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REVIEW

Prospective memory training in older adults and its relevance for successful aging

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Abstract In research on cognitive plasticity, two training approaches have been established: (1) training of *strategies* to improve performance in a given task (e.g., encoding strategies to improve episodic memory performance) and (2) training of basic cognitive *processes* (e.g., working memory, inhibition) that underlie a range of more complex cognitive tasks (e.g., planning) to improve both the training target and the complex transfer tasks. Strategy training aims to compensate or circumvent limitations in underlying processes, while process training attempts to augment or to restore these processes. Although research on both approaches has produced some promising findings, results are still heterogeneous and the impact of most training regimes for everyday life is unknown. We, therefore, discuss recent proposals of training regimes aiming to improve *prospective memory* (i.e., forming and realizing delayed intentions) as this type of complex cognition is highly relevant for independent living. Furthermore, prospective memory is associated with working memory and executive functions and age-related decline is widely reported. We review initial evidence suggesting that both training regimes (i.e., strategy and/or process training) can successfully be applied to improve prospective memory. Conceptual and methodological implications of the findings for research on age-related prospective memory and for training research in general are discussed.

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Introduction

Aging is associated with cognitive decline causing individual and social burdens. Lawton et al. (1999), for example, showed how threatening cognitive decline can be for older adults. They asked 600 older adults how long they would desire to live under the condition of functional limitations (e.g., being in a bedridden state), cognitive impairment (e.g., being confused) or pain. Above 60 % of the participants aged 70 years and older did not wish to live any longer under any condition of cognitive impairment. Indeed, cognitive decline was deemed more threatening for older adults' quality of life than functional impairment or pain. These results illustrate the importance of cognitive wellbeing and independence in old age and reveal the need for interventions aimed at maintaining a high level of cognitive functioning as long as possible. Research following this need faces two challenges: (1) developing effective training interventions that protect or enhance cognitive functions; (2) ensuring that these interventions actually transfer to *everyday life* and impact quality of life in older adults. The present review aims to discuss and connect existing literature on cognitive training to everyday functioning in older adults. To do so, we focus on a key everyday memory skill, *prospective memory*, and its application to cognitive training.

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Prospective memory and aging

Prospective memory describes the ability to plan and successfully execute delayed intentions in the future (e.g., Einstein & McDaniel, 1990; for an overview see Kliegel, McDaniel, & Einstein 2008). Typical prospective memory tasks in everyday life are to take one's medication at the right time, to call friends on their birthday or to pay bills on time. These examples show how important intact prospective remembering is for an individual's everyday and social life. Furthermore, studies show that forgetting planned intentions (e.g., forgetting to make a phone call) belongs to the most frequent memory errors in everyday life (Crovitz & Daniel, 1984; Kliegel & Martin, 2003). Moreover, prospective memory is predictive of a wide range of everyday activities in older adults (Woods, Weinborn, Velnoweth, Rooney, & Bucks, 2012). Specifically, Wood and colleagues found that prospective memory deficits in older adults were associated with problems and greater self-reported dependence in instrumental activities of daily living (e.g., housekeeping, shopping). Hence, an intact prospective memory is a crucial factor for maintaining independence and autonomy. It may therefore be the ideal target for cognitive interventions in old age.

This seems to hold especially, because developmental studies have shown that it may be a particular challenge to keep an intact prospective memory with increasing age. Research on aging and prospective memory reveal a general decline with increasing age in laboratory-based studies compared to young adults (e.g., Altgassen, Kliegel, Brandimonte, & Filippello, 2010; Bisiacchi, Tarantino, & Ciccola, 2008; Einstein, McDaniel, Manzi, Cochran, & Baker, 2000; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). Including 26 studies, Henry, MacLeod, Phillips, and Crawford (2004) reported in their meta-analysis on prospective memory a substantial age-related deficit ($rs = -0.39$ to -0.34) indicating that young adults outperform old adults in laboratory-based prospective memory tasks (see Ihle, Hering, Mahy, Bisiacchi, & Kliegel, 2013; Kliegel, Phillips, & Jäger, 2008 for further meta-analytic evidence confirming those findings). Obviously, the robust age-related decline in older adults raised the question which underlying mechanisms could explain those findings. While there is an ongoing debate over the precise cognitive processes that are associated with age-related decline in prospective memory, there is some consensus that it can partly be linked to the age-related decline of attentional resources and cognitive control (Craik & Byrd, 1982; Kliegel, Ramuschkat, & Martin, 2003; Martin, Kliegel, & McDaniel, 2003; Maylor, Smith, Della Sala, & Logie, 2002; Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010). In particular, age-related decline in working memory, inhibition and shifting has been associated with decline in prospective memory (Gonneaud et al., 2011; Rose et al., 2010; Schnitzspahn, Stahl, Zeintl, Kaller, & Kliegel, 2013). For example, Schnitzspahn et al. (2013) tested 175 young and 110 older adults on a battery of different prospective memory tasks and cognitive tests assessing shifting, updating, inhibition, working memory, and speed. Aiming to disentangle the role of different executive functions on age-related prospective memory performance, the authors found age-related declines in performance on both the prospective memory and executive function measures. Furthermore, they showed that inhibition and shifting play an especially important role in predicting prospective memory performance.

Taken together, prospective memory is of high relevance for older adults, yet there is an age-related decline in prospective memory performance. As a result, it is not surprising that, recently, there has been increasing interest in training interventions that may have the potential to enhance prospective memory performance in older adults and maybe even prevent age-related declines (McDaniel & Bugg, 2012). However, so far, very little has been published in this area. The present review, therefore, aims to offer some insights on a possible rationale for future research in the area of prospective memory training. In the following, we briefly outline a distinction made in the available literature on cognitive training in general that will guide our rationale.

Cognitive training: general remarks and two ways to go

The approach of training cognitive resources is generally motivated by the concept of cognitive plasticity, also described as the malleability of behavior (Greenwood & Parasuraman, 2010; Lövdén, Bäckman, Lindenberger, Schaefer, & Schmiedek, 2010; Willis & Schaie, 2009). In more detail, cognitive plasticity refers to the general potential within a person to change as a function of experience in the sense of improvements (Baltes, 1987). Empirical evidence suggests that cognitive plasticity is still possible in late adulthood (e.g., Carretti, Borella, Zavagnin, & de Beni, 2013; Karbach & Kray, 2009; Singer, Lindenberger, & Baltes, 2003; Verhaeghen, Marcoen, & Goossens, 1992) and also in very late adulthood in individuals aged over 80 years (e.g., Borella, Carretti, Zanoni, Zavagnin, & De Beni, 2013; Buschkuehl et al., 2008; Fernandez-Ballesteros et al., 2012; Zinke, Zeintl, Eschen, Herzog, & Kliegel, 2012; Zinke et al., 2013). Furthermore, the capability to learn principally remains intact even in patients with mild cognitive impairment and Alzheimer's disease (e.g., Carretti, Borella, Fostinelli, & Zavagnin, 2013; Fernandez-Ballesteros et al., 2012).

Considering the available literature, two main approaches exist in the area of cognitive interventions: *strategy*-oriented training and *process*-based training. Strategy training aims to compensate or circumvent limitations in underlying processes, while process training aims to augment or to restore the underlying processes (Reichman, Fiocco, & Rose, 2010).

