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Extending research on self-regulation of physical activity in older age: Role of views on aging within an intensive ambulatory assessment scheme

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Abstract

Objective: Despite the well-known beneficial effects of physical activity (PA), many individuals lead a sedentary lifestyle in older age. This study aimed to examine the self-regulative role of individual views on aging for planning and implementing PA goals among retired, healthy older adults. We hypothesized that aging-related cogni-tions (regarding physical decline, social loss, and continuous growth), as well as sub-jective age, are relevant predictors of PA. We furthermore explored their predictive value over and above the intention to be active, an established predictor derived from the "Theory of Planned Behavior". Method: N=40 retired participants aged 60 to 74 years wore commercially available activity monitors (Fitbit Charge HR) that tracked daily steps and moderate to vigorous PA on 14 consecutive days. Social-cognitive vari-ables, views on aging and health complaints were assessed during home visits. Asso-ciations between variables were analyzed using hierarchical regression analyses. Re-sults: Even after accounting for the intention to be active, views on aging explained additional variance of PA, indicating that participants who viewed aging as a process of social loss walked fewer steps per day. Against expectations, individuals who re-garded aging as an inevitable process of physical decline and who felt older than their chronological age showed higher PA levels. Conclusion: Our findings underline that beliefs about the aging process affect the ability to self-regulate actions related to PA in older adults. We even found evidence for possible paradoxical effects. Further re-search on long-term effects and underlying mechanisms that relate views on aging to PA is needed.

Keywords

Physical activity; older adults; aging-related cognitions; Theory of Planned Behavior; ambulatory activity tracking

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Extending research on self-regulation of physical activity in older age: Role of views on aging within an intensive ambulatory assessment scheme

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1 Introduction

In the light of demographic change, the promotion of physical activity (PA) among older adults is a major public health challenge. Regular PA has been shown to reduce and prevent a range of aging-associated health events, such as cardiovascular diseases, diabetes, and declines in activities of daily living and cognitive functions (e.g., Baker et al. 2009). Despite these established benefits, PA levels often decline considerably with age (i.e., Jefferis et al. 2015), and only 25% of the adults aged 65+ meet the WHO-recommendation of exercising at least 150 minutes per week in at least moderate intensity (Lee et al. 2008; Rütten et al. 2005).

Deficits in self-regulatory processes, e.g., perceived behavioral control, can be seen as one of the main reasons for individuals' failure to move from the intention to the performance of PA or to maintain the activity in the face of internal or external barriers. So far, most intervention studies that implemented behavior change techniques (BCTs) on PA focused on young or middle-aged adults or addressed older adults in specific settings such as rehabilitation programs. However, it would also be important to study the implementation of BCTs among relatively healthy, mobile, community-dwelling older adults.

It is important to note, however, that BCTs that have been shown to be generally effective at increasing PA in younger age groups, may not work equally well in older age. For example, French et al. (2014) conclude in their systematic review on the effectiveness of BCTs for increasing PA that applying techniques involving self-regulation (through planning) was not as successful as expected. Null-findings from a recent randomized-controlled trial that aimed at PA promotion in older adults using self-regulatory BCTs are in line with these results (Warner et al. 2016). Furthermore, PA among older adults in a non-interventional (naturalistic) setting is not well studied either and may not only be associated with established social-cognitive variables, such as attitude or intention towards PA, but also reflect age stereotypes and individual views on aging. Thus, in our study, we aim to enrich traditional social-cognitive models with views on aging in

different life domains in order to better understand the initiation and maintenance of light activity (steps) as well as moderate to vigorous PA (MVPA) in community-dwelling, healthy older adults. In this work, we consider views on aging as a crucial influencing factor for older adults' self-regulation of PA, i.e., the ability to adaptively regulate one's emotions, cognition, and behavior in order to respond effectively to internal as well as environmental demands (McClelland/Cameron 2012; Raffaelli et al. 2005).

