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On the importance of self-control strength for regular physical activity

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ABSTRACT

Objectives: Physical activity intentions do not automatically lead to physical activity behavior, indicating that there are other (psychological) factors involved. In the present study, we tested the assumption that self-control strength is required to bridge the intention-behavior gap in terms of initial and weekly intentions.
Design: A total of $N = 259$ individuals, who registered for a weekly university sports course, were followed for 13 weeks.
Methods: At baseline, trait self-control strength as well as the intention to take part in the respective sports course on a regular basis were measured. Then, we registered weekly participation and asked the participants after each training session to report their intention to show up at next week's training session.
Results: Despite very high baseline as well as weekly exercise intentions, the participation rate dropped considerably over time, indicating a large intention-behavior gap. The association of within-person fluctuations in weekly intentions and actual participation was moderated by self-control: Only in individuals with high levels of trait self-control strength stronger intentions were associated with a higher chance of actual re-attendance. Baseline intention was also associated with participation but not moderated by self-control.
Conclusions: These findings indicate that high levels of self-control strength are beneficial in order to translate short-term intentions into actual behavior. Practical implications on how to improve self-control are discussed.

1. Introduction

Previous research has repeatedly demonstrated that regular physical activity has beneficial effects on several health-related (e.g., overweight, cardiovascular diseases; e.g., Hamilton, Healy, Dunstan, Zderic, & Owen, 2008) and psychological variables (e.g., reduced levels of stress and anxiety, subjective well-being; e.g., Bhui & Fletcher, 2000; Biddle & Mutrie, 2007; Goodwin, 2003; Ströhle, 2009). Regardless of positive health effects, which are well recognized by many people, Hallal et al. (2012) found out that 31% of adults worldwide are physically inactive, meaning that they do not match the World Health Organization's (WHO, 2010) recommendation of at least 150 min of moderate physical activity per week.

These findings seem to indicate that there is an intention-behavior gap, as individuals often have physical activity intentions, but fail to translate them into actual exercise behaviors (e.g., Rhodes, Plotnikoff, & Courneya, 2008). A meta-analysis by Rhodes and de Bruijn (2013) showed that only about half (54%) of adults classified as physical activity (PA) 'intenders' acted on their intention and reached public health guidelines for moderate-to-vigorous physical activity.

Traditional social-cognitive models of physical activity almost exclusively focus on the importance of intentions and how they are built (e.g., Theory of Planned Behavior, Ajzen, 1991). However, these models have been heavily criticized, as intentions alone cannot explain how and why intentions are translated into physical activity behavior (e.g., Rhodes & de Bruijn, 2013; Rhodes & Yao, 2015; Sniehotta, Presseau, & Araújo-Soares, 2014). Interestingly, as Rhodes and Yao (2015) point out in their review, scientific discussions regarding the importance of post-intentional volitional processes can be traced back to the early and mid-20th century (Ach, 1905; Lewin, 1951). More recently developed models of physical activity do not only focus on the importance of intentions, but also investigate the role of volitional variables for regular physical activity (e.g., Hagger, 2010; Schwarzer & Luszczynska, 2008). One important aspect of volition is the ability to control oneself (e.g., Hagger, Wood, Stiff, & Chatzisarantis, 2009).

Self-control enables human beings to focus on long-term goals, while resisting immediate gratifications along the way (e.g., Baumeister, Heatherton, & Tice, 1994). In general, self-control helps

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individuals to suppress dominant impulses and urges, to avoid distraction, or to focus on long-term goals (e.g., de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). One of the most prominent self-control theories is the strength model of self-control (Baumeister, Bratslavsky, Muraven, & Tice, 1998). It is assumed that there is a central energy resource on which all self-control acts are based. However, this metaphorical self-control strength has limited capacity, meaning that self-control cannot be exerted limitlessly. Some individuals' self-control strength possesses a larger capacity than that of others, meaning that the former ones are better at regulating themselves than the latter ones. In this conceptualization, self-control strength can be viewed as a psychological trait (Tangney, Baumeister, & Boone, 2004), which helps an individual inhibit certain behavioral tendencies in order to achieve a more desirable long-term goal. Higher levels of trait self-control strength have been linked to several positive outcomes, for instance better grades, better social relationships, or a healthier lifestyle (for an overview, see de Ridder et al., 2012; Hagger, Wood, Stiff, & Chatzisarantis, 2010).