Strategy-oriented training interventions typically (but not exclusively) train the use of a mnemonic strategy (e.g., rehearsal, imagery, method of loci) to enhance particular functions as encoding or retrieval from memory in a compensatory way (Morrison & Chein, 2011). Meta-analyses by Verhaeghen et al. (1992) and Gross et al. (2012) show substantial effect size for pre-post change scores, indicating large benefits for the training groups compared to control groups. However, these training gains are mostly limited to the training task itself. Although it remains questionable if transfer of training improvements to other new and untrained tasks is possible (McDaniel & Bugg, 2012; Morrison & Chein, 2011), there is some promising positive evidence (for benefits to working memory see, e.g., Carretti, Borella, & De Beni, 2007; for benefits to everyday activities see, e.g., Cavallini, Pagnin, & Vecchi, 2003). In any case, memory strategies have important practical value. They are comparably easy to teach, train and to use in everyday life. However, the scientific challenge is to find the appropriate strategy targeting the relevant cognitive difficulties in older adults' everyday life. For example, as discussed by McDaniel and Bugg (2012), instructing older adults to use a mnemonic strategy to learn a list of items (e.g., grocery list) is fairly easy to do, but might not be used in everyday life because of other compensational strategies or technical devices (e.g., using mobile phone to record a list). Furthermore, other critical aspects that influence possible transfer need to be taken into account, such as the role of homework, the training material, and the transfer tasks (McDaniel & Bugg, 2012). A possibility to extend the benefits of strategy-oriented training could be to combine strategy use with additional metacognitive interventions. For instance, Cavallini, Dunlosky, Bottiroli, Hertzog, and Vecchi (2010) found greater transfer effects in older adults when teaching them mnemonic strategies combined with an instruction phase on how to use these strategies for other tasks. Participants learned two strategies: imagery and sentence generation to learn paired associates and lists of words. One half of the group received additional instructions on how they could use the strategies for other tasks besides the training including two of the transfer tasks; the other half performed only the training. Transfer was measured for four different tasks, two of them were mentioned as examples on how the trained strategies could be used for them, and the other two transfer tasks were not mentioned. One major result showed transfer effects to a non-mentioned transfer task (text learning), which were greater for the instruction phase group than the training only group (see also Craik & Rose, 2012).

Process-based training regimes (sometimes called restorative training) aim to improve a particular cognitive ability (e.g., working memory) by repetitively exercising the underlying core mechanisms (e.g., updating) in a cognitively intensive way, typically by adaptively increasing the difficulty based on the participant's individual performance level (Morrison & Chein, 2011). The rationale behind process-based training is the assumption that the improvement in central or core neuro-cognitive resources should also stimulate benefits in associated cognitive functions (e.g., planning, intelligence). Therefore, the outcome of process-based training should result in broader effects such as near and far transfer.

Importantly for present purposes, what is often criticized in the training literature is the lack of everyday transfer of such process-based training regimes (Craik & Rose, 2012; McDaniel & Bugg, 2012). There exist a few studies targeting this issue so far; however, some promising results were found in *self-reported,* but not objective measures of everyday functioning (Brehmer, Westerberg, & Bäckman, 2012; Willis et al., 2006) or in reading comprehension (e.g., Chein & Morrison, 2010; Loosli, Buschkuehl, Perrig, & Jaeggi, 2012). For example, Brehmer et al. (2012) investigated the effectiveness of a computerized adaptive working memory training compared to a control training. The control group worked with the same task material but practiced on a low level of difficulty throughout the intervention. The training program was applied to younger and older adults for 5 weeks. Besides near and far cognitive transfer measures, they also included a self-rating scale for subjective cognitive functioning in everyday life. The training led to near and far transfer effects for both age groups. More interestingly, the results showed that both training groups reduced their subjective memory complaints more than the active control groups and that this benefit was even maintained across a follow-up interval of 3 months. A limitation of this study is that this everyday transfer is restricted to only self-report improvements. Thus, the question remains if this subjective impression holds true on an objective performance level.

Trainability of prospective memory

Taken together, to this date, evidence of far transfer effects as well as everyday transfer is limited, for both strategy- and process-based training approaches. In this context, McDaniel and Bugg (2012) suggested that this may partly be due to a lack of theory-driven hypotheses for transfer.

For example, the authors criticized memory training interventions that train older adults to perform a strategy or task in the lab, but fail to generalize the training to everyday memory. In their opinion, training should be training for transfer that rests on clear conceptual predictions on the possible overlap between training and transfer tasks, particularly with respect to transfer to everyday functioning. Specifically, they suggested that training programs should aim for a better fit between the trained strategies or processes in the lab and their application in everyday life. Authors argued that it is important to identify everyday problems and develop and train strategies and processes that are realistically applicable and *useful* for those problems in everyday life. As stated in the beginning of this article, prospective memory can be seen as such a target of cognitive interventions (c.f., Kliegel & Bürki, 2012). Also, from a more fundamental cognitive training perspective, prospective memory may be considered an interesting target, as it is associated to executive functions such as task switching and working memory on the one hand and to episodic memory demands on the other hand. As stated earlier, available evidence shows that these associated processes seem to be trainable. In conclusion, this should also be the case for prospective memory.

To guide such interventions, Kliegel, Altgassen, Hering, and Rose (2011) recently proposed a framework for a theory-driven training approach in the area of prospective memory. Specifically, Kliegel et al. (2011) recommended disentangling the process of prospective remembering by its different phases to identify the critical components of prospective memory in need of training in a given population. Remembering delayed intentions at the appropriate moment in the future is conceptualized as a four-phase process (Ellis, 1996; Kliegel, Martin, McDaniel, & Einstein, 2002; Kliegel, McDaniel, & Einstein, 2000). In the first phase—*intention formation*—the individual has to formulate and plan the intention. This first phase relies mainly on encoding and planning processes (Kliegel et al., 2002; Kliegel et al., 2000). After successfully forming an intention, there is the *intention retention* phase. Typically, the individual performs other "ongoing" tasks during a delay. This temporal delay until the initiation of the intention can vary in its length from a few minutes (e.g., to remember to take the pizza out of the oven) up to several days or months (e.g., to remember to pay a monthly bill). During this phase, the intention is maintained in long-term memory. Important for this phase is a more or less elaborate representation of the intended action (e.g., a strong association between intention and content; Marsh, Hicks, Cook, Hansen, & Pallos, 2003)—to facilitate later memory retrieval; and working memory capacity (Martin & Schumann-Hengsteler, 2001) since the intention may need to be refreshed or updated in memory while being engaged in other activities. The last two phases refer to the *intention initiation* and the *intention execution*. The individual has to detect the appropriate moment indicated by the prospective memory cue (event-based prospective memory) or after an elapsed time (time-based prospective memory) and retrieve the intention from memory to successfully execute it. Although these two phases are sometimes considered together as they occur close in real time, Kliegel et al. (2002) describe fine conceptual differences. The intention initiation phase involves the initiation of the planned intention at the appropriate moment. The involved underlying executive processes include monitoring (to detect the appropriate situation by noticing the cue or monitoring the time), cognitive flexibility (to switch between ongoing and intended activity), and inhibition (to inhibit the ongoing activity). The intention execution phase refers to the completion of intentions and depends also on cognitive flexibility. There are two possible outcomes: the correctly retrieved intention could be executed correctly or an incorrect action could be executed. Performance is influenced by the previously formed plan and situational factors that occur while performing the intended tasks. Besides the relevance of these cognitive functions for each phase of prospective remembering, non-cognitive factors such as metacognitive abilities play a role in prospective memory performance as well (e.g., Kliegel, Altgassen, Hering, & Rose, 2011; Meeks, Hicks, & Marsh, 2007; Schnitzspahn, Zeintl, Jaeger, & Kliegel, 2011). To which extent someone rates his or her ability to remember intentions as high or low might also influence which strategies and how many cognitive resources were allocated to the execution of the intentions. A recent study by Rummel and Meiser (2013) in young adults showed that the allocation of attention and monitoring in a prospective memory task was influenced by the metacognitive beliefs about the task demands.

To conclude, successful prospective memory depends on retrospective (episodic) memory processes (e.g., encoding, retrieval), as well as controlled attention/executive processes associated with planning, working memory, and task switching. Given this theoretical process-based framework, a more tailor-made approach could be applied to the development of training programs where different training aspects fit to the different cognitive requirements that underlie prospective remembering (Kliegel & Bürki, 2012). But what is actually known about the malleability of prospective memory?

