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Event-based Prospective Memory and Everyday Forgetting in Healthy Older Adults and Individuals with Mild Cognitive Impairment

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Abstract

An event-based non-focal task was used to evaluate prospective memory (PM), and the relationship between PM, neuropsychological testing data and everyday forgetting. Twenty-four participants with mild cognitive impairment (MCI) and 24 age and education matched cognitively healthy adults responded to a non-focal PM cue, while completing an ongoing working memory task. Neuropsychological testing data and self- and informant-report of frequency of forgetting were also gathered. Compared to healthy adults, the MCI participants exhibited significantly poorer prospective remembering and ongoing task performance, despite similar self-reported effort directed to the PM task. Both self- and informant-report indicated that the MCI group was experiencing a higher frequency of everyday forgetting than the healthy adult group. Self-report of everyday forgetting was correlated with PM task performance for the healthy adults, but not the MCI participants. For the healthy adults, correlational analyses also showed significant relationships between PM accuracy and tests of memory and executive functioning, suggesting that both spontaneous retrieval processes and effortful, strategic monitoring may be important in supporting prospective remembering for this non-focal PM task. The stronger relationships between PM accuracy and memory and language tests for the MCI group suggests that their poorer event-based prospective remembering might be linked to impaired spontaneous retrieval processes, which are thought to be supported by medial temporal structures.

Keywords

mild cognitive impairment; prospective memory; non-focal cue; everyday memory; dementia

Prospective memory (PM) plays an important role in everyday remembering. The ability to carry out a task in the future, such as remembering to take medication when sitting down to eat dinner, is conceptualized as PM. Despite the fact that deficits in PM can have profound impacts on everyday functioning and psychosocial well-being, the majority of memory research in the aging and dementia literature has focused on retrospective memory (RM) deficits (e.g., recalling a list of words or story). Recently, increased attention has been placed on evaluating PM. For example, PM performance has been found to add to the discrimination between mild dementia and healthy aging (Blanco-Campal, Coen, Lawlor, Walsh, & Burke, 2009; Duchek, Balota, & Cortese, 2006), and to be a unique predictor of transition to Alzheimer's disease after accounting for RM (Jones, Livner, & Bäckman, 2006). In this study, we aim to evaluate PM abilities in individuals with mild cognitive impairment (MCI) as well as investigate the relationship between PM deficits,

neuropsychological test performances and self- and informant-report of frequency of everyday forgetting.

Prospective memory tasks involve both prospective and retrospective components (Einstein, Holland, McDaniel, & Guynn, 1992; Ellis, 1996). The retrospective component of PM is responsible for storing information to be carried out, while the prospective component of PM commands the execution of such information. Although the prospective and retrospective components of PM are interconnected, the modest correlation between the two components indicates that these entities are functionally distinct (Jones et al., 2006; Schmitter-Edgecombe, Woo, & Greeley, 2009).

The two major paradigms that have been developed to evaluate PM in the laboratory setting include time-based and event-based tasks. In time-based PM tasks, the prospective task is carried out at a specified time interval (e.g., after 10 minutes). In event-based tasks, the prospective component is carried out in response to a target event or stimulus (e.g., button press when a target word appears). These two types of tasks can differ in levels of cognitive demand and effort. Time-based tasks are generally considered more cognitively demanding than event-based tasks as the former requires more self-initiation and monitoring (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Kliegel, Jäger, & Phillips, 2008).

While several studies have found that individuals with MCI perform more poorly on time-as compared to event-based PM tasks (Costa et al., 2010; Troyer & Murphy, 2007), a recent meta-analytic review of PM in MCI revealed comparably sized deficits for time- and event-based PM performances (van den Berg, Kant, & Postma, 2012). As van den Berg and colleagues (2012) indicated, task type may not be the only determinant of level of sensitivity of a PM task. Consistent with the multi-process framework of PM (McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004), the level of cognitive demand of a PM cue may be manipulated to create a higher level of sensitivity regardless of task type. McDaniel and colleagues (2000; 2004) proposed that successful completion of PM tasks may rely on both automatic processing and effortful, strategic monitoring. According to the multi-process theory, prospective remembering should require more effortful, strategic monitoring in situations where the cue lacks distinctiveness, is peripheral to the ongoing task being completed, and/or is not highly related to the PM action.

