PE, and how their motivation relates to their behavior in PE. The model predicts that the social environment in educational settings fostered by social agents and leaders (e.g., PE teachers) will determine the type or *form* of motivation students experience when performing tasks (e.g., physical activities in PE) and, importantly, their persistence on tasks. Central to the theory is the distinction between autonomous and controlled forms of motivation [10]. Autonomous motivation is a form of motivation reflecting self-endorsed reasons for acting and autonomously motivated individuals tend to persist on tasks and exhibit behavioral persistence. Fostering autonomous motivation through the display of autonomy-supportive behaviors by social agents such as PE teachers will promote autonomous motivation toward physical activities performed in PE. Students who perceive their PE teacher as displaying behaviors that support their autonomy are more likely to report autonomous motivation toward activities in PE [11]. This prediction forms the basis of the first premise of the trans-contextual model: students' perceived autonomy support from their teachers in PE will relate to their autonomous motivation toward physical activity in a PE context.

A central prediction of the trans-contextual model is that there will be a trans-contextual relationship between students' autonomous motivation toward physical activities across PE and leisure-time contexts. This prediction is based on Vallerand's [8] hierarchical model, which describes the process by which motivation is transferred across contexts. Vallerand proposed that individuals experiencing autonomous motivation toward activities in one context will also cite autonomous motives toward similar behaviors in other related contexts. This forms the second premise of the trans-contextual model: school students' level of autonomous motivation toward physical activities in a PE context will be related to their autonomous motivation toward physical activities performed outside of school in their leisure time.

A final prediction of the trans-contextual model is that autonomous motivation toward physical activities in a leisure-time context will be related to students' beliefs and intentions toward, and future participation in, leisure-time physical activity. If an individual has experienced a behavior as autonomously motivated, it is likely to be internalized and integrated into the individual's repertoire of behaviors that satisfy their psychological need for autonomy. They are therefore more likely to actively seek out opportunities to engage in the behavior in future. To do so, they need to align their system of beliefs and intentions involved in the decision to perform that behavior in future. In the trans-contextual model, this process is represented by associations between forms of motivation from self-determination theory and the sets of beliefs from the theory of planned behavior, a leading social cognition theory [9]. Autonomously-motivated individuals are likely to form intentions to perform the behavior in future, and report favorable attitudes, subjective norms, and perceived behavioral control, the immediate belief-based determinants of intentions [12–14]. This forms the third premise of the trans-contextual model: students' autonomous motivation toward physical activity in leisure time will be related to their future participation in leisure-time physical activity mediated by the belief-based social cognition determinants (attitudes, subjective norms, and perceived behavioral control) and their intentions toward participating in leisure-time physical activity in future.

The key premises of the trans-contextual model have received substantial empirical support [5, 15–17]. Furthermore, a meta-analysis of studies applying the model in PE and leisure-time physical activity contexts provides converging evidence supporting model predictions across multiple studies [18].

Extending the model

While the trans-contextual model has displayed utility in identifying the determinants of leisure-time physical activity participation, it is not without limitations. One limitation is the exclusive focus on motivational and social cognition determinants of leisure-time physical activity participation without regard for the influence of implicit beliefs and motives that affect individuals' behavior beyond their awareness [19]. In contrast, dual-process theories of motivation and social cognition propose that individuals' behavior is determined by constructs that reflect conscious, reasoned decision making (e.g., autonomous motivation, social cognition constructs) but also by constructs that reflect implicit decision-making that impact behavior with little reasoned deliberation. Such constructs include implicit attitudes, habits, and individual difference constructs [20–23]. Non-conscious processes are adaptive because they lead to effective, efficient decision-making when reasoned deliberation is unnecessary or particularly costly [24]. Constructs reflecting these non-conscious processes are proposed to impact behavior directly without mediation by intentions, independent of the reasoned processes. These constructs may, therefore, account for the additional variance in leisure-time physical activity participation in the trans-contextual model and serve to provide a more comprehensive prediction of physical activity motivation and behavior in PE and leisure time.

Prominent behavioral determinants that reflect non-conscious processes are habit, trait self-control, and affective attitudes. Focusing on habit, although research has historically considered effects of past behavior as a viable proxy for habitual effects [25], recent research has focused on habit as a psychological construct [21, 26]. Theories of habit suggest that habitual behaviors are a function of behavioral experiences in the presence of consistent environmental, situational, or internal cues, and are often experienced as automatic, effortless, and highly accessible [26]. These components have been captured by self-report measures of habit, which are meta-cognitive measures which tap individuals' experience of target behaviors as 'unthinking' and 'automatic' [21]. Such measures have been shown to predict behavior independent of intention-mediated measures [27–30], and are also associated with action accessibility and behavioral performance in stable contexts [31, 32].

While habits are expected to predict intentions and behavior, they may also be related to motives that form part of the 'motivational sequence' proposed in the trans-contextual model. Individuals that hold autonomous motives toward behaviors like leisure-time physical activity, are more likely to persist with those behaviors, because the behavior fulfils psychological needs and leads to adaptive outcomes in the absence of external contingencies. This has been supported in the research literature on self-determination theory with consistent links between autonomous motivation and physical activity [33]. Related to this, autonomously motivated individuals are also more likely to form habits for those behaviors because they are likely to perform those behaviors in a consistent fashion with high frequency and in stable contexts–the key conditions under which habits form [34, 35]. This has been supported by previous research on the autonomous motivation-habit relationship [36]. Based on these premises, it follows that autonomous motivation toward physical activity in PE and leisure-time contexts is expected to be indirectly related to intentions and physical activity behavior mediated by habits. This proposed effect will be independent of the 'motivational sequence' proposed in the model, consistent with the dual-process approaches outlined previously.

Trait self-control reflects individual differences in capacities and self-regulatory skills that enable individuals to resist impulses and temptations, and engage in sustained, effortful behavior to attain long-term goal-directed outcomes [37]. Trait self-control has been consistently related to adaptive behaviors, including physical activity, across multiple contexts and populations [38]. Research has also demonstrated that behavioral effects of trait self-control may be direct, independent of intentions [39]. Such effects reflect generalized tendencies to engage in adaptive behaviors without the need for deliberation or consideration. However, a case has also been made for effects of trait self-control on behavior mediated by intentions [39]. Such effects reflect situations where individuals have to actively engage in effortful deliberation to overcome a maladaptive behavior, or engage in a new behavior, that requires deliberation. Effects of trait self-control in motivational and social cognition theories may, therefore, relate to behavior via two pathways, directly, and indirectly through intentions. Research incorporating trait self-control in the model has supported these dual effects, with direct and intention-mediated effects on physical activity participation [39].

While self-control has been identified as an independent determinant of intentions and behavior, there is also research that has linked self-control, and self-regulatory processes in general, with the forms of motivation implicated in the motivational sequence of the trans-contextual model. For example, research has highlighted that individuals reporting self-determined motives are less likely to be vulnerable to self-control failure and ego-depletion [40–42], and more likely to report intentions toward, and participate in, future behaviors, including physical activity [36, 39, 43]. These findings are consistent with the self-determination theory hypothesis that autonomous motivation is 'energizing' and individuals with autonomous motives toward behaviors are likely to report greater capacity to perform the behavior, and

hence greater self-control [36]. This hypothesis also aligns with the premise of the trans-contextual model that autonomous motives lead individuals to mobilize their resources to perform need-satisfying behaviors in future. Consistent with these proposals, it is reasonable to expect that autonomous motivation will be indirectly related to leisure-time physical activity intentions and behavior through self-control.