1.1 Determinants of PA and the role of views on aging

Theoretical approaches aimed at explaining health-related behavior, e.g., the "Theory of Planned Behavior" (TPB; Ajzen 1991) or the Health Action Process Approach (HAPA; Schwarzer 1992), address social-cognitive variables such as attitude, risk perception, or self-efficacy. Regarding PA, these models are well-established, and meta-analyses and reviews on behavior change interventions targeting these concepts show that they are generally effective (Williams/French, 2001). However, research in this field is mostly focused on younger and middle-aged adults (i.e., Ashford et al. 2013), limiting the generalizability of study results. Although intention and self-efficacy/perceived behavioral control emerge as relevant predictors of older adults' PA levels, there is evidence that both factors decrease in their mean levels with higher age (Bouchard et al. 2012; Plotnikoff et al. 2009). Hence, established social-cognitive approaches may be limited in explaining PA among older adults as they outline the determinants of goal-directed behavior in general, but are not tailored to the phase of retirement. For example, time-management might be less central for many older people in retirement; retired adults might also be less willing to schedule their everyday lives including PA, but prefer to enjoy the "freedom of retirement" instead. Hence, internal states like beliefs or expectations may be more important. Supporting this view, Bouchard et al. (2012) showed that higher age was associated with reduced readiness (i.e., self-confidence) and lower expectations with regard to lifestyle modification.

Therefore, we argue that in the post-retirement phase, age-specific PA determinants need to receive more attention. In particular, negative age stereotypes that are closely linked to misinterpretations (i.e., "PA in old age is awkward, useless, or even harmful") prevail and may restrict older individuals' activity behavior (Chalabaev et al. 2013; Thogersen-Ntoumani et al. 2008) and thus should be investigated more closely. According to the Stereotype Embodiment Theory (Levy 2009), people adopt such age stereotypes early during their socialization process and integrate them into their self-concepts at older ages. Consequently, as self-directed views on aging, they may influence behavior such as PA in later life.

Conceptually, we regard views on aging as related to the social-cognitive variables of the TPB, but nevertheless essentially distinct. For example, in extended TPB-models, descriptive norm refers to estimations of the number of significant others (e.g.,

people of the same age group) performing PA. Age stereotypes about physical capabilities may be applied in order to arrive at such estimates of physically active older adults. However, age stereotypes go beyond descriptive norm in that they comprise broader aspects of physical functioning, such as health constraints or preferences, in older adults' PA behavior. Similarly, social-cognitive variables, such as outcome expectancies and perceived behavioral control, are closely linked to views on aging which entail beliefs about the possibility to control or even reverse age-related changes. At the same time, views on aging are distinct from the social-cognitive variables of the TPB in that they capture beliefs and expectations about as well as attitude toward the aging process as a whole. Given these links of views on aging with social-cognitive determinants of PA, we argue that the consideration of views on aging is crucial when it comes to studying self-regulation of PA in older adult samples.

The term "views on aging" refers to a broad family of constructs (Diehl et al. 2014). "Views on aging" is used as an umbrella term that reflects both views on aging-related to other people (e.g., age stereotypes) and self-perceptions of peoples own aging process. In this article, we focus on self-directed views on aging – as opposed to generalized views on aging or old age. Self-perceptions of aging describe individuals' subjective experiences of their own aging process and have been originally approached with simple unidimensional variables. One well-established unidimensional variable with a long research tradition is the construct of subjective age which refers to the question of how old a person feels (Kastenbaum et al. 1972). Feeling younger than one's chronological age is an indicator of an overall positive perception of one's aging and has been found to predict various developmental outcomes, including health and well-being (Westerhof et al. 2014). Emerging empirical results suggest a link between views on aging and social-cognitive determinants of PA (Caudroit et al. 2012; Emile et al. 2013; Wolff et al. 2014; Wurm et al. 2010). Those individuals who feel younger than their chronological age report higher intentions to be active, which is partially mediated by higher self-efficacy scores (Caudroit et al. 2012). Furthermore, older adults often mention their own age as a barrier towards PA (Netz et al. 2008; Booth et al. 2002). Wurm et al. (2010) found that older people with more positive views on aging walked more regularly, even in the case of health problems.

Recently, researchers have stressed that self-perceptions of aging comprise positive and negative experiences alike and emphasized the need to discriminate views on aging in different life domains (e.g., Diehl/Wahl 2010; Kornadt/Rothermund 2011; Steverink et al. 2001). A multidimensional approach thus is necessary in order to identify the specific domains of self-perceptions of aging that impede or facilitate an active lifestyle in old age.

A further limitation of existing research on the link between views on aging and PA is the reliance on self-reports for the assessment of PA which comes with limitations regarding the validity and reliability of results (Jørgensen et al. 2009; Westerterp 2009).