The strength model is also suited to explain the intention-behavior gap (e.g., Englert, 2016; Englert & Rummel, 2016; Martin Ginis & Bray, 2010). If individuals are not fully committed to their physical activity program, they may sense external and/or internal hurdles regarding the execution of their intentions. For instance, it might be more gratifying, at any given moment, to relax on the sofa at home, instead of going out for a run in the cold, as originally intended. In these cases, individuals need to resist the immediate temptation of relaxing at home, in order to follow their long-term goal of getting in better shape. Some individuals do not seem to have any problem in controlling themselves, while it seems to be a little more difficult for others (for an overview, see Englert, 2016). Several studies have demonstrated the beneficial effects of high levels of trait self-control strength (de Ridder et al., 2012; Hagger et al., 2010). Bertrams and Englert (2013) asked university students to specify their physical activity intentions for the upcoming weeks. The results revealed that individuals with higher levels of trait self-control strength were more likely to meet their physical activity intentions. In the same vein, a recent study by Stork and colleagues found empirical support for the assumption that trait self-control strength predicts exercise adherence over a 4-week period (Stork, Graham, Bray, & Martin Ginis, 2016). Viewed together, higher levels of trait self-control strength seem to increase the likelihood of translating physical exercise intentions into actual exercise behavior, as it helps an individual to resist immediate gratifications in favor of achieving a long-term goal.

However, the empirical basis for this assumption seems rather weak. In their systematic review on moderating effects on the relationship between intentions and actual physical activity behavior, Rhodes and Dickau (2013) found that intention stability was the most consistent moderator in this context. Moderating effects of self-control strength, however, were not analyzed in the included studies and changes in intentions were mostly considered as changes between two occasions, as in most studies so far (Conroy, Elavsky, Hyde, & Doerksen, 2011). Thus far it has been primarily investigated how self-control moderates the translation of global physical activity intentions, without consideration of within-person variation, into action (e.g., intention to participate in a two-week physical training; Englert & Rummel, 2016). However, as previous research (Conroy et al., 2011, 2013) has shown, there is a large amount of within-person variation in physical activity intentions with only about half of the overall variability in PA intentions between persons. These short-term fluctuations in intentions are related to fluctuations in actual PA behavior (Conroy et al., 2011, 2013). Therefore, in the present study we not only focus on how the translation of global physical activity intentions into action is affected by self-control strength, but furthermore, how self-control strength interplays with weekly fluctuations in physical activity intentions.

The aim of the present study, therefore, was to build on previous findings and to test two hypotheses about how self-control strength moderates intention-behavior relations. We hypothesized that a) higher self-control strength would lead to a higher chance to enact the initial intention to participate in an exercise class regularly, i.e. for persons with higher self-control strength the relation between initial intention and actual participation behavior should be stronger, and b) higher self-control strength would lead to a higher chance to enact weekly intentions, i.e. for persons with higher self-control strength a closer relation between weekly intentions and actual participation following this intentions should be observed.

2. Method

2.1. Participants

Questionnaire data were collected on a weekly basis in 10 sports and gym courses, offered by two German universities during the winter term 2015/16 (6th of October 2015 until 6th of February 2016 for the one university and 13th of October 2015 until 6th of February for the other university). These kind of courses are offered by the departments of collegiate sports to all students and employees of the universities. Courses are offered each term and run from the beginning of the lecture period to the end. To participate, students as well as employees have to register for specific courses in time, as available places are assigned on a 'first come first serve' basis. Only courses of medium size (about 15–30 participants) and weekly training durations of 60–90 min were chosen for the current study, in agreement with the head of collegial sports. This approach led to a total sample of 177 female und 82 male ($N = 259$) university students and employees, who volunteered to participate in the present study, and provided sufficient complete data, which was included in the presented analyses. Course instructors were informed about the study and had to give their consent. The study was carried out in accordance with the Helsinki Declaration of 1975 and was approved by the Data Security Commissioner and the Ethics committee of the respective universities.