There is also research demonstrating that attitudes may predict behavior directly, and such direct effects may also reflect non-conscious decision making [44, 45]. The original conceptualization of the theory of planned behavior specifies that attitudes represent cognitive reflections on future participation in a target behavior and should relate to behavior mediated by intentions. However, direct effects of attitudes have been identified [45], and have been attributed to the affective or *emotional* component of attitude. Research separating the cognitive and affective attitude components has demonstrated independent effects. The affective component is proposed to encompass visceral approach or avoidance responses learned through behavioral experience [44]. Direct effects of attitude on behavior may reflect a further spontaneous, automatic process, which affects behavior independent of intentions.

The present study

In the present study, we aimed to extend the trans-contextual model by including self-control, habits, and attitudes as additional direct determinants of physical activity intentions and behavior participation. This extension is expected to provide additional information on the determinants of leisure-time physical activity behavior, particularly effects of constructs representing non-conscious processes not accounted for in the original model. We also applied the Bayesian analytic approach to test model effects using informative prior values for key model effects derived from a meta-analysis of the model [18]. We also capitalized on previous research on self-reported habit [36, 46] and trait self-control [38] to specify informative priors for these parameters in our test of extensions to the model. We expected to see a reduced level of uncertainty in the distributions of the parameters of the model specified for the current data when informative priors for key model parameters derived from the meta-analysis are specified, reflected in narrowed credibility intervals, compared to the distributions when non-informative priors are specified.

Specifically, the study adopted survey methods and a five-week prospective design with measures of motivational and social cognition constructs, habit, trait-self-control, and past physical activity participation taken at an initial occasion, and self-reported leisure-time physical activity participation taken at follow-up, five weeks later. This time period was selected to provide reasonable medium-term prediction, which exceeds typical time frames in model tests [47]. In addition to testing effects of the motivational and social cognition determinants from the trans-contextual model on students' intentions toward, and actual participation in, leisure-time physical activity, we also tested direct effects of the constructs reflecting non-conscious processes as direct determinants of leisure-time physical activity participation: self-reported habit, trait self-control, and attitudes. Further, effects of autonomous motivation in both contexts were expected to be indirectly related to physical activity intentions and behavior in leisure time mediated by both habit and self-control. Such effects represent processes by which self-determined motivation promotes behavioral enactment by promoting greater perceived self-regulatory capacity [42] and experience of the behavior as automatic [48]. Finally, we also expected model effects to hold in the presence of past behavior, and that there would be an indirect effect of past physical activity behavior on leisure-time physical activity mediated by habit. Such a relationship would illustrate the extent to which past behavior is a function of habit formation, consistent with previous theory and research [27, 48]. The specific predictions

of the proposed model, including direct and indirect effects in the proposed model are summarized in Table 1 and Fig 1.

Method

Participants

Participants were lower secondary school students (N = 502, 43.82% female; M age = 14.52, SD = 0.71) recruited from selected schools across Jyväskylä, Finland with support from the City Education Department. The University institutional review board and Education Department approved the study protocol prior to data collection. Informed consent was sought from the head teacher of each school, and, subsequently, PE teachers and eligible students' parents or legal guardians via the schools' online administration and communication software or via email or post. Opt-in consent was sought from the head teachers and PE teachers, while opt-out consent was sought from students' parents and legal guardians. Qualified full-time PE teachers teaching regular PE lessons in lower secondary schools were eligible to participate in the study and were asked to select one of their PE classes to take part. Students in grades 7 to 9 (typical ages 13 to 15 years) in lower secondary schools were eligible to participate. Students with existing physical or mental health conditions that prevented participation in PE lessons, regular leisure-time physical activity, or completing surveys were excluded.

Design and procedure

Data for this study was collected as part of a larger randomized controlled trial (trial registration: ISRCTN39374060; PETALS). The trial adopted a cluster-randomized, waitlist control, single-group intervention design with randomization by school. The trial comprised a teacher training phase and an implementation phase; full details of the intervention design and content have been published previously [50]. Secondary school PE teachers (N = 29) from 11 secondary schools and their students (N = 502) were invited to participate in the study. The pool of potentially eligible students numbered approximately 5000 across the 11 schools. Baseline data was collected prior to the teacher training phase and participants completed self-report questionnaires assessing demographic, psychological, and behavioral measures. The baseline data collection period was followed by the teacher training phase (12 hours over two weeks) and the implementation phase (one month), after which post-intervention data was collected comprising the same self-report questionnaires as at baseline. Follow-up data was further collected one, three, and six months post-intervention. The present study used measures of motivation and social cognition constructs and leisure-time physical activity participation taken at baseline and post-intervention leisure-time physical activity participation controlling intervention effects at baseline. Data for the present study were collected between September and December 2018.

Measures

Measures of study constructs were adapted from instruments used in previous applications of the trans-contextual model. Measures included in the surveys were: perceived autonomy support from PE teachers [51]; autonomous motivation derived from items measuring self-determined forms of motivation from the perceived locus of causality scales for the PE and leisure-time physical activity contexts [52]; intentions, attitudes, subjective norms, and perceived behavioral control from the theory of planned behavior [53]; self-reported habit [21] and trait self-control [54]; and self-reported leisure-time physical activity participation [55]. All self-report measures were previously translated from English to Finnish using a back-translation process by two bilingual researchers. All measures used in the current research exhibited acceptable construct validity in

Table 1. Summary of hypothesized direct and indirect effects in the extended trans-contextual model.

Hypothesis (H)	Independent variable	Dependent variable	Mediator(s)	Informative priors	
				β	σ^2
Direct effects					
H_1	PAS	Aut. mot. (PE)[a]	–	0.42	0.10
H_2	Aut. mot. (PE)	Aut. mot. (LT)[a]	–	0.56	0.17
H_3	PAS	Aut. mot. (LT)[a]	–	0.29	0.18
H_4	Aut. mot. (LT)	Attitude[a]	–	0.60	0.12
H_5	Aut. mot. (LT)	Subjective norm[a]	–	0.26	0.26
H_6	Aut. mot. (LT)	PBC[a]	–	0.51	0.19
H_7	Aut. mot. (LT)	Intention[a]	–	0.31	0.13
H_8	Attitude	Intention[a]	–	0.68	0.09
H_9	Subjective norm	Intention[a]	–	0.42	0.25
H_{10}	PBC	Intention[a]	–	0.63	0.28
H_{11}	Habit	Intention	–	–	–
H_{12}	Self-control	Intention	–	–	–
H_{13}	Intention	Phys. act.[a]	–	0.60	0.20
H_{14}	Attitude	Phys. act.[a]	–	0.43	0.21
H_{15}	PBC	Phys. act.[a]	–	0.43	0.21
H_{16}	Habit	Phys. act.[b]	–	0.43	0.13
H_{17}	Self-control	Phys. act.[c]	–	0.26	0.09
H_{18}	Aut. mot. (LT)	Phys. act.	–	–	–
H_{19}	Aut. mot. (LT)	Habit[d]	–	0.20	0.43
H_{20}	Aut. mot. (LT)	Self-control	–	–	–
H_{21}	Past behavior	Habit	–	–	–
H_{22}	Past behavior	Phys. act.	–	–	–
Indirect effects					
H_{23}	PAS	Aut. mot. (LT)	Aut. mot. (PE)	–	–
H_{24}	Aut. mot. (PE)	Intention	Aut. mot. (LT)	–	–
			Attitude		
H_{25}	Aut. mot. (PE)	Intention	Aut. mot. (LT)	–	–
			Sub. norm.		
H_{26}	Aut. mot. (PE)	Intention	Aut. mot. (LT)	–	–
			PBC		
H_{27}	Aut. mot. (PE)	Phys. act.	Aut. mot. (LT)	–	–
			Attitude		
			Intention		
H_{28}	Aut. mot. (PE)	Phys. act.	Aut. mot. (LT)	–	–
			Sub. norm.		
			Intention		
H_{29}	Aut. mot. (PE)	Phys. act.	Aut. mot. (LT)	–	–
			PBC		
			Intention		
H_{30}	Aut. mot. (PE)	Phys. act.	Aut. mot. (LT)	–	–
			PBC		
H_{31}	Aut. mot. (LT)	Intention	Attitude	–	–
H_{32}	Aut. mot. (LT)	Intention	Sub. norm.	–	–
H_{33}	Aut. mot. (LT)	Intention	PBC	–	–
H_{34}	Aut. mot. (LT)	Intention	Habit	–	–