For example, restrictions due to recall and response bias (Harada et al. 2001), high intra-individual variations in daily PA (Conroy et al. 2013), low ecological validity (Kaye et al. 2011), or social desirability (Rikli 2000) should be considered. As Prince and colleagues (2008) summarize in their review, self-reported PA levels were both higher and lower than directly measured PA, limiting reliance as well as attempts to correct for differences. Ambulatory monitoring of PA, i.e., accelerometer-based assessment, offers the advantage of a more objective and naturalistic measurement, which is integrated into individual`s daily routines. Thereby, even short bouts of PA are taken into account, which may be forgotten in retrospective self-reports but have been shown to contribute to cardiovascular health benefits (National Institutes of Health, 1996). Moreover, the aggregation of ambulatory PA data over several days or even weeks can attenuate intra-individual variation and better approximate mean levels of PA, facilitating comparison with WHO guidelines for PA (mean=150 min./week), and linkage to relevant (social-cognitive) predictors. Commercially available activity monitors have the advantage of easy handling and self-application, especially if contrasted with laboratory assessments such as calorimetry methods. Furthermore, evidence using energy expenditure as a criterion shows that they are accurate and reliable devices (e.g., Diaz et al. 2015). Therefore, those wearable devices have the potential to be implemented as facilitators of health behavior change.

1.2 The present study: Aims and expectations

The aim of this study was to explore individual views on aging as they may underlie health behavior self-regulation in older adults and could help understanding inconsistencies in the relation between behavioral intentions and actually performed health behavior (Sheeran 2002). To our knowledge, research has not yet examined the role of self-perceptions of aging (as one facet of views on aging) for planning and implementing PA goals among older adults in a naturalistic setting including accelerometer-based PA assessment. Hence, we expected that different facets of views on aging (subjective age as well as cognitions regarding physical decline, social loss, and continuous growth) can help to explain variance in PA levels among older adults, even after taking into account the variables of the Theory of Planned Behavior. In detail, we expected negative views on aging, i.e., an older subjective age, perceiving one's own aging as a process of physical decline, and social losses and with little potential for continuous growth to be associated with lower PA levels.

2 Method

2.1 Recruitment, inclusion criteria and sample description

A total of 95 individuals aged 60 to 75 years from a participant pool of the Department of Psychological Aging Research at Heidelberg University were contacted by mail and invited to participate in a diary study on views on aging and PA monitoring. After mailing a letter to describe the present study, research assistants contacted potential participants by phone. *N*=84 individuals were reached and screened for the following inclusion and exclusion criteria: (1) retired or working less than 10 hours per week (including voluntary work), (2) no severe functional limitations or chronic conditions preventing PA, (3) no severe visual impairments, (3) no cognitive impairment, (4) no acute depressive episode. *N*=17 declined participation because of lack of time or interest, *N*=25 individuals did not meet inclusion criteria due to higher workload (>10h; *N*=14) or physical/mental health issues. *N*=2 participants did not wear their Fitbit longer than one week and had to be excluded subsequently due to missing PA data. Compliance among the remaining participants was very high with complete data over the 14-day period during waking hours. Hence, our final sample consisted of *N*=40 participants aged 60 to 74 years (*M*=66.3 years, *SD*=3.19) living in the Rhine-Neckar Metropolitan Region. 62.5% were female, 72.5% reported living together with a partner, and the majority had comparably high levels of education (67.5% German Abitur). The body mass index (BMI) ranged from 18.69 to 32.74 with a mean of 25.19 (*SD*=3.52). Regarding their past and typical PA-level, 57.5% of our sample reported to meet the WHO guideline of at least 150 minutes per week in at least moderate intensity, 40.0% stated not to meet the recommendation but expressed their wish to increase PA levels, and 2.5% had no intention to increase PA although not meeting the WHO guideline.

2.2 Procedure

Ethical approval for the study was obtained from the Ethic Review Board of the Faculty of Behavioral and Cultural Studies at Heidelberg University in January 2016. Written informed consent was obtained from all study participants upon enrollment. Our study consisted of a telephone interview and three home visits. In the telephone interview, participants were screened for *cognitive impairment* using the Cognitive Telephone Screening Instrument (COGTEL; Kliegel et al. 2007) to assess domains of cognitive function (verbal short-term memory, verbal long-term memory, working memory, verbal fluency, inductive reasoning, and prospective memory). Additionally, *functional limitations* were assessed with the physical functioning subscale of the SF-36 Health Survey (Ware/Sherbourne 1992). A composite score with higher values indicating more limitations is computed by summing up ten items (i.e., “climbing a flight of stairs”) that are rated on a 3-point scale. During the first home visit the main study variables were

assessed (described in the measures section; 2.3) and participants were instructed on wearing and using the activity monitor for PA tracking over the following 14-day period. The second home visit was used to synchronize PA data after seven days, and the third home visit to recollect the tracking device. Participants did not have access to the mobile companion app that is typically used to monitor daily activity data and provides individually tailored goals and feedback.

