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Effects of delay and reminders on time-based prospective memory in a naturalistic task

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ABSTRACT

The current study examined the effect of a delay on naturalistic time-based prospective memory (PM) tasks. Two experiments were performed to compare PM performance on a texting task with delays of 1 to 6 days after an initial session. In the first experiment, half of the participants were asked to repeat their response with the same delay to test whether requiring a second response (i.e., a repeated PM task, such as taking medication at the same time each day) would affect time-based PM performance. In the second experiment, participants were given an implicit or an explicit reminder several hours before their time to respond to examine the effect of type of reminder on this PM task. The results of both experiments showed a significant decline in PM performance between the 1-day and multi-day delays. Repeating responses (Experiment 1) had no effect on accuracy of the PM task, but in Experiment 2, explicit experimenter-initiated reminders significantly increased time-based PM performance compared with implicit reminders. These results are discussed in the context of previous studies that have tested delay effects on time-based PM and current theoretical descriptions of time-based PM.

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Remembering to carry out a future task is referred to as prospective memory (PM) (Einstein & McDaniel, 1990; Meacham & Singer, 1977). PM is something commonly used in day-to-day life. Examples of PM tasks include remembering to take medication at a certain time or remembering to drop off a package when you see the post office on your way to work. There are two types of PM: event-based and time-based. Event-based PM is defined as remembering to carry out a task when a specific cue is present in the environment (e.g., remembering to mail a package when you see the post office). Time-based PM is remembering to carry out a task at a specific time or after a specific period of time (e.g., remembering to take medication at a certain time, remembering to take the cookies out of the oven in 12 min, Einstein & McDaniel, 1990, 2005). PM failures occur when a person forms the intention to carry out a task in the future but forgets to retrieve that intention at the appropriate time or place. PM is heavily relied on in everyday life, and if a PM failure occurs, there are varying degrees of consequences depending on the importance of the task. One factor that can cause PM failures is the delay between intention formation and execution of the task. The current study examined delay as a factor that affects everyday PM tasks.

There are two primary ways researchers have studied PM: in a laboratory or in a naturalistic setting (i.e., performing the task in their everyday lives, such as using their own phone to respond). In a laboratory setting, participants may be asked to remember to complete a simple task (such as press a key) during an ongoing task, either when a specific stimulus appears (such as a specific word, an event-based task) or after a certain amount of time has passed (such as after 5 min, a time-based task). Note that tasks that are externally valid, such as the Executive Performance in Everyday Living (EPELI) video game (Laine et al., 2023) or the Virtual Week task (Rendell & Craik, 2000) can be completed in a lab setting as well. In a naturalistic task, participants may be asked to complete a task, such as call the researcher when they encounter a specific object in their everyday environment (event-based) or send a text message to the experimenter after a specific time period has passed in their daily activities (time-based).

PM researchers have developed descriptions of the processes responsible for completion of PM tasks (see Rummel & Kvavilashvili, 2023, for a recent review of current theoretical descriptions of PM). The most common views suggest that in many cases an ongoing

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task competes for cognitive resources with the PM task, creating costs to the ongoing task. Where the views differ is in whether maintenance of the PM intention can be automatic or is always effortful (Anderson & McDaniel, 2019; Einstein et al., 2005). In the current literature, a theory with strong support is the Multiprocess (MP) view proposed by McDaniel and Einstein (2000). They suggested that there are two processes at play in PM tasks. The first is a controlled process of monitoring for PM cues, which is an effortful process that consumes cognitive resources (Smith, 2003). The second process, spontaneous retrieval, can prompt retrieval of PM intentions under some conditions, such as when PM cues are salient or the ongoing task involves processing that is consistent with PM cues. Therefore, monitoring for PM cues is not necessary since memory can be automatically retrieved by a stimulus that relates to the PM intention, such as a specific word (Guynn et al., 2001; McDaniel & Einstein, 2000). For example, seeing a sign for the post office can prompt spontaneous retrieval of the intended task of mailing a letter. McDaniel and Einstein (2000) suggest that both processes are involved in PM tasks, calling this the MP view of PM. A more recent version of the MP view, the Dynamic Multiprocess Framework Scullin et al., 2013), proposes that monitoring can come and go during a PM task sequence with spontaneous retrieval filling in when effortful monitoring is no longer maintained.