(*Continued*)

Table 1. (Continued)

Hypothesis (H)	Independent variable	Dependent variable	Mediator(s)	Informative priors	
				β	σ^2
H_{35}	Aut. mot. (LT)	Intention	Self-control	–	–
H_{36}	Aut. mot. (LT)	Phys. act.	Attitude	–	–
			Intention		
H_{37}	Aut. mot. (LT)	Phys. act.	Sub. norm.	–	–
			Intention		
H_{38}	Aut. mot. (LT)	Phys. act.	PBC	–	–
			Intention		
H_{39}	Aut. mot. (LT)	Habit	Phys. act	–	–
H_{40}	Aut. mot. (LT)	Self-control	Phys. act	–	–
H_{41}	Past beh.	Habit	Phys. act	–	–

Note. [a]Prior values derived from Hagger and Chatzisarantis [18];

[b]Prior values derived from Gardner et al. [49];

[c]Prior values derived from de Ridder et al. [38];

[d]Prior value derived from Kaushal et al. [36]. PAS = Perceived autonomy support; Aut. mot. = Autonomous motivation; PE = Physical education context; LT = Leisure-time context; PBC = Perceived behavioral control; Sub. norm = Subjective norm; Phys. act = Self-reported leisure-time physical activity participation; Past. beh. = Past leisure-time physical activity behavior.

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previous research applying confirmatory factor analyses. Items tapping each construct exhibited satisfactory factor loadings, average variance extracted, and composite reliability estimates [5, 46, 56]. Furthermore, we also conducted a pilot study in which the validity of the translated trans-contextual measures was tested in the target population [57]. This study used single-indicator latent variable model using omega reliability estimates to control for measurement error. Simulation research using full structural equation models and single-indicator models has revealed little difference in the parameter estimates in models either approach [58]. These data provided support for the use of these measures in this population, particularly the construct and predictive validity of the measures in the context of the trans-contextual model. Full details of the measures used are available in Appendix A in S1 File.

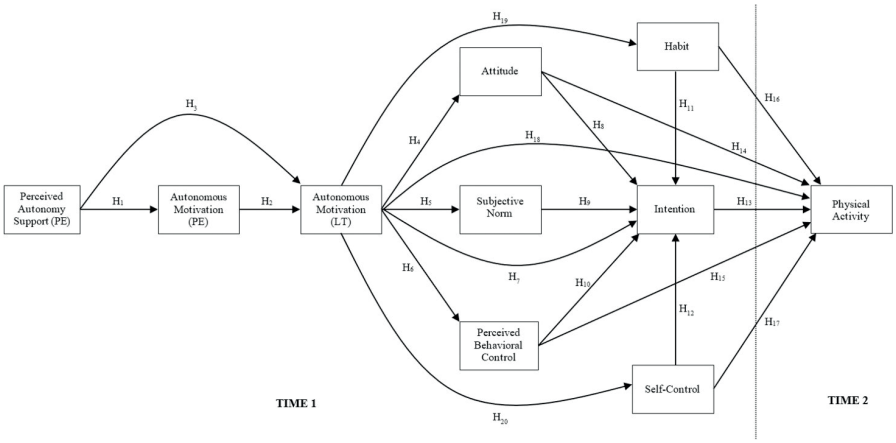

Fig 1. Hypothesized relations among constructs of the extended trans-contextual model. Effects of past behavior on all other model constructs have been omitted for clarity.

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Perceived autonomy support. Students' perceived autonomy support from their PE teacher was measured using items from the Perceived Autonomy Support Scale for Exercise Settings [51]. The scale comprised 13 items (e.g., "I feel that my PE teacher provides me with choices and options to . . .") with responses provided on seven-point scales (1 = *strongly disagree* and 7 = *strongly agree*).

Autonomous motivation. Autonomous motivation toward in-school and out-of-school physical activities was measured using items from the Perceived Locus of Causality Questionnaire [52]. Two items measured *identified regulation* (e.g., "I do PE/physical activity because it is important to me to do well in PE/physical activity") and two items measured *intrinsic motivation* (e.g., "I do PE/physical activity because it is fun"). Responses were provided on seven-point scales (1 = *not true for me* and 7 = *very true for me*). For each of the PE and leisure-time contexts, a composite autonomous motivation score was computed by averaging scores on the identified regulation and intrinsic motivation items.

Theory of planned behavior constructs. Measures of students' attitudes, subjective norms, perceived behavioral control, and intentions with respect to their future participation in leisure-time physical activity were developed according to guidelines [53]. Attitudes were measured on three items in response to a common stem: "Participating in physical activity in the next five weeks will be. . .", with responses provided on seven-point scales (e.g., 1 = *unenjoyable* and 7 = *enjoyable*). Subjective norms (e.g., "Most people who are important to me think I should do active sports and/or vigorous physical activities during my leisure time in the next five weeks"), perceived behavioral control (e.g., "I am confident I could do active sports and/or vigorous physical activities during my leisure time in the next five weeks"), and intentions (e.g., "I intend to do active sports and/or vigorous physical activities during my leisure time in the next five weeks") were measured using two items each with responses provided on seven-point scales (e.g., 1 = *strongly disagree* and 7 = *strongly agree*).

Habit. Habit was measured using automaticity items from the Self-Reported Habit Index [21] which focuses on personal experience of the behavior as 'automatic' and excludes items related to past behavior. The scale comprised four items (e.g., "Physical activity is something I do without thinking") with responses provided on seven-point scales (1 = *completely disagree* and 7 = *completely agree*).

Trait self-control. Students' trait self-control was measured using the 10-item Self-Discipline Scale (e.g., "I tend to carry out my plans") from the IPIP-HEXACO scales [59] with responses provided on four-point scales (1 = *not like me at all* and 4 = *very much like me*).

Behavior. Past leisure-time physical activity at baseline and leisure-time physical activity participation at follow-up was measured using the short form of the International Physical Activity Questionnaire (IPAQ; 55). The IPAQ comprises four items recording the frequency (number of days) and duration (minutes per day) of engagement in moderate and vigorous physical activity, walking, and sitting over the past seven days. IPAQ data were processed according to established guidelines [60]. The procedure gives an estimate of physical activity in MET-minutes per week with higher MET-minute values indicating higher level of physical activity engagement. Full details of calculations used to produce physical activity estimates are presented in Appendix B in S1 File. Internal consistency values for the short-form IPAQ exceed guideline cut-off values and scores on the scale demonstrate reasonable agreement with the long form in previous research [55].

