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ORIGINAL INVESTIGATION

Age effects in prospective memory performance within older adults: the paradoxical impact of implementation intentions

Katharina Marlene Schnitzspahn · Matthias Kliegel

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Abstract This study investigated age effects in prospective memory performance within older adults. The first aim was to explore this issue by examining event- and time-based prospective memory performance in two age groups: young-old (60–75 years) and old-old adults (76–90 years). Moreover, this study for the first time investigated whether forming implementation intentions could be used to improve prospective memory in young-old and old-old adults. Results showed a general effect of age in prospective memory performance for both task types. In addition, no general effect of implementation intentions in prospective memory performance across both task types and age groups was found. However, testing implementation intention effects separately for both age groups revealed that the formation of implementation intentions enhanced prospective memory only for the young-old adults, but did not substantially affect the performance in the time-based task and even impaired it in the event-based task for the old-old adults. Findings indicate that the formation of implementation intentions might be a powerful memory strategy for young-old adults, but not for the very old.

Keywords Prospective memory · Ageing and memory · Young-old · Old-old · Implementation intentions

Introduction

Prospective memory refers to the task of remembering to perform intended actions after a delay without an explicit reminder, such as remembering to take medication on time. Different ways to measure prospective memory performance exist according to the cue that signals the appropriate moment to initiate the planned action (Einstein and McDaniel 1996; Kliegel and Jäger 2006b). Event-based tasks demand the performance of an intended action after the recognition of an external cue in the environment, such as taking one's medication at breakfast. In time-based tasks the action has to be performed after a certain time has elapsed (e.g. the assignment to take one's medication after an hour) or at specific points in time (e.g. to take one's medication at 3.00 p.m.).

One important feature of prospective memory tasks is that they have to be performed when one is busy with a competing activity at the same time (McDaniel and Einstein 2000). This requires that the person has to interrupt current thoughts and activities to carry out the intended action (Ellis and Kvavilashvili 2000). For example, a conversation has to be paused to take one's medication according to the schedule. The activity that participants are engaged in when prospective retrieval should occur is called ongoing task (Ellis and Kvavilashvili 2000).

Prospective memory has been identified as one of the most frequent everyday memory challenges (e.g. Maylor 1990). Several studies have shown that errors in prospective memory account for more than half of the overall memory problems and are crucial for the development and maintenance of independent living (Crovitz and Daniel 1984; Terry 1988), particularly in old age (McDaniel et al. 2008). Therefore, many researchers have focused on factors that may explain age differences in prospective remembering (e.g. Einstein et al. 2001; Ellis and Kvavilashvili 2000; Kliegel et al. 2000; Martin et al. 2003). In this context, time-based tasks have been considered to be more difficult to remember than event-based tasks, because

K. M. Schnitzspahn (✉) · M. Kliegel
Department of Psychology, Technische Universität Dresden, 01062 Dresden, Germany
e-mail: schnitzspahn@psychologie.tu-dresden.de

they lack an external event that signifies the opportunity for recall and require more self-initiated processing for monitoring the time (e.g. Einstein et al. 1995; Kvavilashvili and Fisher 2007). Accordingly, Einstein and McDaniel (1990) proposed that event-based prospective memory tasks might not produce large age effects, while time-based tasks might be more likely to produce age-related deficits. However, while time-based tasks have relative consistently produced age effects, results with event-based tasks are mixed. Some studies reported significant age effects (e.g. Maylor et al. 2002; Smith and Bayen 2006; West and Craik 2001; Zimmerman and Meier 2006), while others failed to obtain age effects (e.g. Cherry and Plauche 2004; Marsh et al. 2007; Reese and Cherry, 2002). Reviewing the available literature, Henry et al. (2004) have reported a meta-analysis revealing that older adults show a reduced performance in laboratory prospective memory tasks in general. They did not find significant age differences in the performance in event- and time-based prospective memory tasks.

