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Prospective Memory Training: Outlining a New Approach

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Abstract

Prospective memory (PM) tasks are those that must be performed in the future (e.g., attend an appointment). While these everyday tasks can be especially relevant for older adults (i.e., medication adherence), and have been associated with age-related decline, PM has been virtually overlooked in the cognitive training domain. This article describes the first comprehensive PM training intervention. Older adults (age 55 to 75) who received training completed 8 weekly PM training sessions that consisted of variable PM training tasks, strategy-focused discussion, and homework assignments. Those assigned to a control group completed only the first and last training task. On both a real-world proxy PM transfer task and the training tasks detailed here, there was a positive impact of PM training, suggesting practical benefits of the current training package for older adults. Benefits may also extend to other special populations who experience PM impairments (e.g., traumatic brain injury [TBI], Parkinson's).

Keywords

aging; event-based; time-based; intervention; prospective memory

A variety of cognitive training interventions have been created in recent years in attempts to forestall the aging declines associated with numerous cognitive domains (see Craik & Salthouse, 2000, 2008 for reviews). While effective training procedures have been identified for retrospective memory (for a meta-analysis, see Verhaeghen, Marcoen, & Goosens, 1992), another type of memory that is just as important in daily life, prospective memory, has surprisingly been almost entirely overlooked in the memory-training domain.

Prospective memory (PM) refers to the ability to remember to perform an action at a specific future point. PM tasks occur frequently in everyday life, and PM failure can result in consequences that range from the slight annoyance of making an extra trip to the store for a forgotten item, to potential health consequences for failing to take a medication on time. Previous studies have indicated not only that PM ability declines with age (for a review, see Henry, MacLeod, Phillips, & Crawford, 2004) but also that older adults tend to report PM failures as some of the most frequent and worrisome of the memory failures they experience

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(McDaniel & Einstein, 2007). Given the ubiquity of PM tasks in daily life, the age-related decline in PM, and the subjective feelings of frustration and anxiety older adults experience concerning PM memory failures, it is quite surprising that PM training has been excluded from every large-scale memory-training intervention (see, e.g., Senior Odyssey Project, Stine-Morrow, Parisi, Morrow, Greene, & Park, 2007; Everyday Memory Clinic Project, Bagwell & West, 2008; IMPACT study, Smith et al., 2009). In this article, we identify components that we assume will be important for a successful PM training intervention, we describe a novel 8-session PM training protocol that incorporates these components, and we demonstrate the tractability and efficacy of this protocol for older adults.

While PM training has been overlooked in all of the extensive memory-training studies, two small-scale studies have investigated PM training techniques with older adults. In an unpublished study, Rose, Craik, Kliegel, Hering, and Rendell (2012) had older adults practice performing the Virtual Week (VW) game (see Rendell & Craik, 2000) during multiple sessions. VW is widely used to study PM, and is often touted as a realistic PM proxy task because it simulates activities and PM demands normally encountered in daily life. Rose et al. found that repeated practice of the VW game improved participants' performance on PM tasks embedded within the game, but practice on this task was not associated with significant transfer to other laboratory PM tasks.

Rose et al. (2012) approached PM training by providing task practice without strategy instruction. By contrast, Schmidt, Berg, and Deelman (2001) trained participants both on the use of external strategies (e.g., using an agenda) and on an internal repetition-visualization strategy. Importantly, Schmidt et al. did not have participants practice these strategies on laboratory based tasks, but instead assigned homework following each session and asked participants to practice the trained strategies in their daily lives. Schmidt et al.'s intervention focused primarily on use of the visualization strategy, which consisted of asking participants to repeatedly visualize the scenario during which they would need to perform a future PM task. The trained group did not show significant increases, relative to a control group, in their ability to make a phone call at a prespecified time, or to respond to words from a particular category (e.g., animals) during a word classification task.

The wide variety of challenges in creating a PM training package may help explain why the two previous PM training studies have reported minimal training effects. Below, we detail each of these challenges in turn, and address how the PM training package we develop here was designed to accommodate each of these challenges.

What Strategies to Train?

Perhaps the primary challenge in creating an effective PM training package is that the literature on PM strategies is much less extensive than that available for retrospective-memory strategies. As a result, it is somewhat unclear what approach to training PM strategies may be the most effective. Given this, it is understandable why Rose et al. (2012) may have chosen to focus their PM training on task practice alone. However, given Rose et al.'s limited training success using the practice-only approach, it appears that as in

retrospective-memory training (e.g., Verhaeghen et al., 1992), the provision of strategy instruction may be vital for substantial PM training gains.

Although research on PM strategy training is somewhat limited, the available literature suggests a number of PM strategies that may be effective. The main complexity is that the research also suggests that different types of PM tasks are associated with different processes (McDaniel & Einstein, 2007), and, thus, likely will require different strategies. *Focal* PM tasks are those in which the cue to perform the PM task can be processed as a focal part of the ongoing task (e.g., respond to the word “banana” during a word classification task). Focal PM task performance can be enhanced with the use of an implementation intention strategy (e.g., McDaniel & Scullin, 2010), an encoding strategy that increases the association between the anticipated PM cues (e.g., a colleague) and the PM intention (a message for the colleague). However, implementation intention strategies have been shown to be relatively less useful for two other types of PM tasks that require active monitoring processes (*nonfocal* PM tasks, Breneiser, 2007, and *time-based* PM tasks, Schnitzspahn & Kliegel, 2009). Unlike focal PM tasks, in nonfocal PM tasks, the cues are not automatically processed as part of the ongoing task (e.g., respond whenever you see the syllable “TOR” presented during a word classification task), but rather require active monitoring for detection of the PM cue (Einstein et al., 2005). Given that implementation intention strategies are thought to enhance intention retrieval (the strong associative encoding between cue and intention supports spontaneous retrieval of the intention; Liu & Park, 2004; McDaniel, Howard, & Butler, 2008), but *not* necessarily cue detection, good performance on nonfocal PM tasks may require the use of an active monitoring strategy.