The courses encompassed various kinds of sports: martial arts (Kickboxing, Taekwondo, Capoeira), aerobic exercise, including dance steps (Zumba, Bokwa), basketball training and Freeletics (a specific set of endurance and strength exercises). The duration of the courses depended on the length of the semester at the respective university (i.e. 13 weekly sessions at one and 14 to 15 sessions at the other university), for comparability only the first 13 sessions were included in our analyses. There was a Christmas holiday break (20th of December 2015 until 7th of January 2016) at both universities, during which no courses were offered.

2.2. Procedure

Individuals who agreed to participate in the study signed a consent form, when attending the course for the first time, and then filled in a baseline questionnaire. The baseline questionnaire and the other questionnaires will be explained in greater detail below.

Student assistants attended all selected courses on a weekly basis. They documented participation and distributed, at the beginning of the course, a short weekly questionnaire to all attending study participants. This questionnaire was recollected at the end of the respective course session. To be able to match the different questionnaires to each participant, each individual generated an anonymous code composed of letters and numbers from family names, year and place of birth.

2.3. Measures

2.3.1. Baseline measures

2.3.1.1. Self-control. After assessing sociodemographic information (gender, age, student status), we applied the German adaption of the short form of the Self-Control Scale (SCS-K-D; Bertrams & Dickhäuser, 2009), which measures trait self-control strength. The SCS-K-D contains

13 items (e.g., *'I am good at resisting temptations'*) which are answered on 5-point Likert-type scales (1 - *not at all* to 5 - *very much*). The internal consistency of the scale was sufficient in the present study (Cronbach's $\alpha = .80$). For this scale and all the other measures applied in the current study, we calculated mean scores, with higher scores always indicating higher values in the respective variable.

2.3.1.2. Intention. The intention towards attending the specific university sports course during the winter term was measured via two items (for this procedure, see de Bruijn, Gardner, van Osch, & Sniehotta, 2014). Participants were asked to rate how strongly they agree with the following statements on 7-point bipolar scales (*totally disagree – totally agree*): "*I intend to participate in this course on a regular (weekly) basis*", and, "*I am sure that I will participate in this course regularly (weekly)*". This conceptualization of a continuum of intention strength relates to the intensity of the commitment to enact a behavior which can be seen as the result of motivational processes (Rhodes & Rebar, 2017).

2.3.1.3. Past exercise. Participants were asked, if they already were regularly exercising (yes/no) and if so, for how long (months).

2.3.2. Weekly questionnaire

2.3.2.1. Attendance. A research student attended every session and recorded weekly participation of each participant (1 = *yes*, 0 = *no*).

2.3.2.2. Weekly intention. At the end of each session, every participant was asked to respond to the intention item: "Do you intend to participate in this course again next week (next time)?" (1 = *absolutely not* to 10 = *at any rate*).

2.4. Statistical analyses

Descriptive statistics were calculated as percentages for categorical data and means and standard deviations for continuous variables. For severely skewed variables, the median is additionally reported.

For the attendance description over time, weekly participation rates were calculated as proportion of all study participants who were still under observation attending a specific week. Some individuals entered the study later in the term and, therefore, had fewer opportunities to participate. We started counting the weeks for every individual, beginning with the first attendance (participation week 0) and from then on numbering the opportunities to re-attend an exercise class (starting with participation week 1).

To predict participation in exercise classes within the term, from baseline self-control and intention (time-invariant) as well as weekly intention values (time-varying) and the interaction of self-control strength with intentions, mixed effect Cox proportional hazard models were estimated as a variant of survival analysis.

These models analyze time-to-event-data, more precisely, the probability of an event is deduced from the length of time until it happens and characteristics of covariates are analyzed in their effect on this probability. Survival analysis was chosen because information on covariates which were measured on a weekly basis was available only for weeks when the event re-attendance occurred. Therefore, the instances that were analyzed were not the weekly events but these time-to-event periods.