Recently, some studies have qualified the notion of a general age deficit in prospective memory by showing that prospective memory further develops within older adults (Huppert et al. 2000; Kliegel and Jäger 2006a; Kvavilashvili et al. 2009; Mäntylä and Nilsson 1997; Rendell and Thomson 1999; Uttl et al. 2001; Zeintl et al. 2007; Zimmerman and Meier 2006). The rationale for this approach rests on the assumption that the group of older adults (60+) seems to be heterogeneous. In consequence, it has been suggested to divide older adults into specific age bands to obtain a more accurate account of prospective memory as a function of age (Ellis and Kvavilashvili 2000).

Following up on this proposal, for example, Kliegel and Jäger (2006a) examined the performance of four age groups, a younger age group (22–31 years), a young-old age group (60–69 years), a middle-old age group (70–79 years) and an old-old age group (80–91 years) on a prospective memory task. They found that performance declined progressively within the three age cohorts of the older adults. Importantly, only the old-old age group differed significantly from the younger age group and the young-old age group. Age differences between the other age groups did not reach statistical significance. This suggests that broadly defined age group comparisons (young vs. old adults) might overestimate the impairment of older people that just passed their 60s or 70s. Zeintl et al. (2007) recently confirmed and extended these findings for a latent prospective memory construct (consisting of three event-based tasks) in a more restricted age range (65–80 years). They revealed age effects for prospective memory even within this narrow age range, which persisted after accounting for individual differences in processing speed and working memory.

Most of the reviewed studies used only event-based tasks to examine the age decline in prospective memory within old age, except for Rendell and Thomson (1999) and Kvavilashvili et al. (2009), who additionally adopted a time-based task. Rendell and Thomson (1999) expected worse performance in the time-based task according to Einstein and McDaniel's (1990) proposal of a distinction in the age-related trends on event- versus time-based prospective memory tasks, but in both task types significant and substantial age-related declines occurred. However, the authors themselves expressed some doubt about whether the two tasks precisely tested the time- versus event-based distinction. Recently, Kvavilashvili et al. (2009) assessed prospective memory with three different laboratory-based tasks. The main experimental task was conducted in an event-based and a time-based condition. Age effects were significant in the time-based but not in the event-based condition and differed as a function of the scoring criterion. When a strict criterion was used, young (18–30 years) participants were reliably better than young-old (61–70 years) and old-old (71–80 years) participants, who did not differ from each other. When a lenient criterion was adopted young and young-old participants were reliably better than old-old adults.

Taken together, so far it is not clear how prospective memory develops within older adults when comparing time- and event-based tasks. Thus, the first aim of the current study was to further explore the age-related decline within older adults' prospective memory functioning. Specifically, we focused on older adults, who were divided into two age groups (young-old adults from 60 to 75 years and old-old adults from 76 to 90 years). Resting on available literature we expected that the young-old adults would outperform the old-old adults. To address the question if age differences depend on the applied task type, we employed an event-based as well as a time-based prospective memory task.

As a second aim, we targeted a potential experimental strategy to improve older adults' prospective memory performance. Recent conceptual approaches have examined the effects that intention formation-related processes like planning might have on prospective memory performance (e.g. Kliegel et al. 2002, 2003, 2007). Kliegel et al. (2007) showed that certain planning aids improved older adults' prospective memory performance to a level equal to that found in young adults. Specifically, in an ill-structured multi-task prospective memory paradigm requiring participants to remember several intentions at once, participants were instructed to develop a plan that explicitly included a cue determining when they intended to start working on the single prospective memory tasks. Kliegel et al. (2007) observed that the structure of successful plans was similar to implementation intentions, which take the form

"If situation X arises, then I will perform behaviour Y" (Gollwitzer 1999). Implementation intentions describe a means of resolving the discrepancy between one's current and desired behaviour by specifying when, where, and how a goal-directed response will be executed. When the specific cues are actually encountered in the environment, they automatically release the previously imagined behaviour (Gollwitzer and Sheeran 2006). It has been argued that implementation intentions thereby represent a powerful self-regulatory strategy that facilitates the need for conscious control by delegating it to pre-specified environmental cues (Gollwitzer 1999).