So far, there is only a small literature on prospective memory training (Fleming, Shum, Strong, & Lightbody, 2005; Kinsella et al., 2009; Radford, Lah, Thayer, Say, & Miller, 2012; Raskin & Sohlberg, 1996; Shum, Fleming, Gill, Gullo, & Strong, 2011), which focuses on clinical samples only [e.g., traumatic brain injury (TBI), mild cognitive impairment] and implements interventions more in a neuropsychological rehabilitation setting (for a reviews see Fish, Wilson, & Manly, 2010; Piras, Borella, Incoccia, & Carlesimo, 2011). While most of the studies investigate small sample groups or single cases, a study by Shum et al. (2011) used a more systematic approach. The authors compared four different training regimes. TBI patients (aged between 18 and 60 years) participated in each of the four training groups. All training regimes consisted of two parts. The first part of the training comprised either 2 weeks of self-awareness training for prospective memory or 2 weeks of a control condition (for details see below). The second part of the training consisted of either 6 weeks of a so-called *compensatory prospective memory training* or 6 weeks of a so-called *remedial prospective memory training*. Combining the two versions of the first part with the two versions of the second part formed the four training groups (i.e., self-awareness + compensatory training; control + compensatory training; self-awareness + remedial training; control + remedial training). The self-awareness training introduced the concept of prospective memory and exercised self-prediction and monitoring of performance on various prospective memory tasks. The corresponding control training contained the discussion of autobiographical memories and life events as well as education about attention and concentration. The compensatory prospective memory training aimed to train strategies to compensate for prospective memory problems in daily life such as training of note-taking and maximizing the use of diaries and organizational devices. The remedial training aimed to restore lost functions. In the case of prospective memory, training involved increasing the time delay for remembering to perform the prospective memory tasks continuously. First, participants' initial prospective memory capacity (i.e., the longest time period for which they could successfully remember the given intentions) was assessed. During the training, the time delay between instruction of the prospective memory task and the appropriate moment to execute the task was increased always by 1 min for the next task if they performed the task successfully. Outcome measures for all training groups were performance on a standardized prospective memory test, a questionnaire to assess the frequency of prospective memory lapses in everyday life, and a rating of everyday functioning by a relative of the training participant. These measures were assessed before and after the training period. Results showed that only both compensatory training groups profited from the training showing larger change scores for the standardized prospective memory test. In contrast, there were found no training effects for the remedial training. Furthermore, the groups with the self-awareness training did not differ concerning their training gains from those without self-awareness training. There were neither effects on the questionnaire nor the everyday functioning ratings. Taken together, results are promising, as they show that patients can benefit from compensatory prospective memory training. However, the studies reported so far did not include far transfer measures or examine healthy individuals. Further research is clearly needed to examine training effects in healthy older adults using bigger samples and to investigate prospective memory interventions from a more theory-driven perspective. In the following sections, we present some evidence from our own work examining the possibilities for prospective memory training following the distinction of strategy and process-based training outlined above.

Strategy-oriented prospective memory training

In the following section, we will discuss external and internal strategy trainings on prospective memory. *External strategy trainings* comprise the use of *external* memory aids such as clocks and phones. Several studies used technological devices as external reminders to overcome problems with self-initiated retrieval (e.g., setting an alarm for an appointment). As already indicated in the study by Shum et al. (2011) and also investigated in other studies in rehabilitation settings, electronic devices indeed supported successfully remembering delayed intentions (for mobile phones and smartphones e.g., DePompei et al., 2008; Thöne-Otto & Walther, 2003; Wade & Troy, 2001; for pager e.g., Wilson, Emslie, Quirk, & Evans, 2001; Wilson, Evans, Emslie, & Malinek, 1997). For example, Thöne-Otto and Walther (2003) compared the efficacy of two electronic devices, mobile phone and palm organizer in 12 brain injured patients. First, participants received some naturalistic, experimenter-given tasks to perform without an electronic device and they should send back a list with all everyday intentions they forgot to the experimenter. In this first phase, participants learned also, how they could use one of the electronic devices. In the second phase, the experimenter gave some naturalistic prospective memory tasks that were already entered in the device and participants could enter their everyday intentions themselves. Again, they had to send back the list of forgotten intentions. Phase 3 and 4 repeated this procedure but for the second device. Results revealed that participants forgot fewer intentions when using the electronic devices and this was especially pronounced for their self-entered everyday tasks. Although electronic devices do not improve prospective memory capacity per se, they help to keep or regain a sufficient level of prospective memory performance from an outcome perspective.

Considering the process-model of prospective memory, *internal strategies* should play a beneficial role, especially for the first phases (intention formation, intention retention), which rely on planning abilities, encoding and memory storage. There is some empirical evidence from cross-sectional designs comparing the effectiveness of different planning and encoding strategies on later prospective memory performance in young and older adults (Brom et al., 2013; Henry, Rendell, Phillips, Dunlop, & Kliegel, 2012; Kliegel, Martin, McDaniel, Einstein, & Moor, 2007; Liu & Park, 2004; Park, Gutchess, Meade, & Stine-Morrow, 2007).

Kliegel et al. (2007) found that older adults' prospective memory performance benefited from different planning aids (e.g., structuring of plans), which facilitated intention initiation. The authors used the modified six-elements task as a complex prospective memory task. The task is a delayed multi-tasking paradigm where participants have to plan the order how they intend to initiate and execute the six delayed tasks while respecting the time limit and other constraining rules concerning the order of the subtasks (Kliegel et al., 2002; Kliegel et al., 2000). To be successful in the task, it is necessary to plan how to proceed, to initiate the tasks appropriately, and to switch between the tasks according to the rules. First, participants received the instruction and had to plan how to perform the six subtasks, which was followed by a delay period with filler tasks. Finally, participants had to self-initiate the execution of the modified six-elements task. Studies using this paradigm show that older adults tend to make less detailed plans compared to young adults and that a less detailed plan is associated with impairment of later realization of delayed intentions (Kliegel et al., 2002; Kliegel et al., 2000).

To overcome this performance deficit in older adults, Kliegel et al. (2007) provided different planning aids to foster different aspects of the planning process of the task in an attempt to improve later prospective memory performance. The authors investigated young and old adults and compared the effectiveness of planning aids with a no-aid condition in both age groups. The aids helped participants to plan in three ways. First, participants were asked to include information about the appropriate moment to initially start the task (self-initiation of intention). Second, participants were asked to include specific cues in their plans that described when and how they wanted to switch between tasks (task switching). Third, a general planning aid helped participants structure and schedule the tasks appropriately (planning). To do so, participants received a flow chart to help plan the order of the six subtasks in advance. In the first two experiments of the study, participants received either a combination of the first and second planning aid or no planning aid. The results showed that participants' prospective memory performance benefited from planning aids. Both age groups in the planning aid condition were more likely to initiate the six-elements task at the appropriate moment compared to participants in the no-aid condition. Furthermore, older adults also profited from the planning aid that benefited their task switching between the subtasks. In the third experiment, the authors compared the effect of three conditions in young and old adults: no planning aid versus the general planning aid versus a combined version of the general and the switching aid. Results showed no influence on self-initiation of intentions (1) but the combined aid of structuring the plans (3) and encouraging task switching (2) improved realization of delayed intentions with a greater effect for old adults than young adults.

A recent study on the influence of reminders on prospective memory performance also shows the benefits of compensatory approaches for older and younger adults (Henry et al., 2012). Henry et al. (2012) found that prospective memory performance of both age groups could be enhanced using reminders either self-initiated or presented by the experimenter. In sum, the findings show that already simpler internal strategies, such as basic planning strategies or provision of reminders, could be a useful approach to foster prospective memory.

A more complex strategy successfully used in prospective memory research is implementation intentions (e.g., Chasteen, Park, & Schwarz, 2001; Liu & Park, 2004; McFarland & Glisky, 2011; Park et al., 2007; Rummel, Einstein, & Rampey, 2012; Schnitzspahn & Kliegel, 2009; Zimmermann & Meier, 2010). The implementation intentions strategy is a goal-directed verbalization of intentions in a "If x arises, then I will perform y" manner (Gollwitzer, 1993, 1999). It is assumed that formulating implementation intentions creates a strong connection between the situation in the "if"-part and the intended action formulated in the "then"-part. When the specific situation is encountered, the planned action is automatically activated and, therefore, more easily retrievable. When applied to prospective memory, there is promising evidence showing that older adults' prospective memory benefits from formulating implementation intentions (e.g., Chasteen et al., 2001; Schnitzspahn & Kliegel, 2009; Zimmermann & Meier, 2010). Interestingly, Zimmermann and Meier (2010) found the beneficial effect of implementation intentions only for the older adults' group but not in younger adults or adolescents. Thus, implementation intentions seem to be especially useful in older adults but the explaining mechanisms are still under debate. Two hypotheses are currently discussed. One assumption is that implementation intentions should improve the encoding of prospective intentions, thereby reducing the need for strategic monitoring. As a result, more automatic detection of the prospective memory cue as well as a more spontaneous retrieval of the intention should occur (Gollwitzer, 1999; McDaniel & Scullin, 2010; Rummel et al., 2012). Alternatively, it has also been argued that implementation intentions strengthen the perceived importance of the intention and foster more monitoring processes at the costs of the ongoing task (Meeks & Marsh, 2010).