2.3 Measurement of the main variables

In order to assess PA, the wrist-worn, commercially available activity monitor Fitbit Charge HR (Fitbit, Inc., San Francisco, USA) was used. The device is based on tri-axial accelerometry. Depending on use, the monitor's battery lasts 5 to 10 days. Fitbit devices have shown high reliability, validity and accuracy in measuring step counts in healthy subjects, over longer durations, and at different walking speeds (Ferguson et al., 2015; Fokkema et al. 2017; Takacs et al. 2013). Results on reliability and validity in measuring PA with higher intensity than steps are scarce, however, indicating satisfying performance of the Fitbit (Ferguson et al. 2015). In our study, we used the device to detect MVPA (the sum of what Fitbit calls "active" and "very active") and light PA (steps per day) as per definition of the device algorithm which calculates active minutes in different intensity levels using metabolic equivalents (METs). Fitbit does not provide raw data such as counts per minute. With 14 consecutive days of measurement, previous recommendations of at least three to four days of physical activity assessment were largely exceeded (Hart et al. 2011) and we were able to cover a large proportion of natural fluctuations. The device was worn on the non-dominant hand during the day and only to be removed for bathing/showering and water activities.

For the assessment of *social-cognitive variables,* the item construction was based on guidelines by Ajzen (2006). Two items were used to measure *intention* (Cronbach`s *α=.77)*, namely, "I intend to be physically active at least 2.5 hours per week" with responses on a 7-point scale ranging from 0 ("not at all") to 6 ("completely right"), and secondly the subjective probability for realizing this goal (0%– 100%). For the mean score, the second item was multiplied by six and divided by 100, then the items were added and the sum was divided by two (i.e. Sieverding et al. 2010). *Attitude* was assessed with 17 bipolar adjectives regarding PA which had to be rated on a 7-point scale (i.e., pleasant – unpleasant), Cronbach`s *α*=.94. For the assessment of *subjective norm*, participants had to rate on a single item if important others expect them to be physically active, with responses on a 7-point scale ranging from 0 ("not at all") to 6 ("completely right"). *Perceived behavioral control* regarding PA was assessed with a single item analogous to attitude on a 7-point scale from 0 ("difficult") to 6 ("easy").

Regarding views on aging, *aging-related cognitions* were assessed with the AgeCog-Battery (Steverink et al. 2001; Wurm et al. 2007) which consists of three

subscales labeled *physical decline, continuous growth,* and *social loss*. Each subscale includes four items that are rated on a scale ranging from 1 (“definitely true”) to 4 (“definitely false”). Example items are “Aging means to me that I am less energetic and fit” (physical decline, Cronbach’s α=.82), “Aging means to me that I can still learn new things” (continuous growth, Cronbach’s α=.70) or “Aging means to me that I feel lonely more often” (social loss, Cronbach’s α=.62). Higher values in mean scores for each subscale indicate more negative aging-related cognitions (i.e., aging is more likely to be associated with physical losses).

Subjective age was assessed according to Kastenbaum and colleagues (1972) on the four dimensions of (1) feel age (how old a person feels), (2) look age (how old a person looks), (3) do age (how involved a person is in doing "things" favored by members of a certain age group), and (4) interest age (how similar a person's interests are to members of a certain age group). As validation studies found one superordinate “subjective age” factor (Teuscher 2009), the four dimensions were averaged into a composite score (Cronbach’s α=.74). This score was divided by the respective participant’s age and thus entered as a “proportional discrepancy score” in all analyses as recommended by Rubin and Berntsen (2006). Hence, subjective age scores reflect the relative deviation of a person’s subjective age from his or her actual age, with negative scores indicating that a person feels younger than s/he actually is.

