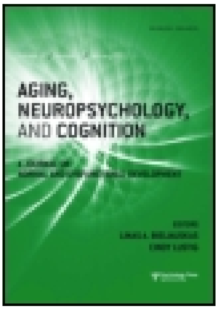

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Differential effects of delay on time-based prospective memory in younger and older adults

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ABSTRACT

The current study measured forgetting in a time-based, naturalistic prospective memory (PM) task. In Experiment 1, younger and older participants were asked to mail a stamped postcard on a date that was delayed 1, 2, 5, 14, or 28 days in the future. In Experiment 2, a different sample of older participants completed the same task with similar delays to replicate results for the older sample in Experiment 1. Overall, older participants were more likely than younger participants to mail the postcard on time. In addition, delay affected on-time return rates more for the younger participants than the older participants. Younger participants' return rates illustrated the typical forgetting curve seen in numerous retrospective memory studies (i.e., rapid decline at shorter delays and slower decline for longer delays). However, older participants' return rates only declined at the longest delays. These results indicate that time-based PM performance declines with an increase in delay, but the form of the decline may differ across age groups.

Keywords: Prospective memory; Forgetting; Aging.

Prospective memory (PM) refers to remembering to perform a future task, such as going to a meeting on time or stopping for an item at the store on your way home from work (Einstein & McDaniel, 1990). Failures in PM can be minor annoyances (e.g., forgetting to buy milk) or can have

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serious health consequences (e.g., forgetting a dose of medication). It has been estimated that about half of the forgetting reported in everyday situations can be attributed to failures in PM (Crovitz & Daniel, 1984). Successful PM performance involves forming the intention and retrieving it, involving spontaneous retrieval (Guynn, McDaniel, & Einstein, 2001) or effortful monitoring processes (Smith, 2003). As noted by McDaniel and Einstein (2000), who proposed a multi-process framework, there is evidence consistent with both approaches. For example, older adults, who typically have deficits in monitoring and attentional processes (Salthouse, 1996) and self-initiating retrieval (Craik, 1986), sometimes show no decrements in PM performance compared to young adults (e.g., Einstein & McDaniel, 1990, but see Maylor, 1993, 1996), thus supporting a spontaneous retrieval account. Conversely, when the ongoing task requires more attentional resources, PM performance declines, supporting a role for attentional monitoring (e.g., McDaniel, Robinson-Riegler, & Einstein, 1998). See McDaniel and Einstein (2007a) and Kliegel, McDaniel, and Einstein (2007) for recent reviews of PM.

Because of the importance of successful PM for an aging population (who frequently have to take medications or schedule follow-up medical appointments), understanding how PM is affected by age and delay is critical for implementing successful interventions. In particular, it is important to assess how individuals remember to perform actions in the context of everyday life, especially when the delay between when the intention to perform these actions is formed and the action is executed is fairly long. Retrospective memory generally shows rapid forgetting early in the retention interval, with a gradual slowing at longer delays. The question addressed here is whether PM also follows a similar decay function and whether younger and older adults show similar forgetting rates and functions.

Types of PM Tasks

In typical PM studies, a PM task is embedded within another ongoing task. In naturalistic studies, a PM task (e.g., mail back a postcard, call the researcher) is given to participants to complete during their everyday activities. In laboratory studies, participants perform trials of an ongoing cognitive task (e.g., making word/nonword decisions) with an additional task (e.g., press a particular key when a target word is presented) given concurrently with the ongoing task. This type of PM task has been described as an event-based task (Einstein & McDaniel, 2005), because the participants are cued to perform the PM task when a specific cue (i.e., event) appears. In time-based tasks participants are asked to perform the PM task at a specific time during the ongoing task (e.g., after 3 minutes or 1 day). With these two classifications of PM tasks, each PM task can be defined by factorially crossing the setting (naturalistic or laboratory-based) and the type of cue (time- or event-based). As we discuss, the majority of studies examining forgetting in

PM in recent years have used event-based laboratory tasks, and there has been relatively little work examining long (over 1 day) retention intervals in naturalistic tasks.

Most recent studies of PM performance have been event-based studies conducted in laboratory settings with relatively few naturalistic, time-based studies being reported. However, a common aspect of PM tasks that people encounter in everyday life, such as remembering to pay a bill on time or taking medication at a set time, are indeed time-based. Thus, because of its relevance to everyday situations in which one must perform actions at a given time, in the absence of explicit cues, we examined a time-based PM task (mailing a postcard back on a specific date) over relatively long delays.

Age Effects in PM Performance

Older adults typically perform worse than younger adults on retrospective memory tasks (e.g., Balota, Dolan, & Duchek, 2000; Salthouse, 1996) as well as in event-based PM tasks (see Henry, MacLeod, Phillips, and Crawford, 2004, for a review). Specific deficits are observed in tasks that require self-initiated performance (Craik, 1986), such as free recall tasks. Thus, older adults are expected to perform particularly poorly in time-based tasks, where external cues (e.g., the target word) are not available and individuals need to rely on self-initiated processes to complete the task (e.g., Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995).