Unlike in standard survival analysis, the event 're-attendance', we were interested in, was not terminal, but recurrent and, unlike in most application of survival or failure time analysis, the event was positively defined. With every attended class, a new interval started, which would then either end with the desirable event 're-attendance' or with the end of the observation period (i.e. case was censored). Interval length was counted in opportunities to participate and constituted the time to the event that was the analyzed outcome of our models. Since most individuals contributed more than one interval (i.e. attended the class more than once), several intervals were nested within the individuals and therefore not independent. Mixed effect models account for these dependencies by allowing for random effects of each person. Additionally, the specific exercise class an individual was participating in was included as another level of nesting (i.e. random effect).

The Cox proportional hazard model predicts the hazard rate (or chance in this case) to participate in the exercise class again (event), compared to a reference group, considering the time duration until this event occurs (time to event) and starting with the time of the preceding attendance. The resulting hazard ratio (HR) can be interpreted as the ratio of re-attendance rates at any given point in time and therefore approximately expresses the probability to re-attend the exercise class, compared to a reference group. Every person was "at risk" of coming back after each attended (or intermittently cancelled) class again, i.e. a new time-to-event interval started. We used the Andersen-Gill (counting process) approach to define the risk set for each interval (Andersen & Gill, 1982). That means that for a given week, all participants for whom the course was still ongoing were part of the risk set, had they attended the subsequent week or any week before. All models included time aspects (participation week, number of attended classes so far, and history of past exercising) as additional predictors to adjust for changes in event rates over time and for the possibility that past successes in translating an intention into action would enhance the chance to act on this intention again.

We followed a stepwise approach of model fitting, starting with a model adjusting for time-effects and exercise history, testing for potential confounders, then adding baseline intention and self-control, as well as their interaction to examine our first hypothesis, and finally including weekly intention values, as well as the interaction with self-control to examine our second hypothesis. Models were compared by likelihood ratio tests. The R-package 'coxme' was used for estimation of the models (Therneau, 2018).

For the weekly measured intention, the variation was decomposed into a between-person and a within-person component. The between component is the mean of the grand-mean centered variable per person (time-invariant), and the within-component is the deviation of the weekly score from this overall mean per person (time-varying) (Bolger & Laurenceau, 2013).

The Cox proportional hazard model assumes that hazard functions for survival curves at different values of a predictor are proportional over time. This assumption was tested by using a standard survival model with an added frailty term to account for non-independence of observations of the same individual.

3. Results

3.1. Descriptive results

259 individuals provided enough information from the baseline questionnaire and allowed for at least one of the weekly questionnaires to be included in the analyses. The sample is described in Tables 1 and 2 in terms of sociodemographic information, past exercising, frequency of attendance, as well as baseline intention and self-control. The sample predominantly consisted of students complemented by a small group of university employees. About two thirds were female, and the mean age

Table 1
Description of the sample ($N = 259$; categorial variables).

Measures	N	%
Gender (% female)	177	68.3
Student status (% students)	233	90.0
Type of sport:		
Basketball	73	28.2
Martial arts	115	44.4
Dancing/funsport	71	27.4
Regular exercising in the past (yes)	190	73.36

Table 2
Description of the sample (N = 259; continous variables).

	M	SD	range
Age (years)	24.51	5.69	16–57
Regular exercising in the past (in months)	91.85	96.58	0–384
Number of weeks attended	5.16	3.47	1–13
Baseline intention	5.95	1.29	1–7
Baseline self-control capacity	3.06	0.59	1.38–4.77

was 24.5 years (SD = 5.7). Although a majority reported regular exercise or sport participation in the past and a very high intention to regularly participate in the chosen exercise class over the entire term, mean frequency of participation was only 5.16 times (SD = 3.47), corresponding to a participation in 44% of offered classes. Baseline intention was highly skewed, resulting in a 'J-shaped' distribution with 38% declaring the highest possible intention. The variable was therefore transformed as inverse of the reflected value and then scaled to have the same range of 1–7 as the original scale. This resulted in a reduction of skewness from −1.57 to 0.02 although no normal distribution could be achieved. Self-control values approximately followed a normal distribution (Shapiro-Wilk-test: $p > 0.20$), and the mean self-control capacity was comparable in size to that of the validation sample of German students (Bertrams & Dickhäuser, 2009) (see Table 2).