In a recent event-based PM study comparing the performances of individuals with MCI/AD and healthy adult groups, Blanco-Campal and colleagues (2009) altered the specificity and saliency of an event-based focal cue. A PM focal cue is broadly defined as a cue that is a prominent part of the ongoing task (e.g., read sentences as an ongoing task and press a button whenever a PM target word appears in the sentence). In the Blanco-Campal et al. study, the PM cue was either a specific target word (specific condition) or an exemplar within a given category (non-specific condition). Half of the cues in each condition were italicized (salient) while the other half were non-italicized (non-salient). All PM cues were embedded in silly sentences. The authors found that all but the specific-salient condition were sensitive to the group differences, noting that the more cognitively effortful non-specific conditions were most powerful in distinguishing MCI/AD from the cognitively healthy adults.

Aside from creating different types of event-based focal cues, a higher cognitive demand may be induced by using a non-focal event-based cue. A non-focal PM cue is conceptualized as one in which the ongoing task does not draw attention to processing of the PM target. Replicating previous findings, McDaniel, Shelton, Breneiser, Moynan, and Balota (2011) demonstrated that very mild dementia participants performed more poorly than healthy older adults in an event-based task that used a focal cue (i.e., press key when

target word appeared during a category decision task). Both groups also performed more poorly in a non-focal cue condition (i.e., press key when a word containing a target syllable appeared during the category decision task) than in a focal cue condition. Surprisingly, the very mild dementia and healthy adults did not differ statistically in the more resource demanding, non-focal cue condition. While one interpretation was that the monitoring processes in very mild AD were not compromised beyond that of normal aging in the more resource demanding event-based PM task, an alternative explanation was that the non-focal cue was too challenging given the near floor performance of the healthy participants. In this study, we further evaluate PM performance in individuals with MCI using a non-focal event-based PM cue that has not shown floor effects in a healthy older adult population (Park, Hertzog, Kidder, Morrell & Mayhorn, 1997).

The current study procedure was modeled after work by Park et al. (1997), which used an event-based PM cue that is considered non-focal in nature (McDaniel et al., 2011). The ongoing task was a verbal working memory task with a high attentional demand. The words used in the ongoing task were presented on a computer screen against a continuously changing patterned background (see Figure 1). The PM task required participants to respond when a specified target background pattern appeared. As evidenced by finding that the non-focal PM task had a higher cost to performance on the concurrent working memory task than a time-based PM task, Park et al. (1997) concluded that the non-focal PM task had a substantial attentional requirement. In work from our laboratory (Schmitter-Edgecombe & Wright, 2004), which directly compared the non-focal PM task used in this study with a comparable focal PM task (i.e., respond when target word appeared as part of the ongoing memory task; background pattern irrelevant), we similarly found that more effort was required to monitor for the PM cue in the non-focal condition as compared to the focal condition. Importantly, neither study showed floor effects for the non-focal PM task. We therefore hypothesized that the MCI group would exhibit poorer prospective remembering than healthy older adults on the event-based non-focal PM task.

As a secondary goal, we also aim to extend research in this area by evaluating the relationship between PM performance in a non-focal paradigm and neuropsychological tests assessing verbal intelligence, speeded processing, working memory, retrospective memory and executive functions. While spontaneous retrieval processes and medial temporal lobe structures have been linked with focal PM task performance, strategic monitoring and prefrontal processes have been linked with non-focal PM task performance (McDaniel et al., 2011; Reynolds, West, & Braver, 2009). In addition, we evaluate the relationship between PM deficits and self- and informant-report of everyday memory lapses. PM deficits have implications for everyday functioning. Data suggest that everyday PM deficits (e.g., forgetting an appointment) are viewed as more frustrating than everyday RM deficits (e.g., forgetting what was eaten for breakfast) to both individuals and caretakers (Smith, Della Sala, Logie, & Maylor, 2000). In addition, subjective and objective measures of PM in healthy adults have been found to account for significant variance in the ability to perform complex instrumental activities of daily living (Woods, Weinborn, Velnoweth, Rooney, and Bucks, 2011). Similarly, PM task performance has been shown to significantly predict everyday functional limitations above and beyond RM deficits for individuals with MCI (Schmitter-Edgecombe et al., 2009).

METHOD

Participants

Thirty-one individuals with amnesic MCI initially completed the PM task. Of the 31 individuals with MCI, one participant was removed for not meeting inclusion criteria (i.e. Geriatric Depression Scale > 18; GDS; Yesavage, et al., 1983) and another for performing

below chance on the ongoing verbal working memory task. An additional five participants were excluded because they failed to respond to a single PM cue and were unable to recall the PM task instructions, suggesting difficulties with the retrospective component of the PM task. This left a total of 24 individuals with MCI and their age and education matched cognitively healthy adults for data analysis (see Table 1 for demographics). The seven amnesic MCI participants that were removed from the analysis did not differ in age ($M = 68.29$, $p = .18$), education ($M = 15.71$, $p = .62$), or gender (43% female, $p = .74$) from the final sample.