2.4 Data analyses

Statistical analyses were performed using SPSS Version 24.0. In addition to hierarchical regression analyses, we conducted relative weight analyses which allow partitioning the explained variance among multiple predictors (Tonidandel/LeBreton 2011), as opposed to the indices commonly produced by multiple regression analyses which fail to appropriately partition variance to the various predictors when they are correlated. In order to reduce the number of predictors for the regression analyses in our relatively small sample, we used only those sociodemographic and health-related variables as covariates that showed significant bivariate correlations with the activity measures.

3 Results

3.1 Preparatory analyses: correlations and predictors of the intention to be active

Chronological age, sex, education level, self-rated health complaints and body mass index were not significantly related to neither steps nor MVPA. Descriptive statistics and correlations of the main study variables are displayed in Table 1. As expected and derived from the TPB (Ajzen 1991), attitude towards PA, perceived behavioral control, and intention were positively associated with higher MVPA levels, whereas subjective norm

did not correlate with intention and PA. Regarding the AgeCog scales, older participants perceived aging more as a process of social loss and less as continuous growth (marginal significant) than younger participants, whereas physical decline was not related to chronological age. The AgeCog scales showed significant intercorrelations in the expected directions with physical decline and social loss being negatively related to continuous growth. In a second preliminary analysis, we tested the postulation of the TPB that the intention towards a behavior can be explained by attitude, subjective norm, and perceived behavioral control. A linear regression analysis confirmed this assumption: Attitude (β=.41, t=2.44, p<.05), subjective norm (β=.18, t=1.87, p=.07) and perceived behavioral control (β=.42, t=2.50, p<.05) were (marginally) significant predictors regarding the intention to be active with a large amount of explained variance (adjusted R^2=.64).

Table 1: Correlations between the main study variables

Variables	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11
1 Chronological Age	66.20	3.21		.06	.32*	-.29^{+}	-.05	-.20	-.22	-.12	-.16	-.02	.07
2 Physical Decline[a]	2.38	.56			.44**	-.53***	.27^{+}	-.01	.00	-.19	-.03	.21	-.05
3 Social Loss[a]	1.48	.48				-.56***	.03	-.32*	-.23	-.40*	-.19	-.22	-.12
4 Continuous Growth[a]	3.26	.47					-.11	-.16	.19	.02	-.11	-.02	-.16
5 Subjective Age[b]	-.12	.09						-.10	.07	.00	.01	.23	.29^{+}
6 Attitude[c]	5.02	1.02							.07	.81***	.82***	.29^{+}	.37*
7 Subjective Norm[c]	4.85	1.35								.05	.21	.02	.18
8 PBC[c,d]	4.90	1.43									.80***	.27^{+}	.27^{+}
9 Intention[c]	5.07	1.28										.29^{+}	.34*
10 Steps[e]	10.30	2.91											.46**
11 MVPA(min)[e]	47.73	30.52											

Notes. N=40;
[a]AgeCog-Scales; possible scores ranging from 1 to 4, higher scores indicate higher agreement
[b]Relative difference score ((FeelAge, LookAge, DoAge, InterestAge) – chronological age)/chronological age
[c]possible scores ranging from 0 to 6, higher scores indicating higher agreement
[d]PBC=Perceived behavioral control
[e]accelerometer-based data (Fitbit), average of daily steps/1000 and average of daily minutes of moderate to vigorous physical activity (MVPA)
$^{+}p < .10$; $^{*}p < .05$; $^{**}p < .01$, $^{***}p < .001$.

3.2 TPB and views on aging as predictors of steps and MVPA

Two hierarchical linear regression analyses were conducted to explore the second assumption of the TPB, namely the contribution of the intention to be physically active regarding the two actual activity behaviors, steps and MVPA. Additionally, we tested our

hypotheses that different operationalizations of views on aging – the AgeCog scales and subjective age – can contribute to variance explanation in light PA (steps) and MVPA, both assessed with the Fitbit and averaged over 14 consecutive days. As mentioned above, potentially relevant sociodemographic control variables were not associated with PA measures and therefore excluded due to parsimonious models. Intention was entered in the first step and the views on aging measures in the second step with the condition to only remain in the model if a marginal significance level of $p<.10$ is reached (stepwise inclusion). Table 2 shows the results of the first regression analysis explaining the average amount of steps per day, an indicator of mostly light PA, and the respective relative weights. As assumed, intention was a (marginally) significant predictor of daily steps. In the second step, two of the AgeCog scales additionally explained 14% of the variance. As expected, the dimension of social loss was negatively associated with light PA, meaning that participants who perceived aging as a process of social loss walked fewer steps over the two week assessment period. In contrast, participants who perceived aging as a process of physical decline walked more steps. The subscale of continuous growth did not reach the .10 significance level and was not included in the stepwise model which was also the case for subjective age and interaction terms. Perceived behavioral control was tested as an additional predictor as the TPB postulates a direct path on behavior and not only on intention, however, it did not contribute to variance explanation. The last column of Table 2 shows the percentage of R^2 explained by the respective predictors (relative weights, $RW_{\%}$).