Effects of delay on time-based PM

Recent studies testing the MP views have mainly focused on event-based PM studied in a laboratory with much less attention paid to time-based tasks. Yet, monitoring the passage of time, a controlled process, is involved in most time-based tasks, and the retrieval of a time-based intention can be triggered by an external cue, such as a clock. These processes are similar to those proposed in the MP views. In addition, many of the earliest PM studies examined naturalistic time-based PM by asking participants to mail postcards to the researcher after a set period of time. For example, Wilkins (as cited in McDaniel & Einstein, 2007) asked participants to mail back postcards after a delay of 2 to 36 days and found no effect of the delay time on performance. More recent time-based PM studies that have been performed in a naturalistic setting have examined the processes that go into successful completion of a PM task. For example, Kvavilashvili and Fisher (2007) completed a study of time-based PM asking participants to make a phone call to the experimenter after a 7-day delay. The results showed that participants rarely relied on self-initiated rehearsal of the task. Instead, they reported thinking about the task after it was triggered by an external cue or spontaneously without any trigger, meaning they used primarily automatic processes to retrieve the intention. However, their study did not manipulate the length of the delay – all participants were asked to respond after a delay of 7 days. Another study that tested 1-day and 3-day delays for a naturalistic time-based PM task was conducted by Schnitzspahn et al. (2020). These researchers compared a number of lab-based and naturalistic event- and time-based tasks in a single study. Mean performance for young adults showed higher performance at the 3-day than the 1-day delay for the naturalistic time-based tasks, but the researchers did not statistically compare the tasks based on delay, and the tasks differed in the type of response requested (send a text for the 1-day delay and call the experimenter for the 3-day delay). Furthermore, the means on this task for the older adults tested showed little difference across delays, with mean performance slightly higher in the 1-day than the 3-day delay and much higher performance than the young adults.

In a study that did compare performance across delays, McBride et al. (2013) examined naturalistic time-based PM in a study looking at how delay affects performance across different age groups (college students and older adults). They included delay periods of 1, 2, 5, 14, or 28 days, asking participants to send a postcard back in the mail after one of these randomly-assigned delays without using any external reminders to help them complete the task. Results showed that for the younger participants, the longer the delay, the more PM performance declined; however, the older adults showed no decline in performance (which was near ceiling) until after the 14-day delay.

Additional studies on time-based PM have taken place in a laboratory setting and involved a relatively short delay period (typically a few minutes) between PM instructions and when participants were asked to complete the PM task. A study by Huang et al. (2014) examined time-based PM in a lab setting. Participants completed an ongoing task and were asked to press a key when 11 min had passed. Participants were discouraged from checking a clock in some conditions, encouraging participants to rely more on internal processes to complete the task. The results showed that, in contrast to participants in the standard clock checking conditions (i.e., clock checking not discouraged), the participants who were discouraged from clock checking had increased costs (i.e., higher reaction times) in the ongoing task when it was paired with the PM task, suggesting that the use of internal processes for time-based PM tasks results in a cost to ongoing tasks. However, this study contained just a single delay of 11 min in all conditions.

In another study, Conte and McBride (2018) compared time- and event-based tasks in a lab setting. The delay periods were between 1 and 6 min. The results showed a decrease in performance for event-based tasks over these time delays, but no difference in performance for time-based tasks across delays. In a follow-up study, McBride and Flaherty (2020) examined the cost of a PM task on ongoing task speed for time- and event-based tasks with a single delay of 7 min. They found evidence supporting the MP predictions for different types of event-based tasks regarding cost to the ongoing task, but for time-based tasks no ongoing task cost was found. In another lab-based study, Guo et al. (2019) increased the length of delay participants received for a time-based PM task by 600 ms in their second experiment compared with their first experiment. In contrast to the Conte and McBride results, these researchers found that a longer delay increased time-based PM performance across experiments. The researchers suggested that the delay provided participants with more time to think about the PM task before it needed to be completed (see Hicks et al., 2000, for a similar argument for event-based PM tasks). Thus, lab-based studies have shown mixed results for effects of delay on time-based PM, with delay decreasing or increasing performance in some cases and showing no effect on performance in others.

Because most recent studies of time-based PM have been laboratory studies where strict environmental control is maintained, the ongoing tasks in many of these studies are somewhat artificial (e.g., lexical decision) compared with naturalistic time-based tasks (e.g., going to meetings throughout one's day). There has been little recent research pertaining to time-based PM studied in a naturalistic setting with some exceptions already noted. There has been even less research on naturalistic time-based PM that examines the effect of delay, with the McBride et al. (2013) study as one exception. Therefore, overall, there are inconsistent findings in the literature on whether a longer delay has a negative effect on time-based PM performance, as it often does for other forms of memory (McBride & Workman, 2017), and this question has not been frequently studied using naturalistic tasks. Some lab studies that have been conducted suggest there is no decline in time-based PM accuracy across shorter delays in the range of a few minutes (Conte & McBride, 2018). Other naturalistic studies have shown that there is a decline in PM performance when the delay is longer (McBride et al., 2013; Schnitzspahn et al., 2020), at least in some conditions. Attempting to resolve these inconsistencies and provide more information about time-based PM studied in a naturalistic setting was the main goal of the current study.