In a recent meta-analysis of age effects in PM, Henry et al. (2004; see also Aberle, Rendell, Rose, McDaniel, & Kliegel, 2010) reported that, although laboratory studies reveal negative effects of age (i.e., younger participants outperform older participants), naturalistic studies show positive effects of age (i.e., older participants outperform younger participants) for both time- and event-based PM tasks, with medium to large effect sizes. This "age-prospective memory paradox" (Rendell & Craik, 2000) indicates that the method with which PM is studied (i.e., laboratory-based tasks that prevent use of external reminders versus naturalistic studies that often allow use of external reminders) appears to be an important factor in determining whether age effects will be positive or negative. Interestingly, even when instructed not to use reminders, older adults can still outperform younger adults in naturalistic tasks (Rendell & Craik, 2000). Possible explanations for this paradox include different levels of motivation (e.g., Aberle et al., 2010, but see Kvavilashvili & Fisher, 2007), increased use of reminders (Masumoto, Nishimura, Tabuchi, & Fujita, 2011), and the notion that older adults have more structured and less active lives (but see Bailey, Henry, Rendell, Phillips, & Kliegel, 2006). Finally, frequency of thought has been found to affect performance on PM tasks, at least in young adults (e.g., Kvavilashvili & Fisher, 2007).

Delay Effects in PM Tasks

The primary goal of the current study was to examine how delay affects completion of a naturalistic, time-based PM task in both young and old adults. As noted earlier, most recent research has focused on event-based laboratory tasks, and most have tested college-aged students. In such studies, delay effects are mixed, with some studies finding no declines across delays of 20 to 30 minutes (Einstein, Holland, McDaniel, & Guynn, 1992; Guynn, McDaniel, & Einstein, 1998) and others finding declines as delay increased (e.g., Brandimonte & Passolunghi, 1994; Loftus, 1971; McBride, Beckner, & Abney, 2011; Meier, Zimmermann, & Perrig, 2006). Furthermore, most studies used short delays of less than 1 hour.

An important issue in naturalistic PM studies, as noted above, concerns the use of external reminders. When reminders, such as making a note on a calendar, are used, it becomes less clear what construct is being measured. In other words, reminders such as writing an appointment in a calendar minimize the memory demands, much as writing down a phone number makes it unnecessary to commit it to memory. Difficulty controlling reminder use has possibly resulted in the relatively limited number of studies examining naturalistic, time-based PM performance. For example, Wilkins (1979, as cited in McDaniel & Einstein, 2007a) asked participants to mail back postcards after 2 to 36 days. Delay did not affect completion of task. However, use of external reminders was not directly examined in this study. Devolder, Brigham, and Pressley (1990) asked young and older adults to make eight phone calls over a 4-week period (2 per week). Older adults outperformed young adults, but there was no report of whether performance changed across the delay and delay was a within-subjects manipulation. Once again, no assessment of reminder use was reported.

In a study that did examine use of external reminders, Meacham and Singer (1977) asked college-aged participants to mail postcards over a period of 8 weeks on dates designated on the cards. They manipulated the incentive given to participants (reinforcement for completing the task or no reinforcement) and compared participants' reported remembering strategies. Overall, most participants reported using external reminders compared to simply remembering the task internally and this was especially true for individuals with an incentive to complete the task. Data showed a trend ($p < .10$) for an association between use of an external reminder and fewer late mailings of the postcards. However, there was no report of how the delay affected performance. More recently, Kvavilashvili and Fisher (2007) found that participants reported few self-initiated reminders when they were asked to call the researcher at a designated time 7 days later. Although participants in this study were explicitly asked to refrain from using external reminders, there was no direct assessment of external reminder use.

Of note, none of the studies in the Henry et al. (2004) review tested delay effects in a naturalistic, time-based PM task. The few that did examine delay in different age groups were standard, laboratory, event-based PM studies with relatively short delays. One such study (Einstein et al., 1992) compared PM task performance across two delays, where the long delay was 15 minutes longer than the short delay and found no effect of delay for younger or older participants. Thus, it remains unclear how longer delay effects interact with age effects in naturalistic, time-based PM tasks.

THE CURRENT STUDY

The current study was designed to examine the effects of delay on a naturalistic PM task that involved multiple intervening tasks as participants went about their daily lives and compare the effects of delay on time-based PM across age groups. Given the mixed findings in past studies regarding delay, we tested the effect of multiple delays. Younger and older participants were asked to mail a stamped postcard after a delay ranging from 1 to 28 or 30 days. Participants were asked not to use external reminders as a way to make these tasks more comparable to laboratory-based tasks where external reminders are typically absent. In a follow-up questionnaire, we asked about factors that have been proposed as causes of PM performance differences across age groups: use of external reminders (e.g., Masumoto et al., 2011; Rendell & Craik, 2000), frequency of thought about the task (e.g., as evidence of more engagement in the task, higher conscientiousness, or higher levels of planning to complete the task, McDaniel & Einstein, 2000), and motivation (e.g., Henry et al., 2004). Participants in both experiments were told that if they remembered to mail in the card they would be entered into a drawing for a $50 gift card, providing additional motivation for completing the PM task. Based on the results of Henry et al.'s (2004) meta-analysis of the effects of age on PM task performance, we expected older participants to outperform younger participants overall on this naturalistic PM task. Experiment 2 tested a second older adult sample in the same tasks to compare a retirement-community-dwelling sample with a community-dwelling sample to rule out effects of reminders from other members of the retirement community who were also involved in the study in Experiment 1.

