Physical activity after cardiac rehabilitation: Explicit and implicit attitudinal components and ambivalence

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Abstract

Objective: Physical activity is crucial in the treatment of cardiac disease. In addition to socio-cognitive theories of behavior change, attitudinal ambivalence and non-conscious factors have also been demonstrated to predict physical activity. We propose an extension to the theory of planned behavior with a dual-systems approach including explicit and implicit attitudes, and different types of attitudinal ambivalence as moderators to predict the physical activity of patients after discharge from inpatient cardiac rehabilitation.

Methods: The sample comprised *N*=111 cardiac patients who provided daily diary reports of intention, cognitive, affective, and implicit attitudes for 21 days after discharge (86% male, M_{age}=62, SD_{age}=11, *n*=2'017 days). Daily moderate–to-vigorous (MVPA) and light (LPA) physical activity were measured using accelerometers. Five types of ambivalence were calculated. Analyses included Bayesian multilevel modeling.

Results: Patients with more positive affective attitudes and more positive implicit attitudes had a higher intention. Higher ambivalence weakened the affective attitudes-intention relationship. On days with more positive implicit attitudes than usual, intention was lower, but only when ambivalence was low. Patients with higher ambivalence engaged in less MVPA. On days with extremely low ambivalence, implicit attitudes were negatively associated with tomorrow's MVPA. Patients with more positive affective attitudes engaged in more LPA, but only when their ambivalence was very low. On days with higher ambivalence than usual, the next day's LPA was shorter. However, another type of ambivalence showed the opposite effect.

Conclusions: The results emphasize the importance of affective and implicit attitudes and ambivalence for the physical activity of cardiac patients.

Key words: cardiac disease, physical activity, theory of planned behavior, implicit attitudes, attitudinal ambivalence

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Cardiovascular diseases are the most frequent cause of death worldwide (World Health Organization - WHO, 2017). Cardiac disease is the most common among cardiovascular diseases and is mainly caused by a combination of lifestyle risk factors such as physical inactivity, smoking or obesity (WHO, 2017). Regular physical activity (PA) has been shown to independently decrease the risk of cardiac disease(Varghese et al., 2016). Consequently, one of the main aims of inpatient cardiac rehabilitation programs is to increase heart disease patients' PA after discharge (Bierbauer et al., 2020). Cardiac rehabilitation reduces cardiovascular mortality and the risk of future hospital admissions, and increases exercise capacity and quality of life (Anderson et al., 2016; Bierbauer et al., 2020). Nevertheless, adherence to PA recommendations after inpatient cardiac rehabilitation remains elusive (ter Hoeve et al., 2015).

The present study's main goal is to identify important determinants for the PA of cardiac disease patients in their everyday lives after inpatient cardiac rehabilitation. For this purpose, the theory of planned behavior (TPB; Ajzen, 1991) serves as a theoretical basis for this study. Yet, the TPB has neglected the possible differential associations of attitudinal components, as well as the potential weakening effects of attitudinal ambivalence on the predictive value of attitudes (e.g., Lawton et al., 2009; Sparks et al., 2004). Taking these elements into account may help in narrowing down the intention-behavior gap, which has been identified as an important weakness of the TPB (e.g., McEachan et al., 2011). Moreover, taking a dual-systems perspective into account has shown promising empirical results, but has also been neglected in the health behavior change literature (Sheeran et al., 2013). Therefore, we propose an extension to the TPB with a detailed structure of attitudes including cognitive, affective, and implicit attitudes, as well as five different types of attitudinal ambivalence as possible moderators of the attitudes-intention, attitudes-behavior, and intention-behavior relationships. Furthermore, the associations in our proposed extension are investigated between individuals (interindividual level) as well as within individuals on a daily basis

over time (intraindividual level; e.g., see (Bolger & Laurenceau, 2013), which has rarely been considered in previous research on cardiac disease patients.

The TPB (Ajzen, 1991) has been successful in predicting the intention to be physically active, as well as PA itself (e.g., Plotnikoff et al., 2010), by using three explicit factors: perceived behavioral control, subjective norm, and explicit attitudes. A meta-analysis (McEachan et al., 2011) showed that across 103 studies, the TPB accounted for 24% of PA variance. Nevertheless, most studies focused exclusively on the interindividual level, which can be problematic: Statistically, findings based on interindividual analyses can be applied to an individual only if the conditions of homogeneity and stationarity are met (Molenaar & Campbell, 2009), which is very rare in psychology. In fact, inter- and intraindividual associations have been found to differ substantially (e.g., Bierbauer et al., 2017). On the basis of the TPB, the present study aims at identifying socio-cognitive factors that are related to the PA of heart disease patients right after inpatient cardiac rehabilitation. To address the neglect of intraindividual associations this will be done within patients over time by taking on an observational approach.

Empirical evidence suggests that there are different aspects in the structure of attitudes that, when not taken into account, may have a diminishing effect on the predictive value of attitudes (e.g., Sparks et al., 2004). The TPB states that explicit attitudes can be divided into two components: *cognitive* and *affective* (Ajzen, 2002). Whereas the first component describes the instrumental or utilitarian evaluative aspects of performing the behavior, the second component focuses more on the experiential evaluation. In the TPB, the two attitudinal components are combined into a single score of explicit attitudes (Ajzen, 2002). Nevertheless, the reasoned action approach (RAA), as well as some empirical findings rather suggest that the components should be investigated as separate predictors (McEachan et al., 2016). Indeed, each component's predictive value may vary depending on the behavior in question: In the case of PA, affective attitudes seem to play a more important role than cognitive ones for intention and contrary to TPB predictions also for PA directly (Lawton et al., 2009). This might be particularly insightful in the case of cardiac disease patients, given that

information they receive pertaining PA typically focuses on its healthy aspects, which only speaks to cognitive attitudes. Therefore, we investigate the cognitive and affective attitudinal components as separate direct predictors of behavioral intention and of PA.