Data analysis

The proposed hypotheses of the extended trans-contextual model (see Table 1 and Fig 1) were tested using Bayesian path analytic models estimated with the Mplus 7.31 statistical software.

We computed composite scales study measures by computing an average of the items for each construct. We controlled for the effects of the intervention in the model by including effects of a binary variable representing intervention group membership (1 = allocated autonomy support intervention group, 0 = allocated to control group) on follow-up leisure-time physical activity participation. We controlled for effects of gender as a binary variable (0 = female, 1 = male) and age as a continuous variable by estimating effects of these variables on all other constructs in the model. Missing data for the model components were imputed using full information maximum likelihood (FIML) in Mplus.

A Markov Chain Monte Carlo (MCMC) simulation process using Gibbs' algorithm [61] was applied to estimate our Bayesian path models in the present study. The first 50% of the iterations (N = 100,000) was used as a burn-in phase with the remainder used to test the specified model parameters. We established convergence of the parameter estimates in the Bayesian models according to the Gelman-Rubin [62] criterion based on a potential scale reduction (PSR) value of 1.01. Our analysis required estimation of two models. We first estimated a model that adopted the non-informative default priors available in Mplus to estimate model parameters. The defaults assumed a normal distribution with a mean of zero and a variance value essentially equivalent to infinity (10^{10}). In our second model, we applied informative prior values taken from previous research [18, 36, 38, 49] to estimate model parameters. Specifically, priors for relations among the trans-contextual model constructs were taken from Hagger and Chatzisarantis' [18] meta-analysis. The prior value for the effect of self-reported habit on leisure-time physical activity participation was derived from Gardner et al.'s [46] meta-analysis of self-reported habit in physical activity. The prior value for the effect of trait self-control on leisure-time physical activity participation was taken from de Ridder et al.'s [38] meta-analysis of trait self-control in health behaviors. The prior value for the effect of autonomous motivation in leisure time on habit was taken from Kaushal et al.'s [36] integrated model test. Finally, we used non-informative prior values for remaining parameters without user-specified priors.

We used multiple published criteria to establish the goodness-of-fit of our proposed models with the data across the iterations of the Bayesian analysis [61]. These criteria included the 95% confidence interval of the difference in the goodness-of-fit chi-square value across the observed and replicated models, as well as the posterior predictive p-value (PPP). The goodness-of-fit chi-square value should have a positive upper limit, a negative lower limit, and be centered about zero, and the PPP value should be greater than .05 and approach .50, for well-fitting models. In addition, we also report the Bayesian Information Criterion (BIC), a relative fit index which allows researchers to identify the model with the greatest parsimony relative to fit as it includes a term that 'penalizes' overfitting. Cut-off values of .95 or greater for the CFI and TLI, and .06 for the RMSEA, have been proposed as indicative of good model fit. Furthermore, the 90% confidence intervals of each index should ideally exceed the cut-off values.

With respect to model parameters, a point estimate and 95% posterior credibility interval was produced for each parameter in the models. A non-zero credibility interval for a parameter provides confirmatory support for the proposed effect in the model. Point estimates and credibility intervals were also produced for the proposed indirect effects in the models [63]. In addition, we also expected that specification of informative prior values in the second model would lead to increased precision in the point estimates. To demonstrate changes in precision, we followed Yuan and McKinnon's method which evaluates the extent to which the posterior credibility intervals about each parameter estimate is narrowed with the introduction of informative priors. If the width of the confidence intervals is reduced, we have sharp confirmation that inclusion of the prior values alongside the current data leads to increased precision in estimates. Data, syntax, and output files for our analyses are available online: https://osf.io/z8axj.

Results

Preliminary analyses

Of the participants who completed the initial survey (N = 502), 370 provided complete data at baseline and 298 participants (50% female; M age = 14.51, SD = 0.70) provided data for analysis after the second survey (19.46% attrition rate). Attrition was due to school absences. Percentage of missing data for the psychological constructs over time was low (M = 1.4%; range = 0.0% to 4.0%) and Little's MCAR test (χ^2 = 63.882, df = 70, p = .683) suggested the data were missing at random. In addition, there were no significant differences between those who completed study measures at both time points and those who did not on gender distribution, ($\chi^2(1)$ = 0.403, p = .526), age ($t(368)$ = -0.463, p = .643), or baseline physical activity ($t(368)$ = -1.103, p = .271). We also conducted a one-way MANOVA to examine differences in psychological variables between those who completed study measures at both time points and those who did not, which was not significant ($F(9, 360)$ = 0.775, p = .639; Wilks' Λ = .981; partial η^2 = .019). All constructs exhibited adequate internal consistency. Means, standard deviations, omega internal consistency coefficients and zero-order intercorrelations among study constructs are presented in Appendix C in S1 File.

Path analyses

Bayesian path analytic models using non-informative (Bayesian posterior predictive χ^2 95% CI = [-26.087, 57.542]; PPP = 0.225; BIC = 9202.749) and informative priors for key model relationships (Bayesian posterior predictive χ^2 95% CI = [-18.211, 67.825]; prior PPP = 0.126; BIC = 9081.715) exhibited adequate goodness-of-fit with the data. In addition, the BIC indicated that the model that included informative priors exhibited better fit than the model with non-informative priors. Parameter estimates and 95% credibility intervals for the analysis with non-informative priors (Model 1) and the analysis including informative priors for key model relationships (Model 2) are presented in Table 2 and Fig 2.

It is important to note that we did not conduct an a priori statistical power analysis for the current study as the main purpose of the trial was to test the effects of the intervention [50]. Nevertheless, we conducted a posteriori power analysis to check whether we had adequate power to test the current model. Our analysis was based on MacCallum, Browne, and Sugawara's [64] statistical power determination based on the RMSEA. The final sample size (N = 298), a null hypothesis RMSEA of 0 and a study hypothesis RMSEA of 0.064, alpha set at 0.05, and 16 degrees of freedom were inputs for the analysis, which was conducted using the Webpower package in R [65]. The resulting power estimate of 0.805 indicated that we had sufficient statistical power to detect effects of the stipulated size.

Assuming the selected priors derived from meta-analyses were indicative of the population point estimates and distributions of effects among model constructs, we expected that Model 2 would yield greater precision in model parameter estimates compared to Model 1 [63]. This was evaluated by examining the extent to which the credibility intervals about each parameter estimate differed across the models (Table 2). Results indicated that the width of the credibility intervals was narrowed for a few of the effects in Model 2 relative to Model 1, but not by a substantial margin in most cases. The adequate fit of both models suggests that including informative priors in the analyses for key model relationships did not have a substantial bearing on the pattern of effects in the model. Nevertheless, given that some parameters were more precise, particularly the direct effects of perceived autonomy support on autonomous motivation in PE and autonomous motivation in PE on autonomous motivation in leisure time, and the indirect effects of autonomous motivation in PE on autonomous motivation in leisure time and

Table 2. Parameter estimates (β) with 95% credibility intervals for hypothesized effects from the Bayesian path analyses of the extended trans-contextual model for leisure-time physical activity.