To examine delay effects, various functions (see Wixted & Ebbesen, 1999, for a range of functions fit to forgetting data) were fit to the on-time return rate data to determine if PM performance declines in a similar fashion to forgetting seen in retrospective memory tasks (i.e., rapid decline for shorter delays and slower decline for longer delays). Results showing forgetting similar to typical retrospective memory in a PM task in young adults were reported by McBride et al. (2011) for an event-based laboratory PM task with short delays (up to 20 minutes). Thus, form of forgetting was examined for the time-based, naturalistic PM task used in the current study in an attempt to extend these findings to other types of PM tasks. In sum, our primary objectives were to: (1) provide missing data concerning the effects of multiple, long delays on naturalistic time-based PM performance; (2) examine the form of forgetting functions in such tasks; (3) determine whether older adults outperform young adults over a delay; and (4) examine factors that may influence effects of delay and age on PM performance (e.g., external reminders, motivation).

Experiment 1

Method

Participants

One hundred participants of each age group (younger and older) were tested. Younger adults (mean age = 19.46, $SD = 1.44$, range 18–25) were recruited from the undergraduate participant pool at Illinois State University and received course credit for their participation. Healthy older adults (mean age = 80.16, $SD = 8.25$, range 57–98) were recruited from retirement communities in central Iowa. An additional seven older subjects were tested, but were omitted from analyses because they either reported current issues with dementia in a screening that involved self-reports ($n = 5$) or asked to be removed from the study after their session ($n = 2$). The mean education level for younger subjects was 13.69 years ($SD = 1.14$); for older subjects it was 15.02 years ($SD = 2.28$), $t(198) = 5.21$, $p < .001$. In the younger group, 20 participants were randomly assigned to each delay condition. In the older group, 19–21 participants were randomly assigned to each delay condition.

Materials and Procedure

Although younger participants were tested individually, and older participants were tested in groups at their retirement community, all participants followed the same procedure. At the session, they completed a packet of questionnaires including a demographic sheet and three other questionnaires unrelated to data reported here. After completing the packet, participants were given a stamped postcard with a date on the back. They were instructed to mail the postcard on the date written on the card. Participants were randomly assigned to delay conditions of 1, 2, 5, 14, or 28 days. Due to an experimenter error, four of the 20 older participants in the 28-day delay condition were asked to mail the postcard back after 31 days instead of 28 days. These individuals were included in the 28-day condition. If the mail date for the card fell on a Sunday, participants were asked to mail the card back on the day after

(Monday). This adjustment only applied to two younger participants and four older participants in the 5-day delay condition.

Participants were asked not to use external reminders to remember to mail the card (e.g., not to write it in their schedule, ask someone to remind them, or use a post-it). If they forgot to mail the card on the date listed, they were asked to mail the card as soon as they remembered after that date. They were also told that if they remembered to mail the card, they would be entered into a drawing for a $50 gift card. Postcards were considered mailed on time if the postmark date on the card was within 2 days of the assigned mail date. For cards with an illegible postmark (23.7 and 17.2% of returned cards from younger and older participants, respectively), cards were judged on time if they were received within 4 days of the mail date assigned to the participant, which was the modal time taken to receive cards with a legible postmark.

Approximately 1 week after the mail date assigned, regardless of whether the postcard had been received, each participant was mailed a follow-up questionnaire and debriefing form. They were asked to complete the questionnaire before reading the debriefing statement. The questionnaire included items regarding how often the participant thought about mailing the card during the delay (i.e., a measure of monitoring[1]); whether they used external reminders to remember to mail the card; if they used external reminders, what the reminders were; and how motivated they were to remember to mail the card on a 1 to 7 scale. Of the 100 subjects in each group, 73 participants in the older age group and 60 participants in the younger age group returned the follow-up questionnaire. For the younger participants, 10–15 from each delay condition returned the questionnaire. For the older participants, 12–17 from each delay condition returned the questionnaires. Thus, questionnaire responses reflect all delay conditions.[2]

Results and Discussion

Within each age group, none of the groups in each condition differed significantly in terms of age or education variables, all Fs < 2.0, all ps $> .12$. Thus, any differences in performance on the PM task cannot be attributed to group differences.

[1] As noted by Kvavilashvili and Fisher (2007), spontaneous retrieval was highly likely to occur in naturalistic PM tasks. We acknowledge that this is possibly reflected in our data; however, our questionnaire did not ask participants to discriminate between intentional and spontaneous retrieval.

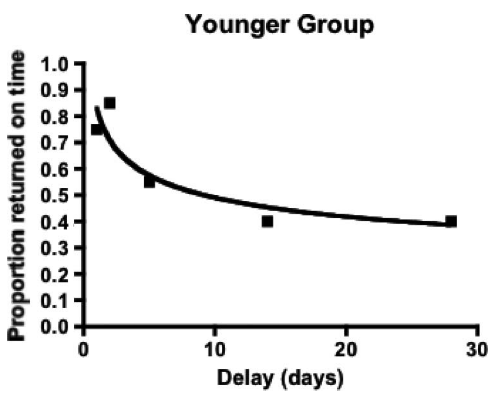
[2] It should be noted that the majority of participants who returned the questionnaire also mailed the postcard on time, thus resulting in a restriction of range for some analyses. Thus, we report primarily qualitative analyses for some of the data.