The development of participation rates over time is depicted in Figure 1. Starting with participation week 0 (i.e. the first week an individual attended the course), participation decreased continually over the term with a participation rate as low as 19% in the last observed week.

The weekly intention showed slight fluctuations but no clear trend over time with the stated intention to re-attend the following week constantly being very high. Since the weekly intention was also highly skewed (weekly means ranged from 8.84 to 9.24 on a scale from 1 to 10) the same transformation, like for the baseline intention, was applied in the regression models. Over the weeks, between 28% and 58% of individuals, who stated the highest possible intention to re-attend the following week, did not actually enact this intention.

3.2. Survival analysis

In the mixed effects Cox proportional hazard models, 1,243 time-to-event intervals from 259 individuals were analyzed of which 982 intervals resulted in the event re-attendance (see Tables 3 and 4). Preparatory analyses revealed that time was best modelled as week plus a quadratic term of week, while the Christmas holiday break had no additional effect. To arrive at a meaningful baseline model, including potential confounders, in a first step potentially relevant background variables, as well as time aspects (participation week, accumulated number of attended classes so far, and past exercising in months), were entered as predictors of time-to-event data. All time aspects, except for self-reported past exercising, significantly predicted participation in the exercise class. Particularly, the chance to re-attend increased by 19% with each time the class had been attended before. None of the socio-demographic background variables was significantly related to attendance but females exhibited slightly lower attendance rates (HR = 0.923, 95% CI: 0.80–1.06). Gender, however, violated the proportional hazard assumption and was, therefore, used as a stratification variable in our baseline model (model 0, used as a baseline for our hypothesis tests) and subsequent models, allowing for different baseline hazards for males and females. In model 1, stratified by gender and adjusted for time course and past exercise history, baseline self-control and intention values as well as their interaction were entered as predictors to test our first hypothesis (stating a moderating effect of self-control strength on the baseline intention - participation relation). Intention significantly predicted higher rates of re-attendance. Neither a meaningful effect of self-control, nor an interaction with baseline intention, was revealed. Hence, our first hypothesis could not be corroborated. The interaction term was therefore removed (model 1b) without impairing model fit (see Table 3). In a final step (model 2), to test our second hypothesis (that self-control strength would moderate the weekly intention – participation relation), weekly intention was entered, decomposed into a (time-invariant) between-person and a (time-varying) within-person component plus an interaction term of the within component with self-control. While the main effect of baseline self-control remained insignificant, there was a significant positive interaction of intra-individual intention fluctuations with self-control, verifying our second hypothesis. The chance of re-attendance was