So far, this strategy has been studied in the social cognitive domain for well over a decade (e.g. Gollwitzer 1993) and its effectiveness has been demonstrated across a variety of tasks, from health-related activities such as breast self-examination (Luszczynska and Schwarzer 2003), physical training (Sniehotta et al. 2005) or eating healthy foods (Verplanken and Faes 1999) to other more experimental task settings such as intentional behaviour in go no-go paradigms (Brandstätter et al. 2001). Yet implementation intentions have attracted increasing interest in the domain of prospective memory only recently. In this context, it has been suggested that implementation intentions may benefit prospective memory performance in at least two (perhaps complementary) ways. First, encoding an implementation intention may lead to a heightened accessibility of the situational cue indicating the appropriate moment to initiate the planned action (either by increased activation or a reduced threshold), therefore helping to facilitate the detection of that cue in the environment. Here it is assumed that they create a state of perceptual readiness (Cohen and Gollwitzer 2008). Second, implementation intentions may increase the likelihood of a strong association between the cue and the associated memory trace, resulting in the memory trace for the intended action being delivered automatically to consciousness (Ellis and Freeman 2008).

Importantly for age-related prospective memory performance, automatic memory processes are less age-dependent as controlled ones (Park 1999); thus, implementation intentions may be a useful strategy for improving the performance of older adults (Park 2000). So far, only two studies exist, which have directly examined this approach. Chasteen et al. (2001) were first to explore explicitly, if implementation intentions instructions improve the prospective memory performance of a broadly defined group of older adults (mean age 71.35 years). One task was to remember to write down the day of the week on every sheet of paper received during the experimental session. Participants who formed an implementation intention were more than twice as likely to self-initiate the intended behaviour compared to the control group. In a second event-based prospective memory task in which the cue to perform was integrated in the ongoing task (e.g. participants were told to press the zero key on the number pad whenever a particular background pattern appeared, while they had to retain words presented every 3 s in the centre of the computer screen), implementation intentions did not improve the prospective memory performance of the participants. Chasteen et al., therefore, concluded that detailed implementation intentions facilitate prospective memory on tasks that lack salient cues and thus require especially high levels of self-initiation.

Following up on this finding, Lui and Park (2004) investigated, if the formation of implementation intentions may also enhance the performance of a group of older adults (mean age 71.4 years) in a health-related prospective memory task in a naturalistic setting. Their study showed that the implementation intentions group performed home blood glucose tests nearly 50% more often than two comparison groups over a period of 3 weeks.

In sum, these results concur with previous research generally demonstrating no or smaller age deficits in automatic cognitive processes than in controlled ones (e.g. Jacoby et al. 1996) and support the utility of this technique for improving prospective memory performance in older adults. In particular, it can be expected that implementation intentions might be especially beneficial to very old adults, who have the greatest limits in cognitive resources required for self-initiated processing (Craik 1986).

So far, no study has explored if the (beneficial) effect of implementation intentions on prospective memory performance may differ between young-old and old-old adults. Therefore, the second aim of the present research was to approach this gap and examine the effects of implementation intentions on prospective memory in two separate age groups, young-old (aged 60–75 years) and old-old (aged 76–90) adults. Further on, we investigated the impact of implementation intentions on prospective memory performance in both types of prospective memory tasks (event- and time-based) within the same population, whereas previous studies concentrated either on event-based (Chasteen et al. 2001) or time-based tasks (Liu and Park 2004).

Method

Participants and design

The sample consisted of 71 participants: 32 young-old adults (6 males, 26 females, mean age 68.2 years, SD = 4.2, range 60–75) and 39 old-old adults (3 males, 36 females, mean age 81.5 years, SD = 2.9, range 76–90), who regularly visited a recreation centre for senior citizens. The young-old and old-old adults did not differ significantly in their level of education, χ^2 (3) = 2.90, $p = 0.41$. No participant reported any of the following conditions: Alzheimer's disease, dementia, diabetes or coronary heart diseases. There was no reliable difference (t (69) = 0.63, $p > 0.05$) on self-rated general health between the young-olds and the old-olds on a five-point rating scale with 1 = very bad and 5 = very good or between the self-reported restrictions in everyday life caused by health-problems, t (69) = 1.31, $p > 0.05$, which were assessed with a four-point rating scale (1 = strong and 4 = not at all). However, concerning the intake of medication there was a trend indicating that the old-olds reported to take slightly more medication than the young-olds, $t\,(69) = -1.74$, $p = 0.09$.