H	Independent variable	Dependent variable	Mediator(s)	Model 1			Model 2			%diff
				β	95% CrI		β	95% CrI		
					LL	UL		LL	UL	
Direct effects										
H_1	PAS	Aut. mot. (PE)†	–	2.403***	1.485	3.018	1.222***	0.625	1.634	-34.18
H_2	Aut. mot. (PE)	Aut. mot. (LT)†	–	0.449***	0.364	0.536	0.452***	0.366	0.537	-0.58
H_3	PAS	Aut. mot. (LT)†	–	0.140*	0.012	0.264	0.138*	0.011	0.265	0.79
H_4	Aut. mot. (LT)	Attitude†	–	0.433***	0.343	0.523	0.437***	0.348	0.526	-1.11
H_5	Aut. mot. (LT)	Sub. norm†	–	0.164*	0.007	0.321	0.166*	0.012	0.322	-1.27
H_6	Aut. mot. (LT)	PBC†	–	0.221***	0.119	0.322	0.225***	0.125	0.326	-0.99
H_7	Aut. mot. (LT)	Intention†	–	0.410***	0.304	0.516	0.403***	0.298	0.507	-1.42
H_8	Attitude	Intention†	–	0.166**	0.057	0.275	0.182***	0.076	0.289	-2.29
H_9	Sub. norm	Intention†	–	0.118***	0.058	0.178	0.118***	0.059	0.178	-0.83
H_{10}	PBC	Intention†	–	0.325***	0.227	0.422	0.324***	0.228	0.420	-1.54
H_{11}	Habit	Intention	–	0.057	-0.029	0.144	0.058	-0.028	0.144	-0.58
H_{12}	Self-control	Intention	–	0.217*	0.032	0.400	0.214*	0.030	0.399	0.27
H_{13}	Intention	Phys. act.†	–	-0.001	-0.062	0.060	0.000	-0.060	0.061	-0.82
H_{14}	Attitude	Phys. act.†	–	0.092**	0.032	0.151	0.093**	0.034	0.152	-0.84
H_{15}	PBC	Phys. act.†	–	-0.029	-0.085	0.026	-0.029	-0.084	0.026	-0.90
H_{16}	Habit	Phys. act.†	–	-0.005	-0.051	0.040	-0.004	-0.049	0.042	0.00
H_{17}	Self-control	Phys. act.†	–	0.104*	0.003	0.206	0.107*	0.007	0.207	-1.48
H_{18}	Aut. mot. (LT)	Phys. act.	–	-0.017	-0.079	0.045	-0.019	-0.080	0.043	-0.81
H_{19}	Aut. mot. (LT)	Habit†	–	0.121	-1.592	2.637	0.532***	0.392	0.671	-93.40
H_{20}	Aut. mot. (LT)	Self-control	–	0.108***	0.046	0.171	0.138***	0.071	0.207	8.80
H_{21}	Past behavior	Habit	–	1.521***	-3.089	0.658	0.799***	0.397	1.206	-78.41
H_{22}	Past beh. (LT)	Phys. act.	–	0.675***	0.519	0.829	0.672***	0.518	0.827	-0.32
Indirect effects										
H_{23}	PAS	Aut. mot. (LT)	Aut. mot. (PE)	1.059***	0.643	1.449	0.547***	0.276	0.777	-37.84
H_{24}	Aut. mot. (PE)	Intention	Aut. mot. (LT)	0.032**	0.011	0.057	0.035***	0.014	0.061	2.17
			Attitude							
H_{25}	Aut. mot. (PE)	Intention	Aut. mot. (LT)	0.008*	0.000	0.020	0.008*	0.001	0.020	-5.00
			Sub. norm.							
H_{26}	Aut. mot. (PE)	Intention	Aut. mot. (LT)	0.032***	0.015	0.053	0.032***	0.016	0.054	0.00
			PBC							
H_{27}	Aut. mot. (PE)	Phys. act.	Aut. mot. (LT)	0.000	-0.002	0.002	0.000	-0.002	0.002	0.00
			Attitude							
			Intention							
H_{28}	Aut. mot. (PE)	Phys. act.	Aut. mot. (LT)	0.000	-0.001	0.001	0.000	-0.001	0.001	0.00
			Sub. norm.							
			Intention							
H_{29}	Aut. mot. (PE)	Phys. act.	Aut. mot. (LT)	0.000	-0.002	0.002	0.000	-0.002	0.002	0.00
			PBC							
			Intention							
H_{30}	Aut. mot. (PE)	Phys. act.	Aut. mot. (LT)	-0.003	-0.009	0.003	-0.003	-0.009	0.003	0.00
			PBC							
H_{31}	Aut. mot. (LT)	Intention	Attitude	0.071**	0.024	0.123	0.079***	0.032	0.131	0.00
H_{32}	Aut. mot. (LT)	Intention	Sub. norm.	0.018*	0.001	0.043	0.019*	0.001	0.044	2.38

(*Continued*)

Table 2. (Continued)

H	Independent variable	Dependent variable	Mediator(s)	Model 1			Model 2			%diff
				β	95% CrI		β	95% CrI		
					LL	UL		LL	UL	
H_{33}	Aut. mot. (LT)	Intention	PBC	0.071***	0.035	0.115	0.072***	0.037	0.115	-2.50
H_{34}	Aut. mot. (LT)	Intention	Habit	0.003	-0.117	0.240	0.030	-0.015	0.079	-73.67
H_{35}	Aut. mot. (LT)	Intention	Self-control	0.022*	0.003	0.052	0.028*	0.004	0.064	22.45
H_{36}	Aut. mot. (LT)	Phys. act.	Attitude	0.000	-0.005	0.005	0.000	-0.005	0.005	0.00
			Intention							
H_{37}	Aut. mot. (LT)	Phys. act.	Sub. norm.	0.000	-0.001	0.001	0.000	-0.001	0.001	0.00
			Intention							
H_{38}	Aut. mot. (LT)	Phys. act.	PBC	0.000	-0.005	0.005	0.000	-0.005	0.005	0.00
			Intention							
H_{39}	Aut. mot. (LT)	Phys. act	Habit	0.000	-0.071	0.056	-0.002	-0.027	0.023	-60.63
H_{40}	Aut. mot. (LT)	Phys. act	Self-control	0.011	0.000	0.026	0.014*	0.001	0.033	23.08
H_{41}	Past beh.	Phys. act	Habit	-0.002	-0.127	0.108	-0.003	-0.042	0.035	-67.23

Note. †Parameters with informative priors. Model 1 = Bayesian path model with non-informative priors; Model 2 = Bayesian path model including informative priors; H = Hypothesis; β = Parameter estimate; 95% CrI = 95% credibility interval of path coefficient; %diff = Percent difference in 95% credibility interval of path coefficients of path analysis including informative priors for specified model relationships compared to analysis using non-informative priors (negative numbers indicate a narrowing of credibility intervals when using informative priors); PAS = Perceived autonomy support; Aut. mot. = Autonomous motivation; PE = Physical education contexts; LT = Leisure-time context; PBC = Perceived behavioral control; Sub. norm = Subjective norm; Phys. act = Self-reported leisure-time physical activity participation; Past. Beh. = Past leisure-time physical activity behavior.

*$p < .05$

**$p < .01$

***$p < .001$.

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intention, we elected to evaluate our hypothesis tests based on the model using informative priors (Model 2). If the posterior distribution for each effect, represented by the credibility intervals about the coefficients, did not include zero, then the effect was considered supported and the posterior probability of a non-zero value for the coefficient exceeds 0.975.