Prospective Memory Task

Overall, 87% of the older participants and 59% of the younger participants mailed the card on time, thus replicating earlier findings of better PM performance in naturalistic tasks in older relative to younger populations. Cards that were received but not considered on time were all received after the participant had been mailed the follow-up questionnaire (3% of sample for younger adults and 4% of sample for older adults). Thus, these participants likely mailed the card only after the follow-up questionnaire provided a reminder to mail the postcard.

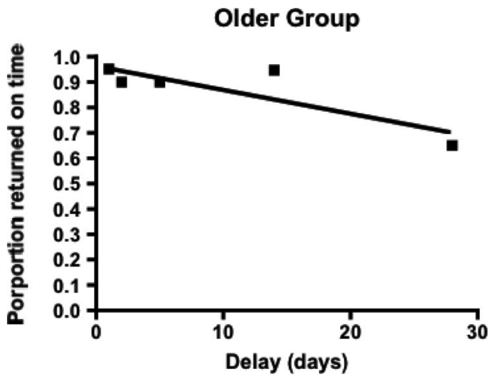
Figures 1 and 2 contain on-time return rates for younger and older participants, respectively, by delay condition.[3] Overall, performance for the younger group was significantly different across delays, Kruskal–Wallis test, $p = .008$. Figure 1 illustrates that PM task performance declined rapidly for shorter delays but more slowly for longer delays. This forgetting function is similar to functions typically seen in retrospective memory tasks and is similar to data reported by McBride et al. (2011) for a laboratory-based PM task, in which subjects could not rely on external reminders. Power, exponential, and linear functions were fit to the on-time return rate data for younger participants. A power function ($R^2 = .82$) was found to fit the data better than an exponential function ($R^2 = .74$) and a linear function ($R^2 = .66$), based on R^2 values and is shown in Figure 1.

FIGURE 1. On-time postcard return rates for younger participants by delay condition for Experiment 1. Best-fit power function is overlaid onto the data points.



[3] We used an ANOVA to examine the age group × delay interaction (see Rosenthal & Rosnow, 1991, for use of ANOVA with dichotomous dependent variables), which was significant, $F(4,190) = 2.53$, $p = .042$, indicating that the pattern of performance across delays differed for the two age groups.

FIGURE 2. On-time postcard return rates for older participants by delay condition for Experiment 1. Best-fit linear function is overlaid onto the data points.



As seen in Figure 2, the older participant data appear to follow a different function from the younger participant data. The on-time return rate for the older participants was very high overall and did not decline across the first four delay conditions according to a Kruskal–Wallis test, $p = .81$. However, when all five delay conditions were compared, there was a significant difference, Kruskal–Wallis test, $p = .001$, indicating that performance only declined for the older participants at the 28-day delay. Exponential and power functions fit to the older participant data both yielded poor descriptions of the older data, $R^2 = .68$ and $R^2 = .43$, respectively. However, a linear function provided a slightly better fit to these data than either of the nonlinear fits, $R^2 = .71$. Thus, this function is shown in Figure 2. Clearly, potential ceiling effects, especially in the older adult data place constraints on model fits; however, the distribution of the data is strikingly different between age groups. As shall be seen, this pattern persists in a second experiment with a different aging sample.

Questionnaire Data

In the follow-up questionnaire, participants indicated how often they thought about the postcard task before the mail date. Table 1 includes the frequency data for these responses. From the frequencies in the table, one can see that younger participants thought about the task more often than older participants, $\chi^2(6) = 14.98$, $p = .02$. Because young adults were less, not more, likely to return the postcard, it seems unlikely that reported thought frequency can account for the PM data. Rather, it is possible that thought frequency reports reflect differences in retrospective memory or biases, such that younger adults remember thinking about the PM task more often or

TABLE 1. Proportion responses for how often participants thought about the task

	Younger	Older: Exp 1	Older: Exp 2
More than once a day	0.12	0.10	0.10
Once a day	0.35	0.16	0.20
Once every couple of days	0.28	0.18	0.25
Once a week	0.05	0.12	0.08
Once before mail date	0.17	0.32	0.27
Never	0.03	0.08	0.05
No response	0.00	0.04	0.03

that older adults underestimated their objective thought frequency. Frequency of thought was related to delay condition in older adults, $\chi^2(24) = 45.30$, $p = .005$, but not in young adults, $\chi^2(20) = 27.01$, $p = .14$. We also examined whether the use of external aids, specifically a calendar, affected thought frequency. It is possible that "off-loading" the reminder into the surrounding environment would reduce the need to think about the PM task. Because older adults were more likely to use external aids and reported thinking about the task less, these two effects might be associated. We compared reported thought frequency across reminder use and found no differences in either age group, both ps $> .56$. This suggests that external reminder use does not have a strong effect on thought frequency. To further examine this, we focused the comparison on the participants reporting use of a calendar and those reporting no reminder use. Once again, there were no differences in reported thought frequency in either age group, both ps $> .71$. Thus, thought frequency does not seem to be influenced by the use of external memory aids.