The present study

As Rummel and Kvavilashvili (2023) recently suggested, current PM theories are closely linked with specific laboratory tasks, and there is a need for additional studies using naturalistic tasks to further refine these theories. Furthermore, both Wójcik et al. (2020) and Schnitzspahn et al. (2020) showed that timed-based PM tasks were more common than event-based tasks when participants reported self-assigned PM tasks in their daily lives. Thus, the current study focused on time-based naturalistic tasks to further our understanding of the factors that can aid or hinder this type of everyday PM. Focusing on these tasks will contribute to our understanding of how specific factors may affect lab-based and naturalistic tasks in different ways. We chose to examine delays between intention formation and the appropriate time to complete the PM task across several days, as this manipulation models more typical everyday PM tasks and has been infrequently studied in these tasks. Further, repetition of PM tasks and types of reminders are key aspects of naturalistic PM tasks. Therefore, each of these factors was tested in one of the current experiments (see the introductions to those experiments for more details).

The present study was designed to test the effect of delays between 1 and 6 days on time-based PM in a naturalistic setting. For this task, participants were asked to text the researcher a specific message at a time between 1 and 6 days after the initial instruction session without using any self-constructed external reminders. At the initial instruction session, participants chose specific target times to send their text responses that worked best according to their schedule on the day that the delay was due to end. By letting the participant choose what time they texted the researcher, it reduced the chance that if PM failed, it was due to the participant being unavailable at the time the text was to be sent. Furthermore, choosing the time to complete the task models many daily PM tasks students complete. Delay was manipulated in both experiments. The hypothesis for both experiments was that the longer the delay period, the more PM performance would decline. This prediction was based on previous research showing that longer delays in time-based PM produce lower PM performance in young adults (McBride et al., 2013; Schnitzspahn et al., 2020).

Experiment 1

Experiment 1 tested time-based PM performance for delays of 1, 3, and 6 days in a between-subjects design. An additional factor of task repetition was also included. Half of the participants were asked to repeat the text response a second time with the same delay as the first response, whereas the other participants were only asked to complete the texting task once after one of the three delay periods. This is an important question because many PM tasks are done repeatedly (e.g., taking medication every 6 hr, picking up children from school at 3:00 pm every weekday). Although a few studies have asked participants to respond multiple times for the same task in a naturalistic time-based task, none we are aware of have compared response accuracy based on multiple responses. For example, Devolder et al. (1990) required participants to respond a total of eight times throughout their experiment. Participants were required to call the experimenter twice per week for 4 weeks. However, no analyses were performed on PM accuracy based on number of responses and no differentiating delay conditions were included in the experiment. In addition, Niedźwieńska and Barzykowski (2012) asked participants to call the experimenter a total of four times. However, no analysis was performed on how PM accuracy differed across the different numbers of responses. Because habitual PM tasks are a common part of everyday life (e.g., routines followed on a daily or weekly basis), there is a need for additional studies that examine how repeated responses over long periods of time affect time-based PM performance. We expected performance to increase for the second response, especially for the shorter delays due to an additional reminder from the completion of the first response and/or the instructions provided by the experimenter for the second response.

Method

Participants

In Experiment 1, 212 Illinois State University undergraduates received course credit for participating in the study. Our goal was to run approximately 30 participants in each of the 6 conditions. Participants who completed the posttest questionnaire were entered into a $50 gift card drawing as an incentive to complete the survey. Each participant was randomly assigned to one of the six between-subjects conditions. From the 212 total, 24 participants were excluded from analyses due to a variety of reasons, such as an inability to send a text message on the day they were asked to send the message ($n = 1$), technical difficulties with the text messaging app sending text messages for a period of time ($n = 10$), complications with the texting app sending text messages to international numbers ($n = 2$), experimenter error ($n = 5$), and a clear lack of understanding the instructions by participants ($n = 6$). Thus, 188 sets of data were analysed, with each condition containing between 28 and 35 participants due to random assignment.

Design

The experiment was a 2×3 between-subjects design. The factors were delay (1-, 3-, or 6-day delay) and recurrence of response (response was repeated, response was not repeated). Accuracy of PM was measured by whether the participants sent the text message early, on-time, late, or if no text was sent or the text was sent 31 min or more past the scheduled time of the text. On-time performance was defined as within a 10-min window around the target time (a definition the participants were not aware of). This time frame has been used in previous studies (e.g., Kvavilashvili & Fisher, 2007; Schnitzspahn et al., 2020) to categorise on-time responses for similar time-based naturalistic tasks ranging across days. Late responses were defined as 30-min after the target time to allow for a specific time at which to send the follow-up survey to the participants in cases where no PM response was made.