Participants were recruited for a series of studies investigating the relationship between memory and everyday abilities in older adults (see Schmitter-Edgecombe, Woo & Greeley, 2009). Recruitment was carried out through local advertisements as well as referrals from physicians and community agencies. Exclusion criteria included the following: (1) head trauma with permanent brain lesion, (2) psychoactive substance abuse currently or within the past year, (3) history of cerebrovascular accidents, and (4) medical, neurological, or psychiatric disorders that resulted in cognitive dysfunctions (e.g., epilepsy, schizophrenia). Medical interview and the telephone interview of Cognitive Status (TICS; Brandt & Folstein, 2003) were conducted in the initial phone screening to exclude participants who did not meet the inclusion criteria. The Clinical Dementia Rating was then completed via phone with potential participants and a knowledgeable informant (CDR; Morris, 1993) to assess dementia staging and to rule out individuals who were significantly cognitively impaired.

Participants who met study screening criteria then completed a battery of experimental and standardized neuropsychological tests. The tests were administered across two testing sessions, each lasting between two to three hours. Inclusion criteria for the amnesic MCI group included: (a) self- or informant-report of memory difficulties for a minimum of at least 6 months; (b) performance at least 1.5 SD below the mean of age and education matched peers on at least one of the following memory measures from the Rey Auditory Verbal Learning Test (RAVLT, Lezak, 1983) or the 7/24 Spatial Recall Task (Rao, Hammeke, McQuillen, Khatri, & Lloyd, 1984): five trial learning, immediate recall, or delayed recall; (c) CDR score of 0.5 (questionable dementia), which is consistent with minimal change in the participant's everyday habits; (d) non-fulfillment of the diagnostic criteria for probable or possible AD (American Psychiatric Association, 2000); (e) generally preserved cognitive functions as confirmed by a normal score on the MMSE (normality cutoff score: 24; Measso, Cavarzeran, Zappalà, & Lebowitz, 1993); and (f) absence of severe depression as confirmed by a score below 18 on the GDS. We did not distinguish further between amnesic MCI single domain ($N = 11$) and multi-domain ($N = 13$) due to small sample size. Collateral medical information, including the results of laboratory and brain imaging studies, were obtained and reviewed when available.

All of the healthy older adults met exclusion criteria, reported no history of cognitive changes, had a CDR score of 0, a GDS score below 18, and an MMSE score within normal limits. As can be seen in Table 1, the MCI group performed more poorly than the cognitively healthy adults on all administered memory and language measures, as well as on a test of attention/speeded processing (Symbol Digit Modalities Test; Smith, 1991), working memory (WAIS-III Letter-number Sequencing subtest; Wechsler, 1997), and executive functioning (Trails B; Reitan, 1958). The two groups did not differ significantly on the Shipley vocabulary measure (Zachary, 1991), Trails A (Reitan, 1958), and three of the four measures of executive functioning (i.e., D-KEFS letter and design fluency subtests; Delis, Kaplan, & Kramer, 2001, and Clox 1; Royall, Cordes, & Polk, 1998).

Stimuli

Twenty high frequency words (Kucera & Francis, 1967) in red lower case letters (Arial, 48 point, bold) were presented in the center of a computer screen. Each word was 4-6 letters in length and 1-2 syllables. Each word was superimposed onto a black and white patterned background. Six different black and white patterns served as the background. The stimuli (i.e., word and patterned background) were presented one at a time for three seconds by Super Pro Beta Version Experimental Lab Software (1999). Words were pseudo-randomized such that words were not repeated more than five times during the experimental task. In addition, at least three trials occurred before a word or patterned background was repeated. All participants received the same presentation sequence. The distance between the computer screen and the participants was measured to roughly 45 cm. The entire stimulus display subtended 11.30° in height and 18.77° in length.

