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Reciprocal Relations between Autonomous Motivation from Self-Determination Theory and Social Cognition Constructs from the Theory of Planned Behavior: A Cross-Lagged Panel Design in Sport Injury Prevention

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Abstract

Objectives: The present study examined reciprocal relations between autonomous motivation from self-determination theory (SDT) and constructs from the theory of planned behavior (TPB) in a sport injury context.

Methods: The study adopted a three-wave longitudinal cross-lagged panel design. Physical education students in China (N = 4414; M_{age} = 14.42, SD = 1.75) completed self-report measures of autonomous motivation, attitude, subjective norm, and perceived behavioral control with respect to sport injury prevention at baseline (T1) and at two follow-up occasions one (T2) and three (T3) months later. Proposed reciprocal relations between autonomous motivation and the TPB constructs controlling for construct stability over time were tested using structural equation modeling.

Results: Three cross-lagged SEMs for effects of constructs measured at T1 on constructs measured at T2 and T3, and effects of constructs measured at T2 on constructs measured at T3 met goodness-of-fit criteria (CFI > .95, TLI > .94, RMSEA = .03, SRMR = .05) with consistent patterns of effects. Across the three models, autonomous motivation predicted the prospectively-measured TPB constructs with small-to-medium effect sizes (β range = .17 to .32, ps < .001), but associations between the TPB variables and prospectively-measured autonomous motivation were markedly smaller in size (β range = .01 to .18, ps range = .001 to .892).

Conclusions: Findings provide initial support for the temporal ordering of the constructs in the integrated model of SDT and TPB in a sport injury context. Autonomous motivation from SDT is likely to be an antecedent of the constructs from the TPB.

Keywords: reciprocal model; sport injury prevention; behavior change model; theoretical integration; self-efficacy; self-determined motivation.

Reciprocal Relations between Autonomous Motivation from Self-Determination Theory and Social Cognition Constructs from the Theory of Planned Behavior: A Cross-Lagged Panel Design in Sport Injury Prevention

Recognition of the salience of regular participation in health behaviors to the promotion of adaptive outcomes has led behavioral scientists to apply psychological theories of motivation and decision making to identify the determinants of health behaviors, and the processes involved (Hagger & Chatzisarantis, 2009, 2012; Hagger, Chatzisarantis, & Biddle, 2002; Hamilton, Kirkpatrick, Rebar, & Hagger, 2017). The primary goal of these applications is to provide formative data on potentially modifiable targets for behavioral interventions aimed at promoting health behavior participation (Chan & Hagger, 2012c; Hagger, 2009; Hagger & Chatzisarantis, 2009). While research adopting single-theories has demonstrated efficacy in the prediction of health behaviors, researchers are increasingly integrating constructs and processes from multiple theories to address the shortcomings and boundary conditions of individual theories, and to arrive at comprehensive, but optimally parsimonious, explanations of behavior (Chan, Ivarsson, et al., 2015; Hagger, 2009).

A relatively recent approach that has gained considerable traction in the health behavior literature is a model based on the integration of two key behavioral theories: self-determination theory (SDT; Deci & Ryan, 1985) and the theory of planned behavior (TPB; Ajzen, 1985). Integration of these theories has provided insight into the motivational and social cognition determinants of health behavior and the processes involved. This integrated approach has been applied in multiple contexts, populations, and health behaviors (Hagger & Chatzisarantis, 2009; Hagger et al., 2002), particularly in sport and exercise settings (Hagger & Chatzisarantis, 2014) such as sport injury prevention (Chan & Hagger, 2012b, 2012c; Chan, Lee, Hagger, Mok, & Yung, 2017; Lee, Standage, Hagger, & Chan, 2019). Although the model has demonstrated value in the prediction of behavior, conceptual and empirical

questions remain. Foremost among these is the temporal ordering of the constructs in the model. Theoretically, researchers have proposed that generalized motivational orientations from SDT serve as determinants of constructs from the TPB (Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002). This is consistent with the SDT prediction that individuals strategically bring their beliefs about future performance of the behavior into line with their generalized motives (Deci & Ryan, 1985). This enables them to form intentions in order to pursue behaviors that are consistent with their motives in future. However, to date, this hypothesis has not been fully tested. The aim of the current research was to test this prediction using a three-wave longitudinal cross-lagged panel design in the context of sport injury prevention. Results are expected to shed light on the motivational processes that underpin sport injury prevention, and provide evidence to support or disconfirm a key prediction of the integrated model. The conceptual basis for the proposed model tested in the current research is outlined next, followed by the specific predictions of the model.