In the TPB, explicit attitudes are usually measured using a semantic differential (Ajzen, 2006). For example, PA would be rated on a bipolar scale from *beneficial* to *harmful* or from *unpleasant* to *pleasant*. However, these scales do not allow the differentiation between univalent attitudes (which contain exclusively positive, negative or neutral evaluations) and ambivalent attitudes (which contain simultaneous positive and negative evaluations; see Conner & Armitage, 2008 for a review). It is, for example, conceivable that a patient might think that PA is healthy (positive cognitive attitude) and harmful (negative cognitive attitude) at the same time perhaps given their fragile condition. The resulting *structural ambivalence* represents the magnitude of conflict between the positive and the negative ratings (Sparks et al., 2004). Whereas *cognitive structural ambivalence* describes the amount of conflict within the cognitive attitudinal component, the *affective structural ambivalence* results from the affective component. Moreover, the cognitive and affective components of attitudes can also represent a source of conflict within the structure of attitudes. This *intercomponential ambivalence* ensues when one component has a positive and the other component a negative evaluation (Conner & Sparks, 2002). As an example, a person may think that PA is healthy (positive cognitive attitude) but may not enjoy it (negative affective attitude). Both structural and intercomponential ambivalence have been found to weaken the relationships between attitudes and intention, attitudes and behavior, as well as between intention and behavior (Conner et al., 2021; Sparks et al., 2004; Tagler & Cozzarelli, 2013). Therefore, the present study takes cognitive structural, affective structural, and intercomponential ambivalence into account. Figure 1 shows an overview of the proposed extension to the TPB with an unspecified type of ambivalence exemplifying the relationships investigated for each type of ambivalence.

Whereas socio-cognitive models of behavior change, such as the TPB, predominantly focus on explicit factors, the dual-systems perspective argues that more automatic influences also play an

important role for health behavior (Sheeran et al., 2013). *Implicit attitudes*, defined as "automatic affective reactions resulting from the particular associations that are activated automatically when one encounters a relevant stimulus" (Gawronski & Bodenhausen, 2006, p. 693), have been repeatedly found to be positively related to PA (e.g., Endrighi et al., 2016; Chevance et al., 2019). Nevertheless, it has been shown in the literature that findings regarding the effect of implicit attitudes on behavior might be overestimated given that studies have rarely controlled for explicit influences (Blanton et al., 2016). For example, Ayres et al. (2012) found that implicit attitudes could not predict food choice over and above explicit affect-related measures. However, the positive long-term impact of implicit attitudes on PA has also been found in pulmonary patients after rehabilitation under consideration of explicit factors (Chevance et al., 2017). Therefore, our extension to the TPB includes implicit attitudes towards PA (see Figure 1). A novel aspect of the present study is the daily measurement of implicit attitudes allowing the analysis of relevant processes at the intraindividual level.

With the introduction of implicit attitudes, a new type of ambivalence in the structure of attitudes arises. Research has shown that explicit and implicit attitudes can result in very different evaluations (Petty et al., 2012). *Implicit ambivalence* describes the degree of discrepancy between the explicit and the implicit measures of attitudes (Petty et al., 2012). A possibility is to examine implicit ambivalence for each attitudinal component (Petty et al., 2006). *Cognitive vs implicit ambivalence* refers to the conflict of cognitive explicit versus implicit attitudes, and *affective vs implicit ambivalence* describes the conflict between affective explicit and implicit attitudes. Similar to the previous types of ambivalence, weakening effects of implicit ambivalence on the relationship between attitudes and behavior have been found (Karpen et al., 2012). Mirroring the results found for other types of ambivalence, the present study also explores the moderating effect that cognitive vs implicit and affective vs implicit ambivalence could have on the relationship between intention and behavior.

In sum, the present study aims at adding to the literature by examining so far neglected factors for the PA of cardiac disease patients: Cognitive explicit, affective explicit, and implicit attitudes, as well as five different types of attitudinal ambivalence as potential moderators of the attitude-intention, attitude-behavior, and intention-behavior relationships. For this purpose, the different factors and relationships presented in the proposed extension to the TPB (see Figure 1 for an overview) are investigated at the inter- and intraindividual levels across 21 days right after inpatient cardiac rehabilitation.

Methods

Study design

The data for the present study were collected as part of the CAMP-project (*C*ardiac disease, *A*djustment disorder, *M*edication adherence, and *P*hysical activity), which had a multi-centric intensive-longitudinal observational design with four comprehensive questionnaires and a diary phase. In CAMP, the diary phase started during inpatient cardiac rehabilitation. However, the present study analyzed the diary phase data starting on the day of discharge from the clinic. The days at the clinic were excluded from analysis because partaking in the exercise program is mandatory for patients during rehabilitation and thus self-regulatory processes are less important. In Switzerland, inpatient cardiac rehabilitation follows the guidelines of the Swiss Working Group for Cardiovascular Prevention, Rehabilitation and Sports Cardiology (https://www.scprs.ch/). Inpatient cardiac rehabilitation lasts 3-4 weeks and includes a minimum of 21 therapy sessions each week. Exercise therapy is adapted to the patient's exercise capacity and consists of endurance training (cycling or treadmill), coordination/balance (gymnastics), outdoor activities (walking), strength training, and in some patients, inspiratory muscle training and relaxation. Moreover, patients also receive psychoeducation and counseling sessions regarding the cardiac disease and cardiac risk factors.

In the present study, the diary phase included short evening questionnaires and the device-based measurement of PA during three weeks at home right after discharge from inpatient cardiac

rehabilitation. All information about the CAMP study design and procedure is described in detail on OSF. The Ethics Committee of the Canton Zurich (KEK; REQ-2017-005-08) cleared the CAMP project.

Sample

Participants in the diary phase of the CAMP study were *N* = 156 cardiac disease patients of four inpatient cardiac rehabilitation centers in Switzerland (see participant flow of CAMP on OSF). *n* = 45 patients had insufficient data (due to technical issues or non-compliace) and were, therefore, excluded. The final sample, *n*=111, had a mean age of *M* = 62.32, *SD* = 10.85, age range: 24 - 83 years. Men represented 85.6% of the sample. There were *n* = 2'017 complete days of data for at least one of the statistical models reported. On average, patients spent *M* = 20.33 days (*SD* = 4.29) in rehabilitation. The most frequent main diagnoses were ischemic heart disease (55.9%), valve disorder (26.1%), heart failure (9.0%), and aortic aneurysm (3.6%). Patients were taking 6.81 (*SD* = 2.19) medications on average, including anticoagulants (87.0%), statins (75.0%), beta-blockers (60.4%), diuretics (42.6%), ACE inhibitors (16.7%), and phenprocoumon (14.8%). The sample did not significantly differ from the excluded patients in terms of age, $t(154) = 0.20$, $p = .84$, gender distribution, $\chi^2(1) = 0.28$, $p = .60$, intention, $t(152) = 1.87$, $p = .06$, perceived behavioral control, $t(152) = 0.60$, $p = .55$, subjective norm, $t(152) = 0.91$, $p = .37$, cognitive attitudes, $t(152) = 0.78$, $p = .44$, affective attitudes, $t(152) = 1.38$, $p = .17$, or implicit attitudes, $t(114) = 1.75$, $p = .08$, during rehabilitation.