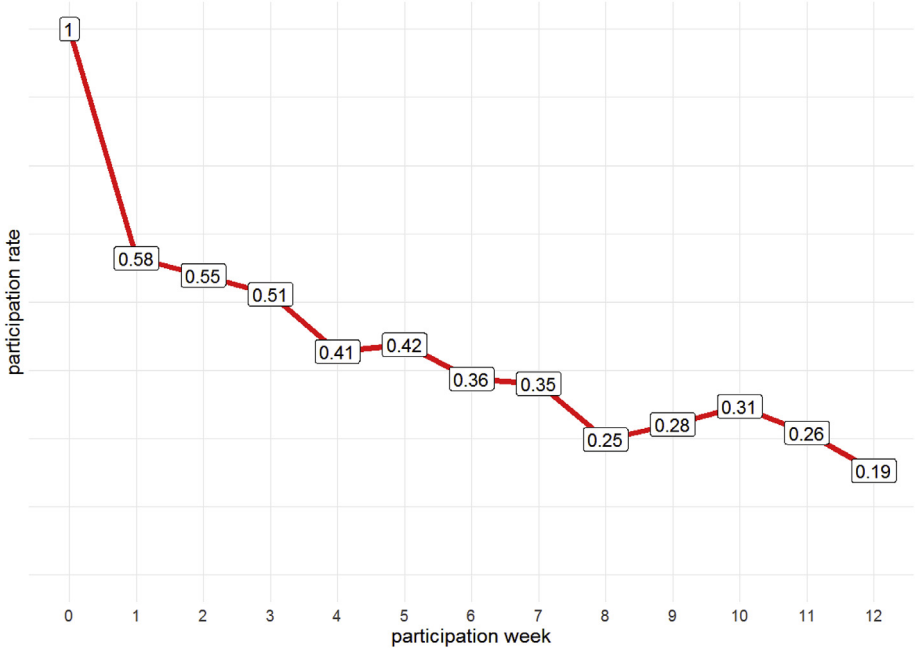

Figure 1. Participation rate over time. Participant weeks start with the first attendance of a participant (week 0). For every week, the participation rate is the proportion of participants attending the class (of all participants who had the opportunity to do so in the given week).

Table 3
Comparison of Log-likelihoods (LL) of the sequence of tested models.

	LL	χ^2	df	p-value
Model 0: baseline model including time aspects (participation week, week^2, accumulated number of attended classes, past exercising (months), stratified by gender)	−3902.81	640.0[a]	6	< 0.001
Model 1: adding baseline values for intention and self-control plus interaction	−3895.83	13.95	3	0.003
Model 1b: removing nonsignificant interaction term	−3895.84	0.01	1	0.907
Model 2: adding values for weekly intention plus interaction with self-control	−3887.44	16.80	3	< 0.001
Model 2b: like 2, but self-control grouped into quintiles for illustration of interaction	−3883.30	8.28	6	0.218

[a] Note. compared against null (empty) model

Table 4
Mixed effect Cox proportional hazard models for the prediction of time to the recurrent event re-attendance at exercise class (259 individuals with 982 events in 1243 intervals).

	Model 0 (stratified by gender, including only time aspects)	Model 1 (+baseline intention and self-control)	Model 2 (+weekly intention and interaction with self-control)
Fixed effects of predictors: HR (95% CI)			
Past exercising (in months)	1.000 (0.999–1.001)	1.000 (0.999–1.001)	1.000 (0.999–1.001)
Accumulated number of attended classes	1.190 (1.112–1.273) ***	1.169 (1.093–1.250)***	1.158 (1.083–1.238)***
Intention (baseline)		1.064 (1.029–1.099)***	1.054 (1.015–1.095)**
Self-control (baseline)		0.947 (0.844–1.062)	0.951 (0.847–1.067)
Intention × self-control (baseline)		1.003 (0.950–1.060)	/
Weekly intention between-persons			1.016 (0.985–1.047)
Weekly intention within-person			1.050 (1.018–1.084)**
Intention within × self-control			1.076 (1.021–1.134)**
Random effects (variance intercept):			
Individual	0.000	0.000	0.000
Exercise class	0.061	0.055	0.055

Note. All models are stratified by gender and adjusted for time (participant week and participant week squared).
*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001; HR = hazard ratio

higher after weeks when an individual expressed a higher intention to re-attend than usual, but this effect was dependent on self-control. The mean level of weekly intention (between-component) of a person, in contrast, showed no significant effect beyond baseline intention.

To further explore and illustrate the interaction effect, self-control values were divided into quintiles. The effect of within-person intention fluctuations was then examined separately for the five groups with the lowest to the highest self-control, by including the interaction of self-control quintiles with weekly intention (model 2b). This model showed a similar model fit, like model 2. It revealed that the intention effect increased from an HR = 0.986 (95% CI: 0.923–1.052, $p = 0.660$) in the group with the lowest self-control over an HR = 1.024 (95% CI: 0.933–1.124, $p = 0.620$) and HR = 1.056 (CI: 0.968–1.153, $p = 0.220$) for medium self-control to an HR = 1.218 (CI: 1.072–1.384, $p = 0.002$) for the fourth self-control quintile, and a HR = 1.135 (CI: 1.030–1.250, $p = 0.010$) for those with the highest self-control values. That is to say, higher weekly intention values were only positively related to higher re-attendance rates in those two groups with the highest trait self-control. Although a higher baseline intention was also positively related to re-attendance, in terms of weekly intentions, not the absolute mean intention level of a person was of importance, but the deviation from that mean level, with higher re-attendance after weeks with higher intention scores only in those with high trait self-control. For those two groups with the highest self-control scores, a one point increase in weekly intention was associated with about 22% and 13.5% higher hazard rates to re-attend, adjusted for time course and baseline intention values, and stratified by gender.