Table 2: Hierarchical regression analysis explaining the average of steps per day

Step	Predictor	β_{step1}	β_{step2}	$RW_{\%}$
1	Intention	$.29^{+}$	$.24^{+}$	32.4
2	*Aging-related cognitions*			
	Physical Decline		$.37^{*}$	35.5
	Social Loss		$-.34^{*}$	32.1
ΔR^2		$.09^{+}$	$.14^{*}$	
adj R_{cum}^2		.06	.16	

Notes. N=40; Method = stepwise;

RW% = Relative weights, percentage of R^2 explained by the respective predictor;

Interaction terms were tested but did not significantly contribute to variance explanation:

$^{+}p < .10$; $^{*}p < .05$; $^{**}p < .01$.

The second hierarchical regression analysis aimed to explain the average daily amount of participants' MVPA during the two weeks. As in the previous analysis of light activity, intention was entered in the first step and explained a large amount of variance (58.7% of the total variance, Table 3). In the second step, only subjective age was a marginally significant predictor, whereas the AgeCog scales, perceived behavioral control, and possible interactions did not contribute to variance explanation. Furthermore, we tested the additional contribution of participant's self-reported past PA level in a typical week which was assessed during the initial telephone interview as an indicator of adherence to WHO recommendations. As this variable failed to reach marginal significance in the third step of the analysis, we did not include it in the final model.

Table 3: Hierarchical regression analysis explaining the average of moderate to vigorous activity per day

Step	Predictor	β_{step1}	β_{step2}	$RW_{\%}$
1	Intention	.34*	.34*	58.7
2	Subjective Age[a]		.28+	41.3
ΔR^2		.12*	.08+	
adj R_{cum}^2		.09	.16	

Notes. N=40; Method = stepwise;
[a]Relative difference score ((FeelAge, LookAge, DoAge, InterestAge) – chronological age)/chronological age
RW% = Relative weights, percentage of R^2 explained by the respective predictor;
Interaction terms were tested but did not significantly contribute to variance explanation;
+p < .10; *$p < .05$; **$p < .01$.

4 Discussion

Using data from a naturalistic and non-interventional setting, the results of the present research indicate that different conceptualizations of individual views on aging contribute significantly to the explanation of variance in ambulatory-assessed PA among older adults. The average of daily steps during the examination period of two weeks was explained by the intention to be active and – to an even larger amount – by aging-related cognitions, namely the two subscales physical decline and social loss. The daily amount of more intense activity, summarized as the average of MVPA, was also predicted by intention and to a marginal extent by the relative difference of participants' subjective age and their actual chronological age. In addition, the results of this study replicate and underpin the explanatory value of the TPB (Ajzen 1991) in our sample of older and

retired adults, with significant contributions of attitude and perceived behavioral control and a marginal contribution of subjective norm regarding intention, and intention in turn explaining PA levels.

4.1 The role of individual views on aging for PA

For steps as well as for MVPA, regression analyses revealed substantial contributions of views on aging measures, although the AgeCog scales failed to reach significance regarding the correlations with both PA measures in our small sample, and subjective age was only marginally correlated to MVPA. At a closer look, the direction of the subscale social loss was as expected, with negative views in this domain (i.e., perceptions of loneliness or being obsolete as one grows older) being associated with a smaller number of daily steps. As the main part of steps during a day is not executed due to sports activities but as part of activities of daily living or mobility, our finding may also be related to a downsized functional status or radius in those areas. The subscale of physical decline explained variance regarding steps to a comparable extent, but in the opposite direction as hypothesized: Those who perceived more losses in this domain performed more steps. This finding may be explained by (1) primary control strategies (Heckhausen/Schulz 1995), i.e., higher walking activity is performed in order to compensate for experienced age-related losses in the physical domain, or (2) anticipatory coping (Aspinwall/Taylor 1997), meaning that perceived age-related physical decline is expected to prevail and exacerbate with increasing age. From this perspective, regular walking activities may be conducted as a means to counteract one's own presumed physical decline in the future. Hence, effects that may seem paradoxical at first glance may indeed indicate self-regulatory efforts to prevent further physical loss. The subscale of continuous growth was not related to the number of steps which might be due to generally high agreement and positive views in this domain in our well-educated and cognitively and physically unimpaired sample.