Measurements and procedure

PA was measured objectively using a triaxial accelerometer (ActiGraph, GT3X Monitors, Pensacola, FL) that participants wore on their hip. Detailed information and scoring of the ActiGraph data can be found in OSF. Because the WHO (2010) recommends cardiovascular patients to engage in at least 150 minutes of moderate activity, 75 minutes of vigorous activity or a combination of both per week, we will take daily minutes of moderate to vigorous PA (MVPA) as primary outcome. Given that light PA (LPA) seems to also reduce cardiovascular mortality (Qiu et al., 2020), we will also investigate daily minutes of LPA as secondary outcome.

During the diary phase, patients filled out an evening diary on a tablet before going to bed. The *intention* to be physically active was measured in the evening questionnaire using one item: "I intend to be physically active tomorrow" (based on Sniehotta et al., 2005). This item and all items in the questionnaire described next were rated on a 6-point Likert scale from *not at all true* (0) to *completely true* (5). *Perceived behavioral control* was measured using the item "I am sure that I can be physically active tomorrow, even if it is difficult" (based on Sniehotta et al., 2005). *Subjective norms* were assessed as the mean score of the following two items: "Most people, who are important to me, would encourage me to be physically active tomorrow" and "Most people, who are important to me, are physically active on a regular basis" (based on Ajzen, 2006; Plotnikoff et al., 2010). Unipolar non-partitioned items were used to assess *explicit attitudes* towards PA (based on Ajzen, 2006; Refling et al., 2013; Rhodes et al., 2009). Following the instruction "For me, to be physically active tomorrow would be…" participants rated the following adjectives: "…harmful" (negative cognitive), "…beneficial" (positive cognitive), "…unpleasant" (negative affective) and "…pleasant" (positive affective). *Cognitive attitudes* were calculated as the positive cognitive rating minus the negative cognitive rating, *affective attitudes* as the difference between the affective ratings.

Implicit attitudes were measured using the affective misattribution procedure (AMP; based on Payne et al., 2005; Payne & Lundberg, 2014). Participants completed eighteen trials of the AMP for PA every evening. We chose this number of trials in order to reduce participant burden for daily measurement while maintaining acceptable reliability (Payne & Lundberg, 2014). During each trial participants saw a word related to PA shortly on the screen. This word acted as a prime and was shown for 225ms followed by a 100ms empty interval. A Chinese character appeared then on the screen for 300ms. Afterwards, participants were instructed to rate the pleasantness of the Chinese symbol on a 4-point scale from *very unpleasant* (-2) to *very pleasant* (+2) and without a middle point (0). Longer presentation times of the prime and target were chosen within the recommendations of Payne and Lundberg (2014) to accommodate older participants' comfort with the task. Eighteen

primes (words related to PA) were chosen using data from a survey conducted by the first and the senior authors in the German-speaking part of Switzerland to gather words (activities or objects) that people relate to PA. In order to adapt the words to our sample, the survey sample was weighted using the expected age and gender of the current sample based on archive data from one of the inpatient cardiac rehabilitation centers (a subsample from Bierbauer et al., 2020). The eighteen most frequent words that people related to PA were chosen for the present study: bicycle, hiking, jogging, ball, swimming, strolling, ski, gardening, trainers, running, tennis racket, household chores, walking, shopping, fitness, stairs, strength training, and sport. 36 Chinese symbols were used as targets. The presentation order was randomized. Whereas interindividual reliability was excellent (R_{KF} = .99), intraindividual reliability was R_C = .32 (Cranford et al., 2006). It should be noted, however, that the latter stems from a bigger error of each "item" (word/prime), which might only be reflecting the randomized daily pairing with one of the Chinese symbols. The final score (the mean of the eighteen trials) would then neutralize this error. The task to measure implicit attitudes was programmed and sent using MobileCoach (Kowatsch et al., 2017).

All types of ambivalence were calculated using the formula developed by Thompson et al. (1995), namely A = (P + N)/2 - |P - N|, where A = ambivalence, P = positive evaluation and N = negative evaluation, which fulfils all three theoretical conditions of ambivalence postulated by Breckler (1994) and is frequently used in the literature. To calculate *cognitive structural ambivalence* the formula was applied using the positive (P) and the negative (N) items measuring cognitive attitudes. The result was then shifted by plus 2.5 in order for scores to be in the positive range and for 0 to represent the absence of ambivalence. Note that if either P or N were 0 as this was indicative of a univalent attitude, that is, the absence of ambivalence. *Affective structural ambivalence* was calculated in exactly the same way by using the positive (P) and negative (N) items for affective attitudes.

In order to calculate *intercomponential ambivalence*, the ambivalence formula was used twice, first for the positive *cognitive* (P) and negative *affective* (N) attitudinal ratings (pro-

cognitive/con-affective score; Conner et al., 2021) and second for the negative *cognitive* (N) and the positive *affective* (P) ratings (con-cognitive/pro-affective score). The two resulting scores were then shifted by plus 2.5 and, as before, if either P or N was 0, coded 0. Finally, the intercomponential ambivalence score was calculated by taking the mean of the two scores.

Cognitive vs implicit ambivalence was calculated as follows: First, the absolute value of the implicit attitudes score was multiplied by 2.5 to get a scale from 0 to 5, thus, matching the range of the scale of the items for explicit attitudes. Note that at this point the result is always positive and represents the magnitude rather than the valence itself. Second, the ambivalence formula was applied using this new implicit attitudes score as N. If the original implicit attitudes score had been negative (or positive), then P was represented by the positive (or negative) cognitive rating. If the original attitude score had been zero, then ambivalence was also defined as zero. Finally, the result from the second step was shifted by plus 2.5, which resulted in the final cognitive vs implicit ambivalence score. *Affective vs implicit ambivalence* was calculated exactly the same way using affective instead of cognitive attitudes.

