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The Effect of Implementation Intentions on Prospective Memory Performance across the Lifespan

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SUMMARY

Differences in the amount and availability of cognitive resources may be responsible for age-related differences in event-based prospective memory tasks. We hypothesised that a manipulation which reduces resource requirements by enhancing automatic processing will reduce age differences. Implementation intentions are assumed to satisfy this requirement. We tested a total of 563 participants, 185 adolescents, 193 young adults and 185 older adults in order to investigate whether providing participants with implementation intention instructions would improve performance, whether any improvement would vary with age, and whether it would affect the prospective component or the retrospective component. The results showed a benefit of implementation intentions for older adults, but not for adolescents and for young adults. Separate analyses for the prospective and the retrospective components revealed that this effect was based mainly on a performance facilitation of the prospective component. These results suggest that implementation intentions provide a means to reduce age differences in prospective memory. Copyright © 2009 John Wiley & Sons, Ltd.

Despite being well motivated, individuals sometimes fail to remember to perform an intended action on the appropriate occasion. Remembering an intention—termed prospective memory—has two components: The prospective component refers to remembering *that* something has to be done and the retrospective component refers to remembering *what* has to be done (Einstein & McDaniel, 1990; Einstein & McDaniel, 1996). Only when both of these components are remembered on the appropriate occasion, can the intended action be carried out. A strategy to improve the likelihood of performing an intended action is to translate a goal intention into an implementation intention (Gollwitzer, 1999). As research on implementation intentions usually comes under motivation or goal-directed behaviour, there has been almost no work to date on how such a strategy might affect prospective memory. The goal of this study is to investigate the impact of implementation intentions on prospective memory across the lifespan. We will first provide a brief review of studies on age-related differences in prospective memory. Next, we provide an overview of studies on implementation intentions. Finally, we present an experiment designed to systematically examine the effect of implementation intentions on the prospective and the retrospective components across the lifespan.

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PROSPECTIVE MEMORY ACROSS THE LIFESPAN

Prospective memory tasks can be carried out early in childhood (Meacham & Colombo, 1980). 4-year-old children are already able to perform prospective memory tasks successfully, and prospective memory performance is known to improve during childhood and adolescence (Kvavilashvili, Messer, & Ebdon, 2001; Passolunghi, Brandimonte, & Cornoldi, 1995; Zimmermann & Meier, 2006). This improvement in performance is thought to be based partly on more effective strategies for using external cues as reminders for the prospective memory task and partly on an increase in processing resources (Maylor, Darby, Logie, Della Sala & Smith, 2002; Meacham & Colombo, 1980). In order to investigate the extent to which failures of the retrospective component might affect the prospective memory performance of children, we assessed the prospective and the retrospective components separately in a previous study. We found that for the retrospective component, kindergarten children showed similar performance to adolescents and young adults. Consequently, we concluded that, in the case of kindergarten children at least, poorer prospective memory performance was almost exclusively due to poorer performance on the prospective component (Zimmermann & Meier, 2006).

In adulthood, prospective memory remains an important ability for effective goal-directed behaviour and in old age it is fundamental for leading an autonomous life. The question as to whether there is an age-related decline in prospective memory, and why this should be, cannot be easily answered. Some findings support the view of an age-related decline (e.g. Dobbs & Rule, 1987; Maylor, 1990; West & Craik, 1999), while others do not (e.g. Cherry & LeCompte, 1999; Einstein & McDaniel, 1990; Einstein, McDaniel, Richardson, Guynn & Cunfer, 1995). There is evidence that an age-related decline occurs most likely in resource demanding situations (Einstein, Smith, McDaniel, & Shaw, 1997; Kidder, Park, Hertzog, & Morrell, 1997) and, in particular, for participants who are low in verbal ability, education or social status (Cherry & LeCompte, 1999; Reese & Cherry, 2002). In our previous study, we found that, in older adults, the lower scores on the prospective memory task are based on both components of prospective memory. Older adults failed more often to notice the prospective memory targets and when they noticed the targets, they failed more often to initiate the intended action. As all participants were able to correctly recall the instructions after the experiment, we interpreted this failure as a problem with concurrently disengaging from the ongoing task and retrieving the retrospective component of the prospective memory task.