Materials

After participants signed up to participate in the study, they were emailed a link to the virtual instruction session and the consent statement. The instruction session took place over Zoom due to pandemic conditions. After participants gave verbal consent, they were asked if they had access to a device with texting capabilities, as this was a necessary requirement in order to complete the experiment. Only one person declined participation for this reason. After the instruction session, the experimenters communicated with the participants via a text messaging app. After participants completed their PM task (either once or twice, depending on assigned condition), or did not complete it within a 30-min time frame, they were texted a link to a short questionnaire and debriefing statement. The questionnaire asked for the last four digits of the participant's phone number so that the experimenters could connect their responses with their texting data. Participants were asked if they used any type of reminder to help them complete their task. If they indicated that they used a reminder, they were asked what type of reminder they used. In order to understand how often participants internally reminded themselves of completing the PM task, the questionnaire asked how often they thought about completing the task. Finally, participants were asked how motivated they were to complete their task on a scale from 1–5 (1 indicating not motivated at all and 5 indicating extremely motivated).

Procedure

At the start of the virtual instruction session, participants were randomly assigned to one of the six conditions. Participants gave verbal consent and were asked if they had access to a device with texting capabilities. The experimenter recorded their phone number and sent them a trial text message. All participants were informed that they would receive course credit for attending the instructional session but would not be placed into the drawing to win the $50 gift card unless they completed the questionnaire at the end of the study to encourage completion of the questionnaire.

For the PM task, participants were asked to send a text message that said, "checking in" to the phone number that the trial text message came from, either 1, 3, or 6 days from the time of the instructional session. The time the text message was to be sent on the day that the delay period expired was chosen by the participant – the experimenter asked them to provide a time when they knew they would be available to send the text message. Once the participant named a specific time, this was recorded by the experimenter and confirmed once more with the participant. Use of any reminders was prohibited, and participants were informed of this. After all instructions were given, the experimenter ended the instruction session.

The participant's PM response was counted as "early" if the participant sent the text message 11 to 30 min before the text was scheduled to be sent (none were sent earlier than 30 min before the scheduled time). It was counted as "on time" if the text message was sent within 10 min (before or after) of the scheduled time. The participant's

PM response was counted as "late" if the text was sent 11 to 30 min after the scheduled time. Any time a text was sent outside of the above time frames, it was counted as a "no response" (cf. Schnitzspahn et al., 2020). However, it was noted if a participant remembered to complete their PM task, even if the text was sent outside of the 30-min window.

After the 30-min response time had passed, participants were either sent a link to the post-study questionnaire and debriefing statement or asked to send another text message (repeating their assigned delay) depending on the response condition they were randomly assigned to. Participants in the repeated response conditions were asked to send another text message 1, 3 or 6 days from the time the first text message was sent (the same delay as the first response). All participants who were asked to schedule a second time to text (90 participants) responded to schedule a second text message regardless of whether they sent the first text message. The time that participants gave to send the second text message was recorded by the experimenter and the same procedure following the "early", "on-time", "late", and "no response" PM task performance categories was followed.

At the end of the experiment, all participants were texted a link to a post-study questionnaire and debriefing statement. The text message also reminded the participants that completing the post-study questionnaire was required in order to be entered into the gift card drawing. The main purpose of the post-study questionnaire was to examine if the participants used reminders to help them complete their PM task. Participants were asked whether or not they used any reminders, and if they admitted to using a reminder, they were asked what type of reminder they used (e.g., an alarm on their phone). In order to examine internal factors PM task performance was impacted by, participants were asked how often they thought about completing their task and how motivated they were to complete it.

Results

Table 1 shows the percentages of participants in each condition who responded on time (within 10 min of the target time), late (11–30 min after the target time), or not at all (which includes those who never responded and those who responded 30 min or more late) for the first PM response.

Table 1. Percentages of responses in each condition and response category for the first PM response.

	On Time	Late	No Response
1 day			
One Response	37.50%	6.25%	56.25%
Two Responses	46.67%	6.67%	46.67%
3 day			
One Response	17.14%	2.86%	77.14%
Two Responses	28.57%	10.71%	60.71%
6 day			
One Response	16.12%	3.23%	77.42%
Two Responses	25.00%	3.13%	71.88%

Note: Out of the 188 total participants analysed, 2 responded early (more than 10 min before the target time) and are not included in the table.

Figure 1 illustrates the percentage of participants who completed the PM task on-time by condition for comparison across delays. A Mann–Whitney U test indicated no difference in PM accuracy across the two response groups for the first PM response, $Z = .275$, $p = .78$. An independent samples Kruskal–Wallis test showed a main effect of delay across the first PM responses for both number of response conditions, $Z = 6.58$, $p = .037$. This effect was then examined for each number of response condition using Jonckheere-Terpstra tests for ordinal factors. For the participants who responded once, the delay effect was significant, $J\text{-}T = 2.01$, $p = .045$, but for the participants who responded twice the delay effect was only near significance, $J\text{-}T = 1.78$, $p = .075$, which is likely due to a decrease in power when the sample was divided in half for the analysis.