An Integrated Model of SDT and TPB

In the integrated model, it is conceptualized that autonomous motivation from SDT (Deci & Ryan, 1985) is the antecedent of the social cognitive factors (i.e., attitude, subjective norm, and perceived behavioral control (PBC)) from TPB (Ajzen, 1985). The integration of SDT and TPB was developed to address noted limitations of each theory and develop a more comprehensive understanding of human behavior (Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002). The TPB identifies the processes by which motivational constructs from SDT lead to future behavioral participation, and SDT provides a basis for the formation of the belief-based constructs from the TPB. Specifically, SDT outlines how satisfaction of psychological needs determines the quality of motivation experienced when performing tasks and actions, and how that motivation relates to behavioral persistence (Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002). Research suggests that satisfaction of

psychological needs of autonomy, competence, and relatedness leads to autonomous motivation, which reflects personally-endorsed, self-referenced reasons for acting (Cheon, Reeve, Lee, & Lee, 2018; Deci & Ryan, 1985, 2000; Zhou, Ntoumanis, & Ntoumani, 2019). Such forms of motivation have been shown to be consistently related to persistence on behaviors and adaptive outcomes (e.g., satisfaction, psychological well-being) across multiple contexts (e.g., education, occupation, sport and health) and populations. On the other hand, the TPB identifies the belief-based constructs that determine intentions to perform behaviors in future, consistent with social cognition approaches. Three constructs are proposed: attitudes, an individual's positive and negative evaluations of performing the target behavior in future, subjective norms, an individual's beliefs that significant others' want them to perform the behavior in future, and perceived behavioral control, an individual's belief in their personal capacity to perform the behavior in future (Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002). The theory has been effective in explaining non-trivial variance in behavior in many behavioral contexts and populations.

The advance of the integrated theory is that it assists in addressing noted gaps in its constituent theories. According to Deci and Ryan (1985, 2000), need satisfaction leads to a desire to seek out and perform autonomously-motivated behaviors in future in order to further satisfy needs (Sheldon, 2002). In order to do so, individuals need to strategically align their systems of beliefs and intentions to perform future behaviors with their motives. However, this process has seldom been formally tested (McLachlan & Hagger, 2011). The integrated model formalizes this process by employing the TPB as a means to demonstrate the processes of alignment of beliefs toward future behavioral participation with motives (Chan, Hardcastle, et al., 2015; Sutton et al., 2003). In addition, self-determination theory provides an indication of the origins of beliefs from the TPB. Ajzen (1991) suggested that attitudes, subjective norms, and perceived behavioral control as belief-based determinants of intentions

and behavior will mediate effects of distal influences on behavior, including individual difference constructs and motives. In specifying needs-based motives as determinants of beliefs toward future behaviors, the integrated model identifies a potential source of information that individuals take into account when forming their beliefs about performing behaviors in future (Hagger & Chatzisarantis, 2016; Hagger & Chatzisarantis, 2012; Hamilton et al., 2017; Lee et al., 2019). In summary, the integration of constructs from SDT and TPB into a single model is consistent with predictions of both theories and provides a detailed explanation of the processes that lead to intentional action.

Evidence in support of the integrated model has been developed across multiple behaviors, particularly participation in health behavior such as leisure-time physical activity (see the summary of study findings from meta-analyses (Hagger & Chatzisarantis, 2016; Hagger & Chatzisarantis, 2009) and systematic reviews (Hagger & Chatzisarantis, 2012, 2014)). However, a growing body of research has extended the application of this model to other contexts such as sport injury prevention (Chan & Hagger, 2012b, 2012c; Chan et al., 2017). For instance, Chan and Hagger (Chan & Hagger, 2012b) applied the integrated model to understand the psychological process of sport injury prevention among young athletes. Consistent with model predictions, autonomous motivation was found to be a positive predictor of attitude, subjective norm, and PBC, and these three social cognition constructs mediated effects of autonomous motivation on intention (Chan & Hagger, 2012b). This pattern of results was also replicated in other injury related contexts, such as sport injury rehabilitation (Chan & Hagger, 2012b; Lee, Yung, Mok, Hagger, & Chan, 2020) and occupational injury prevention and rehabilitation (Chan & Hagger, 2012a). Overall, findings of studies applying the integrated model to the management of sport injury were consistent with the tenets of the integrated model (Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002) and findings applying the model in other contexts (Chan, Fung, Xing, & Hagger, 2014;

Chan, Yang, Mullan, et al., 2015; Hagger, Chatzisarantis, & Harris, 2006b; Hamilton et al., 2017).

Temporal Sequence of SDT and TPB Variables

An important limitation of previous studies applying the integrated model is the exclusive reliance on cross-sectional or prospective designs. Such designs preclude resolution of the temporal sequence of the proposed relations between the SDT and TPB constructs. As noted previously, a core prediction of integrated model is that autonomous motivation from SDT serves as an antecedent of the social cognition constructs from TPB (Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002). This is consistent with Deci and Ryan's proposal that motivational orientations from SDT lead to a strategic alignment of beliefs in order for individuals to perform future behaviors consistent with their motives and needs. This theoretical precedence for the proposed temporal ordering of constructs, has not been formally tested. Experimental research has suggested that individuals can and do distinguish between autonomous and controlled beliefs about behaviors, and that these distinctions are related to global measures of autonomous motivation (McLachlan & Hagger, 2010, 2011). However, to date, research has not provided evidence of the proposed temporal ordering of these constructs, and there is a clear need for research that provides evidence to support this important prediction of the integrated model.