To ensure comparability of groups with respect to their general mental ability, individual difference measures were conducted with a battery of cognitive tests, covering a German vocabulary test (MWT-B; Lehrl 1989), the digit-span subtask of the Wechsler Adult Intelligence Scale (revised version; Wechsler, 1981) and the Stroop interference task (German version from Oswald and Fleischmann 1995). Young-old and old-old adults did not differ in their verbal intelligence or short-term memory. However, concerning the inhibitory control there was a reliable difference between the two age groups, showing that the young-old adults had significantly lower interference scores than the old-olds (see Table 1 for all scores).

The study followed a 2 age (young-old adults vs. old-old adults) × 2 instruction (neutral instruction vs. implementation intentions instruction) between-subjects factorial design. Prospective memory performances in the event- and the time-based task served as dependent variables.

Materials and procedure

General procedure

The procedure consisted of three sessions. In the first individual baseline session, participants filled in a questionnaire, which provided basic demographic information and ratings about their health. Afterwards they were tested in a battery of cognitive tests (see above). The whole session lasted for 30 min.

The two following sessions took place in the context of weekly group meetings in the recreation centre for seniors, in which they usually worked on different intellectual exercises (e.g. reading texts, solving puzzles) in groups up to eight people. One prospective memory task per session, an event- or a time-based task, respectively, could easily be integrated in this routine. As existing groups were tested, it was not possible to randomize task-order (event-based vs. time-based prospective memory task) on an individual level, but it was counterbalanced on the group level.

The groups were age-mixed, but all participants in one group received the same instructions. Specifically, some groups received implementation intentions instructions for the event- and time-based prospective memory task, while the control groups received neutral instructions for both tasks (see below for details). The allocation into the two different instruction groups was randomized on the group level.

Table 1 Participants' mean scores and standard deviations on the neuropsychological tests as a function of age group (young-old vs. old-old)

Neuropsychological tests	Young-old		Old-old		t value
	M	SD	M	SD	
Verbal intelligence	31.88	3.01	31.82	3.53	0.07
Short-term memory					
Digit span forward	4.28	0.89	3.97	1.09	1.28
Digit span backward	3.41	1.07	3.10	1.17	1.13
Inhibitory control	0.25	0.23	0.38	0.21	−2.53*

* $p < 0.05$

Event-based prospective memory task

Following Chasteen et al. (2001), for the event-based task participants were asked at the beginning of the session to write the day of the week at the top right corner of each response sheet they used for the written exercises they would work on during the session. After that, each participant received a picture and had to tell a story about the illustration as a filler task. Subsequently, they were involved in several written mnemonic exercises with low or middle level of difficulty, which served as the ongoing task and were presented on six sheets across the session. To investigate event-based prospective memory performance, we examined the overall number of correctly remembered calendar date entries on the response sheets (maximum of six).

Time-based prospective memory task

For the time-based task, participants had to copy a poem in calligraphy for 10 min as the ongoing task. The actual time-based prospective memory task was to remember to underline the word they were actually writing at the target times of every 2 min. A digital clock, which was easy to read, was placed in front of the participants, so that everyone could see it well. The underlining was scored as being correct if it was performed within a 15-s window after the goal time. To investigate time-based prospective memory performance, we examined the overall number of correctly remembered underlinings (maximum of five).

Implementation intentions manipulation

Following Chasteen et al. (2001), participants in the implementation intentions condition both for the event- and the time-based prospective memory task were asked to state out loud that they intended to follow the given task instruction (e.g. for the event-based task: "I intend to write 'Wednesday' on the top right corner of every sheet of paper I receive.") and mentally imagine themselves carrying out the task in detail (e.g. for the time-based task: "Imagine yourself sitting in this room on your chair, copying the poem and underlining the actually written word every two minutes").