We recently conducted a study investigating the effect of implementation intentions in performing health behaviors in older adults (Brom et al., 2013). The aims of the study were to investigate the effectiveness of implementation intentions in a real-life prospective memory task and to examine possible moderators (e.g., fluid intelligence, conscientiousness) of the effectiveness of the strategy. The study follows up on results by Liu and Park (2004) who also examined the beneficial influence of implementation intentions on prospective memory in health behavior. Liu and Park used implementation intentions to enhance glucose monitoring but in a small sample of older participants ($n = 10$). We decided to use an alternative everyday health task that could be of importance for older adults: remembering to measure one's blood pressure at three times per day for five consecutive days of a week. The treatment consisted of one session where participants were first instructed on how to use a blood pressure monitor and then they were trained to formulate the implementation intention about how they were going to control their blood pressure. Furthermore, standardized tests and questionnaires were used to assess cognitive resources (e.g., fluid intelligence) as well as other possible environmental (e.g., everyday stress) and motivational moderators (e.g., self-efficacy).

In total, 39 healthy older adults with a mean age of 68.8 years ($SD = 4.99$) who had no experience with monitoring blood pressure were included in the study. Participants were randomly assigned to two treatment groups: implementation intention instruction ($n = 19$) and a control instruction ($n = 20$). The groups did not differ in age or intelligence. Participants in the implementation intention condition were asked to think of specific times when they could perform the blood pressure monitoring, where it will take place, and how they will do it. They had to write down all this information on how to perform the blood pressure monitoring during the next 5 days. In a second step, participants transformed this information through the use of the implementation intentions strategy using prepared worksheets (e.g., "If I am in the living room next week from Monday to Friday at 8 a.m., 12 p.m. and 6 p.m., then I will check my blood pressure with the blood pressure monitor"). In a last step, the participants were asked to mentally visualize how they would enact their intentions. Participants in the control group were asked to write down the times when they wanted to check their blood pressure and read an article about blood pressure to ensure equal treatment durations.

The dependent variable was the rate of forgotten blood pressure tests. Comparing the implementation intention group with the control group, a significant main effect of treatment of large effect size emerged. Participants using implementation intentions forgot to check their blood pressure at the intended times considerably less often than participants of the control group. In fact, participants in the implementation intentions training group performed almost perfectly. Furthermore, and extending previous work by Liu and Park (2004), there was a significant interaction between the treatment group and level of fluid intelligence (based on a median split in high and low fluid intelligence). Control participants with a lower level of fluid intelligence forgot more often to check their blood pressure than participants with higher fluid intelligence; however, for the implementation intention group, there was no difference between those with low or high fluid intelligence.

These results provide an example that older adults' prospective memory can benefit from a strategy intervention. More precisely, the moderation effect indicates that implementation intentions benefited prospective remembering by compensating for low fluid intelligence. Furthermore, the study shows the effectiveness of a strategy intervention for an everyday health behavior that is highly relevant for many older adults. However, one limitation of the study is that maintenance effects were not assessed. It would be of interest to know, if participants applied the learned strategy also on other everyday behavior. In terms of future directions, it should be acknowledged that, although the implementation intention effect in the study by Brom et al. (2013) was strong, the strategy was very specific to the task that should benefit from it. It would be of conceptual and applied interest to promote prospective memory also in a more general way and to test transfer to other prospective memory tasks as well as related cognitive abilities. In the next section, we give an example for a process-based approach to train prospective memory that investigated the possibility of transfer from prospective memory training.

Process-based prospective memory training

The training described below (Rose et al., 2012) was based on the Virtual Week paradigm (Rendell & Craik, 2000). Virtual Week is a computerized laboratory prospective memory task in the style of a board game but with everyday life content to increase ecological validity. Participants roll a dice and move a token around a board that symbolizes a virtual day from 7 a.m. to 10 p.m. During this fictitious day, participants pass several event squares that represent different everyday events (e.g., breakfast, shopping, going to the library, dinner). For each of these events, participants have to make choices about how the event would end and what they would do in real life (e.g., deciding what to eat for breakfast or deciding what to buy in the shopping mall). Two clocks are displayed in the middle of the board, one indicating the virtual day time (calibrated to the token position on the board), the other displaying a stop clock that measures the actual play time in minutes and seconds.

The prospective memory tasks are embedded in the story of the game. At the beginning, participants learn different health tasks, which they have to remember to simulate performing over the course of the whole game. For example, participants have to remember to take antibiotics each virtual day at breakfast and dinner events or they have to remember to use an asthma inhaler at 11 a.m. and 9 p.m. These health-related tasks have to be performed regularly—that is, on every virtual day (i.e., one circuit of the board). There are also irregular prospective memory tasks that are instructed for the current virtual day (e.g., pick up dry cleaning at the shopping mall, return book at the library, call the restaurant for a dinner reservation at 5 p.m.). These tasks have to be encoded at the beginning of each new virtual day and during the day. The third type of tasks are stop-clock tasks, in which participants have to perform a certain task after a specific time has elapsed, for example, testing blood sugar when the stop clock reaches 2 and 4 min. Participants are not obliged to perform the regular, irregular and stop-clock prospective memory tasks in real life. They are to simulate performing the task at the appropriate moments, either time-cued or event-cued, by clicking a "perform task" button and selecting the right task from a list. In the original version by Rendell and Craik (2000), participants had to perform 10 tasks per virtual day for 7 virtual days indicating Monday to Sunday.

Previous research has demonstrated that Virtual Week is a useful and reliable tool for prospective memory research with good psychometric properties (Rendell & Henry, 2009). The different task types vary in their demands requiring automatic or strategic processing and working memory abilities (McDaniel & Einstein, 2000; Rose et al., 2010). The distinction between regular and irregular tasks reflects low versus high retrospective memory demands (Foster, Rose, McDaniel, & Rendell, 2013; Mioni, Rendell, Henry, Cantagallo, & Stablum, 2013). Differences based on the cue of the prospective memory task (event-based, time-based and stop clock) result in varying demands on monitoring processes, with time-based and stop-clock tasks being more demanding as they require checking the clocks, whereas event-based tasks require attending to the events which pop up when the participant passes an event-square (Rendell & Henry, 2009; Rose et al., 2010). Furthermore, Rose et al. (2010) showed that individual differences in working memory were predictive of prospective memory performance in the Virtual Week game, especially for high-demanding tasks. Moreover, Virtual Week is an age-sensitive task: Research on aging shows that older adults perform worse compared to young adults for the irregular tasks compared to regular tasks (Aberle, Rendell, Rose, McDaniel, & Kliegel, 2010; Rendell & Craik, 2000; Rose et al., 2010) and also for time-based tasks compared to event-based tasks (e.g., Henry et al., 2012; Rendell et al., 2011).

In the training protocol, we used the original Virtual Week paradigm and extended it to a process-based training version to examine whether older adults' prospective memory could be improved and if training gains could transfer to other cognitive and everyday life tasks (Rose et al., 2012). The study consisted of three experimental groups, one group performed the Virtual Week training; the second group, an active control group, performed a music training; the third group was a waitlist, no-contact control group. In total, 50 older adults between 60 and 80 years participated in the study.

All participants performed a pre- and post-testing session using a battery of established prospective memory measures, neuropsychological tasks and everyday competence tests. We also developed and assessed performance on a novel real-life prospective memory task—the "call-back task" (Rose et al., 2012). While participants were at home engaged in their daily activities, they received a phone call from an experimenter and they were to call the experimenter back in exactly 10, 25, 35 and 40 min. For everyday competence, we administered the timed version of instrumental activities of daily living (Owsley, Sloane, McGwin, & Ball, 2002). In this standard measure of instrumental activities of daily living, participants had to perform short everyday tasks as fast as possible (e.g., counting money, reading out loud ingredients, finding telephone numbers in a phone book). Performance is typically used to assess one's fitness for independent living.