For MVPA, subjective age emerged as a marginal predictor above the contribution of intention, indicating that participants who felt older compared to their chronological age engaged in more MVPA. Again, this was in contrast to our hypothesis, but might be explained in analogy with the physical decline subscale. The occurrence of those paradoxical findings for both intensities of PA (steps and MVPA) and for two conceptions of views on aging (physical decline and subjective age) could be interpreted in terms of robustness or positive replication, but more research is needed to indicate the underlying mechanisms. Furthermore, it has to be mentioned that our sample showed PA levels above average, with reference to typically low proportions of older adults meeting the WHO guideline (cf. Rütten et al. 2005: 8–9; see limitations section), and felt considerably younger than their actual age. Therefore, individuals whose subjective age was closer to (but still lower than) their actual age, were those who exercised most. In

general, views on aging were not as important for MVPA in comparison to the number of steps, which can be due to the goal-directed character of more intense PA. More precisely, it was in line with our expectations and the postulations of the TPB, that the intention is a particularly relevant predictor of planned PA such as exercise.

4.2 Limitations and further research

The combination of a theory-based approach with a naturalistic setting and the use of wearable activity monitors is a major strength of our study. We opted for commercially available devices and thereby accepted possible inaccuracies, with the idea of gaining knowledge on feasibility issues and implementation potential among older adults. Regarding the limitations, the main constraint of our study concerns the small sample size which was due to the intensive study design which involved wearing activity monitors to measure PA, in combination with filling out diaries each day. Moreover, our participants had a relatively high socio-economic background, reported high past PA levels and exhibited high levels of PA during the study period (with 67.5 % reaching the WHO guideline and 50% walking at least 10,000 steps on average per day). As our study was announced as research on activity monitoring, it certainly attracted older adults who were already quite physically active and open to technology-based assessment. Therefore, research is needed to substantiate our findings in larger and more heterogeneous samples. Further possible extensions include the investigation of the impact of mobile companion apps that typically come with commercially available activity monitors. In our study, the Fitbit was primarily applied as an assessment tool, which is why we used home visits to synchronize the data instead of letting participants interact with the app, which certainly would have had a motivational impact requiring quantification. Moreover, reactivity effects need to be considered, as the mere knowledge of wearing an activity monitor has been found to affect participants' activity level (cf. Clemes/Parker 2009: 676). However, as our study was non-interventional and did not aim to increase PA, interactions of reactivity and intervention-based change are not central to our research questions. Nevertheless, research on duration of reactivity to wearing activity monitors indicates that such effects seem to last for several days (but not longer than one week) and return to normal levels afterwards (cf. Clemes/Deans 2012: 1099). With that in mind, our two-week surveillance period should depict a more accurate estimate of habitual activity.

4.3 Conclusion and outlook

Our findings replicate the established and crucial role of intentions or behavioral goals as determinants of (activity) behavior. However, it has been stressed that intention is a necessary but not sufficient condition of behavior change (i.e., Sheeran 2002). The

intention-behavior gap (i.e. maintaining inactivity despite motivation to change) can be due to deficits in behavioral self-regulation. Those are usually targeted by planning interventions that formulate concrete action and coping plans, but our results also indicate views on aging as a possible starting point. The present study has several implications, both from a theoretical and a practical perspective: Theoretically, our findings contribute to existing knowledge on aging-related variables that are worth being taken into account alongside established social-cognitive correlates of PA. Our study may also have practical implications, for example for health professionals trying to promote older adults' engagement in and maintenance of PA. Our findings suggest that individuals who perceive aging as strongly connected to social losses are at a higher risk for inactivity. Those people might profit from group-based training interventions that provide opportunities for social contacts (Rütten et al. 2009), as the reduction of social isolation through structured programs is positively related to higher motivation to engage in PA (Cohen-Mansfield et al. 2003).

5 Declaration of interests and funding

The authors declare no potential conflicts of interest concerning the research, authorship, and/or publication of this article. The present study was supported by Field of Focus 4, University of Heidelberg, funded by the German Excellence Initiative.

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