The Present Study

The present study adopted a three-wave cross-lagged panel design to examine the temporal ordering of autonomous motivation and social cognition variables from the TPB in the integrated model. Sport injury prevention was chosen to the behavioral context in this study not only because it was an important field of research in sport and exercise psychology (Gabriel, Hoch, & Cramer, 2019; Ivarsson et al., 2017; White et al., 2012), but also because integrated model of SDT and TPB had shown to be applicable to predicting behavioral

outcomes in this behavioral context (Chan & Hagger, 2012b, 2012c; Chan et al., 2017; Lee et al., 2019). Adoption of a cross-lagged panel design permits formal assessment of the direction of relationships between psychological or behavioral variables. The design also allows for tests of reciprocal effects, effectively allowing a researcher to rule out effects that may run in the opposite direction, which cannot be tested in correlational data in which the constructs of interest are measured simultaneously (Marsh, Chanal, & Sarrazin, 2006; Marsh & Perry, 2005). Such designs have often been used in sport and exercise psychology research (Hagger, Chatzisarantis, Biddle, & Orbell, 2001; Lindwall, Larsman, & Hagger, 2011; Luszczynska, Mazurkiewicz, Ziegelmann, & Schwarzer, 2007). A typical cross-lagged panel design is illustrated in Figure 1. In the model, measures of the constructs of interest (A and B in Figure 1) are administered at two points in time (T1 and T2, in Figure 1). Model effects are tested using structural equation models in which within-time (synchronous), autoregressive, and cross-lagged paths between model constructs are specified (Selig & Little, 2012). The within-time paths represent the cross-sectional relationships between the study constructs (A and B), measured at both baseline (T1) and follow-up (T2), as illustrated by the bi-directional paths between the constructs at both time points in Figure 1. Autoregressive effects (i.e., $A_{T1} \rightarrow A_{T2}, B_{T1} \rightarrow B_{T2}$) represent the covariance stability or intra-personal change in the constructs over time (Selig & Little, 2012), and control for synchronicity or stationarity (within-time correlations) effects (see paths marked *a* and *b* in Figure 1). Cross-lagged paths (i.e., $A_{T1} \rightarrow B_{T2}, A_{T1} \rightarrow B_{T2}$) can be used to directly compare the prospective prediction between A and B while controlling for the baseline measures and other confounding factors (e.g., age, sex) (see paths *c* and *d* in Figure 1). The cross-lagged paths, in fact, account for the extent to which construct A explains residual change in construct B, or vice versa (Selig & Little, 2012).

Insert Figure 1 about here

Our application of this cross-lagged panel design to test hypothesized relations among constructs of the integrated model is illustrated in Figure 2. In the model, autonomous motivation and TPB constructs are each measured at two points in time, and autoregressive and cross-lagged relations are specified consistent with the typical panel design illustrated in Figure 1. Consistent with our proposal, if the cross-lagged effects of autonomous motivation on the social cognition constructs are larger than the effects of the social cognition constructs on autonomous motivation, we will have confirmatory evidence to support the proposed temporal ordering of the effects in the model (Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002). Specifically, we hypothesized that:

(H1) Cross-lagged effects of autonomous motivation on attitude, subjective norm, and PBC would be positive and non-trivial in size.

(H2) Cross-lagged effects of the social cognition constructs variables on autonomous motivation would be smaller than effects of autonomous motivation on the social cognition variables and trivial in size.

Insert Figure 2 about here

Methods

Participants

We recruited physical education (PE) students (N = 4414; M_{age} = 14.42, SD = 1.75, 65.77% female) from 44 secondary schools in Beijing, China, by approaching the PE teachers and principals of the schools. Apart from taking part in regular PE lessons, 76.30% of the participants reported participating in various sport activities outside of school (e.g., badminton, basketball, football, table tennis). On average, participants spent an average of 5.12 (SD = 5.00) hours per week in sport or other physical activities. In the previous six months, participants reported an average of 1.14 (SD = 3.96) occasions when they had suffered a sport injury, 0.89 (SD = 6.93) times when they had been absent from PE lessons

due to sport injury, 3.32 (*SD* = 12.17) days in which they had been unable to participate in their sport due to injury.

Procedures and Measures

Our research protocol was approved by the Institutional Review Board of The University of Hong Kong (ref: UW 18-440). Participants or their parent or legal guardian if under the age of 18 were required to sign informed consent forms to ensure they understood their rights and that their participation was voluntary. They were asked to complete a survey comprising measures of study variables at T1 (baseline), T2 (1-month follow-up), and T3 (3-month follow-up). Trained research associates were responsible for distributing the questionnaires at three time points, and matching follow-up responses of the participants by unique identifiers (i.e., school, class, and student ID). The survey comprised measures of autonomous motivation based on the Treatment Self-Regulation Questionnaire (Levesque et al., 2007) and attitude, subjective norm, and PBC from the TPB based on standardized guidelines proposed by Ajzen (2002). All measures were taken from previously-validated Chinese translations of these scales and made reference to injury prevention as the target behavior. Participants' responses on these scales were provided on seven-point Likert scales with higher values indicating higher scorings on the constructs. The injury prevention versions of Treatment Self-Regulation Questionnaire (Chan, 2019b) and TPB scale (Chan, 2019a) used in the current study, and information about their scale anchors and scoring, are available online (https://osf.io/dz6ah). Previous studies have provided supportive evidence for the convergent validity and factor structure of these scales among young Chinese sport participants (Chan & Hagger, 2012a, 2012b, 2012d). In addition, the baseline version of the survey also included self-report measures of the following demographic variables: age, sex, sport participation, and sport injury experience.