To evaluate everyday memory abilities, participants and their informants were asked to complete the Memory Functioning Questionnaire (Gilewski & Zelinski, 1988). The questionnaire contains a total of 64 questions and 4 subscales (general frequency of forgetting, seriousness of forgetting, retrospective functioning, and mnemonic usage). The MFQ has been shown to have moderate concurrent validity with memory measures (Zelinski, Gilewski, & Anthony-Bergstone, 1990) and the four subscales have demonstrated invariance across age (Gilewski, Zelinski and Schaie, 1990). For the purpose of this study, we used the general frequency of forgetting subscale (33 questions total), which has shown good internal consistency (Cronbach's $\alpha = .94$; Gilewski et al., 1990). Both the participant and the participant's informant rated the frequency of the participant's everyday memory lapses for each question (e.g., appointments, keeping up correspondences) using a 7-point Likert scale (1 = *always*; 4 = *sometimes*; 7 = *never*).

Procedures

Participants began by first practicing the ongoing task (5 trials) without the PM component. For the ongoing working memory task, participants were instructed to actively monitor the words on the computer screen and at all times to keep in mind the last three words that appeared on the screen. No mention was made at this point of the changing background patterns because they were conceptually unrelated to the working memory task. At varying intervals, when the word "recall" appeared on the computer screen, participants were told to say aloud the last three words that appeared on the screen. The number of words presented prior to each "recall" screen varied between seven to 14 words, with 21 to 42 seconds elapsing. The experimenter, who was blind to the experimental design and hypotheses, recorded the responses of the participants.

Following completion of the practice trials for the ongoing task, the PM instructions were introduced. Participants were shown the target background pattern and told to press the semi-colon key on the keyboard whenever the target background pattern appeared. While participants were told that we were interested in their memory skills and in their ability to remember to do something in the future, it was emphasized that recalling the words was their primary task. Consistent with prior work (e.g., Einstein & McDaniel, 1990; Park et al., 1997), the ongoing task component was emphasized because in everyday life prospective responding generally occurs within the context of another ongoing task. Following presentation of the PM task instructions, participants were asked to describe what they were supposed to do to ensure that the participants understood the instructions and the PM target had been properly encoded. Participants responded to only one target background pattern in the PM condition so that the retrospective component of the PM task would be low. Once the experimental task started (20 recall trials), no further mention was made of the PM cue. Consistent with the Park et al. study design, as well as with recommendations from prior

research regarding the frequency of presenting event-based cues to maximize sensitivity without producing ceiling effects (Ellis, Kvavilashvili, & Milne, 1999), the non-focal PM cue appeared eight times within the last 8 minutes of the 10-minute task.

Following completion of the experimental trials, if the participant failed to respond on the final PM trial, they were queried to determine their memory for the PM instructions. As indicated earlier, five MCI participants were removed for failing to recall the PM instructions indicating a retrospective memory failure. Upon task completion, participants self-reported the amount of conscious attention they felt they had dedicated to looking for the PM cue by providing a conscious effort rating on a 5-point Likert scale (1 = little conscious effort, the pattern popped out when it appeared; 5 = continuously constantly reminded myself to look for the target pattern).

RESULTS

Analyses

Skewness and kurtosis of the PM and ongoing task accuracy measures and the self- and informant-report questionnaire measures fell reasonably close to normal, as suggested by skewness and kurtosis values generally between -1.0 and $+1.0$. T-test analyses were therefore conducted to compare differences between groups on these measures. Non-parametric Mann-Whitney U Tests revealed similar findings for all group comparisons. Cohen's d effect sizes were calculated to indicate the relative strength of significant group differences. Pearson's correlational coefficients were conducted separately for each group to explore the relationships between the PM accuracy measure, the self- and informant-report frequency of everyday forgetting measures, and the neuropsychological tests of verbal intelligence, memory, attention/speed, working memory, executive abilities and language found in Table 1. Non-parametric Spearman's rho and Kendall's tau correlations were also conducted and revealed a similar pattern of findings.

Working Memory and Prospective Memory Performances

The ongoing working memory and PM task accuracies are presented in Figure 2 as the percentage of correct trials (i.e., correct trials/total trials * 100). T-tests were conducted to evaluate group differences on the ongoing task and in prospective remembering. In comparison to the healthy older adults ($M = 87\%$), the MCI group ($M = 79\%$) was significantly less accurate in completing the ongoing task, $t(46) = 2.49$, $d = 0.72$, $p = .02$. The MCI group ($M = 46\%$) also performed more poorly than the healthy adults ($M = 68\%$) on the PM component, $t(46) = 2.15$, $d = 0.62$, $p < 0.04$. To evaluate whether the poorer ongoing task performance of the MCI group affected their prospective remembering, we matched a subset of 15 individuals with MCI ($M = 81\%$) and 15 healthy older adults ($M = 82\%$) in ongoing task performance, $t(28) = .29$, $d = .09$, $p = .77$. Examination of the prospective remembering of this matched subset revealed findings that approached significance, $t(28) = 1.97$, $d = .75$, $p = .06$, with the MCI group responding to the non-focal PM target on average 43% of the time and the healthy older adults 67% of the time. Due to the smaller sample size, the matched subset analysis did not reach statistical significance; however, the effect size was comparable to the full group analysis.