Another type of PM that has shown limited benefit of the implementation intention strategy is *time-based* PM (e.g., Schnitzspahn & Kliegel, 2009). Time-based PM tasks require participants to make a target response at pre-specified times throughout the task (e.g., respond every 3 min during the task), and participants are allowed to check a clock to make these responses accurately. Previous research suggests that efficient clock-monitoring may be the most beneficial strategy to train for these types of tasks. Specifically, a number of studies have reported that participants who monitor the clock more often as the target time approaches produce their time-based responses more accurately than do those who monitor the clock less frequently during the same time period (e.g., Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). What’s more, older adults are less likely to spontaneously produce this efficient clock-monitoring strategy than are younger adults (Einstein et al., 1995, Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). Thus, it seems that providing older adults with a strategy to increase their clock-checking as the target time approaches may be beneficial.

Overall, empirical research on PM provides hints regarding a number of trainable PM strategies that would likely lead to PM improvements. Therefore, in the current PM training protocol, our approach is to teach older adults a number of different PM strategies and to enable them to differentiate between the different types of PM tasks so that they are able to apply the most appropriate strategy in each PM situation.

Training for Transfer

A second challenge in creating a PM training package that promotes transfer to real-world PM tasks is that, compared with retrospective-memory training, it is arguably more challenging to simulate real-world PM tasks in a laboratory setting. For instance, the oft-used technique of repeating a single task over training (used in training attentional control, working memory, retrospective memory, e.g., Bherer et al., 2005; Kramer, Larish, & Strayer, 1995; Rebok & Balcerak, 1989; Redick et al., 2013) may not be ideal for training PM because of the widely variable nature not only of PM tasks themselves but also of the contexts in which these tasks must be performed. As mentioned previously, PM tasks may take the form of focal, nonfocal, and time-based tasks, each of which may require separate strategies. Given the highly variable nature of PM tasks and their associated contexts, we reasoned that training that focused only on a single training task or type of PM would likely fail to transfer to other PM tasks, or perhaps even similar PM tasks performed in a different context.

Following Schmidt et al. (2001), we also assumed that homework assignments may be key in encouraging participants to practice transferring the skills learned in the training sessions to everyday PM tasks. However, we extended Schmidt et al.'s homework-focused approach by combining homework assignments with a wide variety of laboratory PM tasks. These laboratory tasks were created so that each week, both the PM intentions and the ongoing task changed. We thought that varying the nature of the tasks used in every PM training session would help participants learn to classify different types of PM tasks and transfer strategies over the course of training. A third component of our approach was designing the PM training tasks to be engaging and fun (cf. West, Bagwell, & Dark-Freudeman, 2008, for importance of motivation in memory training).

A final component of the PM training method was the element of increasing difficulty. Specifically, we increased the number and difficulty of PM responses over training, and the role of the trainer was also diminished as participants became more familiar with each trained strategy. For instance, while initially the trainer would explicitly instruct strategies prior to practice on a training task, in later weeks, participants were expected to self-initiate use of appropriate strategies. These features align with the two major approaches in the cognitive training literature. The restorative approach to training gradually increases the demands of the task so as to stimulate acquisition of higher levels of ability/skill (e.g., attention training, Mackay-Brandt, 2011; retrospective-memory training, Jennings & Jacoby, 2003); our increase in PM response difficulty over training reflects this approach. The strategy-training approach is sometimes implemented so that the learner is required to initiate and shape the trained strategies for new contexts (e.g., in the occupational therapy domain, Toglia, Rodger, & Polatajko, 2012). Gradually decreasing support from the trainer echoes this approach, and we reasoned it might help participants learn to self-initiate PM strategy use in new tasks and, thus promote transfer.

The Current PM Training Protocol

We next detail this first training protocol to take a comprehensive approach to PM training. The broad features of the protocol were (a) teaching older adults to identify different types of PM tasks, and utilize the strategies that prior research suggests are the most beneficial for each type of task; (b) providing participants with in-session practice on a wide variety of PM tasks; and (c) including weekly discussion sessions and homework assignments to encourage participants to extend the skills learned in training to real-world situations. In the following sections, we provide a complete description of each of the eight weekly training sessions (see Table 1 for a brief description of each session). Before doing so, it is important to note that participants who completed the PM training program detailed here were enrolled in the Exercise and Cognitive Training (EXACT) project (see McDaniel et al., 2014), and completed the PM training as one part of a larger scale cognitive training program. The PM training comprised one of three weekly cognitive training sessions that participants attended over an 8 week period. (The two remaining sessions held each week focused on attention and retrospective-memory training, respectively.) Because no description of the PM training program has yet been provided, we detail the method here. We also report on a modest PM control group that was asked to perform the first and last training task in the absence of any PM training. We compare performance in this control group against the performance of EXACT participants who received PM training.