Between the pre- and post-test there was a delay of 4 weeks. Participants in the no-contact control group performed only the pre- and the post-testing. Participants in the active control group received fifteen 1-h music lessons over 4 weeks. Subjects in the Virtual Week training group participated in twelve 1-h training sessions, three times per week for 4 weeks on the prospective memory training. The Virtual Week training consisted of 24 different levels. One level corresponded to one virtual day that was one circuit of the board. To implement a process-based training design, the levels increased in difficulty in an adaptive manner. We varied the number of tasks to train the retrospective component. The prospective component was also trained by changing the cues across the training and displaying visible but also hidden stop clocks for the stop-clock tasks to put increasing demands on cue detection, monitoring, and cognitive flexibility. Participants had to play two virtual days per training session. After each level, they received feedback about their performance. Participants saw whether they performed each task correctly or not. They had to achieve at least 75 % correct to pass the level or else they had to repeat and practice the day with the same events. However, the game routine differed depending on the rolling of the dice. After each week of training participants filled in a questionnaire on how they performed the different types of tasks during the game.

Over the course of the training, participants increased their performance while the numbers of day repetitions decreased. Pre-post comparisons indicated a training benefit for the prospective memory training group in the original Virtual Week task compared to the control groups. Likewise, participants in the Virtual Week training group tended to show greater improvement in the real-life prospective memory task, the call-back task, after the training compared to both control groups, hinting at some near transfer to performing prospective memory tasks in the real world. Furthermore, participants in the Virtual Week training group showed a greater pre- to post-test improvement in the timed instrumental activities of daily living after the training compared to both control groups, indicating far transfer. Qualitative analyses of the post-training questionnaires further indicated that participants used either no or poor strategies (e.g., "concentrate") at the beginning of the training, but some improved to using better strategies (e.g., "visualize") over the course of the training. Taken together, Rose et al. (2012) showed that older adults could improve their prospective memory performance on the Virtual Week paradigm relative to controls. Furthermore, there were some trends for near and far transfer to everyday naturalistic tasks relative to controls.

Prospective memory training among cognitive training interventions

The examples discussed above show that there is evidence that prospective memory is a suitable candidate for both strategy-oriented and process-based training approaches. However, prospective memory is also a construct that breaks ranks among the other target cognitive abilities in previous training research. The focus of process-based training in the literature lays especially on working memory. The typical training of working memory targets basic cognitive processes constituting working memory by very specific tasks. For example, participants have to perform visuospatial span tasks or n-back tasks with increasing difficulty in a repetitive way (e.g., Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; Klingberg, Forssberg, & Westerberg, 2002). Also, verbal working memory trainings showed promising effects (Borella, Carretti, Riboldi, & De Beni, 2010; Borella et al., 2013; Carretti, Borella, Fostinelli, & Zavagnin, 2013). The question resulting from this approach is if it is really possible to bridge the gap between the highly specific tasks used in training interventions to improvements in everyday life for older adults (e.g., making financial decisions, health behavior, housekeeping). If cognitive training is intended to improve older adults' cognition and increase their independence and wellbeing, then this should be the primary aim. In our opinion, training of prospective memory could actually connect the applied perspective of an attempt to improve everyday life functioning in older adults with the basic research on plasticity and its process-based approach. Of course, this is an empirical question and future research will have to systematically test this proposition.

However, so far, only a few studies have examined the trainability of prospective memory. We discussed examples for both training approaches that showed encouraging results for this line of research. Taken together, we demonstrated the effectiveness of a strategy-oriented approach to improve prospective memory in everyday life (Brom et al., 2013). The second example showed the possibility to train prospective memory with a process-based training regime (Rose et al., 2012). This initial evidence leads to further important research questions: how can we maximize benefits of prospective memory training and how can we ensure robust transfer to the daily requirements of older adults? As discussed previously, each of the two training approaches has its strengths and weaknesses. For training prospective memory, one possibility might be to combine both approaches and perhaps profit from the advantages of each approach and to overcome some of their limitations. For example, in future studies both trainings could be combined. The strategy of implementation intentions could be implemented in the Virtual Week training as well. The training of implementation intentions on the realistic content of Virtual Week could stimulate transfer to everyday tasks of the participants. On the other hand, the adaptive training of prospective memory abilities could be boostered by the strategy. Another route for future research may be to consider the benefits of strategies that help "train for transfer". For example, if we aim to improve older adults' everyday functioning and wellbeing (Craik & Rose, 2012), training the use of strategies for varying stimuli and situations over the course of the intervention could help achieve transfer effects of the training regimes applied. Another crucial point within this discussion is the aim for long-term effects. When improving cognitive functioning by training interventions, the second aim, besides reliable transfer, should be the maintenance of these effects (e.g., Borella et al., 2013; Brehmer et al., 2012; Li et al., 2008; Zinke et al., 2013). For instance, Zinke et al. (2013) found that their working memory training for older adults produced stable training effects as well as near transfer effects at a 9-month follow-up assessment. However, the results of Melby-Lervag and Hulme (2013) were more sobering. In their meta-analysis, they found long-term effects for working memory training on visual working memory tasks, but not on verbal tasks or far transfer measures (e.g., word reading, attention, reasoning). One main problem of evaluating long-term effects rests on the fact that the majority of training studies did not include follow-up assessments. Further training research is clearly needed to determine factors responsible for maintenance effects. Moreover, a limitation of the meta-analysis for the present purpose is, that only a few training studies on older adults were included.

The characterization of prospective memory as a multi-phase process (Kliegel et al., 2002; Kliegel et al., 2000) provides several different targets for combined cognitive interventions. Compensational strategies like implementation intentions are especially helpful for encoding intentions and should, therefore, be especially helpful when deficits are likely to be due to the intention formation phase (e.g., such as in Parkinson patients, see Kliegel et al., 2011). In terms of transfer, implementation intentions seem to be fruitful as they are a rather general strategy with a broad range of possible applications compared to the typical mnemonic strategies that tend to be more specific to retrieval processes (e.g., method of loci). Complementary, traditional process-based training regimes may be especially indicated when the improvement of cognitive components underlying prospective memory is the key target of the intervention. For example, training of working memory or inhibition should reduce deficit levels in these resources (training improvement) and subsequently drive improvements in those prospective memory phases where they are most involved (i.e., intention initiation and execution; far transfer). Finally, training all phases of the prospective memory process at once with a tool such as the Virtual Week game actually provides a learning environment to apply the principles of training, stabilize training gains, and possibly stimulate transfer to other cognitive and everyday life functions. In addition, prospective memory could also be a suitable candidate for a multi-domain training approach. Multi-domain training targets several cognitive domains as an ensemble, for example, simultaneously training memory, reasoning, and attention in one training regime (e.g., Cheng et al., 2012; Oswald, Gunzelmann, Rupprecht, & Hagen, 2006). Whereas single-domain training targets one cognitive function, such as working memory or set shifting. In fact, prospective memory is itself a multi-phase, multi-domain process that is closely related to executive functions and memory. For instance, prospective memory tasks by definition target a full set of functions, such as retrospective memory (for the intention content), monitoring (for the cues) or inhibition (of the ongoing task before initiating the prospective memory task). For example, in a possible training, the episodic memory component could be adaptively increased in difficulty by systemically increasing number, length and/or complexity of the to-be-executed intention and at the same time the difficulty to find the cue and the inhibitory demands of interrupting the ongoing task may be adapted by more and more hiding the cue in the ongoing task and increasing its task demands, respectively. Therefore, using prospective memory tasks as training targets could prove to be a fruitful variant of recent suggestions to use multi-domain training interventions in contrast to single-domain regimes (see also Insel, Einstein, Morrow, & Hepworth, 2013, for a similar proposal; for related conceptualizations in skill acquisition see the review by Schmidt & Bjork, 1992). Cheng et al. (2012) found that both training approaches, single- and multi-domain training, showed immediate training gains. Furthermore, they demonstrated that multi-domain training especially has advantages for maintenance effects of training. Although they included booster sessions after 6 months for both trainings, Cheng et al. showed better long-term effects up to 12 months for multi-domain training in healthy older adults.

To conclude on the presented literature, a tailor-made approach of a holistic prospective memory training combining specific strategy- and process-based components could be of interest for further research. The combination of these two general training traditions in prospective memory training could provide the possibility to not only target one but most of the corresponding processes of prospective memory as an ensemble. Therefore, future studies running this combined approach could be promising attempts to ensure improvements of functioning and well-being in older adults' everyday life through prospective memory training.