Mean group self-reported PM effort ratings were compared to evaluate for any group differences in the amount of conscious effort placed on the PM component. T-test comparison showed no statistically significant difference in the effort ratings of the MCI ($M = 3.14$) and the healthy aging ($M = 2.45$) groups, $t(41) = -1.46$, $d = -0.45$, $p = .15$. Both groups reported that around 50% of the time they consciously reminded themselves to look for the target background pattern, while the remainder of the time the non-focal PM cue

seemed to automatically pop out when it appeared during the ongoing WM task.
Correlations with Neuropsychological Measures

Pearson correlations were conducted between the PM accuracy score and the raw scores of verbal intelligence, memory, attention/speeded processing, working memory, executive functioning and language found in Table 1. As can be seen in Table 2, poorer prospective remembering was associated with poorer RAVLT list learning and short-delay recall performances for both the MCI and healthy adult groups. The PM accuracy score also correlated with the RAVLT long delay memory measure for the healthy older adults, and with the 7/24 visuospatial learning measure for the MCI group. In addition to measures of memory, PM accuracy correlated with measures of executive functioning for both the MCI (D-KEFS total) and healthy older adult (Trails B-A/A; Clox1) groups. Prospective remembering also correlated with a working memory measure (WAIS-III Letter-number Sequencing) for the healthy older adults, while the MCI group showed an additional correlation with a temporal lobe language test (BNT; Kaplan, Goodglass, & Weintraub, 1983). The PM accuracy score did not correlate significantly for either group with the measure of verbal intellectual ability or with the attention/speeded processing measures (see Table 2).

Self- and Informant-report of Frequency of Everyday Forgetting

Self- and informant-report of everyday memory lapses was first compared across groups. Correlations were then conducted between the questionnaire measures and the PM accuracy score and neuropsychological tests in Table 1. Data was missing for one participant and their informant in the MCI group. A t-test comparison revealed that the MCI group ($M = 4.35$, $SD = .73$) self-reported more everyday memory lapses on the MFQ general frequency of forgetting subscale than the healthy adults ($M = 4.97$, $SD = .81$), $t(45) = 2.76$, $d = .80$, $p = .008$. Informants also reported that individuals with MCI ($M = 4.24$, $SD = 1.05$) were experiencing a higher frequency of forgetting in everyday life than the healthy older adults ($M = 5.79$, $SD = .62$), $t(45) = 6.18$, $d = 1.80$, $p < .001$.

For the healthy older adults, a significant correlation emerged between prospective remembering and self-report of everyday forgetting ($r = .45$, $p < .05$), indicating that individuals with poorer PM performance self-reported greater everyday memory lapses. This relationship did not reach significance for informant report ($r = .05$, $p = .82$). In addition, of the neuropsychological measures listed in Table 1, the only test to significantly correlate with the MFQ general frequency of forgetting subscale for the healthy adults was Clox 1 for self-report ($r = .42$, $p < .05$; all other correlations between $-.30$ and $.36$). For the MCI group, prospective remembering showed no significant relationship with either self-report ($r = -.17$, $p = .43$) or informant-report ($r = -.28$, $p = .19$) of everyday memory lapses. In addition, neither self-nor informant-report of the frequency of everyday forgetting correlated significantly with the neuropsychological measures in Table 1 (r 's between $-.40$ and $.38$).

DISCUSSION

This study evaluated prospective remembering in individuals with MCI using a non-focal event-based task. Non-focal PM cues are thought to require effortful, strategic monitoring processes because the cue is typically irrelevant to and has low processing overlap with the ongoing task. Prior work using the current study paradigm suggests that participants recruit attention demanding processes to perform this non-focal PM task (Park et al., 1997; Schmitter-Edgecombe & Wright, 2004). To better understand the cognitive mechanisms that may support prospective remembering in this non-focal task, we also investigated the relationship between PM accuracy, neuropsychological test performances and frequency of everyday forgetting separately for both the MCI and healthy older adult groups.