Method

Participants

Sixty-two participants between the ages of 55 and 75 were recruited for the current project. A total of 47 of these participants (32 females, 15 males) were enrolled into one of two EXACT conditions (i.e., cognitive training alone or cognitive training combined with an exercise intervention). All participants enrolled in the EXACT project met criteria for a Clinical Dementia Rating score = 0.00 (cognitively normal). Participants had no major and/or unstable medical, neurological, or psychiatric disorders, no history of alcohol or substance abuse, and no positive exercise stress test for ischemia. Additional recruitment details, prescreening procedures, and participant demographics for those enrolled in the EXACT project are detailed in McDaniel et al. (2014). An additional 15 participants (12 females, 3 males) who were not involved in the EXACT program were recruited from the Washington University older adult participant pool to participate in the two-session control condition. The participants in the control condition did not differ significantly in age (range: 56–72; $M = 64.4$, $SD = 4.83$) from those in the EXACT conditions whose results are reported here (range: 55–75; $M = 64.08$, $SD = 4.61$). There also was no difference in years of reported education, $t(50) < 1$ for those in the EXACT conditions ($M = 17.22$, $SD = 1.65$) and those in the control group ($M = 17.00$, $SD = 1.73$).

Materials and Procedure

Week 1—During the first PM cognitive training session, the trainer introduced the concept of PM and explained that one session per week would focus on training the ability to remember to perform PM tasks in the context of other attentionally demanding tasks. The

trainer then reviewed different types of PM tasks (e.g., focal, nonfocal, and time-based), and informed the participant that they would encounter each of these different types of PM during training. For the first training task, the trainer explained that the participant should use whatever strategies felt natural, and that the selected strategies would be discussed following task performance. The first training task was “Famous Faces” (cf. Maylor, 1993, 1996; Rendell, McDaniel, Forbes, & Einstein, 2007). Participants were informed that they would be asked to identify 100 famous faces by recording the name associated with each face on a sheet labeled 1 to 100. Faces included those of famous actors, talk-show hosts, and news anchors. Participants were told that their goal should be to indicate the real name of each person presented, but that they would also receive partial credit for recording a movie or TV show the person had appeared in, or even the name of a character for which the person is known. Participants were told that each slide would advance to a feedback screen presenting the correct famous name either upon pressing the spacebar or after 20 s. The trainer then indicated that there would be two additional PM tasks that should also be performed. The first of these PM tasks was to push the “T” key on the keyboard once every 3 min (because the name feedback screen was not presented until the participant made a response to advance, the number of time-based PM responses possible for each participant varied based on participant task pace, [range = 4–14, $M = 8.2$]). Participants were told that they could monitor the time throughout the Famous Faces Task by using a built-in clock that appeared whenever the “C” key was hit on the keyboard. Second, participants were also asked to press the “F” key whenever a picture of a talk-show host or a news anchor (e.g., Tom Brokaw, Brian Williams, Barbara Walters) was presented (seven of these cues were included). Participants then completed a five-item practice session to get accustomed to the task demands and to practice using the built-in clock. The trainer prompted the participant to practice using the clock and to respond to the talk-show-host PM cue (David Letterman) included in the practice session, if the participant failed to perform these actions on his or her own. Note that a similar practice session was included prior to performance of each subsequent week’s training task. Following the Famous Faces training task, the trainer initiated a discussion regarding task performance and strategy use. Feedback was provided regarding participants’ self-reported strategy use. For instance, if a participant reported simply waiting until he or she thought all 3 min had elapsed to check the clock, the trainer noted that frequent checking is a more effective strategy. Likewise, if participants reported somewhat continuous monitoring for the talk-show host–news anchor PM target, the trainer explained that whereas some PM tasks (e.g., nonfocal) do require such active monitoring, the type of focal/obvious cue used in that day’s task can be responded to just as accurately without the use of a demanding monitoring strategy. The trainer ended this discussion by explaining that one of the goals of the PM training would be to learn to identify different types of PM tasks and to use the strategies that are most effective for each. Finally, the trainer assigned homework, which was to identify different types of PM tasks in daily life.

Week 2—To begin the second PM session, the trainer asked the participant to discuss the Week 1 homework of identifying different daily PM tasks and then asked the participant to discuss any common strategies used to perform these tasks. This exchange helped the trainer to determine the degree to which participants initially relied on external PM aides (e.g.,

alarms, calendars) as compared with other cognitive strategies (e.g., monitoring) that would be presented throughout training.

Following discussion, instructions were presented for the second PM training task, “General Knowledge Trivia” (cf. Duchek, Balota, & Cortese, 2006). Participants were asked to respond to 100 different multiple-choice trivia items while also remembering to perform one time-based and one event-based PM task. As in Week 1, participants had a maximum of 20 s to answer each trivia question and then were presented with a feedback screen. In addition, they were asked to push the “T” key on the keyboard once every 3 min (the maximum number of time-based PM targets was 13). Participants were again reminded that they could check a clock by pressing the “C” key. In addition, participants were informed that they should attempt to make their time-based response within 5 s of the target time. This 5 s accuracy goal was also provided prior to task performance in each of the remaining weeks of training. Finally, participants were told that they should push the “F” key each time the word “president” appeared in one of the trivia questions (this cue appeared 8 times during the training task). The trainer then reminded the participant that while they should monitor the clock to perform the time-based task, the “president” cue would most likely lead to automatic retrieval of the PM intention because of its focal nature. Participants then completed the training task, and were subsequently asked to report any strategies used to complete the PM tasks. In addition, the trainer asked the participant to indicate whether strategies used during the task were similar to or different from those strategies participants reported using most often at home. Finally, the trainer asked participants to practice strategies used during the task by either replacing or supplementing an external aid that would typically be relied upon during a real-life PM task (e.g., practice monitoring a clock rather than relying solely on an alarm; put a letter to be mailed by the front door so that you are automatically reminded to mail the letter rather than relying on a note).