Results

Prospective memory performance

Because both dependent variables were not normally distributed, we employed the following analytic strategy to test our predictions. To determine main effects of age and implementation intentions, performance was collapsed across both age and instruction conditions, respectively, and two Mann–Whitney *U* tests were applied (see, Kliegel et al. (2009), for a similar approach). In order to determine possible differential effects of instruction condition on prospective memory performance in young- versus old-old adults, two separate Mann–Whitney *U* tests were applied analysing the implementation intentions effect separately for both age groups.[1] The results are presented in Fig. 1, as percentage of correct prospective memory performance across the two age groups and the two instruction conditions in the event-based task and in Fig. 2 for the performance in the time-based task.

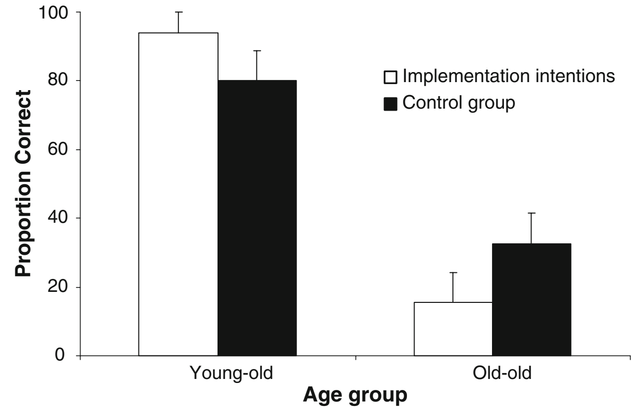

Fig. 1 Correct prospective memory performance in the event-based task for both age and instruction groups. *Error bars* represent the standard error (SE). All means are significantly different from zero

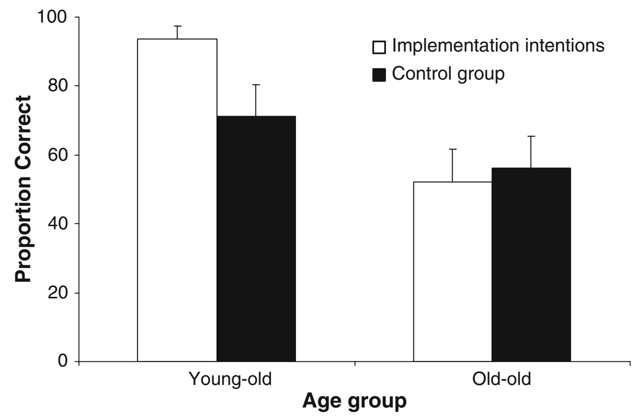

Fig. 2 Correct prospective memory performance in the time-based task for both age and instruction groups. *Error bars* represent the standard error (SE)

Event-based task

Comparing the two age groups collapsed across both instruction conditions revealed a significant large-sized main effect of age ($U = 198.50$, $p < 0.001$, $r = -0.63$). The young-old adults performed significantly better in the event-based prospective memory task than the old-old adults. Comparing prospective memory performance in the event-based task for the two instruction conditions collapsed across both age groups, revealed no significant main effect of implementation intentions ($U = 618.50$, $p = 0.90$, $r = -0.02$). Overall, participants who received the implementation intentions instruction did not perform different from participants in the control group.

However, importantly, testing the implementation intentions effect for the two age groups separately, revealed a medium effect for young-old ($r = -0.35$) and old-old adults ($r = -0.32$). While the formation of implementation intentions significantly enhanced the performance of the young-old adults, $U = 90.00$, $p < 0.05$, it significantly impaired the performance of the old-old adults, $U = 128.00$, $p < 0.05$.