Participants also indicated if they had used external reminders to remember to mail the card and if so, what type of reminder they used. Table 2 presents frequency data for these responses. Reminder use did not vary as a function of delay, in either the older adults, $\chi^2(20) = 22.04$, $p = .34$, or in the younger adults, $\chi^2(20) = 24.73$, $p = .21$. The most common reminder used in both groups was to leave the card in view (something we could not prevent without asking the participants to place the card someplace out of view, which is comparable to asking them to "hide the card"). We include this response in the category of reminder use because it is the most conservative approach. Older participants (60%) reported that they used an external reminder more than the younger participants (52%). A χ^2 analysis indicated a significant difference in responses shown in Table 1 for the two age groups, $\chi^2(6) = 13.89$, $p = .03$. This difference may provide one possible explanation for the higher performance in the older group. To investigate this possibility, we examined PM accuracy including only participants who reported using no reminders. These data are displayed in Table 3. Older participants still show

Table 2. Proportion responses for use of external reminders

	Younger	Older: Exp. 1	Older: Exp. 2
No use of reminder	0.43	0.30	0.30
Put in calendar	0.07	0.25	0.13
Used post-it	0.01	0.00	0.02
Left card in view	0.43	0.32	0.45
Kept date in mind	0.02	0.01	0.03
No response	0.03	0.11	0.03

Table 3. PM accuracy rates by delay and age group for subjects who did not report use of external reminders

	Including "Left Card in View" responses						Omitting "Left Card in View" responses					
	Younger		Older: Exp. 1		Older: Exp. 2		Younger		Older: Exp. 1		Older: Exp. 2	
	n	*M*	*n*	*M*	*n*	*M*	*n*	*M*	*n*	*M*	*n*	*M*
Delay												
1 day	13	0.62	0.10	0.90	16	0.87	5	0.83	4	1.00	6	0.86
2 days	15	0.80	0.13	0.92	14	0.93	4	0.67	4	0.88	5	1.00
5 days	14	0.43	0.13	0.92	19	0.79	5	0.83	6	1.00	7	0.78
14 days	13	0.31	0.10	1.00	20	0.75	3	0.75	4	1.00	3	0.50
30 days	14	0.29	0.11	0.45	16	0.87	3	0.75	1	0.33	3	0.75

Note: Means in the left-most columns include participants who "left the card in view" because omission of these data resulted in very few participants in each group. The means reflecting the more conservative scoring in which "leaving the card in view" was considered an external reminder are presented in the right-most columns.

higher performance than younger participants for the first four delays, with a significant decline in performance for the 28-day delay. Thus, at least at the earlier delays, the pattern of PM accuracy does not change when people reporting use of external reminders are removed. Clearly this analysis is limited because of the very small number of participants in each age group who did not use some sort of reminder (22 older adults and 26 younger adults). Using a more liberal approach, in which leaving the card in view was not included as a reminder, a very similar pattern was observed, in which older adults still outperform younger adults at all delays. In terms of ecological validity, leaving the card in view seems a plausible behavior, much like someone taking a medication might leave it on the counter in view.

Another possible explanation may be motivation to perform the task: Older participants ($M = 6.26$) reported being more motivated than the younger subjects ($M = 5.52$), $t(131) = 3.08$, $p = .003$. In fact, 83.5% of older adults rated their motivation as a 6 or 7, whereas only 60% of younger adults gave the highest ratings for motivation. The difference in the distribution of motivation levels as a function of age was reliable, $\chi^2(1) = 8.34$, $p = .004$. Thus, the higher motivation level of the older group may have contributed to their higher performance in all delay conditions (see Aberle et al., 2010). Motivation was related to PM accuracy in the younger adult sample, $r(60) = .26$, $p = .048$, but was not related to PM accuracy in the older adult sample, $r(73) = .01$, $p = .98$.

Experiment 2

One concern about the high PM performance for older adults in Experiment 1 is that, because participants were living in residential communities, they might have discussed the study or reminded one another of the task. To address this issue, we tested a different sample of older community-dwelling participants. Furthermore, because participants were tested individually, we were able to collect more fine-grained measures of cognitive performance (presented in Table 4).

Method

Participants

Participants were recruited from the community surrounding Waterville, Maine, and lived independently. Postcards were initially given to 119 participants. As in Experiment 1, all participants were informed their names would be entered into a drawing for a $50 gift card. Fifteen participants' data were omitted from the final analyses based on their responses to the post-test questionnaire: five reported they were out of town on the mail date, two indicated they had misunderstood the directions, one indicated being under 60, and one reported asking someone else to mail it. An additional six participants' data (i.e., three couples) were omitted because they were married or cohabiting and we wanted to minimize the possibility of incidental or intentional reminders from other participants in the study. Finally, data from one participant were omitted because of concerns about cognitive impairment. Thus, the final data set included 20 participants in the 1-day condition, 20 in the 2-day condition, 20 in the 5-day condition, 21 in the 14-day condition, and 22 in the 30-day condition. Participants completed the same questionnaires and were given the same instructions as in Experiment 1. All but 11 participants were tested individually and also administered a battery of cognitive tasks assessing working memory (Operation Span task; Unsworth, Heitz, Schrock, & Engle, 2005), vocabulary (Shipley, 1940), executive control (Trails B; Reitan, 1958), and processing speed (Digit Symbol Substitution Test, DSST; Wechsler, 1997). The other 11 participants were members of a local American Association of University Women (AAUW) and were given the questionnaires and postcards