In terms of direct effects, we found a non-zero effect of perceived autonomy support in PE on autonomous motivation in PE (H_1; β = 1.222, 95% CI [0.6425, 1.634], $p < .001$). There was also a non-zero trans-contextual effect of autonomous motivation in PE on autonomous motivation in leisure time (H_2; β = 0.452, 95% CI [0.366, 0.537], $p < .001$), and perceived autonomy support in PE also had a non-zero effect on autonomous motivation in leisure time (H_3; β = 0.138, 95% CI [0.011, 0.265], $p < .001$). We also found non-zero effects of autonomous motivation in leisure time on attitudes (H_4; β = 0.437, 95% CI [0.348, 0.526], $p < .001$), subjective norms (H_5; β = 0.166, 95% CI [0.012, 0.322], $p = .017$), and perceived behavioral control (H_6; β = 0.225, 95% CI [0.125, 0.326], $p < .001$). There were also non-zero effects of attitudes (H_8; β = 0.182, 95% CI [0.076, 0.289], $p < .001$), subjective norms (H_9; β = 0.118, 95% CI [0.059, 0.178], $p < .001$), and perceived behavioral control (H_{10}; β = 0.324, 95% CI [0.228, 0.420], $p < .001$) on intentions. Moreover, there were non-zero effects of autonomous motivation in leisure time (H_7; β = 0.403, 95% CI [0.298, 0.507], $p < .001$) and trait self-control (H_{12}; β = 0.214, 95% CI [0.030, 0.399], $p = .012$) on intentions, but the effect of habit on intention (H_{11}) was no different from zero. We found non-zero effects of attitude (H_{14}; β = 0.093, 95% CI [0.034, 0.152], $p = .001$), trait self-control (H_{17}; β = 0.107, 95% CI [0.007, 0.207], $p = .018$), and past physical activity participation (H_{22}; β = 0.672, 95% CI [0.518, 0.827], $p < .001$) on leisure-time physical activity participation at follow-up, while effects of intention (H_{13}), perceived behavioral

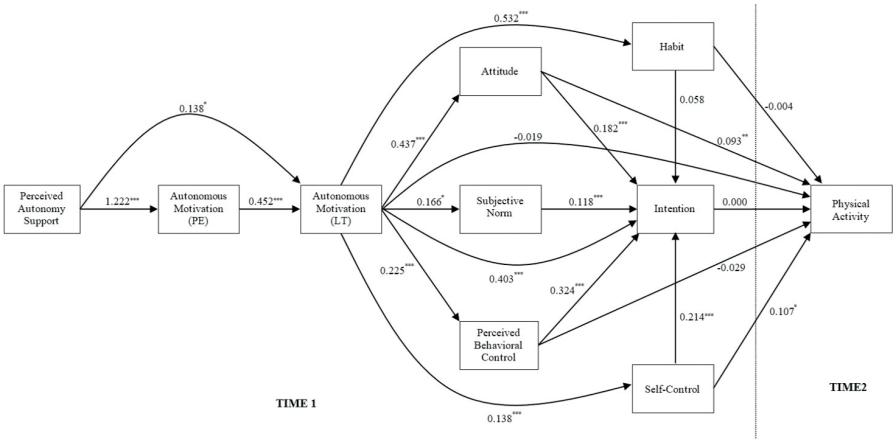

Fig 2. Parameter estimates from the Bayesian path analysis of the extended trans-contextual model for leisure-time physical activity including informative priors. PE = Physical education context; LT = Leisure time context. Model parameters omitted for clarity: past physical activity behavior→perceived autonomy support, β = 0.390, 95% CI [0.116, 0.664], p = .003; past physical activity behavior→autonomous motivation (PE), β = 0.368, 95% CI [-0.076, 0.799], p = .051; past physical activity behavior→autonomous motivation (LT), β = 1.382, 95% CI [1.109, 1.654], $p <$ .001; past physical activity behavior→attitude, β = 0.194, 95% CI [-0.109, 0.495], p = .106; past physical activity behavior→subjective norms, β = 0.337, 95% CI [-0.193, 0.867], p = .103; past physical activity behavior→perceived behavioral control, β = 0.593, 95% CI [0.249, 0.938], $p <$ .001; past physical activity behavior→intention, β = 0.293, 95% CI [0.014, 0.574], p = .019; past physical activity behavior→habit, β = 0.799, 95% CI [0.397, 1.206], $p <$ .001; past physical activity behavior→self-control, β = 0.153, 95% CI [-0.041, 0.348], p = .061; past physical activity behavior→physical activity behavior, β = 0.672, 95% CI [0.518, 0.827], p = .001.

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control (H_{15}), habit (H_{16}), and autonomous motivation in leisure time (H_{18}) were no different from zero. In addition, there were non-zero effects of autonomous motivation in leisure time on habit (H_{19}; β = 0.532, 95% CI [0.392, 0.671], $p <$ .001) and trait self-control (H_{20}; β = 0.138, 95% CI [0.071, 0.207], $p <$ .001). Finally, we found a non-zero effect of past behavior on habit (H_{21}; β = 0.799, 95% CI [0.397, 1.206], $p <$ .001). All effects were small-to-medium in size.

Focusing on the indirect effects, we found non-zero indirect effects of perceived autonomy support on autonomous motivation in leisure time mediated by autonomous motivation in PE (H_{23}; β = 0.547, 95% CI [0.276, 0.777], $p <$ .001). There were also non-zero effects of autonomous motivation in PE on intentions mediated by autonomous motivation in leisure time and attitude (H_{24}; β = 0.035, 95% CI [0.014, 0.061], $p <$ .001), subjective norms (H_{25}; β = 0.008, 95% CI [0.001, 0.020], p = .017), and perceived behavioral control (H_{26}; β = 0.032, 95% CI [0.016, 0.054], $p <$ .001). Similarly, there were also non-zero indirect effects of autonomous motivation in leisure time on intentions mediated by attitude (H_{31}; β = 0.079, 95% CI [0.032, 0.131], $p <$ .001), subjective norms (H_{32}; β = 0.019, 95% CI [0.001, 0.044], p = .017), and perceived behavioral control (H_{33}; β = 0.072, 95% CI [0.037, 0.115], $p <$ .001). There were also non-zero indirect effects of autonomous motivation in leisure-time on intention (H_{35}; β = 0.028, 95% CI [0.004, 0.064], p = .012) and physical activity participation (H_{40}; β = 0.014, 95% CI [0.001, 0.033], p = .018) mediated by trait self-control, but indirect effects mediated by habit were no different from zero (H_{34}, H_{39}). However, indirect effects of autonomous motivation in the PE (H_{27}–H_{30}) and leisure-time (H_{36}–H_{38}) contexts through the social cognition constructs on leisure-time physical activity participation were no different from zero, primarily because the intention-behavior relationship was also no different from zero. The indirect effect of past behavior on physical activity participation mediated by habit (H_{41}) was also no different from zero. Finally, effects of the intervention on leisure-time physical activity participation, and effects of age on model constructs, were no different from zero. However, we found non-zero

effects of gender on autonomous motivation in PE (β = -.401, 95% CI [-0.717, -0.099], p = .004), with girls experiencing higher levels than boys, autonomous motivation in leisure time (β = 0.256, 95% CI [0.055, 0.458], p = .007), and attitudes (β = 0.210, 95% CI [0.016, 0.402], p = .017).