Time-based task

Comparing the two age groups in time-based prospective memory performance collapsed across both instruction conditions revealed a significant main effect of age ($U = 369.00$, $p < 0.01$, $r = -0.37$). The young-old adults performed significantly better than the old-old adults. Comparing prospective memory performance in the

[1] Applying an alternative analytical strategy suggested by an anonymous reviewer we z-standardized prospective memory scores and conducted an overall 2 (age) × 2 (instruction) × 2 (PM task) ANOVA which confirmed the critical age x instruction condition interaction ($F(1,67) = 3.9$, $p \leq 0.05$).

time-based task for the two instruction conditions collapsed across both age groups, revealed no significant main effect of implementation intentions ($U = 544.50$, $p = 0.30$, $r = -0.12$). Overall, participants who received the implementation intentions instruction did not perform better in the time-based prospective memory task than participants in the control group.

However, importantly, testing the implementation intentions effect for the two age conditions separately, revealed a significant effect of medium size for the young-old adults ($r = -0.36$), but there was no significant effect for the old-old adults ($r = -0.05$). Specifically, while the formation of implementation intentions significantly enhanced the performance of the young-old adults in the time-based prospective memory task, $U = 82.50$, $p < 0.05$, there was no difference between the implementation intentions group and the control group in the old-old adults, $U = 177.50$, $p = 0.74$.

Discussion

For the first time, the present study explored the effects of implementation intentions on prospective memory performance for both young-old and old-old adults. In doing so, the age-related decline within older adults' prospective memory functioning was further explored by comparing the performance of young-old and old-old adults in a time- and an event-based task.

A first finding was the age deficit in prospective memory performance for both task types. The young-old adults outperformed the old-old adults in the event-based as well as in the time-based task. Second, regarding the impact of implementation intentions, the present results showed no general effect in prospective memory performance across both age groups and task types. Most importantly, the observed results revealed that the formation of implementation intentions significantly enhanced the prospective memory performance only for the young-old adults in both task types. In contrast, for the old-old adults, the formation of implementation intentions did not substantially affect the prospective memory performance in the time-based task and even impaired it in the event-based task.

The first result nicely dovetails with current research showing that prospective memory further develops within older adults (e.g. Kvavilashvili et al. 2009; Rendell and Thomson 1999). As previous studies (e.g. Kliegel and Jäger 2006a; Mäntylä and Nilsson 1997; Zeintl et al. 2007) we found an age-related decline in prospective memory performance in the event-based task. With respect to time-based prospective memory, the present study is only the third study which tested the age effect also for a time-based task. Here, we could confirm a decline within older adults also in time-based prospective memory. This result is in line with the findings from Rendell and Thomson (1999). In contrast, Kvavilashvili et al. (2009) only found age effects in a time-based prospective memory task but not in an event-based one. Taken together, it does not seem to be entirely clear, if both task types consistently produce age effects within older adults, although our results add evidence in favour of an age deficit in both task types of prospective memory. Conceptually, this issue is comparable with previous approaches that examined age effects in prospective memory performance comparing homogenous groups of old adults with young adults, in which results with event-based tasks were also mixed (e.g. West and Craik 2001; Reese and Cherry 2002). Nevertheless, our results suggest that age differences in prospective memory performance between young-old and old-old adults exist independently of the applied task type.

The most important finding of the present study was that the formation of implementation intentions did not substantially improve prospective memory performance in general. This is in contrast to the two existing studies that examined whether implementation intentions improve the performance of older adults in event-based (Chasteen et al. 2001) or time-based prospective memory tasks (Liu and Park 2004), which both showed a beneficial effect of the implementation intentions. Extending those studies that have explored the effect of implementation intentions only by examining a homogenous group of young-old adults, we examined two separate age groups. Our data indicate that implementation intentions are indeed a useful strategy to enhance prospective memory performance in young-old adults, but not in old-old adults. For this age group, the formation of implementation intentions clearly did not improve prospective memory performance. In contrast, forming implementation intentions even impaired the prospective memory performance in the event-based task.

To our knowledge only one other study reported that implementation intentions did not produce the desired effect in a defined population: Powers et al. (2005) found that socially prescribed perfectionism was associated with worse progress in an implementation intentions condition relative to the control condition. Their data suggested that the formation of implementation intentions for people with pervasive, critical, evaluative concerns appears to evoke a process that can obstruct goal progress. The underlying mechanism, however, remained to be clarified. Nevertheless, this study suggests that an interaction of individual differences and the effectiveness of implementation intentions exists and should be taken into account in future research.