IMPLEMENTATION INTENTIONS

Theories on motivation and goal-directed behaviour are mainly concerned with goals and goal intentions. Goal intentions are focussed on a wish or a desire and they typically have the structure ‘I intend to achieve Z’, in which Z specifies a desired outcome to which an individual feels committed (Gollwitzer, 1999). However, forming a goal intention does not guarantee that the goal will be reached. To enhance this chance, implementation intentions can be formed to specify the appropriate occasion for initiating the planned behaviour and the necessary actions to achieve the desired outcome. Therefore, implementation intentions have the structure ‘if situation X occurs, I will perform behaviour Y to achieve Z’. Forming an implementation intention is assumed to facilitate goal-directed behaviour on the basis of cognitive processes that are related both to the anticipated situation and the

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specified actions (Gollwitzer & Sheeran, 2006). It involves the activation of a mental representation of the anticipated situation and increases the accessibility of the plan in the appropriate situation. Therefore, it is assumed that the detection of the target event that is supposed to trigger retrieval of the intended action is facilitated. This facilitation may be particularly effective when it is necessary to interrupt an ongoing activity. In addition, retrieval of an intended action may be triggered more quickly because of the strong link that has been formed between the critical target event and the intended action. Hence, implementation intentions are assumed to provide automatic action control by deliberately delegating the goal-directed behaviour towards specific situational target events (Gollwitzer, 1999).

A number of studies have provided empirical support for the effectiveness of implementation intentions. Gollwitzer and Brandstätter (1997) have found that the performance of an intention that had to be performed on an inconvenient occasion (i.e. writing a report about christmas eve on the following days) was facilitated by implementation intentions. Other studies have shown the effectiveness of implementation intentions for actions that are considered intrusive, uncomfortable, unnecessary or too time-consuming, such as engaging in physical exercise (Milne, Orbell, & Sheeran, 2002; Prestwich, Lawton, & Conner, 2003), undergoing cervical cancer screenings (Sheeran & Orbell, 2000), attendance at workplace safety training sessions (Sheeran & Silverman, 2003) and regular breast examinations (Orbell, Hodginks, & Sheeran, 1997).

Lengfelder and Gollwitzer (2001) found better task performance for frontal lobe patients in a Go/NoGo task when they had previously formed implementation intentions, even under high cognitive load. In a similar task, a performance benefit was found for schizophrenic patients as a consequence of deliberately forming implementation intentions (Brandstätter, Lengfelder, & Gollwitzer, 2001). Since schizophrenic patients are known to experience difficulties in attending to relevant stimuli and ignoring irrelevant stimuli, the superior results support the hypothesis that implementation intentions induce automatic action initiation even in the face of possible distractors. From these studies it is clear that, so far, implementation intentions have been investigated mainly to overcome motivational problems and to reduce the influence of distraction. In contrast, only sparse information is available on whether implementation intentions can improve intention retrieval.

IMPLEMENTATION INTENTIONS AND PROSPECTIVE MEMORY

Despite the fact that research on implementation intentions and on prospective memory both examine the carrying out of previously intended plans at some appropriate time in the future, there are some inherent differences in the relative approaches. Research on implementation intention focuses on motivational and goal-directed behaviour and the memory component is typically not the most critical part. This is reflected by the fact that many studies on implementation intentions focus on the initiation of unpleasant activities, such as changing a habit. Additionally, in these studies the action component, that is, the retrospective component, is typically more complex than in standard prospective memory tests. In contrast, in the field of prospective memory the retrospective component is typically kept as simple as possible (e.g. press a particular key on a computer keyboard), and the focus is on the memory requirements for recognising a target event at the appropriate moment (i.e. the prospective component).

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So far only a few studies have explicitly linked research on implementation intentions and prospective memory. Chasteen, Park, and Schwarz (2001) examined whether the translation of a goal intention into an implementation intention affected prospective memory in younger and older adults. In the implementation intention condition, participants were instructed to imagine themselves executing the planned behaviour while saying out loud that they intended to perform a specific action whenever they came across a particular target event. Chasteen et al. found a performance benefit for older adults using implementation intentions for a naturalistic prospective memory task (i.e. remember to write the day of the week on each sheet of paper, the 'day of the week' task), but not for a laboratory task (i.e. remember to press a key when a specific colour background appeared within a computerised recall task). They suggested that forming an implementation intention is more likely to improve prospective memory performance if the task requires a high degree of self-initiation. They also assumed that this performance benefit was due to automatic rather than controlled processes. However, as Chasteen et al. did not measure whether the prospective memory task induced costs in the ongoing task for the 'day of the week' task, this assumption remains to be tested. In the present study, we used a design that allowed the investigation of whether implementation intentions eliminate the resource demands of the prospective memory task. This is an important issue because one of the prominent theories on prospective memory, the preparatory, attentional and memory process (PAM) theory, suggests that successful performance in a prospective memory task is always accompanied by a cost in the ongoing task (Smith, 2003). In order to test this assumption, we used a control group that did not receive the prospective memory task instructions.