TABLE 4. Demographic characteristics and cognitive scores of participants in Experiment 2

			Operation Span		Shipley Vocabulary		Digit Symbol Substitution		Trails B	
Condition	Age (SD)	Education (SD)	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N
1 day	68.45 (6.87)	15 (2.2)	22.39 (10.04)	18	35.44 (3.63)	16	47.33 (10.30)	18	92.56 (39.22)	18
2 days	68.30 (7.64)	16.05 (3.22)	22.23 (7.34)	13	34.64 (4.43)	14	53.60 (10.10)	15	72.93 (30.91)	15
5days	69.39 (7.27)	16.60 (3.75)	19.12 (8.75)	16	34.57 (3.72)	14	53.50 (7.88)	16	84.13 (51)	16
14 days	68.10 (5.56)	15.33 (2.48)	19.11 (6.72)	18	34.47 (4.98)	17	50.39 (12.34)	18	90.89 (60.04)	18
30 days	69.96 (6.45)	17 (1.85)	21.76 (7.02)	17	35.53 (2.94)	17	49.06 (11.57)	17	84.37 (37.22)	18

individually following a meeting and thus did not complete the cognitive battery. Table 4 presents demographic data for all participants as a function of condition. Participants' mean age in Experiment 2 was 67.69 (SD = 5.73, range = 60–87).

Results and Discussion

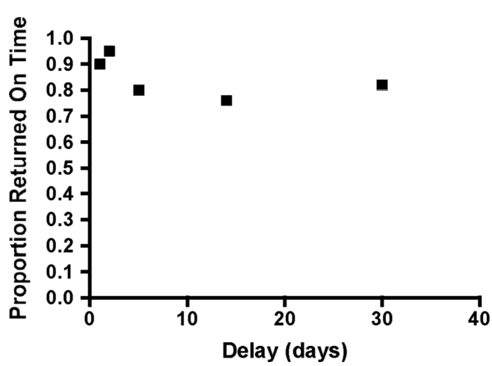
None of the groups differed significantly in terms of age, education, or any cognitive variables, all Fs < 2.0, all ps > .11. Thus, any differences in performance on the PM task cannot be attributed to group differences.

Prospective Memory Task

In Experiment 2, accuracy on the task was determined from the postmark: Accurate responses were defined by a postmark on the due date or within 2 days of the due date. For cards not returned on the correct date, the majority was postmarked for a day after the follow-up questionnaire should have been received. The mean return rate for Experiment 2 was 85%. This is highly consistent with return rates seen in the older sample in Experiment 1 (M = 87%). Thus, the type of sample (retirement community vs. community-dwelling) did not influence overall PM accuracy.

Figure 3 presents the on-time return rates for Experiment 2 by delay. As in Experiment 1, PM accuracy was high and declined little across the delays. A Kruskal–Wallis test showed no significant change across delays, p = .46. None of the functions fit to these data fit well (power, R^2 = .56, linear, R^2 = .27), thus, no best-fit function is included in Figure 3.[4]

FIGURE 3. On-time postcard return rates for Experiment 2 by delay condition.



[4] To examine whether individual differences as assessed by the measures of cognitive abilities modulated PM accuracy, we performed a logistic regression in which PM accuracy was the outcome variable and

Questionnaire Data

Follow-up questionnaire data indicated similar responses to those seen in the sample in Experiment 1. Table 1 indicates how often subjects thought about the PM task: Most participants thought about the task once before the mail date or every couple of days. Fewer participants indicated using reminders in Experiment 2 than Experiment 1, with the highest percentage again reporting that they left the card in view in their residence. Table 2 presents the breakdown of responses on this item. As in Experiment 1, reminder use did not vary across delay conditions, $\chi^2(24) = 19.73$, $p = .71$. Table 3 shows response rates by delay for participants in Experiment 2 who did not report using an external reminder as consistent with our instructions. Response rates are similar to those seen in Figure 3; therefore, use of external reminders did not affect PM accuracy rates. Finally, motivation rates for completing the task remained high in the older adults. Of those who returned the questionnaire, 82.3% rated their motivation as 6 or 7 on the 7-point scale provided and mean motivation rating was 6.32, which is very similar to the mean motivation rating in the older sample in Experiment 1 ($M = 6.26$). In contrast to Experiment 1, motivation was related to accuracy for the older adults in Experiment 2, $r(93) = .25$, $p < .013$.