Discussion

The purpose of the current research was to examine the determinants of lower secondary school students' leisure-time physical activity participation using an extended version of the trans-contextual model [5]. Specifically, the model was augmented to include two constructs that reflect non-conscious processes as predictors of leisure-time physical activity participation: self-reported habit [21] and trait self-control [37]. In addition, attitude was also set as a direct predictor of leisure-time physical activity participation, representing a further non-conscious process [44, 45]. Hypothesized relations among the extended trans-contextual model constructs were tested using a two-wave prospective survey design in a convenience sample of lower secondary school students. Data were analyzed using two Bayesian path analytic models: one specifying non-informative priors and one in which informed priors for key relations in the model derived from previous research were specified. Results indicated adequate fit of both models with the data. Perceived autonomy support predicted autonomous motivation in PE and leisure-time contexts, autonomous motivation in PE predicted autonomous motivation in a leisure-time context, and autonomous motivation in a leisure-time context predicted social cognition constructs (attitudes, perceived behavioral control) and intentions toward leisure-time physical activity participation. There were also indirect effects of perceived autonomy support on autonomous motivation in leisure time mediated by autonomous motivation in PE, and of autonomous motivation in PE and leisure time on intentions through the social cognition constructs. In contrast, the hypothesized indirect effects of autonomous motivation in both contexts on leisure-time physical activity participation were not supported, primarily due to effects of intention and perceived behavioral control on behavior that were no different from zero. However, attitudes and trait self-control predicted both intentions and behavior. Furthermore, there were indirect effects of autonomous motivation in leisure-time on intentions and physical activity participation mediated by self-control, but not habit. The Bayesian analytic approach demonstrated that the model was tenable with the model incorporating informative prior knowledge demonstrating better fit with the data and more precision for some of the parameter estimates.

Overall, current results supported hypotheses relating to the first two premises of the trans-contextual model, that is, the premises specifying effects of perceived autonomy support on autonomous motivation in PE, and the trans-contextual effects of autonomous motivation across PE and leisure time context [5, 18]. It also provided support for the effects of autonomous motivation in leisure time on intentions to participate in leisure-time physical activity mediated by the attitude, subjective norm, and perceived behavioral control constructs from the theory of planned behavior. However, there was scant evidence for the third premise, due to an intention-physical activity participation relationship that was no different from zero. These findings suggest that, in the current sample, the trans-contextual model is effective in identifying motivational and social cognition determinants of secondary school students' intentions to participate in leisure-time physical activity, and the processes involved, but not their actual participation. We propose four possible interpretations of the current findings. First, results may raise questions on the effectiveness of the trans-contextual model in identifying the determinants of leisure-time physical activity participation. There have been occasions where studies on the motivational and social cognition constructs in multi-theory, integrated

models have failed to yield non-zero effects for the primary predicted determinants of behavior [17, 20, 66]. Nevertheless, such occasions are rare, and are contrary to the substantive body of meta-analytic evidence applying the trans-contextual model [18] and other integrated models that have supported effects more broadly and in multiple populations and contexts [67, 68]. Therefore, it may be premature to use the current data as a basis for rejecting the trans-contextual model.

A second interpretation may be that some of the hypothesized effects in the model were attenuated due to contextual factors that affected relations among constructs, particularly the intention-behavior relationship. It is important to note that the intention-behavior relationship is integral to the model as it is a key link in the 'motivational sequence' by which perceived autonomy support in PE and autonomous motivation in both contexts relates to leisure-time physical activity participation. An intention-behavior relationship that is no different from zero, therefore, suggests that the indirect effect of autonomy support and autonomous motivation in both contexts on behavior, a key premise of the model, is not supported. This should not, however, invalidate the model. Rather it may signpost potential contextual or environmental factors that lead to effects in the model are attenuated. For example, research has shown that extraneous constructs moderate the intention-behavior relationship [69].

One possibility is that the current research was conducted in the context of an intervention. However, correlations of the intervention with key model constructs, particularly intentions and follow-up physical activity participation were no different from zero. In fact, the only effects of the intervention on variables from the current study were on perceived autonomy support and attitudes at baseline, and these effects were opposite to the predicted direction and were taken prior to the intervention. Furthermore, we also controlled for intervention effects in the current model, so reported effects were independent of intervention effects. This leaves the possibility of other extraneous constructs attenuating the intention-physical activity participation relationship in the current study. It is possible, for example, that students' intentions were particularly unstable or inconsistent with their subsequent behavior, given research that has confirmed these intention properties moderate these relations [69]. However, this possibility remains speculative as we have no data on intention stability or consistency, nor do we have any contextual or demographic information that would explain such inconsistencies.

A third explanation may be that participation in leisure-time physical activity in the current sample of school students was largely determined by constructs that reflect individual-level non-conscious processes, that is, constructs that impact behavior directly independent of intentions. That the only determinants of leisure-time physical activity participation in the current study were past physical activity participation, attitude, and trait self-control is consistent with this interpretation. Focusing first on the direct effect of trait self-control on behavior, this construct is proposed to reflect non-conscious processes insofar as those endorsing it are purported to exhibit adaptive self-regulatory skills that assist in pursuing goal-directed behaviors and help resist temptations to engage in alternative behaviors that may derail pursuit of the behavior [39, 43]. On the surface, such an effect implies that individuals applying such skills must engage in active, effortful decision making to ensure focus on the target behavior and manage distractions, a conscious process. This may be the case for behaviors with which the individual has little experience. However, where the individual has substantive experience and has engaged in such active deliberation over the management of the behavior and application of their skills, they are likely to have well-learned behavioral scripts or schemas stored in memory to manage distractions and maintain behavioral engagement, obviating the need for such conscious deliberation. This is consistent with research suggesting that individuals with good trait self-control are highly effective in managing their environment so as not to be encumbered by distractions and to ensure that the cues to their desired behavior are

omnipresent [38]. While this mechanistic explanation is speculative, it may explain the direct effect of trait self-control on behavior in the current model and provides justification to explore the role of this constructs within the trans-contextual model.

A fourth and final interpretation is that social environmental factors may have contributed to the weak intention-behavior relationship. The high availability of inactive highly-appealing pastimes available to young people (e.g., computer games) and social norms within families and peer groups to engage in inactive pastimes may have contributed to failure of students to engage in physical activity even if they had autonomous motives and intentions to do so. This is consistent with the current data in which students' average intentions to engage in physical activity in their leisure time was above the scale mid-point ($M = 5.651$, $SD = 1.282$). The effects of peer norms are especially strong in this age group, so young people with intentions to be active may find that they are superseded by their need to conform. These premises are consistent with ecological models that stress environmental influences [e.g., 70], and research suggesting that such influences are important predictors of behavior beyond social cognition determinants [e.g., 71]. Analogously, if a child has low or no intention to participate in physical activity, they may still be compelled to spontaneously do so if their peer groups decides to have a 'kick about' with a football in their local park. The current study did not measure environmental influences, so such determinants cannot be empirically verified from the current data and should be considered speculative. Nevertheless, it points to the potential importance of incorporating constructs that reflect these environmental determinants within integrated models such as the trans-contextual model.

Turning to the direct effect of attitude on leisure-time physical activity participation, current findings are consistent with previous research that has found a direct effect of attitude components on behavior in multiple health contexts [44, 45]. Such effects might represent affective motives to engage in a behavior learned through positive or negative experiences that coincide with the behavior [72]. As a consequence, the anticipation of rewarding affective responses may be reasons why children and adolescents engage in physical activities outside of school without the need for reasoned decision making. Such an effect has not been identified in previous research adopting the trans-contextual model, but has been consistently identified in research applying the theory of planned behavior in health behavior contexts, including physical activity [45, 72].

With respect to the direct effect of past physical activity behavior, current findings corroborate previous research reporting effects of past behavior on subsequent behavior in social cognition theories [e.g., 14, 25, 47, 73]. This research demonstrates that past behavior accounts for substantive variance in behavior and often attenuates effects of other constructs. The inclusion of past behavior in social cognition models is important as it provides an indication of the sufficiency of the theory [9, 73]. The absence of effects of theory constructs other than past behavior provides an indication that the theory may be inadequate as a means to explain behavior beyond the stability of the behavior itself. Although in the case of the current research, the exclusion of past behavior did not restore effects of other constructs such as intention on behavior.