The following *control variables* were taken into account: (1) a *time* variable representing linear time counting the diary days starting at 0 (discharge day) and going up to 21; (2) *weekday* (weekday = 1, weekend day = 0); (3) ActiGraph *wear time* in minutes centered at the grand mean; (4) gender (female = 0, male = 1); and (5) previous day (lagged) outcome centered at the grand mean. Age, low variance of questionnaire answers, depression score, PTSD score, and rehabilitation duration were also adjusted for in sensitivity analyses and are described in the supplementary material.

Statistical analyses

Using the brms package (Buerkner, 2018) within R (R Core Team, 2018), multilevel modeling with Bayesian estimation was applied to investigate the proposed relationships with intention, MVPA and LPA, respectively as outcomes. The non or very weakly informative default priors of the brm function were used (Buerkner, 2018). The main predictors were intention (only in MVPA and LPA

models), perceived behavioral control, subjective norm (only in the intention model), cognitive attitudes, affective attitudes, implicit attitudes, cognitive structural ambivalence, affective structural ambivalence, intercomponential ambivalence, cognitive vs implicit ambivalence, and affective vs implicit ambivalence. Because for any given day the evening diary items referred to the next day's PA, all main predictors were lagged by one day for the MVPA and LPA models. The interindividual level predictors were centered at the grand mean across participants (Bolger & Laurenceau, 2013). Values higher/lower than 0 indicate that the person's mean is above/below average in the sample. The intraindividual level predictors, on the other hand, were calculated by centering the daily scores at each participant's average across the study (Bolger & Laurenceau, 2013). Thus, intraindividual values higher/lower than 0 indicate that on that particular day the score is higher/lower than usual for that individual during the study. Essential control variables, that is, variables that were adjusted for in all models were time, and, in the case of the MVPA and LPA models, centered previous day outcome and accelerometer wear time. In order to reduce model complexity, thereby facilitating interpretation and optimizing statistical power, we used the leave-one-out information criterion (LOOIC) for model comparison (interpreting a difference between the models' LOOICs of at least two times its standard error as an indication that one of the models showed a better fit; Vehtari et al., 2017). In order to arrive at a final model for each outcome, we proceeded as follows. First, all control variables and the main fixed effects of all predictors were included in the model. Next, non-significant control variables causing a reduction in sample size (PTSD score, depression score, or rehabilitation duration) were removed from the model in order to allow for model comparison. The next step involved removing all non-essential non-significant control variables. The model with the better fit was chosen. If there was no clear difference, the simpler model was chosen. Afterwards the random slope of each pertinent variable in the model was added stepwise. The given random slope was only kept in the model, if it improved model fit. Subsequently, the interactions of each ambivalence type with cognitive attitudes, affective attitudes, implicit attitudes, and intention (only in the MVPA and LPA models) were included stepwise. An interaction was kept only if the inclusion

improved the model fit or, if it proved to be significant. If an interaction was kept, the random slope of the person-mean-centered interaction was included in the model, but kept only if the model fit improved. The resulting models are reported in the results section. For a final sensitivity analysis reported in the supplementary material, all control variables left out were added to the models. To interpret the relevance of each significant interaction correctly, the interactions were visualized and decomposed using the application developed by Preacher and colleagues (2020).

Results

The descriptive statistics of all predictors and outcomes, as well as their inter- and intraindividual correlations, can be found in Table 1. Note that there are some differences between the inter- and intraindividual correlations. For example, affective attitudes correlated positively with MVPA at the inter- but not at the intraindividual level. MVPA and LPA showed a negative correlation at the intraindividual, but not at the interindividual level. Intention to be physically active tomorrow correlated positively with the next day's MVPA at both levels of analysis, which was not the case for LPA.

Prediction of intention. At the interindividual level, perceived behavioral control, subjective norm, affective attitudes, and implicit attitudes showed a significant positive association with the intention to be physically active (see Table 2). In the case of implicit attitudes, the results showed that on average across the diary phase people with a unit more positive implicit attitudes had a 0.28 units higher intention to be physically active compared to people with a unit less positive implicit attitudes Furthermore, patients with a unit higher cognitive structural ambivalence on average across the study had a 0.27 lower intention to be physically active than patients with a unit lower cognitive structural ambivalence. In addition, the interindividual level interaction between affective attitudes and affective structural ambivalence had a negative significant effect on intention (see Panel A of Figure 2). The region of significance was found outside of the affective attitudes values between -0.81 and 41.23, and outside the affective structural ambivalence values between 1.91 and 48.80. As a reference, person-mean-centered affective attitudes had a range from -5.25 to 1.74 (*M* =

-0.10, *SD* = 1.63), and affective structural ambivalence had a range from -1.07 and 3.69 (*M* = 0.08, *SD* = 1.38).

At the intraindividual level, on days with higher perceived behavioral control or higher subjective norm than usual, the intention to be physically active was higher. In addition, the interaction between implicit attitudes and cognitive structural ambivalence was significant (see Panel B of Figure 2). The region of significance was found outside of the implicit attitudes (range: -3.37 to 1.41; *M*±*SD* = ±0.29) values between 0.09 and 2.17, and outside of the cognitive structural ambivalence (range: -4.24 to 7.14; *M*±*SD* = ±0.86) interval between -0.18 and 3.17.

Prediction of MVPA. At the interindividual level, only intercomponential ambivalence had a significant effect (see Table 3). On average across time, patients with a unit higher intercomponential ambivalence engaged in 25.89 minutes less MVPA per day compared to other patients. At the intraindividual level, intention predicted MVPA. On days with one unit higher than usual intention to be physically active tomorrow, patients engage in 4.44 minutes more MVPA the next day. The intraindividual level interaction between implicit attitudes and cognitive vs implicit ambivalence was also significant (see Panel C of Figure 2). The region of significance was found outside of values of implicit attitudes (range: -3.33 to 1.39; *M*±*SD* = ±0.29) between -1.70 and 1.01, and outside the values of cognitive vs implicit ambivalence (range: -2.82 to 7.12; *M*±*SD* = ±0.75) between -1.67 and 3.62.