4. Discussion

The intention-behavior gap describes a discrepancy between what an individual intends to do in a given situation (e.g., going to the gym) and what the individual is actually doing (e.g., meeting with friends; Rhodes et al., 2008). It has not been yet empirically tested whether self-control moderates the intention-behavior gap in terms of short-term intentions, long-term intentions, or both. In the present study, we addressed this shortcoming by analyzing both moderator effects of trait self-control, on the effects of the initial intention to participate in an exercise class regularly over the whole term, as well as on the weekly intentions to re-attend the class in the upcoming week, and particularly within-person fluctuations in this intention. We hypothesized that self-control strength would moderate both effects in the same line, namely by strengthening the observed positive associations with attendance as the behavior in question.

Our results show that, in a sample with overall typical self-control strength, individuals with higher levels of trait self-control strength were more likely to translate their short-term intentions into action. This result was in line with our second hypothesis. In this relation, not the absolute magnitude of intention was crucial, but the magnitude of the deviation from the intra-individual mean level. The result that within-person fluctuations are more important than between-person differences, even for short-term intentions measured on repeated occasions, is in line with other studies on the relation between short-term intentions and physical activity (Conroy et al., 2011, 2013). Baseline intention was also positively related to attendance but, contradicting our first hypothesis, this effect was not moderated by self-control.

Even though baseline as well as weekly intentions were better predictors of participation in the exercise classes than self-control, there was a remarkable inconsistency between intentions and actual behavior. Although nearly all individuals expressed extremely high intentions at baseline, as well as on a weekly basis, participation rates showed a steep decline. Mean intention scores for the two-item baseline intention were considerably higher than in most other studies that used this scale with college students (Conroy, Elavsky, Doerksen, & Maher, 2013; de Bruijn et al., 2014), although one smaller study also reported a rather high mean score for a similar two-item measure of weekly intentions (Conroy et al, 2011). The result that most participants did not transfer their (short- or long-term) intentions into action, further underpins the need to look for moderators of the intention-behavior relationship, not only in terms of long-term intentions measured once, but

also for short-term intentions. Although within-person fluctuations in intentions did predict behavior in our study, a great deal of attendance was not explained in view of the constantly high intention scores. Particularly, between 28% and 58% of those individuals who stated the highest possible intention to re-attend the following week actually did not enact this intention. The number of accumulated training sessions during the term significantly increased the chance to re-attend the class. This finding can be interpreted as indicating a self-enhancing effect of successfully enacting an intended behavior. However, no interaction with intention was revealed (data not shown), i.e. we could not find that successfully enacting the behavior increased the intention-behavior relation.

The fact that we did not find a statistically significant main effect of self-control is to be expected, since as a moderator self-control is primarily needed for the translation of motivation into actions, i.e. intentions are required (Rhodes & Dickau, 2013). If an individual does not have the intention to work out regularly, it does not matter if he/she has high levels of self-control strength or not as there is no intention which needs to be shielded from distracting or tempting alternative behaviors (e.g., Englert, 2016).

4.1. Strengths and limitations

This study has several merits. First, PA behavior was observed for a period of several months in a relatively large sample. Secondly, the predicted criterion participation in the exercise class was measured quasi-objectively by weekly registration of attendance. Thirdly, we included intention measured at baseline, as well as within-person intention fluctuations, which constitute a large portion of PA intention variability that seems to be important for PA. Fourthly, the timeframe of our intention measures directly corresponded to the observed behavior as advised for intention measures.

However, we would also like to discuss the potential shortcomings of the present study. First, a high number of individuals dropped out during the course of the semester and did no longer attend the exercise classes. We neither have any information regarding the reasons for the high attrition, nor on the current intentions of those not attending at a specific week. A weekly online-survey would be a possibility to monitor those not attending the course, although the motivation to regularly participate in such an online-survey after leaving the exercise course seems questionable.