Moreover, since the study by Chasteen et al. (2001) did not separately assess the prospective and the retrospective component of prospective memory, it remains unclear whether implementation intentions facilitate identification of target events (i.e. the prospective component) or retrieval of the intended actions and switching from the ongoing activity to the prospective memory task (i.e. the retrospective component). One might expect that pre-processing highly specified if-then plans might result in increased accessibility for both target events and intended actions. To test this assumption, we used a design that allowed the separate assessment of the prospective and the retrospective component.

OVERVIEW OF THE PRESENT STUDY

To date, no study has systematically examined the effect of implementation intentions across the lifespan. The first goal of the present study was to fill this gap. We tested a group of adolescents, young adults and older adults. The selection of age groups was based on the results of our previous lifespan study (Zimmermann & Meier, 2006). There, we tested five different age groups (4–6-year-old children, 13–14-year-old adolescents, 19–26-year-old adults, 55–65-year-old adults and 65–75-year-old adults). As we found no differences between the groups of 19–26-year-old and 55–65-year-old participants in the previous study, only a group of younger adults was included in the present study. In addition, due to the higher demands of the ongoing task in the present study compared to the previous study, it was not possible to test kindergarten children.

As an ongoing task we used a lexical decision task. In order to keep ongoing task difficulty constant for all participants, the pace of presentation was individually adjusted.

Words of the taxonomic category 'animal' served as prospective memory targets. Three instruction conditions were used: Conventional prospective memory instructions, implementation intention instructions or no prospective memory instructions. The latter condition was included to test whether adding a prospective memory task will affect the ongoing lexical decision task.

The impact of implementation intentions was measured separately for the prospective and the retrospective components (see Cohen, West, & Craik, 2001; West & Krompinger, 2005 for a similar approach). The specific method has been used successfully in our previous life-span study and it is based on typical behaviour patterns of participants in prospective memory experiments (Meier, Zimmermann, & Perrig, 2006; Zimmermann & Meier, 2006). Participants were required to continuously press a specific key (i.e. the *shift*-key) during the ongoing task. The prospective memory task was to press a different key with the same finger as soon as a prospective memory target occurred. To fulfil this request, participants had to release the *shift*-key first. Observations in our lab have shown that upon recognition of a prospective memory target, participants often move back in their chairs (sometimes accompanied by exclamations such as 'now I have to do something', 'what am I supposed to do no?', cf. Meier et al., 2006). We assume that this behaviour is triggered when participants recognise that something is 'special' about the present stimulus—without necessarily already identifying it as a prospective memory target. Therefore, releasing the *shift*-key is an indicator of the prospective component. We acknowledge that the release of the *shift*-key does not in all cases occur automatically. For example, if a person is constantly monitoring for prospective memory targets, releasing the *shift*-key might be functionally similar to just press the appropriate key (i.e. the retrospective component). However, the interruption of the ongoing task is probably the most pure measure of the prospective component ('ProM proper', see Graf & Uttl, 2001; Meier & Graf, 2000). Retrieval of the intended action was taken as an indicator of the retrospective component. Participants were interviewed at the end of the experiment in order to establish whether they still remembered the initial instructions. Only those who remembered the instructions were included in the analyses. With this procedure we made sure that remembering the target events—which can be seen as one part of the retrospective component—did not vary across individuals and conditions, and that differences in the retrospective component were due to failures to retrieve the intended action.

Because implementation intentions are assumed to increase accessibility of both target events and intended actions, we expected superior prospective memory performance for both components with the implementation intention instruction compared to the conventional prospective memory instruction. Because adolescents and older adults are assumed to have fewer processing resources (e.g. De Ribaupierre, 2002), we expected that their prospective memory performance would benefit more from the automatic processes induced by implementation intentions compared to younger adults. Moreover, we also expected a benefit for older adults on the retrospective component because we assumed that implementation intentions would increase the accessibility of the intention. In particular, a stronger association between the prospective and retrospective components might help older adults to compensate for the difficulties in disengaging from the ongoing task that we have observed in our previous study (Zimmermann & Meier, 2006). In order to directly test whether performance benefits from the implementation intentions were based on higher levels of automatic processing, we examined monitoring costs in the ongoing task. If implementation intentions recruit automatic rather than strategic processes, we expected no or at least reduced monitoring costs for this condition.