Prediction of LPA. Patients with a higher perceived behavioral control on average across the diary phase engaged in less LPA than other patients (see Table 4). The interindividual level interaction between affective attitudes and affective structural ambivalence was negative and significant (see Panel D of Figure 2). The region of significance was found outside the values of affective attitudes (range: -5.26 to 1.74; *M* = -0.10; *SD* = 1.62) between -16.15 and 1.24, and outside the values of affective structural ambivalence (range: -1.08 to 3.68; *M* = 0.08; ±*SD* = 1.36) between -1.30 and 9.55.At the intraindividual level, one unit higher intercomponential ambivalence than usual was

associated with 5.56 less LPA minutes the next day. Finally, one unit higher cognitive vs implicit ambivalence than usual was associated with 6.73 minutes *more* LPA the next day.

Discussion

The main goal of the present study was to identify important factors for the PA of cardiac disease patients at the inter- and intraindividual levels right after inpatient cardiac rehabilitation. In order to achieve this goal, we proposed an extension to the TPB (Ajzen, 1991) with a dual-systems perspective and a detailed structure of attitudes and attitudinal ambivalence (see Figure 1).

Results at the interindividual level will be discussed first. In line with the TPB, cardiac patients with higher perceived behavioral control, higher subjective norms, and more positive affective attitudes showed a higher intention to be physically active. As cognitive attitudes were not significantly associated with intention, these results add to the literature finding affective attitudes to be more relevant than cognitive attitudes for the intention to be physically active (e.g., Lawton et al., 2009). The relevance of affect-related factors was further supported by the attenuating moderation effect of affective structural ambivalence on the relationship between affective attitudes and intention. Beyond the TPB, taking a dual-systems perspective with the inclusion of implicit attitudes proved fruitful as patients with more positive implicit attitudes towards PA tended to also have a higher intention to be physically active. This result adds to the literature finding a significant effect of implicit attitudes over and above explicit factors in general (e.g., Chevance et al., 2017), which has been controversial due to mixed results in the literature (Ayres et al., 2012; Blanton et al., 2016). In particular, our findings show that implicit attitudes can be predictive of intention over and above explicit affect-related variables. A possible explanation for the relevance of affective and implicit attitudes is that they might indicate a higher intrinsic motivation, whereas cognitive attitudes might rather speak to extrinsic motivation (Ryan & Deci, 2020).

Only intercomponential ambivalence was a significant predictor of MVPA at the interindividual level. This is surprising, as intention has been repeatedly found to be a good interindividual predictor of PA (e.g., McEachan et al., 2011). However, previous research did not

control for some of the variables in the model, such as implicit attitudes and the different types of ambivalence, which might explain these results. Moreover, intention did show an association with MVPA at the intraindividual level, which further highlights the importance of considering the intraindividual level of analysis into account. Furthermore, the significant interindividual main effect of intercomponential ambivalence joins the literature postulating main effects of ambivalence on behavior (e.g., Berndsen & van der Pligt, 2004), which has been uncommon compared to the vast research focusing and finding moderation effects of ambivalence (Conner & Armitage, 2008).

In terms of LPA, patients with more positive affective attitudes engaged in more LPA, but only when affective structural ambivalence was low. In fact, the lower the ambivalence the stronger this relationship. This finding reflects the expected moderation of ambivalence and again highlights the importance of affective attitudinal components for the PA of cardiac patients.

At the intraindividual level and as predicted by the TPB, perceived behavioral control and subjective norm were positively associated with Surprisingly, on days with low cognitive structural ambivalence and more negative implicit attitudes than usual, intention was higher. A possible explanation could be that more negative implicit attitudes than usual might indicate a higher risk of not actually engaging in PA the next day. If perceived, this higher risk paired with a strong conviction pertaining the benefits of PA (low cognitive structural ambivalence) could lead to increasing intention in order to reduce the perceived risk of inactivity. This novel finding highlights the importance of reducing conflict in the cognitive evaluations, that is, not only promoting positive cognitive attitudes, but also reducing negative ones. This could be done by addressing patients' insecurities pertaining possible negative consequences of PA on their health.

As predicted by the TPB (Ajzen, 1991), on days with a higher intention than usual to be physically active tomorrow, objectively assessed MVPA was indeed higher the next day. Implicit attitudes were also related to MVPA. Contrary to expectations, on days with *extremely low* cognitive vs implicit ambivalence and more positive implicit attitudes than usual, the next day's MVPA was *shorter*. On the other hand, on days with *extremely high* cognitive vs implicit ambivalence and more

positive than usual implicit attitudes, the next day's MVPA was *longer*. Discrepancies between the explicit and the implicit systems have previously been found to deplete volitional strength (e.g., Kehr, 2004), which might in turn lead to individuals relying more on the implicit system. Intraindividually, intercomponential ambivalence related negatively and cognitive vs implicit ambivalence related positively with LPA. The former finding highlights the importance of reducing conflict between the cognitive and the affective attitudinal components. The latter suggests that cognitive vs implicit ambivalence can drive processes in favor of health behavior. In this instance, perhaps unusually high conflict between cognitive and implicit attitudes might make PA more salient and call for elaboration, which in turn could lead the person to be more active. Alternatively, a high conflict between cognitive and implicit attitudes might lead to higher restlessness and, in turn, to more LPA. More research is needed to understand the effects of cognitive vs implicit ambivalence on PA and their underlying mechanisms.

Overall, the results highlight that next to the socio-cognitive factors of the TPB (Ajzen, 1991), affective and implicit attitudinal components and ambivalence also play an important role for the daily PA of cardiac disease patients. Therefore, future research and interventions should take these aspects into account. Of the five different types of ambivalence considered, only affective vs implicit ambivalence proved irrelevant throughout our analyses. In general, replication and further investigation would be useful in order to better understand the associations and their underlying mechanisms.

Importantly, it should be noted that given the study design and correlative nature of the data, it is impossible to infer causality for any of the associations found. Future research could come closer to inferring causality by manipulating the attitudinal components and including a control group. Recommended would be to promote more positive affective and cognitive attitudes by addressing not only the positive but also by reducing the negative evaluations. Moreover, interventions to modify implicit attitudes, such as evaluative conditioning, attentional bias

modification or approach-avoidance training, could prove fruitful (Sheeran et al., 2013).interventions should also focus on increasing the amount of LPA and reducing sedentary time.