The findings revealed that individuals with amnesic MCI performed more poorly than healthy older adults on a PM task that utilized a non-focal event-based cue. While the non-focal PM cue was challenging, the healthy older adult group performed above chance. These findings contrast with the results of McDaniel et al. (2011) who did not observe significant differences between MCI and healthy aging groups in a non-focal cue condition; however, poorer than expected PM performances were found for both of their groups. This is consistent with the interpretation that the non-focal cue used by McDaniel et al. may have been too difficult for the healthy older adults thus obscuring a possible difference between the MCI and non-clinical groups.

In this study, participants were instructed to focus primarily on the ongoing task. This was done to mimic everyday living where a PM task is typically initiated in the midst of an ongoing event which is the focus of attention. Given that the MCI group performed more poorly than healthy older adults on the ongoing working memory task, it is possible that the ongoing task required more effort of the MCI participants leading to poorer detection of the non-focal cue. We consider this explanation of the findings less likely for several reasons. First, when a subset of MCI and healthy older adult participants were matched for ongoing working memory task accuracy, prospective remembering continued to be poorer in the MCI group. Second, self-ratings of effort directed to the PM task revealed no significant differences between the MCI and healthy adult groups.

It has recently been suggested that spontaneous retrieval processes supported by medial temporal structures may be prominently involved in PM performance for focal PM tasks (McDaniel et al., 2011). In contrast, strategic monitoring processes and prefrontal structures may be more involved in PM performance for non-focal PM tasks (Foster, McDaniel, Repovs, & Hershey, 2009; McDaniel et al., 2011). For the healthy older adults, correlational analyses revealed that the PM accuracy score showed significant relationships with verbal learning and memory measures (i.e., RAVLT) and with tests of working memory and executive functioning. In contrast, the PM accuracy of the healthy adults was not significantly correlated with verbal intelligence, attention/speeded processing or language measures. The significant relationships between PM accuracy and tests predominantly supported by medial temporal lobe and prefrontal structures may suggest that both spontaneous retrieval processes and effortful, strategic monitoring play important roles in supporting PM performance for this non-focal PM task. This argument is also consistent with participant self-ratings of effort, which suggested that close to half of the time they had to consciously remind themselves to look for the target pattern, while the other half of the time the target pattern seemed to spontaneously pop out.

Turning to the cognitive mechanisms that may have contributed to the PM deficits of the MCI participants, correlational analyses revealed that the PM accuracy score significantly correlated with tests of memory, and with a language test (i.e., BNT) thought to be dependent on temporal lobe structures (Balthazar et al., 2010). The PM accuracy score did not correlate significantly with the measures of verbal intelligence and attention/speeded processing. Furthermore, only one of the five working memory and executive measures correlated with PM accuracy. The significant relationship between PM accuracy and tests thought to be predominately supported by medial temporal lobe structures suggests a possible link between the deficient PM memory performance of the MCI participants and impaired spontaneous retrieval processes for this non-focal PM task. This is based on data which suggests that medial temporal structures both support spontaneous associative retrieval (Moscovitch, 1992; 1994) and are prominent areas for plaques and tangles in early AD (Fichman, Oliver, & Fernandes, 2011). In addition, McDaniel et al. (2011) recently suggested that deficits observed on a focal PM task in very early Alzheimer's disease (AD) were linked to impaired spontaneous retrieval. These authors further interpreted the lack of

group differences on the non-focal PM task as suggesting the possibility that very mild AD may not further compromise monitoring processes over that produced by normal aging.

The cognitive correlates that contribute to PM deficits in individuals with amnesic MCI and AD expectedly appear to contrast with findings from individuals with Parkinson's disease and other frontal systems conditions (e.g. Pagni et al., 2009; Raskin et al., 2011). For example, studies with Parkinson's disease patients have generally revealed a stronger link between PM performance and working memory and executive functioning as compared to retrospective memory (Costa, Peppe, Caltagirone, & Carlesimon, 2008; Pagni et al., 2011). Individuals with Parkinson's disease have also been found to perform more poorly than healthy older adults on a non-focal PM task designed to elicit strategic, attentional monitoring, but not on a less effortful focal PM task (Foster et al., 2009). These findings suggest that different impaired cognitive mechanisms (e.g., spontaneous retrieval in individuals with MCI and strategic monitoring in Parkinson's patients), resulting from different underlying brain pathology and associated effects on brain structures (e.g., medial temporal versus prefrontal), may influence performance on event-based PM tasks. Future research is needed to better understand the cognitive mechanisms that result in PM deficits among different clinical populations.