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METHOD

Participants

One hundred and eighty-five adolescents aged between 10 and 14 years ($M = 12.8$, $SD = 1.1$), 193 young adults aged between 17 and 30 years ($M = 22.7$, $SD = 3.1$) and 185 older adults aged between 64 and 75 years ($M = 68.7$, $SD = 3.3$) participated voluntarily in this study. Adolescents were recruited from local schools, young adults from undergraduate courses and older adults from a senior education program of the University of Bern. All participants had normal or corrected to normal binocular vision. They were randomly assigned to one of three conditions, the implementation intention instruction condition, the conventional prospective memory instruction condition or the control condition. For each age group, 73–78 participants were tested per experimental condition, and 35–38 participants were tested per control condition.

Design

For analysing prospective memory performance, a 3×2 design was used with age group (adolescents, young adults, older adults) and instruction condition (conventional prospective memory instruction, implementation intention instruction) manipulated between groups. For analysing monitoring costs, a 3×3 design was used with age group (adolescents, young adults, older adults) and instruction condition (no prospective memory instruction, conventional prospective memory instruction, implementation intention instruction) manipulated between groups.

Material and apparatus

For the lexical decision task, a total of 128 German nouns with medium to high frequency were selected (CELEX 2 database, Baayen, Piepenbrock, & Gulikers, 1995). For each word, a non-word was generated by changing the order of the letters, such that the letter-string was difficult to pronounce. Sixteen words and non-words were used to adjust ongoing task difficulty and 16 words and non-words served as stimuli in the baseline trials. Ninety-two words and 96 non-words were presented in the ongoing task in which the prospective memory targets occurred. An additional four words were used as prospective memory targets. They were instances of the category ‘animals’ and consisted of the German nouns ‘Pferd’ (horse), ‘Vogel’ (bird), ‘Fuchs’ (fox) and ‘Frosch’ (frog).

Words and non-words were presented in 18-point font in the centre of the screen. Presentation of stimuli was controlled by E-Prime 1.1 software (Psychology Software Tools, www.pstnet.com) running on IBM-compatible computers with 15″ VGA monitors.

Procedure

After giving consent, participants were informed that they were required to decide whether a letter string was a word or a non-word and then press an appropriate key (*b* and *n*) with the index and the middle fingers of the right hand. They were instructed to continuously press the *shift*-key with the left index finger to keep the task going. If they mistakenly released this key, the program did not continue until they pressed it again. These instructions were explained until participants understood and were able to repeat them. Next, 32 trials of the

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lexical decision task were administered to individually adjust difficulty of the lexical decision task. Specifically, presentation times of words and non-words were adjusted for the baseline and ongoing task. Stimuli were presented in pseudo-randomised order with an initial presentation time of 2 seconds. Each trial started with a fixation cross in the centre of the screen for 1 second, followed by a 250 ms blank screen and the presentation of the stimulus. As soon as participants responded, the next trial was started. Each time a correct response was given, the presentation time for the next trial decreased by 250 ms (with a lower bound of 250 ms). Each time an incorrect response was given, presentation time increased by 250 ms (no upper bound was set). The presentation time of the last trial was used to individually adjust the presentation time for the rest of the experiment[1]. Then, the baseline phase followed, in which a total of 16 words and 16 non-words were presented.

Next, participants were given instructions for the prospective memory task (except in the control conditions). They were told to press the 1-key with their left index finger whenever a word of an animal appeared. As they were continuously keeping the *shift*-key pressed with the same finger, this instruction implied to release the *shift*-key before pressing the 1-key. They were requested to repeat the instructions in their own words as soon as they had understood them. Participants in the implementation intention conditions received the same instructions. In addition, however, these participants had to read the instructions aloud three times that were formulated in the first person (i.e. *whenever I see an animal word I will press the* 1-*key with my left index finger as quickly as possible*). This procedure was adopted from the method typically used by Gollwitzer and coworkers (e.g. Achtziger, Gollwitzer, & Sheeran, 2008).

Next, an unrelated questionnaire was administered for 10 minutes to create a filled retention interval. Then, the ongoing task including the embedded prospective memory task was started. The prospective memory task was not mentioned again. A total of 192 trials were presented. Prospective memory targets occurred on the 47th, 95th, 143rd and 191st trials. The selection of one of four prospective memory targets was random without replacement. Whenever participants released the *shift*-key, the ongoing task was interrupted. When they appropriately released the *shift*-key and pressed the 1-key for the prospective memory task, a screen with the request to 'press the *shift*-key to continue' appeared.