Figure 2 shows the percentage of participants who had a scheduled second PM response by delay condition for accuracy on the first and second PM responses. A related-samples Wilcoxon Signed Rank test showed no significant difference between PM 1 and PM 2 responses for the participants who made two PM responses, $z = .18$, $p = .86$. Testing this difference at each delay, showed no significant difference in the accuracy of responses when the 1-, 3-, or 6-day delays were repeated. For the 1-day delay, the difference in accuracy of responses between PM 1 and PM 2 was not significant according to a related-samples Wilcoxon signed rank test, $p = .509$. This was also the case when the 3-day delay condition was repeated, $p = .134$, and when the 6-day delay was repeated, $p = .782$.

Post study questionnaire results

Out of the 188 participants in Experiment 1, 125 (66.49%) completed the post-study survey. Table 2 contains a breakdown of the responses on these items. Only a small percentage reported using self-reminders, despite the instruction to refrain from these remainders. A majority of the participants reported thinking about the task at least once per day, with about half reporting thinking about the task more than once per day. The results of a Pearson r correlation test showed that people who were more motivated completed their PM tasks more accurately, $r(123) = .419$, $p < .01$. Chi-square analyses also indicated that frequency of thought was related to complete and accurate PM1 and PM 2 responses, all $ps \leq .031$. In addition, motivation was significantly correlated with frequency of thought, $r(123) = .396$, $p < .01$, which may be one reason they were more accurate in their responses.

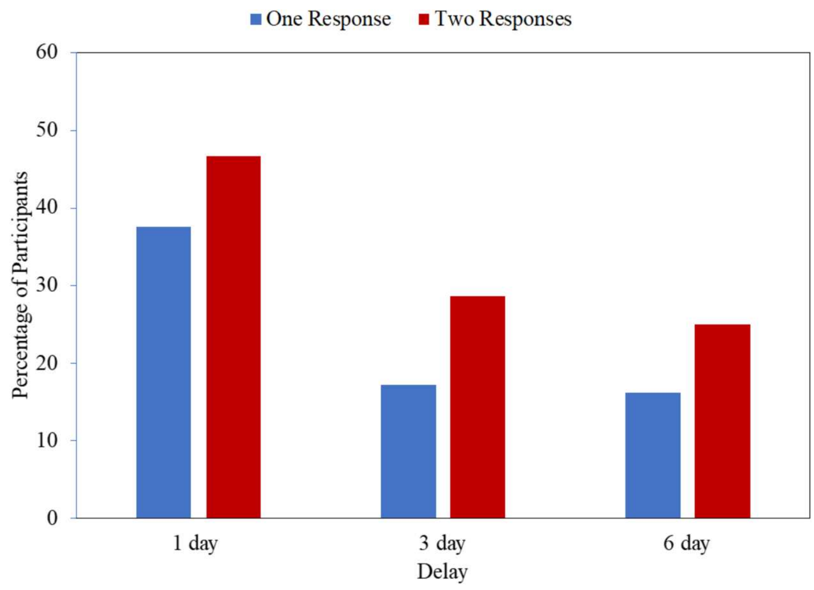

Figure 1. Percentage of participants who responded on time for their first PM response by number of responses condition in Experiment 1.

Experiment 2

Experiment 2 was designed to attempt to replicate the effect of delay on the time-based PM task found in Experiment 1 and to test the new factor of type of reminder. Due to the Experiment 1 results showing no decline in PM performance between the 3- and 6-day delays, we only included the 1- and 6-day delays in Experiment 2 for simplicity and to maximise effect size of the delay effect. Participants received either an explicit or implicit reminder of the PM task from the experimenter several hours before they were to send their text. If spontaneous retrieval is effective for completion of time-based PM tasks, both types of reminders should lead to successful PM performance. However, if spontaneous retrieval is less effective than explicit reminders that likely prompts a monitoring response (at least for a period of time), the explicit reminders should result in better PM performance than the implicit reminders.

One additional change in the methodology of the study should be noted. For practical reasons, we constrained the times participants could choose for their target response times to 2–5 pm. This was done to allow for a reminder time on the morning of the target day that was several hours before participants were to respond. However, participants still chose a specific time within this range (e.g., 3:30 pm) as their target response time, as in Experiment 1.