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References

Aberle, I., Rendell, P. G., Rose, N. S., McDaniel, M. A., & Kliegel, M. (2010). The age prospective memory paradox: young adults may not give their best outside of the lab. *Developmental Psychology, 46*(6), 1444–1453. doi:10.1037/A0020718.

Altgassen, M., Kliegel, M., Brandimonte, M., & Filippello, P. (2010). Are older adults more social than younger adults? social importance increases older adults' prospective memory performance. *Aging Neuropsychology and Cognition, 17*(3), 312–328. doi:10.1080/13825580903281308.

Baltes, P. B. (1987). Theoretical propositions of life-span developmental-psychology—on the dynamics between growth and decline. *Developmental Psychology, 23*(5), 611–626. doi:10.1037/0012-1649.23.5.611.

Bisiacchi, P. S., Tarantino, V., & Ciccola, A. (2008). Aging and prospective memory: the role of working memory and monitoring processes. *Aging Clinical and Experimental Research, 20*(6), 569–577.

Borella, E., Carretti, B., Riboldi, F., & De Beni, R. (2010). Working memory training in older adults evidence of transfer and maintenance effects. *Psychology and Aging, 25*(4), 767–778. doi:10.1037/A0020683.

Borella, E., Carretti, B., Zanoni, G., Zavagnin, M., & De Beni, R. (2013). Working memory training in old age: an examination of transfer and maintenance effects. *Archives of Clinical Neuropsychology, 28*(4), 331–347. doi:10.1093/Arclin/Act020.

Brehmer, Y., Westerberg, H., & Bäckman, L. (2012). Working-memory training in younger and older adults: training gains, transfer, and maintenance. *Frontiers in Human Neuroscience, 6*:63. doi:10.3389/Fnhum.2012.00063.

Brom, S. S., Schnitzspahn, K. M., Melzer, M., Hagner, F., Bernhard, A., & Kliegel, M. (2013). Fluid mechanics moderate the effect of implementation intentions on a health prospective memory task in older adults. *European Journal of Ageing, 19*, 1–10. doi:10.1007/s10433-013-0288-2.

Buschkuehl, M., Jaeggi, S. M., Hutchison, S., Perrig-Chiello, P., Däpp, C., Müller, M., et al. (2008). Impact of working memory training on memory performance in old–old adults. *Psychology and Aging, 23*(4), 743–753. doi:10.1037/A0014342.

Carretti, B., Borella, E., & De Beni, R. (2007). Does strategic memory training improve the working memory performance of younger and older adults? *Experimental Psychology, 54*(4), 311–320. doi:10.1027/1618-3169.54.4.311.

Carretti, B., Borella, E., Fostinelli, S., & Zavagnin, M. (2013a). Benefits of training working memory in amnestic mild cognitive impairment: specific and transfer effects. *International Psychogeriatrics, 25*(4), 617–626. doi:10.1017/S1041610212002177.

Carretti, B., Borella, E., Zavagnin, M., & de Beni, R. (2013b). Gains in language comprehension relating to working memory training in healthy older adults. *International Journal of Geriatric Psychiatry, 28*(5), 539–546. doi:10.1002/gps.3859.

Cavallini, E., Dunlosky, J., Bottiroli, S., Hertzog, C., & Vecchi, T. (2010). Promoting transfer in memory training for older adults. *Aging Clinical and Experimental Research, 22*(4), 314–323. doi:10.3275/6704.

Cavallini, E., Pagnin, A., & Vecchi, T. (2003). Aging and everyday memory: the beneficial effect of memory training. *Archives of Gerontology and Geriatrics, 37*(3), 241–257. doi:10.1016/S0167-4943(03)00063-3.

Chasteen, A. L., Park, D. C., & Schwarz, N. (2001). Implementation intentions and facilitation of prospective memory. *Psychological Science, 12*(6), 457–461. doi:10.1111/1467-9280.00385.

Chein, J. M., & Morrison, A. B. (2010). Expanding the mind's workspace: training and transfer effects with a complex working memory span task. *Psychonomic Bulletin & Review, 17*(2), 193–199. doi:10.3758/Pbr.17.2.193.

Cheng, Y., Wu, W. Y., Feng, W., Wang, J. Q., Chen, Y., Shen, Y., et al. (2012). The effects of multi-domain versus single-domain cognitive training in non-demented older people: a randomized controlled trial. *BMC Medicine, 10*:30. doi:10.1186/1741-7015-10-30.

Craik, F. I. M., & Byrd, M. (1982). Aging and cognitive deficits: the role of attentional resources. In F. I. M. Craik & S. E. Trehub (Eds.), *Aging and cognitive processes* (pp. 191–211). New York: Plenum.

Craik, F. I. M., & Rose, N. S. (2012). Training cognition: parallels with physical fitness? *Journal of Applied Research in Memory and Cognition, 1*(1), 51–52. doi:10.1016/j.jarmac.2011.12.001.

Crovitz, H. F., & Daniel, W. F. (1984). Measurements of everyday memory—toward the prevention of forgetting. *Bulletin of the Psychonomic Society, 22*(5), 413–414.

DePompei, R., Gillette, Y., Goetz, E., Xenopoulos-Oddsson, A., Bryen, D., & Dowds, M. (2008). Practical applications for use of PDAs and smartphones with children and adolescents who have traumatic brain injury. *Neurorehabilitation, 23*(6), 487–499.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology-Learning Memory and Cognition, 16*(4), 717–726. doi:10.1037/0278-7393.16.4.717.

Einstein, G. O., McDaniel, M. A., Manzi, M., Cochran, B., & Baker, M. (2000). Prospective memory and aging: forgetting intentions over short delays. *Psychology and Aging, 15*(4), 671–683. doi:10.1037//0882-7974.15.4.671.

Ellis, J. (1996). Prospective memory or the realization of delayed intentions: A conceptual framework for research. In M. A. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: theory and applications* (pp. 1–22). Mahwah: Lawrence Erlbaum.

Fernandez-Ballesteros, R., Botella, J., Zamarron, M. D., Molina, M. A., Cabras, E., Schettini, R., et al. (2012). Cognitive plasticity in normal and pathological aging. *Clinical Interventions in Aging, 7*, 15–25. doi:10.2147/Cia.S27008.

Fish, J., Wilson, B. A., & Manly, T. (2010). The assessment and rehabilitation of prospective memory problems in people with neurological disorders: a review. *Neuropsychological Rehabilitation, 20*(2), 161–179. doi:10.1080/09602010903126029.

Fleming, J. M., Shum, D., Strong, J., & Lightbody, S. (2005). Prospective memory rehabilitation for adults with traumatic brain injury: a compensatory training programme. *Brain Injury, 19*(1), 1–10. doi:10.1080/02699050410001720059.

Foster, E. R., Rose, N. S., McDaniel, M. A., & Rendell, P. G. (2013). Prospective memory in Parkinson disease during a virtual week: effects of both prospective and retrospective demands. *Neuropsychology, 27*(2), 170–181. doi:10.1037/A0031946.

Gollwitzer, P. M. (1993). Goal achievement: the role of intentions. *European Review of Social Psychology, 4*(1), 141–185. doi:10.1080/14792779343000059.

Gollwitzer, P. M. (1999). Implementation intentions—strong effects of simple plans. *American Psychologist, 54*(7), 493–503. doi:10.1037//0003-066x.54.7.493.

Gonneaud, J., Kalpouzos, G., Bon, L., Viader, F., Eustache, F., & Desgranges, B. (2011). Distinct and shared cognitive functions mediate event- and time-based prospective memory impairment in normal ageing. *Memory, 19*(4), 360–377. doi:10.1080/09658211.2011.570765.

Greenwood, P. M., & Parasuraman, R. (2010). Neuronal and cognitive plasticity: a neurocognitive framework for ameliorating cognitive aging. *Frontiers in Aging Neuroscience, 2*:150. doi:10.3389/fnagi.2010.00150.

Gross, A. L., Parisi, J. M., Spira, A. P., Kueider, A. M., Ko, J. Y., Saczynski, J. S., et al. (2012). Memory training interventions for older adults: a meta-analysis. *Aging & Mental Health, 16*(6), 722–734. doi:10.1080/13607863.2012.667783.