At the end of the experiment, participants who had never responded to any of the prospective memory targets were asked whether they remembered that they were requested to perform an additional task. Participants, who were not able to recall the instructions, were excluded from data analyses (20 adolescents, 9 young adults and 14 older adults). Consequently, only subjects who showed retrospective memory for the task demands were included and thus, failures to release the *shift*-key when the target event occurred reflected failures of prospective memory.

In addition, participants who performed below an accuracy of eighty percent in the ongoing task (49 adolescents, 6 young adults and 28 older adults) were also excluded from the analyses in order to ensure that for all participants the ongoing task was the primary task. Low scores in the lexical decision task are likely to reflect a strategy of permanent monitoring for prospective memory targets. Therefore, a final sample of 437 participants remained in the analyses: 116 adolescents (24 in the control condition, 47 in the

[1]Mean presentation times were 307 ms (SD = 348 ms). An analysis of variance (ANOVA) with the three different age groups as between-subject factor revealed a significant effect, $F(2, 560) = 3.869$, $p < .05$ ($M = 363$ ms for adolescents, $M = 266$ ms for young adults and $M = 293$ ms for older adults). *Post hoc* Tukey HSD tests showed that adolescents were significantly slower than young adults ($p < .05$). No other differences were significant.

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conventional condition and 45 in the implementation intention condition), 178 young adults (35 in the control condition, 76 in the conventional condition and 67 in the implementation intention condition) and 143 older adults (29 in the control condition, 68 in the conventional condition and 46 in the implementation intention condition).

RESULTS

For all statistical analyses α was set at .05. As a first step, overall prospective memory performance was analysed. A response was scored as correct when the *shift*-key was released and the 1-key was pressed on the appropriate occasion. Proportions of correct responses are displayed in Figure 1. A two-factorial analysis of variance (ANOVA) with age group and instruction as between subject factors was conducted. Both, age group, $F(2, 343) = 11.068$, $p < .001$, MSE = .121, $\eta_p^2 = .061$ ($M = 0.25$ for adolescents, $M = 0.44$ for young adults and $M = 0.25$ for older adults) and instruction, $F(1, 343) = 5.743$, $p < .05$, MSE = .121, $\eta_p^2 = .016$ ($M = 0.29$ for the prospective memory conditions and $M = 0.37$ for the implementation intention conditions) affected prospective memory performance. The interaction was not significant, $F(2, 343) = 2.17$; $p = .116$; MSE = .121; $\eta_p^2 = .012$. *Post hoc* Tukey HSD tests showed that young adults scored significantly higher than adolescents and older adults (all ps < .001). Performance of the latter two groups did not differ statistically. As there was no reliable interaction between age group and instruction condition it would appear that the effect of implementation intentions was consistent across age groups. However, due to the theoretical and practical significance of the instruction manipulation, separate analyses were conducted for each age group. A series of *t*-tests showed a numerical, but not statistically significant, effect of instruction condition for

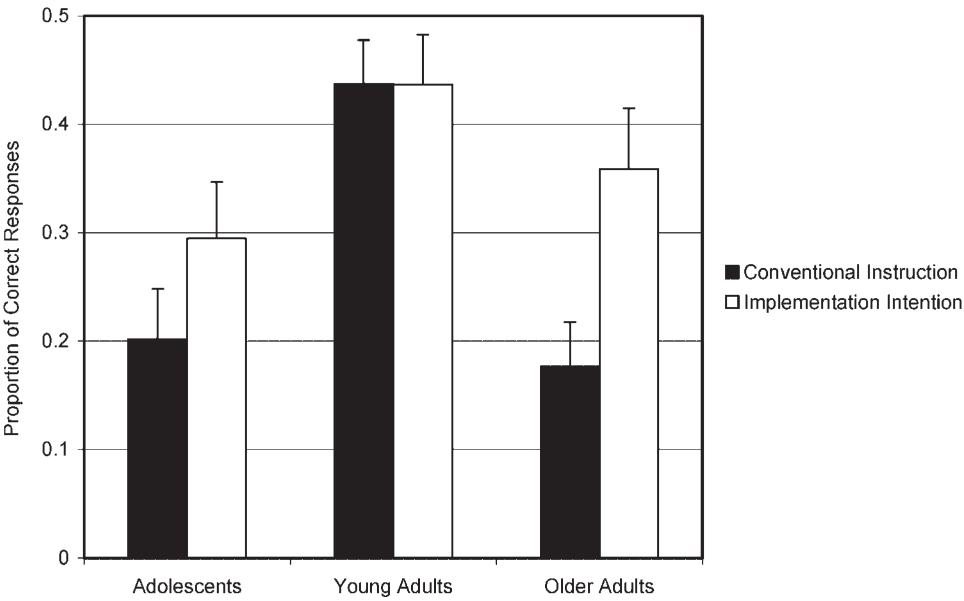

Figure 1. Mean proportions of correct responses for overall prospective memory performance. Error bars represent standard errors