So, what might the large-sized effect of past behavior represent? Researchers have suggested that past behavior may model effects of unmeasured constructs in tests of these theories [9, 25]. Given social cognition theories incorporate constructs that reflect reasoned, deliberative processes, past behavior effects may model effects of constructs representing non-conscious processes such as habits and implicit beliefs. The substantive effect of past physical activity behavior on leisure-time physical activity participation in the current study suggests that lower secondary school students' physical activity in their leisure time may be a function of these kinds of constructs. Current findings suggest, however, that habit may not be among these

determinants, given that the independent effect of self-reported habit on leisure-time physical activity participation was no different from zero, and habit did not mediate effects of past behavior on physical activity participation. Although it must be stressed that the current measure of habit focused exclusively on automaticity, one aspect of habit, and may not have sufficiently captured all habitual influences [e.g., 74]. The current study did not include measures that capture other aspects of habit such as context stability and accessibility of relevant cues to the behavior [26]. In addition, we did not measure other constructs that may reflect these non-conscious processes, such as implicitly held beliefs developed through past experiences of the behavior covarying with evaluations [24]. Research has suggested that measures of implicit beliefs predict behavior, including physical activity participation, independent of intentions [20] and may also mediate effects of past behavior on subsequent behavior [28]. The effects of past behavior in the current study may, therefore, indicate that physical activity behavior in leisure time may be a function of unmeasured constructs reflecting implicit processes, but such an inference is speculative and requires empirical verification.

Finally, consistent with previous research on self-determination theory, we found an indirect effect of autonomous motivation in leisure-time on both intentions and behavior mediated by trait self-control. Research on self-determination theory suggests that autonomous motivation is associated with better self-regulatory capacity and resilience in the face of self-control resource depletion [40, 42]. These findings are an important augmentation of trans-contextual model as they provide an alternative process by which individuals enact leisure-time physical activity in the absence of the 'motivational sequence' outlined in the original model. This finding lends additional support to the 'energizing' effect of autonomous motivation–students in the current study were more likely to report greater self-control if they perceived their behavior to be autonomous. As self-control was measured as a trait and was not specific to physical activity in the current study, the self-control-autonomous motivation relationship in the current study may, in fact, reflect a general tendency for autonomously motivated individuals to report greater self-control. This needs to be corroborated at the trait level, such as examining relations between causality orientations from self-determination theory and trait self-control, and examine whether such individual differences are behaviorally relevant [75].

The current research also illustrates the value of adopting a Bayesian analytic approach to combine prior knowledge of the distributions of model effects with the observed distributions to produce precise estimates and variability among model constructs. This was demonstrated by the narrowing of the credibility intervals about some of the model parameters. Importantly, the data used for the informative priors was highly reliable given they were derived from meta-analyses of multiple studies with large samples sizes. It is, however, also important to note that although the informative priors for the trans-contextual model effects were a meta-analysis of studies on samples of school students with similar profile to the participants in the current study [18], priors for the effects of the additional variables, self-reported habit and trait self-control were derived from research from multiple populations and mostly adult samples [38, 46]. Therefore, the priors were not directly comparable to the current sample. Nevertheless, current findings may be of value as a source of informative priors for future applications of the extended trans-contextual model. Consistent with the Bayesian approach, the current study should form part of an ongoing iterative research process that yields increasingly precise estimates of effects in the model.

Strengths, limitations and recommendations for future research

Strengths of the current study include (1) a focus on the determinants of lower secondary school students' leisure-time physical activity participation, a priority area of research; (2) the

application of an extended trans-contextual model, an integrative multi-theory approach that provided a priori hypotheses on the relations among the determinants and leisure-time physical activity participation; (3) adoption of a two-wave prospective design using validated measures of model determinants and behavior; and (4) application of Bayesian analytic procedures that enabled utilization of prior knowledge to arrive at precise estimates of model effects. However, it is also important to note limitations of the current research that may affect interpretation of the findings and the extent to which they can be generalized.

While we endeavored to incorporate additional constructs representing non-conscious determinants of leisure-time physical activity participation in the current study, our measures did not encompass a full range of candidate determinants. For example, the current study did not include measures of implicit cognition and motivation with respect to school students' leisure-time physical activity participation. Given that measures of constructs such as implicit beliefs and autonomous motivation have been shown to predict behavior directly independent of intentions in adult samples [20, 28, 76], future tests of the extended trans-contextual model should consider incorporating measures of these constructs as predictors of leisure-time physical activity participation. This is particularly important given the lack of effects of the intentional or motivational constructs on leisure-time physical activity participation in the current study, and inclusion of implicit beliefs may assist in providing an explanation of the effects of past behavior.

We also did not include the beliefs that underpin the attitude and subjective norm constructs [9]. Their effects on intentions and behavior are typically mediated by the direct attitude and subjective norm measures. Similarly, we did not include constructs related to socioecological environment that may determine behavior, and whose effects on behavior may be mediated by the social cognition constructs in the model [70]. There is precedence for the indirect effect of these beliefs and socio-ecological constructs in the model. Research has demonstrated that beliefs and socio-ecological factors relating to context and environment are related to the social cognition constructs that predict health behavior, and those constructs mediate the effects of the beliefs and socio-ecological factors on behavior [77, 78]. While the constructs in the current model are proposed to account for the effects of these variables, such influences need empirical verification and serve as an avenue for future research.

In addition, current data are correlational, which limits the extent to which we could infer causal relations among the extended trans-contextual model constructs. As with many model tests, including those of the trans-contextual model, causal effects are inferred from theory not the data [18]. Future research should consider the adoption of panel designs that permit modeling of temporal change and direction among trans-contextual model constructs over time through cross-lagged effects [12]. Such designs should also consider examining measuring model constructs over longer periods of time to test the capacity of the model to account for long-term change in its constructs and physical activity behavior, see Jacobs et al. [79] for an example. In addition, intervention and experimental designs that adopt appropriate behavior change techniques [80, 81] are needed to test the effect of manipulating the constructs found to have a direct effect on leisure-time physical activity participation [82]. For example, interventions targeting attitudes should seek to promote enjoyment and positive affect through positive experiences of physical activity, and interventions targeting self-discipline should seek to provide self-regulatory skills that promote better control over impulses to spend excessive time on leisure-time alternatives to physical activity (e.g., video games, watching television) and identify and manage barriers.

Conclusion

The current research is the first to test an extended version of the trans-contextual model to identify determinants of leisure-time physical activity participation in lower secondary school

students. Results indicate that the traditional motivational and social cognition constructs are effective in predicting leisure-time physical activity intentions, but not actual behavior. However, we found direct effects of trait self-control and attitude on leisure-time physical activity participation, suggesting that students' physical activity participation was determined by constructs representing non-conscious processes. A further innovation of the current research is the application of a Bayesian analytic approach to update the effects and variability estimates of model parameters based on previous meta-analytic findings. Results raise questions over the effectiveness of the original trans-contextual model constructs in determining leisure-time physical activity participation, at least in the current societal context in which the physical environment may not support engagement in physical activity and offers various competing, non-active alternatives (e.g., video games). However, current findings highlight the potential of including additional constructs representing non-conscious processes. However, these data should not be considered unequivocal evidence to support rejection of the model as unmeasured moderator variables may have affected model effects. Further replication of the extended trans-contextual model predictions in larger samples is warranted.

Supporting information

S1 File.
(DOCX)

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