Week 3—Following discussion of the previous homework assignment, participants were told that in addition to the computer task they would perform later, they should also give the trainer their watch (or some other personal item) and should remember to ask for its return prior to leaving that day. After collecting the participant’s watch, the trainer provided instruction for the “Spot the Difference” task. During this task, participants were told that they would be presented with two nearly identical pictures, and that they should identify and record the small changes between the two presented pictures (e.g., the picture on the left side of the screen may have included a small object that was absent from a nearly identical picture presented on the right side of the screen).

Participants were told how many total changes to look for in each set of pictures and were asked to continue looking for differences either until all the differences were located, or until the time allotted for that set of pictures expired and a feedback screen presented (participants were allowed a maximum of 2.5 min for each picture set, but they were not given this information explicitly). Participants were told that in addition to finding all the differences between 20 sets of pictures, they should also remember to press the “T” key each time 5 min elapsed (a maximum of 10 time-based targets occurred during the task). As in previous weeks, participants were reminded that pressing the “C” key would display the elapsed time. Participants were also asked to remember to press the “F” key each time a set of pictures

included the ocean or things that live in the ocean (3 of these cues were included in the training task). After completing the training task, the trainer asked about and provided feedback regarding strategy use and then assigned homework that required participants to call or text the trainer at an agreed-upon time prior to the following week's PM session. The trainer indicated that the participant could use any PM strategy to help the participant remember this task other than relying on external aids (e.g., alarm, spouse, etc.). Finally, prior to the participant's departure, the trainer returned the participant's watch if the participant failed to remember to ask for it to be returned on his or her own. Because the watch was returned just prior to the participant's leaving, discussion regarding this task was reserved until the following week.

Week 4—At the outset of the Week 4 session, both the previous week's watch-returning task and the homework phone-call task were discussed. Participants were asked to report their strategies for each of these tasks, and the trainer then discussed how an implementation intention strategy could help to make such tasks easier to remember to perform. The trainer explained how to use implementation intentions and asked the participant to practice using this strategy during that day's task—the "Memory Card" task (The Charley Harper Memory Game™ was used for this task because it includes more artistic/complex pictures than those in many children's versions of this game). During this task, participants were asked to find matching pairs of cards from an array of cards placed face down on the table in front of them. They were told that they could turn over two cards at a time to look for a match. When a match was located, it was to be removed from the array. If the two chosen cards did not match, participants were instructed to return them to their face-down position and select two new cards.

In addition to finding card matches, participants were also asked to remember to push specific keys on the keyboard (the laptop was placed just to the side of the card array) each time they found a card pair that contained certain characteristics. Specifically, participants were told to push the "F" key each time they found a pair of cards that included a bird(s) that was wholly or partially red in color (6 of these pairs were included). They were also told to push the "L" key whenever a card pair had a pink background (3 of these pairs were included). Finally, the time-based PM task was to push the "T" key each time 5 min elapsed (5 time-based targets occurred during the task). The designated "C" key on the keyboard could be pushed at any time to check the elapsed time. Prior to beginning the Memory Card task, the trainer had the participant make implementation intentions for each of the PM tasks by forming an if-then statement for each of the intentions (e.g., "If I find a pair with pink backgrounds, I will push the "L" key on the keyboard."). Participants were asked to repeat each if-then statement three times, and then asked to imagine encountering the PM cue and performing each PM task (30 s were allowed for imagery).

Following instruction and the implementation procedure, participants performed the Memory Card task. If all pairs were located prior to the 26 min total task time, the cards were shuffled and arranged so that the participant could continue working on the task until the full task time elapsed. Following task completion, performance and strategy use were discussed. Finally, the participant was asked to form a homework assignment involving the use of the implementation intention strategy.

Week 5—The fifth session began with a discussion of the implementation intention homework assigned the previous week. The trainer suggested that the participant continue using this implementation intention strategy during the remaining weeks of training in addition to any other strategies they also use (e.g., monitoring for nonfocal and time-based tasks). In addition, prior to performing that day's PM task, the trainer held a more in-depth conversation regarding time-based PM clock-monitoring than had been presented in previous weeks. In addition to stating that more frequent monitoring leading up to the time-based PM target time is an effective strategy, the trainer reviewed some relevant research indicating that age-related declines in time-based PM have been linked to infrequent clock-checking (Einstein et al., 1995; Park et al., 1997), and that those older adults who check the clock more frequently (especially in the interval proximal to the target time) perform these tasks more accurately than those who utilize the clock less often (Einstein et al., 1995). Participants were asked to use the efficient clock-checking strategy during that day's "Bananagrams™" task.

Bananagrams™ is a game that involves arranging letter tiles into words that form a grid (much like Scrabble™, except that it can be played in a solitary version). The goal of Bananagrams™ is to utilize as many of the letter tiles as possible. Participants were given the Bananagrams™ instructions, and the letter tiles were placed on the desk in front of the participant. Slightly off to the side of the letter tiles, a laptop was also set up. Participants were told that different background patterns would flash on the laptop screen while they were playing Bananagrams™ (each pattern was displayed for 3 s) and that they would need to press the "F" key on the keyboard each time a particular pattern was displayed (the target pattern was presented 18 times during the training task). Participants were also told that they should use the "C" key on the keyboard to check the clock and press the "T" key every 7 min (maximum of three time-based PM responses were possible). Prior to beginning the training task, participants were reminded that both an implementation intention and active monitoring would be beneficial for performing the event-based PM task, because the cue would be primarily outside the focus of attention. Participants were finally reminded to try to use the clock as efficiently as possible to make their time-based PM responses.

Upon completion of the training task, participants were asked to discuss their strategies and performance. Finally, participants were asked to come up with a homework assignment that would involve efficient use of the clock-checking strategy discussed during the session.