Analysis

We examined the reciprocal model by structural equation modeling (SEM) using a robust maximum likelihood estimation method in Mplus version 8.1(Muthén & Muthén, 1998-2017). Overall fit of the proposed cross-lagged panel models was evaluated using multiple goodness-of-fit indices: the Comparative fit index (CFI), the Tucker-Lewis Index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Models were considered to have acceptable goodness-of-fit with the data if CFI and TLI values approached or exceeded .90 and RMSEA and SRMR values were less than .08 (Marsh, 2007). Hypothesized directional effects in the proposed model were tested by examining the parameter estimates for the cross-lagged paths between autonomous motivation and the social cognition constructs from the TPB. As this was a three-wave longitudinal study, we examined our hypotheses in three separate cross-lagged panel models, each examining the hypothesized reciprocal paths across two time points. Model 1 examined relations between constructs of the proposed integrated model measured at T1 and T2, Model 2 for constructs measured at T1 and T3, and Model 3 for constructs measured at T2 and T3. These three models allowed a comprehensive test of the reciprocal relations between autonomous motivation and social cognition constructs across all assessment points, and tested if a consistent pattern of results for the predicted temporal ordering emerged across the different time points. To test hypotheses, we compared effect sizes of the cross-lagged paths of autonomous motivation at T1 on the social cognition constructs at T2 with the effect sizes of the reciprocal paths at T2 on T1 using confidence intervals about the parameter estimates with a formal test provided by Schenker and Gentleman (2001). In addition to estimating the cross-lagged and autoregressive paths in the proposed model, we included demographic variables that exhibited substantive non-zero correlations with the study variables in correlation analyses as covariates (Lindwall et al.,

2011; Luszczynska et al., 2007; Marsh et al., 2006). The dataset and syntax of the analysis we used in this study are available online (https://osf.io/dz6ah).

Results

Preliminary Analysis

Preliminary analyses revealed that study variables had normal range, skewness, and kurtosis estimates. Cumulative sample attrition rates due to dropout at follow-up were 23.29% at T2 and 30.86% at T3. In addition, Little's (1988) MCAR test across all constructs revealed that data were missing completely at random. Total proportion of missing values, taking attrition and data values missing at random into account, was 29.81%. Missing values were imputed in the data analysis using full information maximum likelihood method (Shin, Davison, & Long, 2017). Descriptive statistics and the zero-order correlation matrix for the study variables are presented in Table 1. Demographic variables (age, sex, sport participation, and sport injury experience) were consistently associated with study variables at all time points, with the exception of days absent from PE due to sport injury. These variables were included as covariates in the cross-lagged panel models.

Insert Table 1 about here

Hypothesis Tests

Parameter estimates and associated distribution statistics for the cross-lagged and autoregressive paths in Model 1, Model 2, and Model 3 are presented in Table 2. Parameter estimates for the three models were highly consistent and largely supported study hypotheses. In support of H1, cross-lagged paths for autonomous motivation at T1 on attitude (β range =.25 to .32, *p*s < .001), subjective norm (β range =.21 to .30, *p*s <. 001), and PBC (β range = .17 to .28, *p*s <. 001) at T2 were positive the three models with confidence intervals that did not include zero and small-to-medium effect sizes. In support of H2, cross-lagged paths for attitude (β range =.12 to .18, *p*s < .001), subjective norm (β range = .01 to .05, *p*s range

= .297 to .892), and PBC (β range =-.05 to .05, *p*s range = .236 to .329) on autonomous motivation were smaller in size than their respective reciprocal effects and, in many cases, trivial in size with confidence intervals that included the value of zero. The larger effect sizes for the cross-lagged paths for autonomous motivation on the social cognition constructs compared to the reciprocal effects were supported by a lack of an overlap in the 95% confidence intervals of the parameter estimates for each path confirmed by Schenker and Gentleman's (2001) test. The only exception to this pattern was the effect of autonomous motivation on attitude for Model 3. Although the observed parameter estimate for the effect of autonomous motivation on attitude was larger (β =.25, $p < .001$) than the estimate for the effect of attitude on autonomous motivation (β =.18, $p < .001$), there was substantive overlap in the confidence intervals and the difference in the estimates was not statistically significant ($t = 0.96$, $p = .339$).