Henry, J. D., MacLeod, M. S., Phillips, L. H., & Crawford, J. R. (2004). A meta-analytic review of prospective memory and aging. *Psychology and Aging, 19*(1), 27–39. doi:10.1037/0882-7974.19.1.27.

Henry, J. D., Rendell, P. G., Phillips, L. H., Dunlop, L., & Kliegel, M. (2012). Prospective memory reminders: a laboratory investigation of initiation source and age effects. *Quarterly Journal of Experimental Psychology, 65*(7), 1274–1287. doi:10.1080/17470218.2011.651091.

Ihle, A., Hering, A., Mahy, C. E. V., Bisiacchi, P. S., & Kliegel, M. (2013). Adult age differences, response management, and cue focality in event-based prospective memory: a meta-analysis on the role of task order specificity. *Psychology and Aging, 28*(3), 714–720. doi:10.1037/A0033653.

Insel, K. C., Einstein, G. O., Morrow, D. G., & Hepworth, J. T. (2013). A multifaceted prospective memory intervention to improve medication adherence: Design of a randomized control trial. *Contemporary Clinical Trials, 34*(1), 45–52. doi:10.1016/j.cct.2012.09.005.

Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Perrig, W. J. (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences of the United States of America, 105*(19), 6829–6833. doi:10.1073/Pnas.0801268105.

Karbach, J., & Kray, J. (2009). How useful is executive control training? Age differences in near and far transfer of task-switching training. *Developmental Science, 12*(6), 978–990. doi:10.1111/J1467-7687.2009.00846.X.

Kinsella, G. J., Mullaly, E., Rand, E., Ong, B., Burton, C., Price, S., et al. (2009). Early intervention for mild cognitive impairment: a randomised controlled trial. *Journal of Neurology, Neurosurgery and Psychiatry, 80*(7), 730–736. doi:10.1136/Jnnp.2008.148346.

Kliegel, M., Altgassen, M., Hering, A., & Rose, N. S. (2011). A process-model based approach to prospective memory impairment in Parkinson's disease. *Neuropsychologia, 49*(8), 2166–2177. doi:10.1016/J.Neuropsychologia.2011.01.024.

Kliegel, M., & Bürki, C. (2012). Memory training interventions require a tailor-made approach: commentary on McDaniel and Bugg. *Journal of Applied Research in Memory and Cognition, 1*, 58–60. doi:10.1016/j.jarmac.2012.01.002.

Kliegel, M., & Martin, M. (2003). Prospective memory research: why is it relevant? *International Journal of Psychology, 38*(4), 193–194. doi:10.1080/00207590244000205.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G. O. (2002). Complex prospective memory and executive control of working memory: a process model. *Psychologische Beiträge, 22*, 303–318.

Kliegel, M., Martin, M., McDaniel, M. A., Einstein, G. O., & Moor, C. (2007). Realizing complex delayed intentions in young and old adults: the role of planning aids. *Memory & Cognition, 35*(7), 1735–1746. doi:10.3758/Bf03193506.

Kliegel, M., McDaniel, M. A., & Einstein, G. O. (2000). Plan formation, retention, and execution in prospective memory: a new approach and age-related effects. *Memory & Cognition, 28*(6), 1041–1049. doi:10.3758/Bf03209352.

Kliegel, M., McDaniel, M. A., & Einstein, G. O. (Eds.). (2008). *Prospective memory: cognitive, neuroscience, developmental, and applied perspectives*. Mahweh: Lawrence Erlbaum Associates.

Kliegel, M., Phillips, L. H., & Jäger, T. (2008). Adult age differences in event-based prospective memory: a meta-analysis on the role of focal versus nonfocal cues. *Psychology and Aging, 23*(1), 203–208. doi:10.1037/0882-7974.23.1.203.

Kliegel, M., Ramuschkat, G., & Martin, M. (2003). Executive functions and prospective memory performance in old age: an analysis of event-based and time-based prospective memory. *Zeitschrift fur Gerontologie und Geriatrie, 36*(1), 35–41. doi:10.1007/S00391-003-0081-5.

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology, 24*(6), 781–791. doi:10.1076/Jcen.24.6.781.8395.

Lawton, M. P., Moss, M., Hoffman, C., Grant, R., Ten Have, T., & Kleban, M. H. (1999). Health, valuation of life, and the wish to live. *Gerontologist, 39*(4), 406–416.

Li, S. C., Schmiedek, F., Huxhold, O., Rocke, C., Smith, J., & Lindenberger, U. (2008). Working memory plasticity in old age: practice gain, transfer, and maintenance. *Psychology and Aging, 23*(4), 731–742. doi:10.1037/A0014343.

Liu, L. L., & Park, D. C. (2004). Aging and medical adherence: the use of automatic processes to achieve effortful things. *Psychology and Aging, 19*(2), 318–325. doi:10.1037/0882-7974.19.2.318.

Loosli, S. V., Buschkuehl, M., Perrig, W. J., & Jaeggi, S. M. (2012). Working memory training improves reading processes in typically developing children. *Child Neuropsychology, 18*(1), 62–78. doi:10.1080/09297049.2011.575772.

Lövdén, M., Bäckman, L., Lindenberger, U., Schaefer, S., & Schmiedek, F. (2010). A theoretical framework for the study of adult cognitive plasticity. *Psychological Bulletin, 136*(4), 659–676. doi:10.1037/A0020080.

Marsh, R. L., Hicks, J. L., Cook, G. I., Hansen, J. S., & Pallos, A. L. (2003). Interference to ongoing activities covaries with the characteristics of an event-based intention. *Journal of Experimental Psychology-Learning Memory and Cognition, 29*(5), 861–870. doi:10.1037/0278-7393.29.5.861.

Martin, M., Kliegel, M., & McDaniel, M. A. (2003). The involvement of executive functions in prospective memory performance of adults. *International Journal of Psychology, 38*(4), 195–206. doi:10.1080/00207590244000205.

Martin, M., & Schumann-Hengsteler, R. (2001). How task demands influence time-based prospective memory performance in young and older adults. *International Journal of Behavioral Development, 25*(4), 386–391.

Maylor, E. A., Smith, G., Della Sala, S., & Logie, R. H. (2002). Prospective and retrospective memory in normal aging and dementia: an experimental study. *Memory & Cognition, 30*(6), 871–884. doi:10.3758/Bf03195773.

McDaniel, M. A., & Bugg, J. M. (2012). Memory training interventions: what has been forgotten? *Journal of Applied Research in Memory and Cognition, 1*(1), 45–50.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: a multiprocess framework. *Applied Cognitive Psychology, 14*, S127–S144. doi:10.1002/Acp.775.

McDaniel, M. A., & Scullin, M. K. (2010). Implementation intention encoding does not automatize prospective memory responding. *Memory & Cognition, 38*(2), 221–232. doi:10.3758/Mc.38.2.221.

McFarland, C. P., & Glisky, E. L. (2011). Implementation intentions and prospective memory among older adults: an investigation of the role of frontal lobe function. *Aging Neuropsychology and Cognition, 18*(6), 633–652. doi:10.1080/13825585.2011.613449.

Meeks, J. T., Hicks, J. L., & Marsh, R. L. (2007). Metacognitive awareness of event-based prospective memory. *Consciousness and Cognition, 16*(4), 997–1004. doi:10.1016/j.concog.2006.09.005.

Meeks, J. T., & Marsh, R. L. (2010). Implementation intentions about nonfocal event-based prospective memory tasks. *Psychological Research-Psychologische Forschung, 74*(1), 82–89. doi:10.1007/S00426-008-0223-X.

Melby-Lervag, M., & Hulme, C. (2013). Is working memory training effective? a meta-analytic review. *Developmental Psychology, 49*(2), 270–291. doi:10.1037/A0028228.

Mioni, G., Rendell, P. G., Henry, J. D., Cantagallo, A., & Stablum, F. (2013). An investigation of propsective memory functions in people with traumatic brain injury using Virtual Week. *Journal of Clinical and Experimental Neuropsychology, 35*(6), 617–630. doi:10.1080/13803395.2013.804036

Morrison, A. B., & Chein, J. M. (2011). Does working memory training work? the promise and challenges of enhancing cognition by training working memory. *Psychonomic Bulletin & Review, 18*(1), 46–60. doi:10.3758/S13423-010-0034-0.