Week 6—Week 6 began with a discussion of the time-based PM homework assigned the previous week. The trainer then indicated that the next training task would include multiple different types of PM tasks. Particularly, participants were told that they would be performing a "Where's Waldo" search task during which they would be asked to locate a particular object in each of 100 busy scenes. The target object for each scene was located at the top of the screen, and the participant was told to push "N" on the keyboard if he or she did not think the target object was actually in the scene, and the "Y" key if he or she did locate the object in the scene. Participants were informed that the target object would be in the scene on about 50% of the trials, and that a maximum of 20 s would be allowed for each "Y" or "N" response. In addition to the object location task, participants were told to push the "F" key whenever Waldo was the target search object (i.e., Waldo was the picture located

at the top of the screen that the participant was to search for). This PM cue was presented 7 times during the training task. Participants were also asked to push the “L” key whenever Wendy was either the search target at the top of the screen, or present anywhere in the scene (Wendy was presented 14 times during the training task). Finally, participants were asked to push the “T” key once every 7 min (maximum of 4 time-based PM targets occurred during the task). They were told the “C” key could be pushed at any time to check the clock. Prior to beginning the training task, the trainer specified the appropriate strategies for each of these tasks. Participants then completed the training task and were asked to discuss performance and strategy use. Finally, participants’ homework was to utilize each of the discussed strategies in appropriate real-world situations.

Week 7—After discussing the Week 6 homework assignment, participants performed a card-matching task similar to that used in Week 4 with the exception that the cards were taken from the game “Codebreaker™” rather than the Charley Harper Memory™ game used in Week 4. During this task, participants were to find card matches and also remember to press the “F” key on the keyboard whenever the word “Cogno” appeared on a pair of matched cards (3 pairs included this cue), and to push the “L” key whenever a card match contained a character that was wearing a necklace (4 of the pairs included this cue). Finally, participants were to push the “T” key once every 10 min, and as always were allowed to use the “C” key to display the elapsed time whenever they wished. A total of three time-based responses were possible during the task. After task instruction, the trainer informed the participant that they should use whatever strategies they felt were appropriate for performing the day’s tasks. The participant then began the training task; if all pairs were located prior to the 31 min task duration, the cards were shuffled and placed into a new grid. Upon completion, the trainer discussed strategy use and provided feedback. Assigned homework focused on using different PM strategies in appropriate situations.

Week 8—During the final week of PM training, the session opened with a discussion regarding the previous week’s homework assignment. The trainer then introduced the participants to the final training task, which was the “Driving” task. This task required participants to observe a car drive around a virtual environment on the computer screen. The ongoing task was to press the “M” key on the keyboard whenever the car made a driving error. These errors included swerving, driving off the road, leaving a blinker on too long, etc. Note that this mistake monitoring task was considered a subjective task. For instance, some participants might indicate a mistake every time the car swerved to a small degree while others might indicate a mistake only when the car swerved over the center line. As such, this task could not be scored for accuracy.

In addition to responding to driving errors, participants were to push the “F” key whenever another car passed the observed car (100 total occurrences), and to push “L” whenever the observed car passed a red and white advertisement/billboard (10 total occurrences). Finally, participants were to push the “T” key every time 10 min elapsed (3 time-based targets occurred during the task), and could check the time throughout the task using the “C” key. Other than providing task instruction, the trainer did not give explicit strategy instruction prior to the task.

Following task completion, the trainer elicited a discussion concerning task performance and strategy use and finally presented an overview of all PM tasks and associated strategies covered during training.

Control Condition

Participants recruited for the control condition completed the tasks described above under Week 1 (Famous Faces) and Week 8 (Driving). Participants performed the Famous Faces task during their first session and the Driving task during a separate session held approximately one week later. As in the training condition, those in the control condition were given an accuracy goal of ± 5 s for the time-based prospective memory task embedded in the driving task. However, contrary to the PM training sessions, there was no pre- or post-task discussion regarding types of PM tasks or strategies, and no homework was assigned for those in the control condition.

Results

Adherence

Of the 47 participants who were assigned to an EXACT condition, 10 neither completed the training interventions nor the battery of follow-up post-tests included in the EXACT study. Data from these participants are not included here. Of the 37 participants who met criteria for completion of the cognitive training intervention, 32 completed all eight PM training tasks ($M = 7.65$, $SD = 1.08$). Fourteen of the 15 participants recruited for the control condition completed both PM tasks.

Training Task Performance

Time-based PM—We first assessed time-based PM training effects by analyzing time-based PM performance on the later Driving task while controlling for baseline time-based performance on the Famous Faces task. To do this, Famous Faces time-based PM performance was included as a covariate in an ANCOVA conducted on the proportion of correct time-based PM responses in the Driving task using group (trained vs. control) as the between subjects factor. Correct time-based PM responses were defined as any produced within ± 5 s of the target time (see Figure 1 for the mean PM performances for the Famous Faces and Driving tasks). This analysis revealed a significant main effect of condition, $F(1, 46) = 11.16$, $p = .002$, such that time-based PM performance on the Driving task was significantly better in the trained condition than in the control condition, even after controlling for baseline PM differences on the initial Famous Faces task (adjusted PM means for the Driving task are 0.73 and 0.38, for the trained and control conditions, respectively).