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adolescents, $t(90) = 1.328$; $p > .15$ ($M = 0.20$ for the prospective memory condition and $M = 0.29$ for the implementation intention condition), no difference for young adults, $t(141) = .015$; $p > .9$ ($M = 0.44$ for both, prospective memory condition and implementation intention condition), and a highly significant effect for older adults, $t(112) = 2.819$; $p < .01$ ($M = 0.18$ for the prospective memory condition and $M = 0.36$ for the implementation intention condition).

Next, prospective memory performance was analysed separately for the prospective component. A response was scored as correct when the *shift*-key was released on the appropriate occasion. Proportions of correct responses for the prospective component are displayed in Table 1 (left column). Again, a two-factorial ANOVA with age group and instruction as between subject factors was conducted. Both age group, $F(2, 343) = 11.637$, $p < .001$, MSE $= .131$, $\eta_p^2 = .064$ ($M = 0.26$ for adolescents, $M = 0.47$ for young adults and $M = 0.29$ for older adults) and instruction type, $F(1, 343) = 4.451$, $p < .05$, MSE $= .131$, $\eta_p^2 = .013$ ($M = 0.32$ for the prospective memory conditions and $M = 0.40$ for the implementation intention conditions) affected performance. The interaction was not significant, $F(2, 343) = 1.69$; $p = .187$; MSE $= .131$; $\eta_p^2 = .01$. *Post hoc* Tukey HSD tests showed that young adults scored significantly higher than adolescents and older adults (all ps $< .001$), whose performance was not statistically different. Separate t-tests for each age group showed a numerical, but not statistical difference for adolescents, $t(90) = 1.113$; $p = .25$ ($M = 0.22$ for the prospective memory condition and $M = 0.31$ for the implementation intention condition), no difference for young adults, $t(141) = .003$; $p > .9$ ($M = 0.47$ for both conditions), and a significant effect for older adults, $t(112) = 2.475$; $p < .05$ ($M = 0.22$ for the prospective memory condition and $M = 0.39$ for the implementation intention condition).

Overall, 192 of the 349 participants correctly interrupted the ongoing task at least once. For these participants performance of the retrospective component was calculated as conditional probability. The retrospective component was scored as correct when the 1-key was pressed after the *shift*-key was released. Proportions of correct responses across the conditions are also shown in Table 1 (right column). A two-factorial ANOVA with age group and instruction as between subject factors was conducted. Age group affected performance for the retrospective component, $F(2, 186) = 3.288$, $p < .05$, MSE $= .034$, $\eta_p^2 = .061$ ($M = 0.95$ for adolescents, $M = 0.91$ for young adults and $M = 0.82$ for older adults). There was a tendency for an effect of instruction, $F(1, 186) = 2.913$, $p = .09$, MSE $= .061$, $\eta_p^2 = .015$ ($M = 0.87$ for the prospective memory instruction and $M = 0.92$ for the implementation intention instruction). Neither the main effect of instruction nor the interaction was significant (all Fs < 3; ps $> .09$; MSE $= .061$; all $\eta_p^2 < .02$). *Post hoc* Tukey

Table 1. Proportions of correct responses for the prospective and the retrospective components of the prospective memory task

Age group	Instruction	Prospective component	Retrospective component
Adolescents	Conventional	.22 (.05)	.91 (.04)
	Implementation intention	.31 (.05)	.98 (.02)
Young adults	Conventional	.47 (.04)	.91 (.04)
	Implementation intention	.47 (.05)	.92 (.02)
Older adults	Conventional	.22 (.04)	.76 (.07)
	Implementation intention	.39 (.06)	.88 (.06)

Note: The retrospective component is presented as conditional probability for participants who correctly responded to at least one prospective memory target. Standard errors in parentheses.