Secondly, the study was an observational study, and even though we predicted future events from preceding characteristics, causality of the observed effects cannot be determined.

Thirdly, the quality of the employed one-item intention measure remains unclear and the skewed distribution of the (baseline and weekly) intention scores points to a ceiling effect. Social desirability may possibly have also played a role. However, since the intention effects were large, even when considering these limitations, they may very well be underestimated in our study. Two-item-intention measures were used in many studies before and we are not aware of others reporting problems with highly skewed scores. Nevertheless, the development of short/one-item intention scales with proven measurement properties is highly necessary.

Fourthly, only intentions one week before the actual behavior were measured, with possible change in intentions during the week until the actual participation not being observed. Since other studies (Conroy et al, 2013) show considerable day-to-day-variation in PA intentions, one possible explanation for the low rate of enactment of the generally high weekly intentions is a decrease in motivation during the week until participation was able to take place. Since intention was only measured in those participants attending the exercise class in any given week, intentions moreover may seem higher than they were, because those people not attending the class, owing to a currently low intention on class day, did not provide data in these weeks.

Furthermore, past exercise history was self-reported and the item has not been validated. It is therefore possible that the nonsignificant effect was due to low reliability of the item.

We would also like to mention, that it appears as if self-control and conscientiousness are similar psychological constructs. Conscientiousness can also be considered a personality trait which describes a tendency to be orderly, achievement striving, self-disciplined, and deliberate. A systematic review revealed, that conscientiousness moderates the intention-behavior gap (Rhodes & Dickau, 2013). Future research should try to investigate the similarities and differences between these psychological constructs and how they contribute to the intention-behavior gap.

4.2. Implications

According to the strength model, individuals do not only differ in their trait self-control strength but also in their state self-control strength (Baumeister et al., 1994). If individuals had to control themselves during the course of the day, their self-control resources might be depleted in the evening, when they had originally intended to be physically active (Englert & Rummel, 2016). This temporary loss of self-control strength is termed *ego depletion* (Baumeister et al., 1994). In a state of ego depletion individuals are less capable at controlling themselves (e.g., Hagger et al., 2010). In the present study, we focused on trait self-control strength, which is why future research should also investigate the effects of state self-control strength on the intention-behavior gap. Especially, since we found evidence that only the effect of weekly intention fluctuations was moderated by trait self-control, it is possible that weekly fluctuations in self-control show even stronger effects on the intention-behavior gap. However, we would also like to mention that a recent replication study did not find empirical evidence for the ego depletion effect (Hagger et al., 2016), which is why alternative theoretical models might be better suited to explain temporary self-control impairments. For instance, the process model of self-control proposes that self-control impairments are not caused by ego depletion but rather by shifts in attention, motivation and emotions after previous self-control demands (Inzlicht & Schmeichel, 2012). Therefore, future research should also focus on how attentional, motivational, and emotional process might influence the intention-behavior gap (cf. Rhodes & Dickau, 2013).

As it has been reliably shown that trait self-control strength is associated with several positive outcomes, it should be investigated how self-control strength can be improved. Baumeister et al. (1994) compare self-control strength to a muscle, which can be trained. It has been empirically shown, that practicing self-control regularly improves self-control performance in the long-run (Baumeister, Gailliot, DeWall, & Oaten, 2006). For example, individuals who had been instructed to control certain behavioral tendencies over a 2-week period (e.g., use of the non-dominant hand in everyday life) displayed better self-control performances than participants from a control group afterwards (e.g., Gailliot, Plant, Butz, & Baumeister, 2007). Interestingly, interventions to improve self-control strength have not been tested rigorously in sport and exercise contexts, which is a shortcoming that needs to be addressed in future research.

4.3. Conclusion

In conclusion, the present study underlines the importance of trait self-control strength in physical exercise contexts. Interventions aimed at improving self-control strength might help to reduce the intention-behavior gap and enable individuals to exercise on a regular basis, which is required for achieving lasting health benefits.

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Conflicts of interest

The authors hereby declare that there is no conflict of interest.

Declarations of interest

None.

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