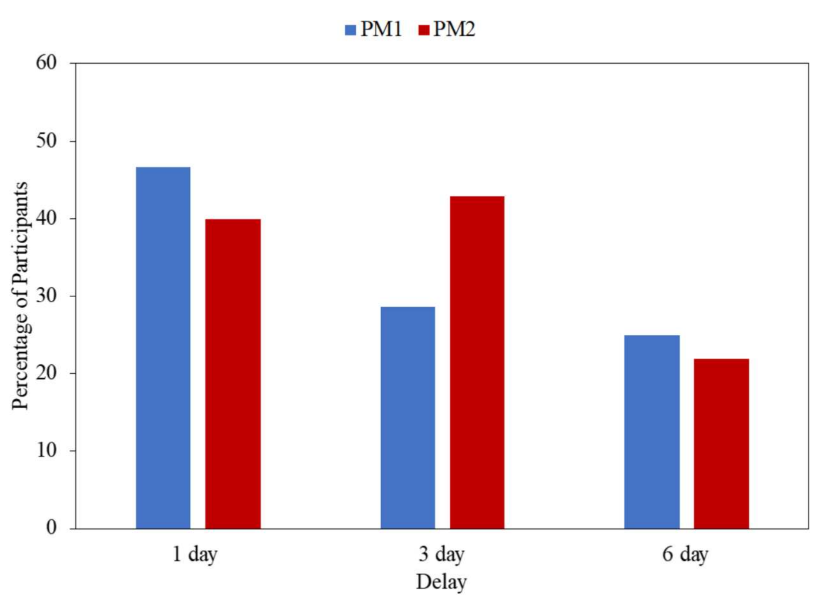

Figure 2. Percentage of participants who completed two PM responses and responded on time in Experiment 1.

Table 2. Posttest Questionnaire Data for Experiments 1 and 2.

	Experiment 1	Experiment 2
Used reminders	6.45%	10.26%
Frequency of thought		
Never	10.48%	6.76%
Right before text	12.10%	6.76%
Once per day	29.84%	36.49%
More than once per day	47.58%	50.00%
Mean Motivation Rating	3.63	3.75

Note. Motivation ratings were given on a 1 to 5 scale. Reminders for Experiment 2 were external self-reminders and did not include the experimenter-provided reminders. These data include participants' reports for both PM 1 and PM 2 responses in Experiment 1, as the survey was given at the end of the study for both groups.

Method

Participants

Experiment 2 included 126 undergraduates enrolled at Illinois State University who received course credit for participating. Participants were randomly assigned to one of the four between-subjects conditions. Each condition had between 28 and 32 participants. A total of 8 participants were excluded from analyses due to experimenter error ($n = 6$), complications with the text messaging app sending text messages to international numbers ($n = 1$), and a participant's reported inability to send a text message within the target timeframe ($n = 1$), leaving 118 sets of data for analyses.

Design

Experiment 2 was a 2×2 between-subjects design. The factors were delay (1- or 6-day delay) and reminder type (implicit or explicit). Accuracy of PM was measured by whether the participant sent the text message on-time (within the 3-hr target window) or outside of the target window/not at all (i.e., "no response").

Materials and procedure

The materials and procedure for Experiment 2 were similar to those used in Experiment 1. However, in Experiment 2, the target response time chosen by the participant was restricted to a 3-hr window on the target day – the participants were instructed that the text message needed to be sent at a time they chose at the instruction session between 2 and 5 pm on the day they were asked to respond. Then, the participants chose a specific time in that window that worked best for them to send their text message (e.g., 4:00 pm). Once the participant chose a time between 2 and 5 pm, the experimenter confirmed this time with them. In addition, the participants were only asked to respond to the PM task once during the study and only the 1- and 6-day delays were included. However, in Experiment 2, a reminder was provided for the PM task to all participants. Half of the participants received an implicit reminder ("BOWL Study: Have a nice day!"), and the other half received an explicit reminder ("BOWL Study: Please do not forget to send a text message to this phone number today at your scheduled time that says, checking in") at 10 am on the day they were scheduled to respond by text for the PM task. This served as a reminder because the participants were aware that the name of this study was BOWL. Participants signed up for the study under its name BOWL and were reminded of the study's name at the instructional session. They also had access to the study's code name in the SONA participant sign-up system we used for recruitment.

As in Experiment 1, participants were also instructed not to use any reminders of their own to help them remember to send the text message, excluding the reminders that the experimenters sent. Participants' responses were recorded as "on-time" if the text was sent within 10 min before or after the target time chosen at the instruction session. Responses were recorded as "within the target window" if the text was sent somewhere between 2–5 pm, but not within 10 min of the chosen time, which allowed for equal time from the reminder to the response. It was marked as "no response" if the text message was sent outside of the 2–5 pm target window or not at all. After the 2–5 pm time frame had passed, participants were texted a link to the post-study questionnaire and debriefing statement.

Table 3. Percentages of accurate PM responses in each condition for Experiment 2.

	On Time	Late	No Response
1 day			
Implicit Reminder	34.48%	44.83%	20.69%
Explicit Reminder	41.38%	55.17%	3.45%
6 day			
Implicit Reminder	12.90%	29.03%	58.07%
Explicit Reminder	31.03%	41.38%.	27.59%

Results

The results of Experiment 2 shown in Table 3 suggest that explicit reminders were more effective for both complete and accurate responses than implicit reminders. In fact, comparing percentages across experiments, the explicit reminders at both delays seemed to increase completion performance relative to no reminders in Experiment 1, yet the implicit reminders seemed to increase completion performance only for the 1-day delay relative to no reminders. However, as the experiments did differ in small ways others than the reminders, this comparison should be viewed with caution.