The proposed study has several strengths and adds to the extant literature in different ways. First, the daily assessments allowed analyses at the inter- and the intraindividual level. Moreover, these daily assessments are a novel aspect in the case of implicit attitudes. Second, PA was measured objectively. Third, the different types of ambivalence had not been analyzed simultaneously or considered the separate attitudinal components (cognitive and affective). Moreover, both explicit and implicit influences were taken into account. The detailed attitudinal structure allowed us to identify which elements play an active role for intention, MVPA and LPA, and at which level. This, in turn, gives a direction for future research and interventions.

This study has also some limitations. First, our measurements might have caused a certain reactivity (e.g., Baumann et al., 2018) Second, our sample could be prone to selectivity bias. Third, our measurement of implicit attitudes showed a low intraindividual reliability. This might only be a reflection of the nature of the task (the randomized pairing of the primes and the Chinese symbols), which is further supported by the fact that there were intraindividual significant findings pertaining implicit attitudes. Even so, results regarding implicit attitudes at the intraindividual level should be interpreted with caution. Finally, for building an ambivalence score combined elements were given the same weight (e.g., positive and negative ratings for structural ambivalence) without knowing if the two elements had different weights (e.g., positivity or negativity bias).

In sum, the results of the present study emphasize that next to the socio-cognitive factors of the TPB, affective and implicit attitudes as well as cognitive structural, affective structural, intercomponential and cognitive vs implicit ambivalence are important for the PA of cardiac disease patients right after discharge from inpatient cardiac rehabilitation.

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Table 1

Means, standard deviations, inter- and intraindividual correlations of all predictors and outcomes

	range	M_b	SD_b	SD_w	*ICC*	1	2	3	4	5	6	7	8	9	10	11	12	13
1. PBC lg	[0 ; 5]	4.11	0.86	0.41	.73		.11***	.05*	.13***	-.01	-.09***	-.07**	-.08***	.00	-.02	.53***	.07**	-.02
2. Subjective norm lg	[0 ; 5]	3.87	0.74	0.27	.83	.53***		.08***	.12***	.03	-.09***	-.07**	-.08***	-.08***	-.07**	.13***	.05*	-.01
3. Cognitive attit. lg	[-5 ; 5]	3.86	1.16	1.14	.25	.42***	.33***		.46***	.04	-.28***	-.13***	-.43***	-.18***	-.12***	.08***	.03	-.02
4. Affective attit. lg	[-5 ; 5]	3.13	1.71	1.13	.55	.39***	.29**	.50***		-.01	-.10***	-.45***	-.46***	-.12***	-.23***	.11***	.00	-.02
5. Implicit attit. lg	[-2 ; 2]	0.27	0.67	0.25	.84	.35***	.10	.21*	.36***		-.01	.00	-.02	-.22***	-.16***	.00	.02	.01
6. Structural cognitive ambiv. lg	[0 ; 7.5]	0.49	0.93	0.55	.50	-.31***	-.24**	-.68***	-.48***	-.15		.20***	.48***	.09***	.01	-.14***	-.02	.01
7. Structural affective ambiv. lg	[0 ; 7.5]	1.19	1.37	0.95	.57	-.30**	-.27**	-.42***	-.87***	-.29**	.56***		.68***	.01	.21***	-.06**	.00	.01
8. Intercompon. ambiv. lg	[0 ; 7.5]	0.90	1.02	0.77	.53	-.35***	-.29**	-.63***	-.85***	-.30**	.78***	.88***		.12***	.15***	-.09***	-.01	-.01
9. Cognitive vs implicit ambiv. lg	[0 ; 7.5]	1.93	0.74	0.68	.48	-.32***	-.13	-.31**	-.44***	-.79***	.39***	.34***	.46***		.65***	-.05*	-.02	.08**
10. Affective vs implicit ambiv. lg	[0 ; 7.5]	2.16	0.82	0.72	.47	-.32***	-.14	-.27**	-.63***	-.66***	.35***	.59***	.55***	.81***		-.04	-.03	.07**
11. Intention lg	[0 ; 5]	4.36	0.60	0.42	.52	.57***	.45***	.54***	.56***	.40***	-.51***	-.46***	-.55***	-.40***	-.38***		.09***	.03
12. MVPA	[0 ; 409]	47.18	33.02	25.96	.53	.21*	.15	.14	.26**	.06	-.25*	-.24*	-.31**	-.15	-.18	.21*		-.11***
13. LPA	[58 ; 645]	287.52	75.55	62.01	.56	-.10	-.05	-.07	.11	-.10	.00	-.13	-.03	.13	.07	.10	.12	

Note. Interindividual correlations below diagonal. Intraindividual correlations above diagonal. M_b = interindividual mean. SD_b = interindividual standard deviation. SD_w = pooled intraindividual standard deviation. *ICC* = intraclass correlation (percentage of variance that is related to interindividual differences). PBC = perceived behavioral control. lg = lagged (previous day variable). Attit. = attitudes. Ambiv. = ambivalence. MVPA = moderate to vigorous physical activity in minutes. LPA = light physical activity in minutes. Significance levels: $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

Table 2

Bayesian multilevel model with intention as outcome

Fixed effects	Estimate	*SE*	95% CI	
			LL	UL
Intercept	4.28*	0.06	4.16	4.39
Interindividual level				
Perceived behavioral control	0.18*	0.06	0.06	0.3
Subjective norm	0.14*	0.06	0.02	0.27
Cognitive attitudes	-0.1	0.07	-0.24	0.05
Affective attitudes	0.22*	0.06	0.1	0.34
Implicit attitudes	0.28*	0.1	0.09	0.48
Cognitive structural ambivalence	-0.27*	0.09	-0.44	-0.10
Cognitive structural ambivalence x Implicit attitudes	0.04	0.08	-0.11	0.19
Affective structural ambivalence	0.11	0.08	-0.04	0.27
Affective structural ambivalence x Affective attitudes	-0.05*	0.02	-0.10	-0.003
Intercomponential ambivalence	-0.07	0.14	-0.34	0.19
Cognitive vs implicit ambivalence	0.18	0.11	-0.04	0.4
Affective vs implicit ambivalence	0.01	0.08	-0.16	0.17
Intraindividual level				
Perceived behavioral control	0.43*	0.04	0.34	0.52
Subjective norm	0.11*	0.03	0.04	0.18
Cognitive attitudes	0.01	0.01	-0.01	0.03
Affective attitudes	0.003	0.01	-0.01	0.02
Implicit attitudes	-0.05	0.04	-0.12	0.02
Cognitive structural ambivalence	-0.04*	0.01	-0.07	-0.01
Cognitive structural ambivalence x Implicit attitudes	0.12*	0.05	0.02	0.21
Affective structural ambivalence	-0.01	0.02	-0.04	0.03
Affective structural ambivalence x Affective attitudes	-0.002	0.005	-0.01	0.01
Intercomponential ambivalence	0.01	0.02	-0.02	0.05
Cognitive vs implicit ambivalence	-0.03	0.02	-0.07	0.01
Affective vs implicit ambivalence	-0.002	0.02	-0.04	0.04
Control variables				
Time	0.002	0.002	-0.002	0.005

Note. *n* = 111 cardiac disease patients. *n* = 1’924 available days. *SE* stands for standard error of the estimate. 95% CI represents the 95% credible interval. LL = lower limit. UL = upper limit. Estimates marked with an “*” represent significant results inferred from the credible interval excluding zero. Estimated random effect of perceived behavioral control: *SD* = 0.33, *SE* = 0.04.