Oswald, W. D., Gunzelmann, T., Rupprecht, R., & Hagen, B. (2006). Differential effects of single versus combined cognitive and physical training with older adults: the SimA study in a 5-year perspective. *European Journal of Ageing, 3*(4), 179–192. doi:10.1007/s10433-006-0035-z.

Owsley, C., Sloane, M., McGwin, G., & Ball, K. (2002). Timed instrumental activities of daily living tasks: relationship to cognitive function and everyday performance assessments in older adults. *Gerontology, 48*(4), 254–265. doi:10.1159/000058360.

Park, D. C., Gutchess, A. H., Meade, M. L., & Stine-Morrow, E. A. L. (2007). Improving cognitive function in older adults: nontraditional approaches. *Journals of Gerontology Series B-Psychological Sciences and Social Sciences, 62*, 45–52.

Park, D. C., Hertzog, C., Kidder, D. P., Morrell, R. W., & Mayhorn, C. B. (1997). Effect of age on event-based and time-based prospective memory. *Psychology and Aging, 12*(2), 314–327. doi:10.1037//0882-7974.12.2.314.

Piras, F., Borella, E., Incoccia, C., & Carlesimo, G. A. (2011). Evidence-based practice recommendations for memory rehabilitation. *European Journal of Physical and Rehabilitation Medicine, 47*(1), 149–175.

Radford, K., Lah, S., Thayer, Z., Say, M. J., & Miller, L. A. (2012). Improving memory in outpatients with neurological disorders using a group-based training program. *Journal of the International Neuropsychological Society, 18*(4), 738–748. doi:10.1017/S1355617712000379.

Raskin, S. A., & Sohlberg, M. M. (1996). The efficacy of prospective memory training in two adults with brain injury. *Journal of Head Trauma Rehabilitation, 11*(3), 32–51.

Reichman, W. E., Fiocco, A. J., & Rose, N. S. (2010). Exercising the brain to avoid cognitive decline: examining the evidence. *Aging Health, 6*(5), 565–584.

Rendell, P. G., & Craik, F. I. M. (2000). Virtual week and actual week: age-related differences in prospective memory. *Applied Cognitive Psychology, 14*, S43–S62. doi:10.1002/Acp.770.

Rendell, P. G., & Henry, J. D. (2009). A review of virtual week for prospective memory assessment: clinical implications. *Brain Impairment, 10*(1), 14–22.

Rendell, P. G., Phillips, L. H., Henry, J. D., Brumby-Rendell, T., Garcia, X. D., Altgassen, M., et al. (2011). Prospective memory, emotional valence and ageing. *Cognition and Emotion, 25*(5), 916–925. doi:10.1080/02699931.2010.508610.

Rose, N. S., Craik, F. I. M., Hering, A., Rendell, P., Moreno, S., Bidelman, G., & Kliegel, M. (2012). *Training older adults' prospective memory with the Virtual Week video game.* Poster presented at the Cognitive Aging Conference, Atlanta, GA.

Rose, N. S., Rendell, P. G., McDaniel, M. A., Aberle, I., & Kliegel, M. (2010). Age and individual differences in prospective memory during a "Virtual Week": the roles of working memory, vigilance, task regularity, and cue focality. *Psychology and Aging, 25*(3), 595–605. doi:10.1037/A0019771.

Rummel, J., Einstein, G. O., & Rampey, H. (2012). Implementation-intention encoding in a prospective memory task enhances spontaneous retrieval of intentions. *Memory, 20*(8), 803–817. doi:10.1080/09658211.2012.707214.

Rummel, J., & Meiser, T. (2013). The role of metacognition in prospective memory: anticipated task demands influence attention allocation strategies. *Consciousness and Cognition, 22*(3), 931–943. doi:10.1016/j.concog.2013.06.006.

Schmidt, R. A., & Bjork, R. A. (1992). New conceptualizations of practice–common principles in 3 paradigms suggest new concepts for training. *Psychological Science, 3*(4), 207–217. doi:10.1111/J.1467-9280.1992.Tb00029.X.

Schnitzspahn, K. M., & Kliegel, M. (2009). Age effects in prospective memory performance within older adults: the paradoxical impact of implementation intentions. *European Journal of Ageing, 6*(2), 147–155. doi:10.1007/S10433-009-0116-X.

Schnitzspahn, K. M., Stahl, C., Zeintl, M., Kaller, C. P., & Kliegel, M. (2013). The role of shifting, updating, and inhibition in prospective memory performance in young and older adults. *Developmental Psychology, 49*(8), 1544–1553. doi:10.1037/a0030579.

Schnitzspahn, K. M., Zeintl, M., Jaeger, T., & Kliegel, M. (2011). Metacognition in prospective memory: are performance predictions accurate? *Canadian Journal of Experimental Psychology-Revue Canadienne De Psychologie Experimentale, 65*(1), 19–26. doi:10.1037/A0022842.

Shum, D., Fleming, J., Gill, H., Gullo, M. J., & Strong, J. (2011). A randomized controlled trial of prospective memory rehabilitation in adults with traumatic brain injury. *Journal of Rehabilitation Medicine, 43*(3), 216–223. doi:10.2340/16501977-0647.

Singer, T., Lindenberger, U., & Baltes, P. B. (2003). Plasticity of memory for new learning in very old age: a story of major loss? *Psychology and Aging, 18*(2), 306–317. doi:10.1037/0882-7974.18.2.306.

Thöne-Otto, A. I. T., & Walther, K. (2003). How to design an electronic memory aid for brain-injured patients: considerations on the basis of a model of prospective memory. *International Journal of Psychology, 38*(4), 236–244. doi:10.1080/00207590244000205.

Verhaeghen, P., Marcoen, A., & Goossens, L. (1992). Improving memory performance in the aged through mnemonic training—a meta-analytic study. *Psychology and Aging, 7*(2), 242–251. doi:10.1037//0882-7974.7.2.242.

Wade, T. K., & Troy, J. C. (2001). Mobile phones as a new memory aid: a preliminary investigation using case studies. *Brain Injury, 15*(4), 305–320. doi:10.1080/026990501750111256.

Willis, S. L., & Schaie, K. W. (2009). Cognitive training and plasticity: theoretical perspective and methodological consequences. *Restorative Neurology and Neuroscience, 27*(5), 375–389. doi:10.3233/Rnn-2009-0527.

Willis, S. L., Tennstedt, S. L., Marsiske, M., & et al. (2006). Long-term effects of cognitive training on everyday functional outcomes in older adults. *Journal of the American Medical Association, 296*(23), 2805–2814. doi:10.1001/jama.296.23.2805.

Wilson, B. A., Emslie, H. C., Quirk, K., & Evans, J. J. (2001). Reducing everyday memory and planning problems by means of a paging system: a randomised control crossover study. *Journal of Neurology, Neurosurgery and Psychiatry, 70*(4), 477–482. doi:10.1136/Jnnp.70.4.477.

Wilson, B. A., Evans, J. J., Emslie, H., & Malinek, V. (1997). Evaluation of NEUROPAGE: a new memory aid. *Journal of Neurology, Neurosurgery and Psychiatry, 63*(1), 113–115. doi:10.1136/Jnnp.63.1.113.

Woods, S. P., Weinborn, M., Velnoweth, A., Rooney, A., & Bucks, R. S. (2012). Memory for intentions is uniquely associated with instrumental activities of daily living in healthy older adults. *Journal of the International Neuropsychological Society, 18*(1), 134–138. doi:10.1017/S1355617711001263.

Zimmermann, T. D., & Meier, B. (2010). The effect of implementation intentions on prospective memory performance across the lifespan. *Applied Cognitive Psychology, 24*(5), 645–658. doi:10.1002/Acp.1576.

Zinke, K., Zeintl, M., Eschen, A., Herzog, C., & Kliegel, M. (2012). Potentials and limits of plasticity induced by working memory training in old–old age. *Gerontology, 58*(1), 79–87. doi:10.1159/000324240.

Zinke, K., Zeintl, M., Rose, N. S., Putzmann, J., Pydde, A., & Kliegel, M. (2013). Working memory training and transfer in older adults: effects of age, baseline performance, and training gains. *Developmental Psychology., 50*(1), 304–315. doi:10.1037/a0032982.