Given the training effect on time-based PM performance, and prior research that points to an important role for increased clock-checking proximal to the target time for successful PM performance (e.g. Einstein et al., 1995), we investigated clock-checking rates in the minute prior to the target times in the Driving task while accounting for baseline levels of clock-checking during proximal minute intervals in the Famous Faces task. If the training served to increase participants' clock-checking, we should see more clock-checks in the minute prior to the Driving task target times for those in the trained group compared with those in the

control group. Controlling for the baseline (Famous Faces) clock-checking rate, the average number of clock-checks made in the minute proximal to the target times in the trained condition was significantly higher for the trained group ($M = 3.33$, $SD = 1.97$) than the control group ($M = 1.24$, $SD = 1.23$), $F(1, 45) = 8.82$, $p = .005$. This finding suggests that the trained clock-checking strategy was successful, and likely contributed to the increased time-based PM performance observed in the trained group.

Event-based PM—Next, to investigate event-based PM training effects, we included baseline event-based PM performance on the Famous Faces task as a covariate in an ANCOVA conducted on the proportion of correct event-based PM in the Driving task using group (trained vs. control) as the between subjects factor.¹ As can be seen from Figure 2, this analysis did not reveal a significant main effect of condition (adjusted means are 0.52 and 0.56 for trained and control conditions, respectively; $F < 1$).²

While there was no indication of a training benefit for accurate production of the event-based PM responses, it is of interest to note that participants in the trained group pushed the “M” key during the Driving task to indicate the driver was making an error significantly more often ($M = 343.52$, $SD = 226.59$) than did those in the control condition ($M = 189.36$, $SD = 115.88$), $t(43) = 2.40$, $p = .021$.³ Thus, participants in the trained group showed significantly more improvement on the final time-based PM task and equivalent performance on the final event-based PM task despite potentially devoting more resources to the ongoing mistake monitoring task.

Discussion

Despite commonly reported PM declines in older adults and several other special populations (e.g., Parkinson’s disease, schizophrenia, traumatic brain injury [TBI]), there is a glaring absence of PM training interventions that might help to alleviate the physical and psychological ramifications of declining PM abilities. In fact, the PM training method presented here is only the third PM training protocol of which we are aware, and is the first to take a comprehensive approach to PM training. Specifically, our method is the first to combine PM strategy instruction and laboratory task practice. Previous training studies have provided strategy training without in-laboratory practice using those strategies (Schmidt et al., 2001), or practice on a laboratory task without explicit strategy instruction (Rose et al., 2012). Our intervention also extended previous approaches by including a number of other components that may be beneficial for transfer beyond training. For instance, contrary to most training approaches, we varied the training tasks used in each session rather than using a single task across sessions. This unique approach allowed us to train multiple PM

¹The billboard/advertisement event-based prospective memory (PM) task included in the Driving task was used for analysis because the “car passing” task was more akin to a vigilance task than a PM task (i.e., there were 100 car-passing cues presented during the task). The billboard task included only 10 cues, and thus was a more appropriate PM comparison to the talk-show host–news anchor task (seven cues) of the Famous Faces task.

²Performance on the name identification component of the Famous Faces task did not differ between the trained ($M = 83.97$, $SD = 41.39$) and control group ($M = 100.57$, $SD = 45.93$), $t(44) = 1.21$, $p = .23$. Participants’ scores were calculated by awarding 2 points if both the first and last name of the presented celebrity were recalled correctly. One point was awarded either if only the first or last name was recalled or if a participant recorded the name of a TV show/movie or character the person is known for.

³One participant who made more than 3,000 “M” responses (4.96 standard deviations above the grand mean of the trained group) was removed from the analysis. There were no other outliers in either group (i.e., none more than ± 2 SD s from the mean).

strategies and allowed participants to practice applying them in a variety of situations. In addition, we included weekly discussion and homework assignments aimed at encouraging participants to practice applying the skills learned during training to real-world scenarios.

To test the utility of our new PM training method, two groups of participants were tested. One group completed eight weeks of PM training as part of the larger EXACT project (see McDaniel et al., 2014). The second group was a control group who received no training and was not part of the EXACT study. We compared performance on the final training task across the trained and control groups while controlling for baseline PM differences on the initial task. The results indicate that those who received training showed significantly greater time-based PM performance on the final task (Driving) than did the control group. In addition, while the trained group did not show a similar advantage over the control group on final event-based PM performance, it is clear that those in the trained group made more responses during the subjective ongoing monitoring task of the final training than did those in the control group. Therefore, participants in the trained group were able to perform the event-based PM task as well as the control group despite devoting arguably more resources to the ongoing mistake monitoring task. This result suggests that PM training allows PM to be supported with less attention-demanding processes after training (a qualitative shift), in turn, allowing for extra resources to be devoted to ongoing task performance.

We are hesitant, however, to make strong claims based on the training data given a number of limiting factors. For instance, while there was no apparent improvement across tasks on event-based PM accuracy, it should be noted that the event-based PM task used in the first task (Famous Faces) consisted of a focal task, whereas that used in the last task (Driving) would be considered nonfocal. This mismatch in cue focality across the two tasks limits our ability to interpret the event-based PM results. Additional factors such as the small size of the control group and potential differences in engagement across the control and trained groups also potentially limit the results reported here. For instance, the trained group was continually being tested, whereas the control group was not; maybe the trained group was simply improving because of experience gained through testing (e.g., perhaps confidence and familiarity with computer-based tasks increased performance on VW). This did not seem to be the case, however, because in the EXACT project, the no-cognitive-training groups did not show even nominal improvement on the transfer PM task from pre- to post-testing (McDaniel et al., 2014). In addition, contrary to the PM training gain observed on VW, no such gains were observed on the computer administered attention or retrospective-memory outcome measures also included in the EXACT study. If it were the case that increased familiarity or confidence with the training tasks was the source of the PM training effects, we would have expected to observe similar training gains for all of the outcome measures, but this was not the case.