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HSD tests revealed that older adults scored significantly lower than adolescents ($p < .05$) and marginally lower than young adults ($p = .063$). Adolescents and young adults did not differ ($p > .7$). Separate *t*-tests for the three age groups showed a numerical effect for adolescents, $t(36) = 1.493$; $p = .144$ ($M = 0.91$ for the prospective memory conditions and $M = 0.98$ for the implementation intention conditions), no difference for young adults $t(100) = .31$; $p > .75$ ($M = 0.91$ for the prospective memory conditions and $M = 0.92$ for the implementation intention conditions), and a numerical effect for older adults, $t(50) = 1.29$; $p = .203$ ($M = 0.76$ for the prospective memory conditions and $M = 0.88$ for the implementation intention conditions).

We also assessed how many times the *shift*-key was released when no prospective memory target was presented. Overall 43 of the 349 participants (11 adolescents, 17 young adults and 15 older adults) released the *shift*-key at least once when no prospective memory target was presented. A two-factorial ANOVA with age group and instruction as between subject factors yielded a highly significant effect for instruction type, $F(1, 343) = 7.211$, $p < .01$, MSE = .197, $\eta_p^2 = .02$ ($M = 0.21$ times for the prospective memory conditions and $M = 0.08$ times for the implementation intention conditions, respectively). No other effect was significant.

In order to investigate the impact of the prospective memory task on the lexical decision task the reaction times of the baseline and the ongoing task was calculated for correct responses on word trials. The four prospective memory targets and the three subsequent trials, as well as trials for which participants mistakenly released the *shift*-key were excluded. A paired sample t-test revealed that reaction times were significantly slower for the ongoing task (709 ms) compared to the baseline task (661 ms), $t(348) = 7.445$; $p < .001$. The difference in mean reaction times was calculated separately for each condition as a measure of monitoring costs. Positive values indicate a slowing in reaction times for the ongoing task compared to baseline. These difference scores are presented in Table 2. A two-factorial ANOVA with age group and instruction (now including also the control condition) as between-subject factors was conducted. Instruction significantly affected monitoring costs, $F(2, 428) = 7.364$, $p < .001$, MSE = 13010, $\eta_p^2 = .033$ ($M = -1$ for the control condition, $M = 39$ for the prospective memory instruction condition and $M = 57$ for the implementation intention condition). *Post hoc* Tukey HSD tests revealed lower costs for the control group compared to the two instruction conditions (all ps $< .05$). No differences were found between the prospective memory condition and the implementation intention condition. The main effect for age group and the interaction

Table 2. Means of reaction times for the baseline and the ongoing task, and resulting difference as a measure of monitoring costs (in milliseconds)

Age group	Instruction	Baseline	Ongoing task	Monitoring costs
Adolescents	No	744 (50)	733 (35)	−11 (27)
	Conventional	713 (25)	739 (19)	25 (17)
	Implementation intention	763 (38)	812 (36)	50 (18)
Young adults	No	565 (17)	576 (16)	11 (9)
	Conventional	554 (17)	625 (14)	71 (12)
	Implementation intention	554 (13)	612 (12)	58 (9)
Older adults	No	712 (63)	704 (51)	−8 (20)
	Conventional	755 (48)	768 (39)	14 (17)
	Implementation intention	705 (36)	767 (36)	62 (21)

Note: Standard errors in parentheses.

were not significant (all $Fs < 2.2$, $ps > .11$). Nevertheless, the pattern of results suggests that the superior prospective memory performance of older adults in the implementation intention condition was accompanied by higher monitoring costs. However, an independent sample *t*-test revealed no significant difference between the implementation intention condition (62 ms) and the prospective memory condition (14 ms), $t(112) = 1.763$, $p > .05$.

DISCUSSION

The goal of this study was to investigate the impact of implementation intentions on prospective memory across the lifespan. A conventional prospective memory instruction was compared to an implementation intention instruction and memory performance was assessed separately for both components of prospective memory. The results showed that implementation intentions improved overall prospective memory performance for older adults. Separate analyses for the prospective and retrospective components revealed that this effect was based mainly on a performance facilitation of the prospective component.

For the conventional prospective memory instruction condition, the results replicated our previous study (Zimmermann & Meier, 2006). That is, for the prospective component, performance showed an inverted u-shaped curve across the lifespan and for the retrospective component, a performance decline was found for the older adults. Retrieval of the retrospective component and switching tasks draw from the same pool of processing resources concurrently. As resource-demanding processes require time to complete, competition can result in a completion failure of already initiated processes (Meier, Morger, & Graf, 2003). As a consequence, instead of pressing the appropriate key to fulfil the retrospective component of the prospective memory task, older adults rather seemed to continue with the still activated ongoing task.