Comparison of Experiments 1 and 2

Although the overall response rate in Experiment 2 was similar to that seen for older adults in Experiment 1, a different pattern of forgetting was seen in the data in Experiment 2. In Experiment 2, a non-significant decline was seen after 2 days, whereas in Experiment 1 the decline in accuracy was not seen until after the 14-day delay. In Experiment 1, PM accuracy for older adults remained at or above 90% for delays of 1 to 14 days, whereas in Experiment 2, PM accuracy declined below 90% after 2 days. Response rates for the longer delays in Experiment 2 ranged between 82 and 76%, which is slightly higher than the 28-day delay rate in Experiment 1 ($M = 65\%$). Thus, the type of sample affected the specific pattern of decline in PM accuracy, with the Experiment 2 sample showing no significant forgetting across delays and high PM accuracy for the longest delay than the sample in Experiment 1. The two older samples differed in age, $t(178) = 11.48$, $p < .001$, and years of education, $t(180) = 2.69$, $p = .008$. However, these differences do not explain the higher rates seen in the Experiment 1 older sample, as the older sample in Experiment 1 was both older ($M = 80.15$, $SD = 8.25$) and less educated

delay, age, education, and the scores from the O-Span, DSST, Trails B, and Shipley were entered as predictors. Only two of the predictors approached conventional significance levels: Years of education was negatively related to PM performance ($B = -0.30$, $p = .053$) and working memory, as assessed by the O-Span task, was positively related to PM accuracy ($B = 0.12$, $p = .068$).

($M = 14.94$, $SD = 2.41$) than the sample in Experiment 2 (age: $M = 67.69$, $SD = 5.73$, years of education: $M = 15.98$, $SD = 2.77$).

Because we did not perform any formal dementia screening in either experiment, but relied instead on self-reports, it is possible that some individuals with very early stage dementia or mild cognitive impairment were included in the samples. However, if anything, inclusion of such participants should have resulted in overall depressed PM performance, as individuals with dementia typically perform worse than younger adults and healthy controls on PM tasks (e.g., Duchek, Balota, & Cortese, 2006). However, the absence of formal screening might account for the small differences in overall levels of PM performance across experiments, which were slightly lower in Experiment 2 than in Experiment 1. As noted, only one participant's data were omitted in Experiment 2 because of possible cognitive impairment compared to the five in Experiment 1. One possibility is that the individuals in the residential community might have been more likely to self-report than community-dwelling older adults.

An apparent discrepancy emerged in the two experiments regarding the role of motivation and PM performance. Whereas younger adults in Experiment 1 and older adults in Experiment 2 showed positive relationships between motivation and accuracy of approximately the same magnitude ($r = .26$ and .25, respectively), older adults in Experiment 1 failed to show a significant correlation. To examine this discrepancy further, we compared the distribution of responses to the motivation question for the two groups of older adults. There was no difference in the frequency of responses, $\chi^2(7) = 10.69$, $p = .15$, suggesting that motivation was equivalent across groups. However, when we compared accuracy rates across the older groups, there was a marginally significant difference, such that performance in Experiment 1 ($M = 0.93$) was higher than performance in Experiment 2 ($M = 0.84$), $t(175) = 1.89$, $p = .06$. Thus, it is possible that the failure to detect a correlation between motivation and accuracy in Experiment 1 could be due to the functional ceiling effects in PM accuracy. However, in the two samples with greater variability in PM performance (younger adults and older adults in Experiment 2), it appears that increased motivation to complete the task can be associated with actual performance.

GENERAL DISCUSSION

There were four primary goals in the current study: to further test the effects of delay in naturalistic, time-based PM tasks, to compare these effects across age groups, to examine the form of the forgetting functions for these groups, and to examine factors that might explain age groups differences in naturalistic PM tasks. In both experiments, older adults showed very high levels of performance with little forgetting even at the longest delay, whereas younger adults' data showed a forgetting curve similar to that observed in retrospective memory studies (see Wixted & Ebbesen, 1999). Thus, even after an extended delay, older adults still outperform younger adults in time-based naturalistic PM tasks.

In Experiment 1, PM performance declined across delays for both younger and older participants. Importantly, the nature of the decline differed by age group. For younger participants a power function accounted for a large portion of the variance in these data. Older participants' performance showed no decline across delays of 1 to 14 days, but declined between 14- and 28-day delays. These results are consistent with those reported in previous studies (e.g., Kvavilashvili & Fisher, 2007) that found higher performance for older than younger participants for naturalistic PM tasks. Experiment 2 confirmed the high rates of PM accuracy for this task in a community-dwelling older adult sample. Although no significant decline was seen in the response rates in Experiment 2, overall rates were similar to those seen in Experiment 1. Thus, the type of older adult sample did not affect overall rates. Although older adults living in a retirement community might have been able to benefit from reminders within the community to support high levels of performance, this does not seem to have been driving the overall effects, considering the similarity between the two older adult groups.