Another interpretational issue arises because the trained group received retrospective-memory and attentional switching/control training modules as part of the EXACT project, in addition to the PM training detailed herein. However, because cognitive training effects in the EXACT project were not observed on outcomes tasks closely overlapping with the retrospective-memory and attentional control training modules (see McDaniel et al., 2014,

for details), it seems unlikely that these non-PM training experiences had an effect on the PM tasks (which did not overlap highly with the non-PM training tasks).

It is clear that our training design does not allow us to make strong conclusions regarding training task gains because of the difficulty in comparing performance across the widely variable tasks that were used. It is worth emphasizing, though, that there were training-related improvements on VW, the primary “real-world” PM outcome measured in the EXACT project (reported in McDaniel et al., 2014). Participants who received cognitive training improved significantly on the VW task from pre-training to post-training, whereas control (no cognitive training and no exercise) and exercise-only groups showed no improvement from pre- to post-training. Benefits of training extended to both routine PM tasks that were performed regularly during each virtual day (a 14% gain), and the nonroutine PM tasks that were not repeated (a 13% gain) and that are particularly difficult for older adults. These findings imply that our PM training protocol likely benefits transfer to a real-world PM proxy task. Future research that includes everyday, naturalistic PM tasks would help substantiate the possibility that the PM training protocol could improve older adults’ real-life PM. Additional work investigating the component of variable training tasks would help to address whether the task variability in the current PM training protocol was particularly beneficial in helping participants practice “transferring” across training. Future work comparing variable training tasks such as those used in the current study against a training method that employs only a single task would help to clarify whether task variability does indeed benefit transfer of training.

In conclusion, the initial results associated with our novel PM training package are promising. What’s more, because the tasks included in training were created using games, they seemed to be intuitive (e.g., participants were able to perform the tasks with little trainer instruction), engaging, and fun for older adults. In addition, because the training tasks varied from week to week, engagement seemed to remain at a high level across the 8 weeks of training. This may not have been the case had we used a repetitive, single-task training scheme. We believe that the present PM training protocol can be effectively used on its own or in combination with training interventions targeting other cognitive abilities (e.g., the EXACT trial, McDaniel et al., 2014). A similar package may also be useful for helping other special populations who struggle with PM tasks, which are vital for sustained independent living.

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References

- Bagwell DK, West RL. Assessing compliance: Active vs. inactive trainees in a memory intervention. *Clinical Interventions in Aging*. 2008; 3:371–382. [PubMed: 18686759]
- Bherer L, Kramer AF, Peterson MS, Colcombe S, Erickson K, Becic E. Training effects on dual-task performance: Are there age-related differences in plasticity of attentional control? *Psychology and Aging*. 2005; 20:695–709. [PubMed: 16420143]
- Breneiser, J. Unpublished doctoral dissertation. Washington University; St. Louis, MO: 2007. Implementation intentions and cost in prospective memory retrieval.
- Craik, FIM.; Salthouse, TA., editors. *The handbook of aging and cognition*. 2. Mahwah, NJ: Lawrence Erlbaum; 2000.
- Craik, FIM.; Salthouse, TA., editors. *Handbook of aging and cognition*. 3. New York, NY: Psychology Press; 2008.
- Duchek JM, Balota DA, Cortese M. Prospective memory and apolipoprotein e in healthy aging and early stage Alzheimer's disease. *Neuropsychology*. 2006; 20:633–644. [PubMed: 17100508]
- Einstein GO, McDaniel MA, Richardson SL, Guynn MJ, Cunfer AR. Aging and prospective memory: Examining the influences of self-initiated retrieval processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 1995; 21:996–1007.
- Einstein GO, McDaniel MA, Thomas R, Mayfield S, Shank H, Morrisette N, Breneiser J. Multiple processes in prospective memory retrieval: Factors determining monitoring versus spontaneous retrieval. *Journal of Experimental Psychology: General*. 2005; 134:327–342. [PubMed: 16131267]
- Henry JD, MacLeod MS, Phillips LH, Crawford JR. A meta-analytic review of prospective memory and aging. *Psychology and Aging*. 2004; 19:27–39. [PubMed: 15065929]
- Jennings JM, Jacoby LL. Improving memory in older adults: Training recollection. *Neuropsychological Rehabilitation*. 2003; 13:417–440.
- Kramer AF, Larish JF, Strayer DL. Training for attentional control in dual task settings: A comparison of young and old adults. *Journal of Experimental Psychology: Applied*. 1995; 1(1):50–76.
- Liu LL, Park DC. Aging and medical adherence: The use of automatic processes to achieve effortful things. *Psychology and Aging*. 2004; 19:318–325. [PubMed: 15222825]
- Mackay-Brandt A. Training attentional control in older adults. *Aging, Neuropsychology, and Cognition*. 2011; 18:432–451.