For the implementation intention condition, the findings are also consistent with previous research. Similar to Chasteen et al. (2001) we found a performance benefit for the implementation intention instructions compared to the conventional instructions. Moreover older adults benefited more than young adults, and the pattern of results suggests that adolescent also showed at least a numerical benefit. Thus, consistent with our prediction, implementation intentions provide a means to reduce age differences in prospective memory. They seem to make prospective memory retrieval happen more automatically, which seems particularly useful for individuals with reduced processing resources.

In contrast to the study by Chasteen et al. (2001), our procedure allowed the separate assessment of the prospective and the retrospective components. For the prospective component, our results showed a general benefit for older adults. For the retrospective component, the results showed also a numerical improvement for older adults. However, a ceiling effect probably prevented a similar benefit occurring in adolescents and young adults. The findings indicate that implementation intentions can help older adults to disengage from the ongoing task in order to retrieve and implement the prospective memory task. This interpretation is supported by the fact that all participants included in data analysis perfectly remembered the prospective memory instructions after the prospective memory task. It is likely that the implementation intention group encoded the task as pressing a key when they saw animals whereas the conventional group did not organise it as such. It therefore seems that forming an implementation intention

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strengthened the association between target event and intended action as suggested by Gollwitzer (1999), and encountering the prospective memory target then triggered *reflexive-associative retrieval* (McDaniel et al., 2004).

However, the analysis of monitoring costs only partially supports a *reflexive-associative retrieval* account. Indeed, our results showed that the performance benefit in the implementation intention conditions was not due to enhanced monitoring. Monitoring costs for implementation intention conditions did not differ significantly from those in the conventional instruction conditions. Even so, in both conditions, costs were higher than in the control condition which did not involve a prospective memory task. This result is rather more consistent with PAM-theory than with a *reflexive-associative retrieval* account. According to PAM, prospective memory retrieval is always costly, whilst according to a *reflexive-associative retrieval* account performance in the ongoing task should not be affected by prospective memory task demands. Nevertheless, the trade-off between higher prospective memory performance and equal costs in the ongoing task suggests that implementation intentions still lead to more efficient prospective memory task performance compared to conventional instructions. However, since it is not clear to what extent *reflexive-associative retrieval* can be triggered by categorical targets we would expect that with specific targets the performance benefit may be even more accentuated. Thus, future research is necessary to examine the relative effect of implementation intentions on specific versus categorical prospective memory targets.

The finding of age-related differences in prospective memory performance, in particular on the prospective component, is consistent with many studies that have investigated age effects in prospective memory. However, it is possible that age-related decline may be reduced or even absent with different test arrangements. For example, lexical decision tasks require lexical rather than conceptual processing of the letter strings (Richardson-Klavehn & Bjork, 1988). In contrast, for recognising a word as pertaining to the category of animals (i.e. as a prospective memory target), conceptual processing is required. As a consequence, there was no concurrent overlap between ongoing task and prospective memory task requirements (Meier & Graf, 2000). Performance might have been less resource demanding if there had been a processing overlap and hence age-related decline might have been reduced. In addition, we have used categorical rather than specific prospective memory targets. There is ample evidence for a performance benefit with specific targets and age differences across the lifespan can be reduced with specific and focal targets (Cherry, Martin, Simmons-D'Gerolamo, Pinkston, Griffing, & Gouvier, 2001). Therefore, the trajectory of prospective memory performance across the lifespan may vary for different types of prospective memory test arrangements.

For future studies on prospective memory across the lifespan we want to point out some shortcomings of the present study. First, we have assessed only a small number of cognitive and demographical variables and therefore, we cannot exclude that the different age groups differed in educational attainment or other potentially important individual difference characteristics. Second, a significant proportion of older adults were dropped because they performed below-criterion in the ongoing task. We used this criterion to exclude the possibility that the results are confounded by consistent monitoring for prospective memory targets. However, it is possible that older participants were just more likely to be tired out in the course of the experiment. Future research is necessary to clarify this issue.

Taken together, the results suggest that implementation intentions are successful in improving prospective memory performance. This technique seems to be highly applicable

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particularly for individuals with reduced processing resources, and in situations where individuals tend to rely on spontaneous remembering. Our results indicate that implementation intentions do not only lead to more efficient target identification, they also facilitate switching from the ongoing activity to the prospective memory task. The performance benefit of implementation intentions does not rely on more extensive monitoring of target events. Therefore, investing processing resources in formulating implementation intentions really pays off.

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