Insert Table 2 about here

Discussion

The aim of the current study was to test reciprocal relations between autonomous motivation from SDT and the social cognition constructs from the TPB among adolescent sport participants with respect to sport injury prevention. We expected effects of autonomous motivation on the social cognition constructs to be larger than their respective reciprocal effects. These hypotheses are consistent with a central tenet of models integrating SDT and TPB that individuals strategically align their beliefs with their motives in order to pursue need-satisfying behaviors in future (Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002). The study employed a three-wave longitudinal cross-lagged panel design in which survey measures of autonomous motivation from SDT and the social cognition constructs from the TPB (attitude, subjective norm, and perceived behavioral control) at an initial time point (T1) and at one (T2) and three (T3) month follow-up time points. Three SEMs were

estimated to test the hypothesized reciprocal effects. Consistent with hypotheses, results demonstrated consistent positive cross-lagged effects of autonomous motivation on the social cognition variables (i.e., attitude, subjective norm, and PBC), with small-to-medium effect sizes, while the reciprocal paths were smaller and, in many cases, no different from zero. The only exception were the reciprocal effects of autonomous motivation at T1 on attitudes at T3, which did not differ significantly. This overall consistent pattern of effects provide preliminary support for the proposed hypothesis of the integrated model and suggested that autonomous motivation from SDT may be antecedent to the social cognition constructs from the TPB.

While previous research has supported relations between autonomous motivation from SDT and social cognition constructs from the TPB across multiple health behaviors (Hagger & Chatzisarantis, 2009; Hamilton et al., 2017) and, in particular, in sport-related contexts such as sport injury prevention (Chan & Hagger, 2012b, 2012c; Chan et al., 2017), injury rehabilitation (Chan & Hagger, 2012a, 2012c; Lee et al., 2020), and physical activity participation (Hagger & Chatzisarantis, 2014; Hagger et al., 2002; Hagger et al., 2006b), the extant research does not provide strong evidence for the directional, temporal ordering of the proposed effects. The value of the current research is that it extends research on the integrated model to provide stronger evidence for the temporal ordering of model effects. Our design enabled us to compere effects of autonomous motivation on the social cognition constructs from the TPB with effects of the beliefs on autonomous motivation across three time points while simultaneously controlling for covariance stability of the constructs, stationarity effects, and effects of relevant covariates. Results show a clear pattern of effects consistent with hypotheses. Effects of autonomous motivation on attitudes, subjective norms, and perceived behavioral control were larger than matched effects in the opposite direction, indicating that autonomous motivation serves as an antecedent of the beliefs consistent with

hypotheses of the integrated model. Results suggest that individuals actively seek to align their personal, normative, and competence beliefs (Chan, Hardcastle, et al., 2015; Sutton et al., 2003) with their motivational orientations (Sheldon, 2002) toward sport injury prevention in order to pursue behaviors in this context in future (Chan & Hagger, 2012d; Chan, Hagger, & Spray, 2011). Consistent with self-determination theory (Deci & Ryan, 1985), this may be because individuals who pursue these behaviors for autonomous reasons recognize them as behaviors that fulfil psychological needs. The individual is likely to have internalized such behaviors into their repertoire of need-satisfying behaviors, and are likely to be motivated to pursue such behaviors again in future. From the perspective of injury prevention, autonomous motivation toward injury prevention behaviors are likely to be highly functional in enabling the individual to pursue their sport goals, something to which they likely attach high value (Chan & Hagger, 2012d; Chan et al., 2011). Therefore, the current model outlines the motivational process that compels sport participants to actively pursue internalized, need-satisfying injury prevention behaviors in future, and how they strategically align their beliefs with their internalize motives in order to do so.

It should be noted that attitude and PBC were also predictors of autonomous motivation, but sizes of these effects were considerably smaller than those for the effects of autonomous motivation on attitude and PBC. So while the predominant directional effects are consistent with theory, the presence of smaller reciprocal effects suggest that beliefs may also contribute to the formation of, or maintenance of, autonomous motivation. This may suggest a more dynamic process identified in the integrated model, such that beliefs serve as a potential source of information for the formation autonomous motives. A possible reason for this pattern of effects might be that individuals with considerable experience with the target behavior are likely to have formed beliefs with respect to that behavior in the past, informed by previous autonomous motives, and, therefore, such beliefs provide additional feedback to

the individual when they form autonomous motives in future (Hagger & Chatzisarantis, 2016; Hagger & Chatzisarantis, 2009, 2014; Hagger et al., 2002; Hagger et al., 2006b).

In contrast, the effects of subjective norm on autonomous motivation were small and no different from zero. Unlike attitude and PBC that exhibit reciprocal effects on autonomous motivation, the effects of autonomous motivation and subjective norm appears to be unidirectional. In the original proposals of the integrated model, it was hypothesized that autonomous motivation was not compatible with subjective norm because the construct reflects perceived external demands or pressures from salient others that are controlling (Chatzisarantis, Hagger, Smith, & Sage, 2006; Hagger, Chatzisarantis, & Harris, 2006a; Hagger et al., 2006b). However, findings of our present study, and also of other studies in sport injury (Chan & Hagger, 2012a, 2012b; Lee et al., 2020) or health contexts (Chan et al., 2014; Chan, Yang, Mullan, et al., 2015; Hagger & Chatzisarantis, 2009; Hagger et al., 2002; Hamilton et al., 2017), have found positive relations between autonomous motivation and subjective norm. Such findings have led researchers to suggest that subjective norms may not solely capture beliefs about external pressures, but potentially need-satisfying support from others. Current findings suggest that individuals who view their actions as autonomously motivated tend to report higher subjective norm. This pattern of effects may imply that individuals with autonomous motivation tend to interpret the desires of significant others with respect to their future behavior as need satisfying, therefore, the effect captures the process of internalization i.e. reimagining potentially controlling contingencies as supporting autonomous motives.