Table 3

Bayesian multilevel model with MVPA as outcome

Fixed effects	Estimate	*SE*	95% CI	
			LL	UL
Intercept	44.00*	3.83	36.37	51.52
Interindividual level				
Intention	0.20	7.37	-14.78	14.89
Perceived behavioral control	5.73	4.68	-3.19	14.92
Cognitive attitudes	-6.76	5.24	-16.77	3.89
Affective attitudes	-1.01	4.92	-11.08	8.73
Implicit attitudes	-6.81	9.31	-25.2	11.7
Cognitive structural ambivalence	2.97	7.8	-12.41	18.01
Affective structural ambivalence	9.15	6.88	-4.2	22.4
Intercomponential ambivalence	-25.89*	12.8	-51.48	-0.94
Cognitive vs implicit ambivalence	-0.42	10.48	-20.89	20.35
Cognitive vs implicit ambivalence x Implicit attitudes	-2.94	4.32	-11.13	5.72
Affective vs implicit ambivalence	-4.35	6.91	-17.53	9.53
Intraindividual level				
Intention	4.44*	1.82	0.85	8.00
Perceived behavioral control	3.45	1.95	-0.44	7.19
Cognitive attitudes	1.14	0.73	-0.28	2.56
Affective attitudes	-1.21	0.81	-2.82	0.39
Implicit attitudes	-2.59	3.19	-8.91	3.82
Cognitive structural ambivalence	0.18	1.17	-2.14	2.44
Affective structural ambivalence	-0.46	1.12	-2.67	1.69
Intercomponential ambivalence	0.85	1.49	-2.04	3.78
Cognitive vs implicit ambivalence	0.67	1.59	-2.38	3.71
Cognitive vs implicit ambivalence x Implicit attitudes	3.80*	1.54	0.73	6.82
Affective vs implicit ambivalence	-0.93	1.54	-4.00	2.05
Control variables				
Time	0.30*	0.15	0.004	0.59
Previous day MVPA	0.06*	0.03	0.01	0.13
Wear time	0.01	0.01	-0.01	0.03

Note. *n* = 103 cardiac disease patients. *n* = 1’436 available days. *SE* stands for standard error of the estimate. 95% CI represents the 95% credible interval. LL = lower limit. UL = upper limit. Estimates marked with an “*” represent significant results inferred from the credible interval excluding zero. Intraindividual predictors are all lagged (previous day predictors). No random slope was included in the model.

Table 4

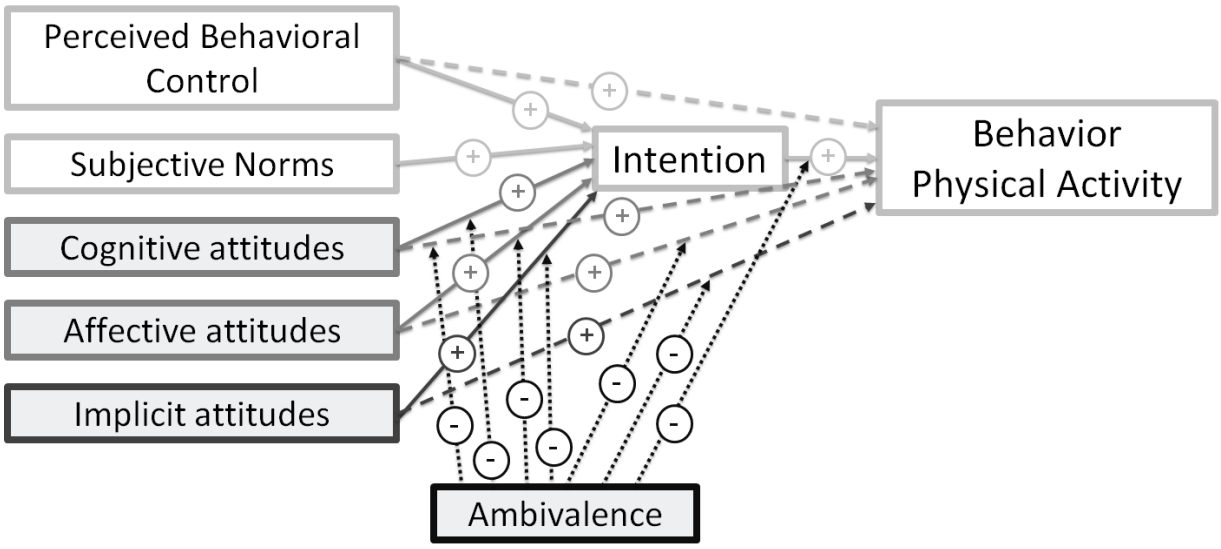
Bayesian multilevel model with LPA as outcome