Figure 3 shows the accuracy of PM responses by delay and reminder conditions. An independent samples Mann–Whitney U test confirmed that the participants who received an explicit reminder completed their PM task more accurately (i.e., had more "on-time" responses) than participants who received an implicit reminder, $z = 3.07$, $p = .002$. A second independent-samples Mann–Whitney U test showed that significantly more participants in the 1-day delay condition responded "on-time" than in the 6-day delay condition, $z = 2.06$, $p = .04$. The delay

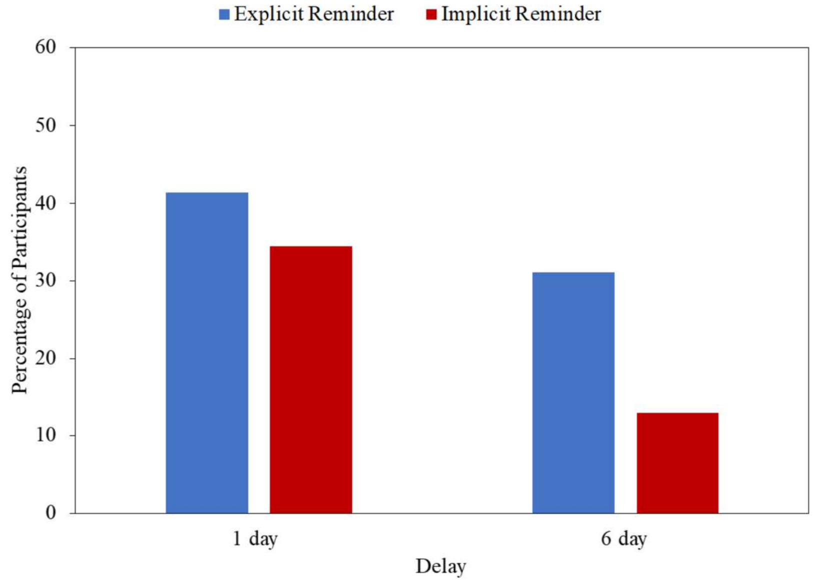

Figure 3. Percentage of participants who were given an implicit or explicit reminder and completed their PM task on time in Experiment 2.

effect was then examined in separate Mann–Whitney U tests for each reminder condition. For the participants who received an implicit reminder, the performance declined from the 1- to 6-day delay as in Experiment 1, $z = 1.96$, $p = .05$. But for those who received an explicit reminder, no delay effect was found, $z = .81$, $p = .42$.

Separate independent-samples Mann–Whitney U tests on PM complete (participants made a response within the 2–5 pm response window, even if it was more than 10 min late, or made no response) and accurate responses (participants made a response within 10 min of the target time or not) for each reminder condition revealed that performance declined across delays for the implicit reminder participants, $p = .007$ for complete responses, $p = .003$ for accurate responses, but did not differ across delays for explicit reminder participants, $p = .09$ for complete responses, $p = .08$ for accurate responses. However, there was a slight trend towards a delay effect (about a 10% decrease) in the explicit reminder condition (see Figure 3).

Post-study questionnaire results

A total of 78 of the 118 participants (66.1%) responded to the post-study survey in Experiment 2. Table 1 shows the percentage responses for these items. The responses were similar to those from Experiment 1: About 10% of the participants reported using self-reminders and half of the participants reported thinking about the task more than once per day. Pearson *r* correlation tests showed that people who thought of the task more often completed their PM tasks more often, $r(36) = .328$, $p = .04$, and more accurately, $r(36) = .373$, $p = .02$, when they received implicit reminders. However, no correlations with frequency of thought were found for those who received explicit reminders, *p*s > .34, providing further evidence that the explicit reminders aided performance much more than the implicit reminders, as those with explicit reminders did not need to think of the task to perform it accurately. There were also no correlations between PM performance and motivation ratings for either reminder condition, *p*s > .10. In addition, motivation was not significantly correlated with frequency of thought in Experiment 2, *p*s > .53.

General discussion

The current study tested the effects of delay, repetition of the PM task (Experiment 1), and type of reminder (Experiment 2) on naturalistic, time-based PM. In Experiment 1, PM performance decreased between the 1- and 3-day delays and the 1- and 6-day delays. These results are similar to those reported by McBride et al. (2013) for young adults in their naturalistic time-based PM study. Their results showed rapid decline of performance at the shortest delays, resembling a typical forgetting function. However, they used an analog task (mail a postcard) in their study and performance did not consistently decline for young adults over the first 5 days. In the current study, although the 3- vs. 6-day delay conditions were not significantly different from each other in terms of PM accuracy, the percentage of participants accurately responding on time declined numerically from the 3- to the 6-day delays in Experiment 1 (see Table 1). This result suggests that forgetting might still have been occurring within this time frame but at a much slower (and less detectable) rate.