Three possible causes for the higher performance on the PM task for older than younger participants were explored: use of reminders, frequency of thought about the task, and motivation to complete the task. A larger proportion of older participants reported using external reminders on the posttest questionnaires than younger participants, despite being instructed not to use such reminders. Importantly, however, an examination of the PM accuracy data with these participants removed showed similar results to the full data set in both experiments. Thus, the use of external reminders was not the likely cause of the higher performance in the older group. However, the higher motivation ratings provided by the older participants support the idea that they placed a greater importance on the task than the younger participants. Older adults have reported higher motivation levels than young adults in PM studies (e.g., Aberle et al., 2010), although, as noted above, both older and younger adults' accuracy was positively related to their motivation level. Thus, both age groups do show the predicted relationship between motivation and PM performance. What we suggest here, however, is that the overall motivation level of the older group was higher ($M = 6.26$ and $M = 6.32$ in Experiments 1 and 2, respectively) than the motivation reported by young adults ($M = 5.52$) and that this absolute motivation level underscores the performance difference. Clearly, we cannot directly address the role of motivation here, because we do not have a group of participants who were not given incentives, but we can assume, based on prior work (e.g., Aberle et al., 2010) that incentives did increase both groups' motivation levels. Interestingly, increasing motivation, for example, by offering monetary incentives, does not always result in similar benefits in retrospective memory (Hartley, Harker, & Walsh, 1980; Hill, Storandt, & Simeone, 1990). Placing greater emphasis on the task may have resulted in more attentional resources devoted to remembering the task in the older group, thus resulting in a shifting of priorities toward the task (Castel, 2008).

The embedding of the PM task in one's everyday tasks might have also contributed to older adults' high performance. Hicks, Marsh, and Russell (2000) found that intervening tasks could boost PM performance in laboratory-based tasks. Although this has not been directly tested in time-based naturalistic tasks, it is possible that older adults benefitted from the opportunity to retrieve the PM intention throughout the delay. Further, there may have been fewer tasks competing for the older participants' attention during the delay. The older participants who were living in retirement communities were likely to have fewer daily activities to keep track of and more regular, structured lives than the college students (Henry et al., 2004; Rendell & Thomson, 1999; but see Bailey et al., 2006). However, because the same pattern was observed in a community-dwelling sample, it is unlikely this is the main cause of the high PM performance.

Interestingly, younger adults reported thinking about the PM task more frequently than either of the older adult samples. It is possible that the group living arrangement for the older participants in Experiment 1 may have allowed them to prompt each other to complete the task, although no participants reported being reminded by another person on the posttest questionnaire. Furthermore, similar results on the PM task and on the post-test questionnaire items were found across the two older adult samples in Experiments 1 and 2, showing that type of older adult sample was not a likely cause for the results seen in the older adults in Experiment 1.

One possibility is that thoughts about the PM task allowed participants to create event connections with the time-based task. For example, if one was asked to mail the card on Wednesday, they could have thought "I will mail the card before I leave for my [doctor's] appointment on Wednesday". This might have in a sense functionally transformed the time-based task into an event-based task. However, our questionnaire data do not allow us to determine the likelihood of this occurring and this is a potential issue in most naturalistic tasks, in which the level of experimenter control is necessarily reduced and participants might engage in a variety of strategies.

Although the current study was not designed to test between competing accounts of the processes underlying PM performance, we believe the current results are consistent with predictions made by multi-process theory (McDaniel & Einstein, 2000). Although multi-process theory was originally developed to explain performance in event-based PM tasks, it may also apply to time-based tasks. The majority of the participants who returned the follow-up questionnaire reported using an external cue strategy, with the largest proportion of individuals in all samples indicating they left the card in view as a reminder. Thus, it is likely that these external cues allowed subjects to spontaneously retrieve the PM task at least once before the mail date. Given the larger proportion of older adults reporting use of external reminders than the proportion in the younger sample, reliance on external cues for spontaneous retrieval of the PM task may account for the higher PM accuracy in the older samples overall. It is also possible that older participants in the current study spontaneously retrieved the PM task more often than younger participants across the time delays due to the greater emphasis they placed on the task. Posttest questionnaire data show that, overall, younger participants thought about the task more frequently than older participants, but this does not rule out the possibility that older participants increased thoughts about the task as the mail date approached.

Another factor that might have supported older adults' performance is the "regularity" of the task: As Aberle et al. (2010) reported, more regular tasks resulted in no age effects, whereas irregular tasks showed typical age effects, with younger adults outperforming the older adults. It seems possible that older adults, who have more experience maintaining a household and having regularly occurring bills, are simply more used to planning and scheduling an event such as posting something in the mail. Thus, they might have been better able to form a rich and detailed intention when given the task, thus supporting their enhanced performance (Kliegel, Martin, McDaniel, Einstein, & Moor, 2007). In addition, younger adults might be more likely to communicate and pay bills electronically or online, accounting for the observed age differences. Future studies might address this directly by varying the type of PM task (e.g., emailing or sending a text message to the researcher). However, we note that studies requiring participants to call the researchers (e.g., Kvavilashvili & Fisher, 2007) also report equivalent or higher accuracy in older than younger adults (who, one assumes, are highly experienced with cell phone usage).

In summary, the current study provides evidence that naturalistic, time-based PM task performance declines in a similar manner to retrospective memory task performance for some populations (i.e., younger participants). In addition, the current results indicate that forgetting functions for younger and older participants differ for such PM tasks with older participants showing immunity to forgetting for delays up to 14 days in Experiment 1 and no statistically significant decline in performance across 1 to 30 days in Experiment 2. The knowledge gained in this study may be useful in creating situations where older adults will excel at simple PM tasks. For example, the older subjects in the current study showed superior performance to younger subjects for delays shorter than 1 month when they were motivated to perform the task. Future studies should further explore the relative importance of these factors (delay, motivation, external reminders) in completion of naturalistic, time-based PM tasks.

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