Fixed effects	Estimate	*SE*	95% CI	
			LL	UL
Intercept	303.65*	18.16	269.21	340.42
Interindividual level				
Intention	16.26	15.93	-14.92	47.4
Perceived behavioral control	-18.74*	9.25	-37.31	-0.45
Cognitive attitudes	-15.38	11.2	-37.04	6.69
Affective attitudes	16.48	11.52	-5.66	39.23
Implicit attitudes	-18.39	16.58	-51.25	12.38
Cognitive structural ambivalence	-1.34	15.23	-30.23	29.59
Affective structural ambivalence	-18.85	13.87	-44.56	8.80
Affective structural ambivalence x Affective attitudes	-8.88*	3.94	-16.45	-0.94
Intercomponential ambivalence	13.62	23.91	-33.01	59.22
Cognitive vs implicit ambivalence	-4.27	19.1	-41.16	33.5
Affective vs implicit ambivalence	9.7	13.83	-17.47	36.47
Intraindividual level				
Intention	4.32	3.45	-2.43	10.99
Perceived behavioral control	-3.49	3.67	-10.83	3.61
Cognitive attitudes	0.57	1.34	-2.00	3.15
Affective attitudes	-2.3	1.52	-5.23	0.76
Implicit attitudes	2.75	5.69	-8.61	14.07
Cognitive structural ambivalence	1.95	2.14	-2.19	6.26
Affective structural ambivalence	0.23	2.52	-4.7	5.23
Affective structural ambivalence x Affective attitudes	-0.77	0.79	-2.29	0.83
Intercomponential ambivalence	-5.56*	2.86	-11.25	-0.003
Cognitive vs implicit ambivalence	6.73*	2.88	1.11	12.28
Affective vs implicit ambivalence	1.33	2.78	-4.15	6.74
Control variables				
Time	0.87*	0.28	0.32	1.42
Previous day LPA	0.09*	0.03	0.04	0.15
Wear time	0.26*	0.02	0.22	0.29
Weekday	12.48*	3.47	5.61	19.34
Gender (male)	-54.23*	18.09	-89.13	-19.04

Note. *n* = 103 cardiac disease patients. *n* = 1'436 available days. *SE* stands for standard error of the estimate. 95% CI represents the 95% credible interval. LL = lower limit. UL = upper limit. Estimates marked with an "*" represent significant results inferred from the credible interval excluding zero. Intraindividual predictors are all lagged (previous day predictors). No random slope was included in the model.

Figure 1

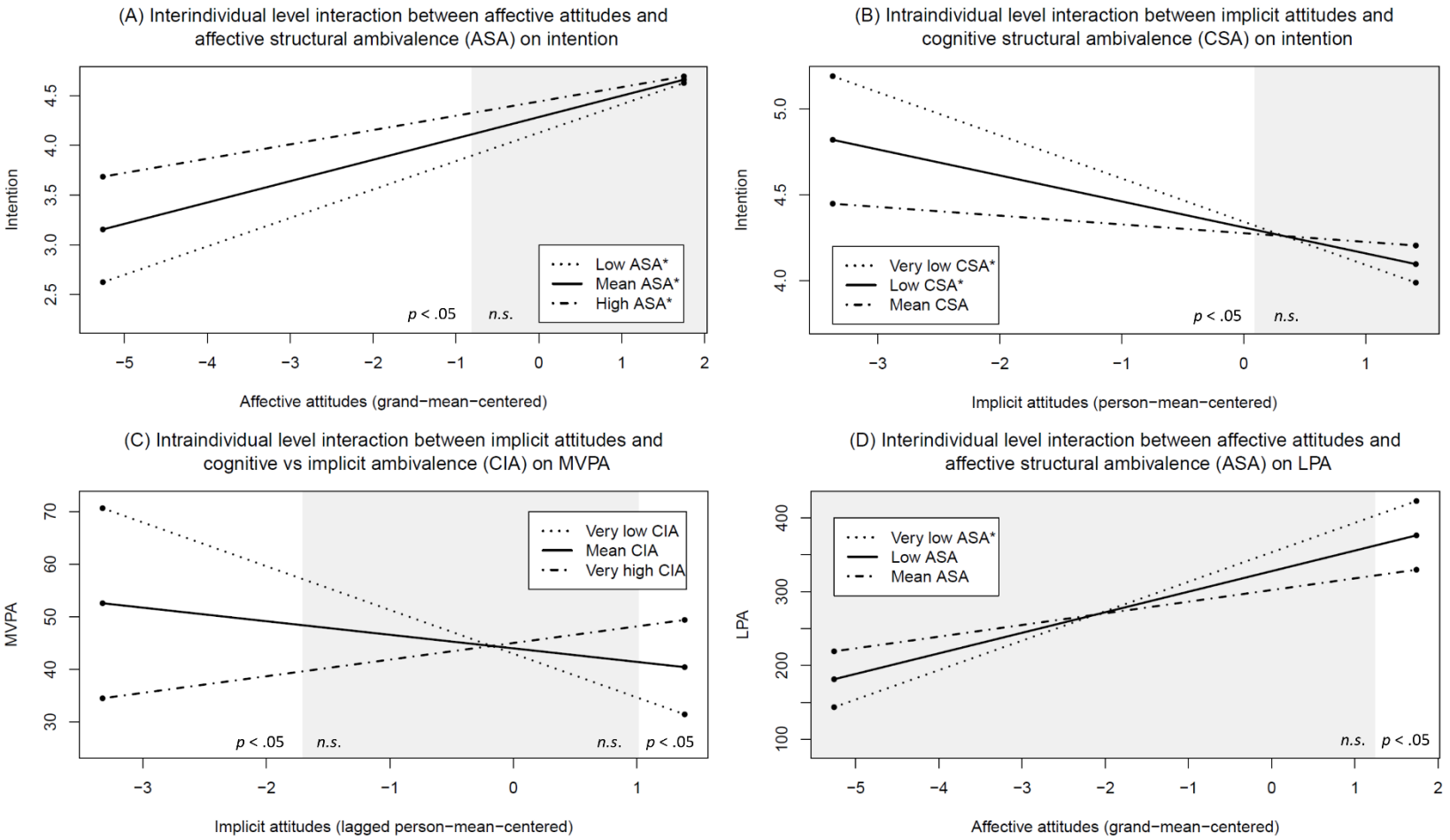
Proposed extension to the TPB



Note. The figure shows an unspecified type of ambivalence in order to exemplify the moderation effects tested for each type of ambivalence, that is, for cognitive structural, affective structural, intercomponential, cognitive vs implicit and affective vs implicit ambivalence.

Figure 2

Visualization of all significant interactions in the multilevel models



Note. The simple slopes start at the minimum and end at the maximum in the data of the variable in the x-axis. Low and high levels of the moderator (ambivalence) correspond to the mean ± one standard deviation, accordingly. Very low and very high ambivalence corresponds to the mean ± two standard deviations. Simple slopes lying within the region of significance in the ambivalence scale are marked with "*" in the legend. The region of significance in the attitudes scale is marked by a white background compared to a grey background for non-significance.