In this study, we conceptualized RM as the process responsible for recalling the event-based target (i.e., the *what* component) and we confirmed that all participants remembered what action needed to be executed for the PM component. However, recall of the event-based target following the task does not necessarily ensure that the target was recognized *during* the task (Smith & Bayen, 2006). Future research should utilize more advanced techniques and modeling (e.g., multinomial processing tree model; Smith & Bayen, 2004; 2006; Pavawalla, Schmitter-Edgecombe, & Smith, 2012) to examine the retrospective recognition component (i.e., the *when* component) thought to be responsible for discriminating between PM targets and nontargets (Smith & Bayen, 2004). The retrospective recognition process could be associated with the poorer PM performance of MCI participants given the significant correlations with the neuropsychological tests of memory.

As expected, both self-report and informant report of everyday forgetting revealed that the MCI group was experiencing a greater frequency of forgetting in everyday life than the healthy older adults. We further found that the healthy older adults who self-reported a higher frequency of forgetting also performed more poorly on the PM task. Aside from performance on Clox 1, no other significant relationships emerged for the healthy older adult group between self-reported frequency of forgetting and cognitive processes, including retrospective memory. This is consistent with prior work that has shown that PM ability is associated with performance on complex activities of daily living in healthy older adults (Woods et al., 2011) and in MCI even after controlling for retrospective memory deficits (Schmitter-Edgecombe et al., 2009). No notable relationships were found in informant data for either the MCI or control group. In addition, for the MCI group, self-report of everyday frequency of forgetting showed no significant relationship with prospective remembering or any other assessed cognitive process. While this may partially reflect inaccurate awareness of everyday memory functioning by the MCI participants (Perrotin, Belleville, & Isingrini, 2007; Vogel et al., 2004), significant relationships between objective measures of memory and subjective self-report of memory abilities have not consistently been found in the literature for either neurologically intact or clinical populations (e.g. Schmidt, Berq, & Deelman, 2001; Suchy, Kraybill, & Franchow, 2011). One possible explanation is that in everyday life compensatory strategies (e.g., writing lists, keeping a daily planner, keeping a routine) can assist in minimizing prospective memory deficits. Consistent with this idea, a recent naturalistic study found that MCI participants who were impaired on laboratory PM

tasks were effectively able to implement delayed intentions in everyday life (Thompson, Henry, Withall, Rendell, & Brodaty, 2011).

Regarding study limitations, the generalizability of the study is limited as the sample consisted of highly educated and Caucasian individuals. The small sample size also lowered the study's power to detect potentially significant relationships between PM accuracy and the neuropsychological testing data, as a moderate correlation was needed for statistical significance. In addition, this study was conducted in a laboratory setting, which reduces the ecological validity of the findings. We also relied on self- and informant-reports as the measure of frequency of everyday forgetting, which may be subjective and requires insight and awareness. In addition, while our study showed poorer PM task performance in the MCI group, future studies should consider collecting data on the ongoing task without the added PM task so that stronger conclusions can be drawn about the effect of the PM manipulation on ongoing task performance.

In summary, we investigated PM abilities using a non-focal event-based task and evaluated the relationship between PM abilities, neuropsychological testing data and frequency of forgetting in everyday life based on self- and informant-report ratings. We found that individuals with MCI performed more poorly than healthy older adults on this non-focal PM task. For the healthy older adults, prospective remembering in this non-focal task appeared to be supported by both spontaneous retrieval processes and effortful, strategic monitoring and was related to self-report of everyday frequency of forgetting. For the MCI participants, the stronger link between prospective remembering and memory and language tests (supported by medial temporal lobe structures) as opposed to executive tests, may suggest that the MCI participants deficient PM performances on this non-focal PM task were particularly linked to impaired spontaneous retrieval processes.

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Figure 1.
Example of stimulus items.

Figure 2. Percentage Correct on the Ongoing Working Memory and Prospective Memory Tasks for the MCI and Healthy Older Adult Groups (bar represents standard error). * $p < .05$

Table 1
Demographic and Neuropsychological Testing Data for the MCI and Healthy Older Adult Groups