Limitation and Future Direction

The present study has numerous strengths including: specification of a clear set of theory-determined predictions on relations between motivation from SDT and beliefs from the TPB; recruitment of a large representative sample of sport participants in sport injury

preventing setting; and adoption of a three-wave longitudinal design enabling analysis of stability and cross-lagged effects among the SDT and TPB constructs. Despite these strengths and the unique contribution the study makes to understanding motivational processes for sport injury prevention behaviors, we should acknowledge a few limitations and identify emerging directions for future research. First, although cross-lagged panel models offer insight into the temporal order of relations among constructs, these data are still correlational and, therefore, should do not be used to infer causal effects (Hamaker, Kuiper, & Grasman, 2015; Lindwall et al., 2011; Selig & Little, 2012). As a consequence, current findings do not allow us to conclude that autonomous motivation causes change in social cognitive variables. Consistent with previous research, any causal relations are inferred from theory alone, not the data (Hagger & Chatzisarantis, 2016; Hagger & Chatzisarantis, 2009). Future studies should adopt randomized controlled designs with multiple arms that independently manipulate each of the variables within the integrated model to provide evidence on the causal relationships between SDT and TPB variables, a recognized priority for behavior change research (Hagger, Moyers, McAnally, & McKinley, in press; Suls et al., 2020). Second, we did not include all the variables from the integrated model in the current study. For example, we did not include measures of controlled motivation, which may have provided a more complete test of reciprocal relations between forms of motivation from SDT and social cognition constructs from the TPB. Similarly, we did not include a measure of intention, proposed as a key mediator of the effects of attitudes, subjective norm, and perceived behavioral control on behavior in the TPB. Future studies should aim to incorporate these constructs and examine directional effects among them in the integrated model. Future investigations should also consider including measures of psychological need satisfaction and actual behavior, preferably using a non-self-report method, that may assist in providing a more comprehensive evaluation of processes within the integrated model (Hagger & Chatzisarantis, 2009, 2014).

Finally, it is important to point out that we only examined the study hypotheses in a sport injury prevention setting. A key basic assumption of the underlying theories that contribute to the predictions of the integrated model is that they represent universal, generalizable effects that should reflect the processes that determine behavior across multiple contexts, behaviors, and populations, with only the relative contribution or *strength* varying, rather than the pattern of effects. Therefore, we would assume that the pattern of effects identified in the sport injury context may also be reflected in other behaviors. However, this needs verification and future studies should replicate the current test of reciprocal relations among the integrated model constructs beyond sport injury prevention settings (Chan, Yang, Hamamura, et al., 2015).

Conclusion

The present tested reciprocal relations between autonomous motivation from SDT and the social cognition constructs from the TPB in a sport injury prevention context. Data from three-wave longitudinal study adopting a cross-lagged panel design among PE students, revealed a consistent pattern of findings in which effects of autonomous motivation on the social cognition constructs were larger than their reciprocal relations, supporting the proposed temporal ordering of these effects. Results support a key prediction from the integrated model in a sport injury context. The current pattern of effects may be informative of the process by which individuals beliefs are shaped by their motives. Future studies should seek to replicate the current pattern of reciprocal relations, and extend them to test a more complete integrated model of SDT and TPB in multiple behaviors, contexts, and populations. Experimental and intervention research should also be conducted to examine effects of manipulating autonomous motivation through autonomy support on the social cognition constructs from the TPB and subsequent injury prevention behavior.

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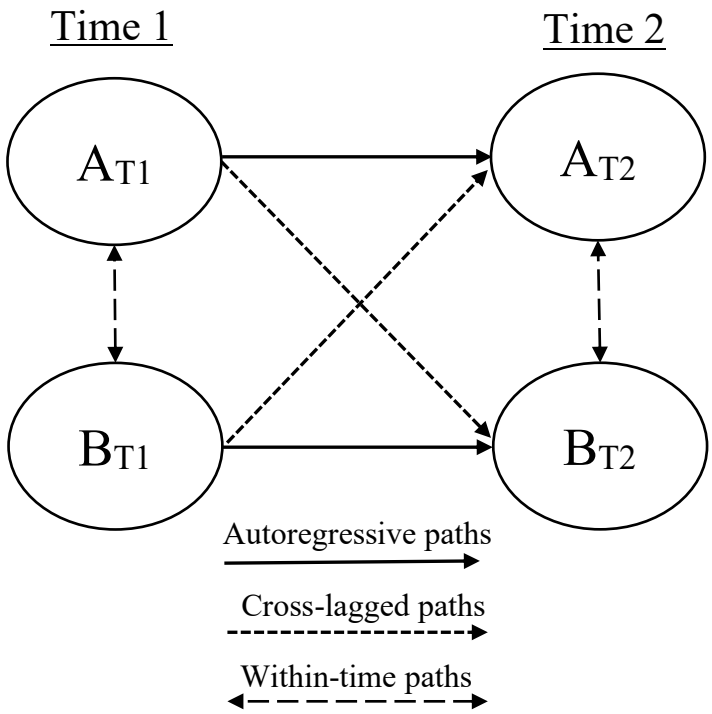

Figure 1. Illustration of autoregressive and cross-lagged paths.