- Maylor EA. Aging and forgetting in prospective and retrospective memory tasks. *Psychology and Aging*. 1993; 8:420–428. [PubMed: 8216962]
- Maylor EA. Age-related impairment in an event-based prospective-memory task. *Psychology and Aging*. 1996; 11:74–78. [PubMed: 8726372]
- McDaniel MA, Binder E, Bugg JM, Waldum ER, Dufault C, Meyer A, Kudelka C. Effects of cognitive training with and without aerobic exercise on cognitively-demanding everyday activities. *Psychology and Aging*. 2014; 29:717–730. [PubMed: 25244489]
- McDaniel, MA.; Einstein, GO. *Prospective memory: An overview and synthesis of an emerging field*. Thousand Oaks, CA: Sage; 2007.
- McDaniel MA, Howard DC, Butler KM. Implementation intentions facilitate prospective memory under high attention demands. *Memory & Cognition*. 2008; 36:716–724. [PubMed: 18604955]
- McDaniel MA, Scullin MK. Implementation intention encoding does not automatize prospective memory responding. *Memory & Cognition*. 2010; 38:221–232. [PubMed: 20173194]
- Park DC, Hertzog C, Kidder DP, Morrell RW, Mayhorn CB. Effect of age on event-based and time-based prospective memory. *Psychology and Aging*. 1997; 12:314–327. [PubMed: 9189992]
- Rebok GW, Balcerak LJ. Memory self-efficacy and performance differences in young and old adults: The effect of mnemonic training. *Developmental Psychology*. 1989; 25:714–721.
- Redick TS, Shipstead Z, Harrison TL, Hicks KL, Fried DE, Hambrick DZ, Engle RW. No evidence of intelligence improvement after working memory training: A randomized, placebo-controlled study. *Journal of Experimental Psychology: General*. 2013; 142:359–379. [PubMed: 22708717]
- Rendell PG, Craik FI. Virtual week and actual week: Age-related differences in prospective memory. *Applied Cognitive Psychology*. 2000; 14:S43–S62.
- Rendell PG, McDaniel MA, Forbes RD, Einstein GO. Age-related effects in prospective memory are modulated by ongoing task complexity and relation to target cue. *Aging, Neuropsychology, and Cognition*. 2007; 14:236–256.
- Rose, NS.; Craik, FIM.; Kliegel, M.; Hering, A.; Rendell, PG. Cognitive and neural plasticity in older adults' prospective memory following training with the virtual week computer game. Poster presented at the Annual Meeting of the Psychonomic Society; Minneapolis, MN. 2012 Nov.
- Schmidt IW, Berg IJ, Deelman BG. Prospective memory training in older adults. *Educational Gerontology*. 2001; 27:455–478.
- Schnitzspahn K, Kliegel M. Age effects in prospective memory performance within older adults: The paradoxical impact of implementation intentions. *European Journal of Ageing*. 2009; 6:147–155.
- Smith GE, Housen P, Yaffe K, Ruff R, Kennison RF, Mahncke HW, Zelinski EM. A cognitive training program based on principles of brain plasticity: Results from the improvement in memory with plasticity-based adaptive cognitive training (IMPACT) study. *Journal of the American Geriatrics Society*. 2009; 57:594–603. [PubMed: 19220558]
- Stine-Morrow AL, Parisi JM, Morrow DG, Greene J, Park DC. The Senior Odyssey Project: A model of intellectual and social engagement. *The Journals of Gerontology, Series B: Psychological Sciences & Social Sciences*. 2007; 62:62–69.
- Toglia JP, Rodger SA, Polatajko HJ. Anatomy of cognitive strategies: A therapist's primer for enabling occupational performance. *Canadian Journal of Occupational Therapy*. 2012; 79:225–236.
- Verhaeghen P, Marcoen A, Goossens L. Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging*. 1992; 7:242–251. [PubMed: 1535198]
- West RL, Bagwell DK, Dark-Freudeman A. Self-efficacy and memory aging: The impact of a memory intervention based on self-efficacy. *Aging, Neuropsychology, and Cognition*. 2008; 15:302–329.

Figure 1. Proportion of correct time-based PM responses in the first (Famous Faces) and last (Driving) training tasks.

Note. Error bars represent $\pm SE$ of the mean. PM = prospective memory.

Figure 2.

Proportion of correct event-based PM responses in the first (Famous Faces) and last (Driving) training tasks.

Note. Error bars represent $\pm SE$ of the mean. PM = prospective memory.

Table 1

PM Training Method Outline by Week.

Week	Task instruction	Training session			At-home	
		Ongoing task	PM training task		Time-based PM interval	HW assignment
			Event-based PM cue(s)			
1	Use any strategy	Famous faces	1 News anchors 2 Talk-show hosts		3 min	Identify real-life examples of PM during upcoming week.
2	Spontaneous retrieval for focal PM Clock-checking for time-based PM	General knowledge trivia	1 The word "president"		3 min	Replace or supplement an external strategy with one discussed during training.
3	Clock-checking for time-based PM	Spot the difference	1 Picture of the ocean or any ocean life 2 Naturalistic task: ask for personal item back at end of session		5 min	Call experimenter at agreed-upon time during next week.
4	Implementation intention (II) for each PM task	Memory card-matching	1 Red bird(s) on card match 2 Pink background on card match		5 min	Utilize II strategy for real-world PM task.
5	Clock-checking for time-based PM Active monitoring for nonfocal PM II for all PM tasks	Bananagrams	1 Specific pattern presented on laptop		7 min	Apply clock-monitoring strategy to real-life time-based task.
6	Clock-checking for time-based PM Active monitoring for nonfocal PM II for all PM tasks	Where's Waldo	1 Waldo as the search target 2 Wendy anywhere in the scene		7 min	Use multiple strategies during the week and be prepared to report how they did or did not work.
7	Self-generate appropriate strategies for each PM task	Codebreaker card-matching	1 The word "Cognito" on card match 2 Necklace on card match		10 min	Use multiple strategies during the week, and be prepared to report how they worked.
8	Self-generate appropriate PM strategies for each PM task	Driving	1 Passing car 2 Red and white advertisement		10 min	Continue to apply newly learned strategies in life going forward.

Note. All sessions included a pretask discussion, a PM training task consisting of an ongoing task and PM response(s), post-task strategy feedback, and finally a homework assignment. Please see section "Method" for pre- and post-task discussion topics and details. PM = prospective memory; HW = homework.