In the context of prospective memory research, Mäntylä and Nilsson (1997) observed that younger adults benefited more than older adults from the provision of cues through the experimenter in an event-based prospective memory task. This pattern of result has also been found in the retrospective memory literature and has been interpreted to suggest that younger adults have quicker access to the cognitive resources that enable utilization of support (Salthouse 1982, 1985). It is possible that old-old adults in the present study had comparable difficulties with the utilization of the cue, which was offered through the formation of implementation intentions.

Moreover, research on retrospective memory has shown that the ability to profit from the application of memory strategies such as the "method of loci" as well as the potential to develop memory strategies are strongly reduced in old-old adults (Singer et al. 2003). Thus, it is possible that the development and execution of strategies like implementation intentions are also difficult for old-old adults in the context of prospective memory tasks. Maybe the older participants in the present study were overstrained by the task instructions and would have needed more practice, before they could benefit from the new memory strategy. This idea is further supported by the finding that the young-old and the old-old adults did only differ in their inhibitory control, but not in verbal intelligence or short-term memory. Neuropsychological test data suggest that worse prospective memory performance of the old-old adults does not reflect a general cognitive deficit, but perhaps a specific implementation problem.

Although these conclusions have to remain speculative at this point, there is evidence that implementation intentions may cause some attention-related costs (Cohen et al. 2008). Ellis and Freeman (2008) indicate that the assumption that implementation intentions in general use relatively few attentional resources is potentially oversimplistic. Hence, it may be possible that the formation of implementation intentions in our study increased the cognitive load and therefore led to a decreased prospective memory performance in the old-old adults.

As a potential limitation, it has to be considered that in contrast to the described studies by Chasteen et al. (2001) and Liu and Park (2004), the present study took place in a group setting. In this regard, it is possible that the participants had difficulties to concentrate while forming the implementation intentions through imaging and that this difficulty especially affected the old-old adults, who showed worse inhibitory control and therefore already might have had problems to concentrate.

Two methodological issues need to be addressed. First, in the present study, age differences within older adults were explored and therefore two distinct age groups (young-old versus old-old adults) were examined. In such an approach, representativeness and generalizability are important issues to consider, because of sample selectivity or non-random sample attrition. Gerontological research has shown that participation likelihood and (in longitudinal studies) duration of participation are usually correlated with certain characteristics such as good health status, higher social class and higher cognitive functioning (e.g. Lindenberger et al. 1999). Such health- and mortality-related selectivity is likely to be of more importance in an elderly sample stratified by age than in a random sample of older adults (Lindenberger et al. 1999). Therefore, it can be assumed that participants in the group of the old-old adults are strongly selected and show a high level of cognitive functioning compared to the respective age cohort. Lately, Yang et al. (2006) suggested a clever way to deal with this common problem using cognitive measures for which population norms were available. Hence, they were able to set their results in proportion to a representative sample. While the present study represents a first step in exploring age-related effects of implementation intentions on prospective memory performance, those general methodological issues will need to be more closely considered in future research. However, as the results in the cognitive baseline measures (no age differences in crystallized intelligence and simple short-term memory but age differences in inhibitory control) reflect common age-related trajectories, the current findings on prospective memory at least do not appear to be strongly affected by sample selectivity. As a second sample-related issue, we acknowledge the low number of male participants in the present convenience sample preventing to test for possible gender effects.[2] However, gender effects were no a-priori aim of the present study. Thus, future research will have to explore possible gender differences in the effects of implementation intentions on age-related prospective memory performance.

In sum, considering the few acknowledged methodological caveats, the present study for the first time suggests that implementation intentions, whose beneficial impact on goal progress and prospective memory has been found before in different age groups, might be unsuitable for the improvement of prospective memory performance in old-old adults. Future research is needed to further explore the question under which circumstances the formation of implementation intentions does not enhance prospective memory performance or even impair it.

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