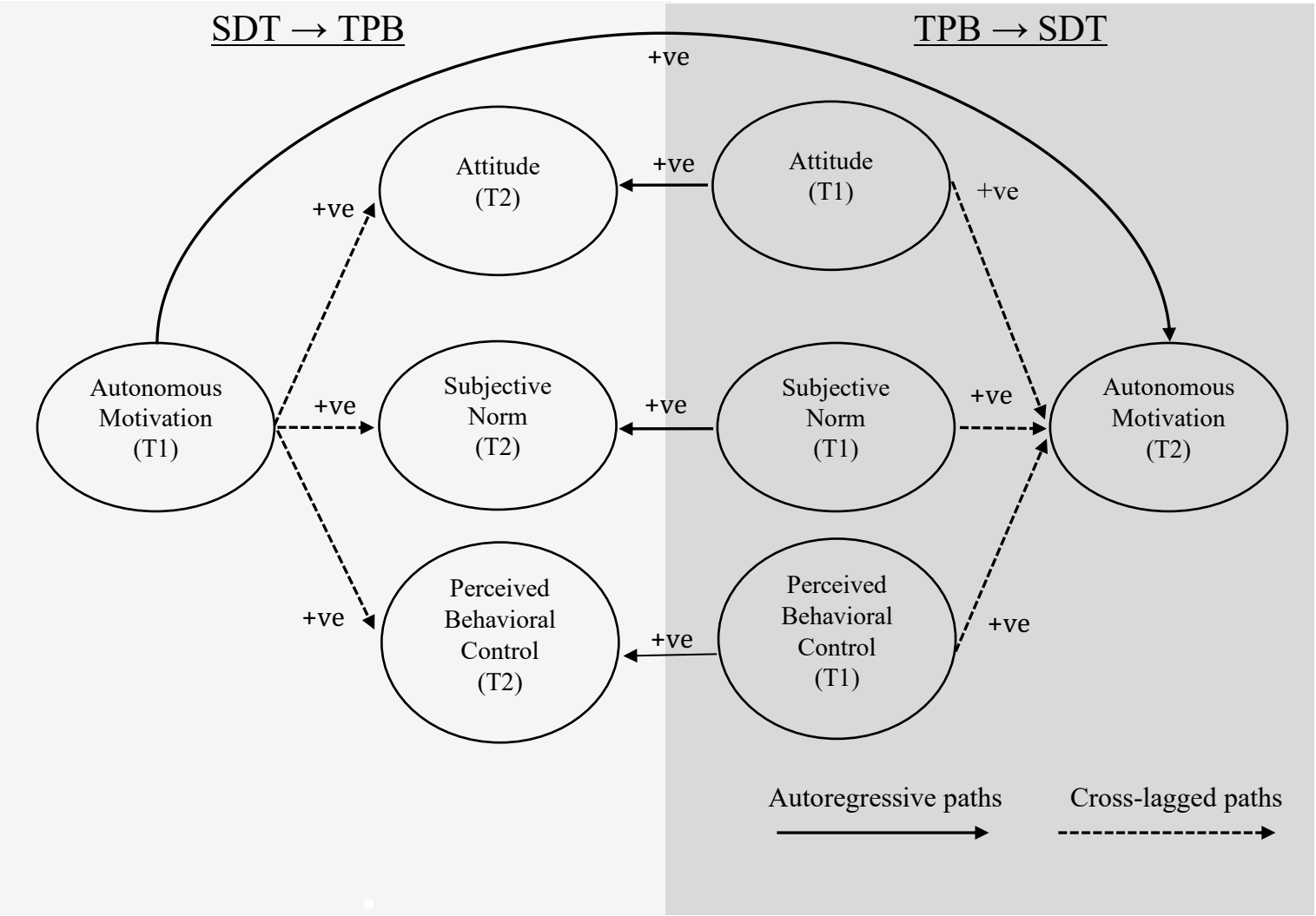

Figure 2. Hypothesized paths of the reciprocal effects between autonomous motivation and constructs from the theory of planned behavior in the structural equation models tested in the current study. Within-time correlations between model constructs at each time point were estimated but omitted from the figure for clarity.