	MCI (N=24)		Healthy Older Adults (N=24)		<i>t</i>	<i>p</i>	<i>d</i>
	Mean	SD	Mean	SD			
Age (yrs)	73.88	10.76	73.25	9.03	-0.22	.83	0.05
Education (yrs)	16.17	2.65	16.08	2.70	-0.11	.92	0.03
Gender	12f, 12m	--	15f, 9m	--	--	--	--
Ethnicity	24 C	--	24 C	--			
CDR	0.5 ^a	--	0 ^a	--	--	--	--
MMSE	27.22 ^a	1.65	28.63	1.38	3.18	.003 [*]	0.93
<i>Verbal Intelligence</i>							
SILS Vocabulary	33.96	6.91	36.00	5.59	1.98	.054	.32
<i>Memory</i>							
RAVLT - LL	34.75	6.52	47.54	9.79	5.33	<.001 [*]	1.54
RAVLT - SD	4.92	2.99	9.38	2.83	5.32	<.001 [*]	1.53
RAVLT-LD	5.04	2.84	9.21	3.19	4.78	<.001 [*]	1.38
7/24 learning	23.38	6.22	30.17	4.77	4.25	<.001 [*]	1.23
7/24 - SD	4.30 ^a	1.96	5.67	2.06	2.32	.03 [*]	0.68
7/24 - LD	4.33	1.99	5.58	1.79	2.29	.03 [*]	0.66
<i>Attention/speed</i>							
SDMT written	33.67	8.43	42.38	11.54	2.99	.005 [*]	0.86
Trails A (time)	45.35	9.37	39.71	13.18	-1.69	.10	0.49
<i>Working memory</i>							
WAIS-III LN	7.79	2.17	10.01	2.65	3.46	.001 [*]	0.92
<i>Executive</i>							
D-KEFS LF	36.96	14.25	37.25	10.81	.08	.94	0.02
Trails B-A/A	2.15 ^a	.97	1.41	.85	-2.78	.008 [*]	0.81
D-KEFS DF	20.83 ^a	6.86	24.21	6.93	1.68	.10	0.49

	MCI (N=24)		Healthy Older Adults (N=24)		<i>t</i>	<i>p</i>	<i>d</i>
	Mean	SD	Mean	SD			
Clox 1	11.79	2.19	12.92	2.26	1.75	.09	0.51
<i>Language</i>							
BNT	51.00	9.10	56.46	2.96	2.80	.008*	0.81
D-KEFS CF	35.46	8.52	40.58	8.94	2.03	.048*	0.59

Notes. Unless otherwise indicated, mean scores are raw scores. MCI = Mild Cognitive Impairment; CDR = Clinical Dementia Rating; MMSE = Mini Mental State Exam; SILS = Shipley Institute of Living Scale; RA VLT = Rey Auditory Verbal Learning Test; SD = Short Delay; LL = List Learning; LD = List Learning; 7/24 = 7/24 Spatial Recall Task; SDMT = Symbol Digit Modalities; WAIS-III = Wechsler Adult Intelligence Scale-Third Edition; D-KEFS = Delis-Kaplan Executive Functioning Scale; LF = Letter Fluency subtest; CF = Category Fluency subtest; BNT = Boston Naming Test; C = Caucasian.

^a n = 23.
* *p* < 0.05.

Table 2

Correlations of Neuropsychological Testing Data with Prospective Memory Accuracy for the MCI and Healthy Older Adult Groups

	<u>Prospective Memory Accuracy</u>	
	MCI (N=24)	Healthy Older Adults (N=24)
<i>Verbal Intelligence</i>		
SILS Vocabulary	.07	.38
<i>Memory</i>		
RAVLT - LL	.62 **	.57 **
RAVLT - SD ^a	.44 *	.69 **
RAVLT-LD	.34	.55 **
7/24 learning	.65 **	.01
7/24 SD	.24	-.01
7/24 - LD	.34	-.09
<i>Attention/speed</i>		
SDMT written	.39	.37
Trails A (time)	-.22	-.14
<i>Working memory</i>		
WAIS-III LN	.29	.43 *
<i>Executive</i>		
D-KEFS LF	-.31	.25
Trails B-A/A ^a	.05	-.45 *
D-KEFS DF ^a	.45 *	.31
Clox 1	.05	.45 *
<i>Language</i>		
BNT	.45 *	.33
D-KEFS CF	.31	.30

Notes. MCI = Mild Cognitive Impairment; SILS = Shipley Institute of Living Scale; RAVLT = Rey Auditory Verbal Learning Test; SD = Short Delay; LL = List Learning, LD = Long Delay; 7/24 = 7/24 Spatial Recall Task; SDMT = Symbol Digit Modalities; WAIS-III = Wechsler Adult Intelligence Scale-Third Edition; D-KEFS = Delis-Kaplan Executive Functioning Scale; LF = Letter Fluency subtest; DF = Design Fluency subtest; CF = Category Fluency subtest; BNT = Boston Naming Test

^a n = 23.

* p < 0.05

** p < .005.