Table 1

Zero-Order Correlations, Means, and Standard Deviation of the Study Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
T1																		
1. Autonomous motivation	1																	
2. Attitude	.61**	1																
3. Subjective norm	.51**	.47**	1															
4. PBC	.47**	.46**	.64**	1														
T2																		
5. Autonomous motivation	.53**	.46**	.38**	.38**	1													
6. Attitude	.46**	.52**	.36**	.34**	.71**	1												
7. Subjective norm	.38**	.36**	.45**	.39**	.61**	.58**	1											
8. PBC	.38**	.35**	.38**	.45**	.62**	.56**	.71**	1										
T3																		
9. Autonomous motivation	.46**	.43**	.36**	.33**	.59**	.53**	.44**	.42**	1									
10. Attitude	.46**	.51**	.36**	.31**	.54**	.60**	.43**	.40**	.75**	1								
11. Subjective norm	.39**	.37**	.41**	.36**	.50**	.44**	.55**	.49**	.67**	.63**	1							
12. PBC	.38**	.35**	.38**	.42**	.48**	.42**	.48**	.56**	.66**	.63**	.75**	1						
Demographic variables (T1)																		
13. Age	-.05**	-.05**	-.02	-.01	-.11**	-.10**	-.05*	-.04	-.13**	-.12**	-.10**	-.10**	1					
14. Sex	-.04*	-.01	-.08**	-.09**	-.07**	-.03	-.08**	-.08**	-.05*	-.01	-.09**	-.08**	-.04*	1				
15. Weekly hours in sport	.10**	.09**	.13**	.12**	.11**	.08**	.08**	.10**	.12**	.12**	.12**	.11	-.02	-.08**	1			
16. Incidence of sport injury	-.03	-.06**	-.02	-.01	.01	-.00	.02	-.04*	-.06*	-.06*	-.03	-.03	-.05*	-.09**	.09**	1		
17. Absence from PE	-.02	.01	-.01	.01	-.01	-.02	.00	.00	.02	-.01	.01	.00	.02	.01	.03	.06**	1	
18. Absence from sport	.01	.02	.03*	.04*	.02	.01	.02	-.01	.05*	.01	.03	.00	.04*	.00	.05**	.17**	.59**	1
Mean	5.53	5.73	5.10	5.02	5.61	5.85	5.38	5.26	5.69	5.86	5.50	5.37	14.42	1.56	5.12	1.14	.89	3.32
SD	1.15	1.18	1.36	1.30	1.19	1.21	1.37	1.35	1.24	1.23	1.37	1.37	1.75	.50	5.00	3.96	6.93	12.17
Cronbach's Alpha	.82	.90	.85	.89	.87	.93	.88	.92	.90	.94	.90	.93	N/A	N/A	N/A	N/A	N/A	N/A
McDonald's Omega	.78	.87	.85	.85	.77	.89	.84	.86	.81	.89	.85	.86	N/A	N/A	N/A	N/A	N/A	N/A

Note. T1 = Time 1; T2 = Time 2; T3 = Time 3; PBC = Perceived behavioral control; Weekly hours in sport = Number of hours participants spent in sport or physical activity in a typical week; Incidence of sport injury = Number of sport injuries in the last 6 months; Days absence from PE = Number of days student could not take PE lessons due to sport injury; Days without sport = Number of days student could not participate in sport due to sport injury; N/A = Not applicable.

*$p < .05$, **$p < .01$ (two tailed)

Table 2

Parameter estimates of Model 1 (for T1 and T2), Model 2 (for T1 and T3), and Model 3 (for T2 and T3).

	Model 1 (T1 → T2)		Model 2 (T1 → T3)		Model 3 (T2→T3)	
	β	95%CI	β	95%CI	β	95%CI
Cross-lagged pathways						
Autonomous motivation → attitude	.27**	[.20-.34]	.29**	[.21-.37]	.25**	[.16-.35]
Autonomous motivation ← attitude	.12**	[.05-.18]	.11**	[.04-.18]	.17**	[.09-.25]
Autonomous motivation → subjective norm	.25**	[.18-.32]	.31**	[.24-.38]	.29**	[.21-.38]
Autonomous motivation ← subjective norm	.01	[-.05-.06]	.02	[-.04-.08]	.01	[-.07-.08]
Autonomous motivation → PBC	.26**	[.18-.33]	.28**	[.21-.35]	.27**	[.19-.35]
Autonomous motivation ← PBC	.06**	[.00-.11]	.04	[-.02-.09]	-.02	[-.08-.05]
Autoregressive pathways						
Autonomous motivation → autonomous motivation	.43**	[.35-.50]	.36**	[.27-.45]	.46**	[.37-.55]
Attitude → attitude	.31**	[.24-.39]	.28**	[.20-.36]	.40**	[.30-.50]
Subjective norm → subjective norm	.26**	[.20-.33]	.17**	[.11-.24]	.31**	[.23-.38]
PBC → PBC	.25**	[.18-.32]	.23**	[.17-.29]	.35**	[.27-.42]

Note. PBC = perceived behavioral control. Effects of the covariates (e.g., age, sex) are omitted from the table to ease presentation, but could be obtained from the first author on request.

*$p < 0.05$, **$p < 0.01$(two-tailed)