The results of Experiment 2 replicated the delay effect on time-based PM accuracy, but only significantly for those who received implicit reminders. Completion performance (making a response within the 2–5 pm response window) in the explicit reminder conditions was very high (near 100% after a 1-day delay), perhaps due to a ceiling effect, but accuracy performance (making a response within 10 min of the target time) also showed less decline with explicit reminders than with no reminders in Experiment 1. Thus, the explicit reminders may have slowed forgetting of the intention by providing a reminder about 4 hr before the target response window. These results suggest that although implicit reminders may help with overall completion rates, they are less effective than explicit reminders at aiding completion accuracy for a specific response time.

Overall, the results in the current study provide some clarification of discrepancies in previous research on whether longer delays decrease time-based PM performance. Some previous studies have shown that delay has no effect on time-based PM performance (e.g., Conte & McBride, 2018), whereas other studies have shown that delay decreases time-based PM performance (e.g., McBride et al., 2013), and one study reported an increase in time-based PM performance after a delay across experiments (Guo et al., 2019). One difference across these studies is whether they were conducted with controlled laboratory tasks or with more naturalistic tasks. The lab-based studies examined delays on a shorter time scale than the current study. The McBride et al. (2013) study is the only time-based naturalistic PM study to compare delays across days. The results from that study and the current study suggest that time-based PM tasks show a negative effect of delay, at least in young adults.

Although an examination of delay effects was the primary goal of the current study, we also tested effects of repeated responses (Experiment 1) and types of reminders (Experiment 2). In Experiment 1, requiring a second response had no effect on PM performance – PM2 responses showed a similar pattern to PM 1 responses (see Figures 1 and 2) with no pairwise differences between PM1 and PM2 at any of the delays. One difference, however, in the PM2 responses was that there was less decline in performance between the 1- and 3-day responses than for PM1 responses. In fact, for PM2 responses, the larger decline was between the 3- and 6-day delays (see Figure 2). This trend may indicate the start of a routine for the PM task responses. However, in the current study, only two responses were included. Time-based tasks with more habitual responses may show no effects of delay and should be tested in future studies.

In Experiment 2, the delay effect differed according to the type of reminder given. The average rate of correct responding (i.e., "on time" responses) decreased between the 1- and 6-day delays significantly in the implicit reminder conditions, but not in the explicit reminder conditions (see Figure 3). These results suggest that overall, explicit reminders aid PM, as the rate of accurate responding was significantly higher in the explicit reminder condition than the implicit reminder condition. However, delay effects depended on the type of reminder set up for the time-based task. Explicit experimenter-initiated reminders yielded very high time-based task completion rates regardless of delay length, although "on-time" performance was considerably lower, even with explicit reminders. This difference between explicit and implicit reminders found in the current study has practical implications for use of reminders in everyday life. Although the reminders given in this study were experimenter-initiated, the results may indicate that more implicit reminders (experimenter- or self-initiated) that do not specifically indicate the task to be performed are less helpful in the completion of PM tasks over time. These results also have implications for theoretical descriptions of PM. Implicit reminders might have served as a cue for spontaneous retrieval of the PM intention, similar to the process suggested by the MP view for event-based PM tasks. Yet, these reminders were found to be much less effective than explicit reminders of the time-based task in the present study. Thus, spontaneous retrieval of the PM task from implicit reminders did not aid performance nearly as much as an explicit reminder of the task given at the same time to the participants, suggesting that extending the MP (or dynamic MP) view of PM to time-based tasks may not provide an adequate description of these tasks.

In fact, Szarras and Niedźwieńska (2011) found that only self-initiated plans increased the completion of self-reported PM tasks when compared with accidental cues and tasks with no cues. Their results further support the conclusion that spontaneous retrieval may not lead to successful completion of naturalistic tasks. In contrast, Kvavilashvili and Fisher (2007) found that participants reported the largest number of both external and internal reminders of their time-based PM task as automatic and non-cued (i.e., the task simply popped into their minds without any external cue or effort to remember the task). Furthermore, they found a significant correlation between these non-cued reminders and successful performance of the time-based task. Thus, another possibility is that the implicit reminders provided in the current study did not sufficiently cue spontaneous retrieval of the task. As Kvavilashvili and Fisher pointed out, spontaneous internal reminders of a PM task are important for understanding the processes by which we perform time-based tasks in daily life. This issue presents an interesting avenue for future work in this area to investigate differences in external and internal reminders that are automatically generated in the delay period for a time-based task.

There are a limited number of studies that have examined the effects of experimenter-initiated reminders and these studies have focused only on salient reminders given by the experimenter (Chen et al., 2017; Cook et al., 2005; Huang et al., 2014). These reminders are typically explicit reminders about the intention (e.g., a message that shows up on a computer screen that says, "do not forget to press the G key when 11 min has passed"). A study by Chen et al. (2017) examined the effects of such explicit reminders on event-based PM and found that explicit reminders improved PM performance. In addition, a small number of studies exist that have examined the effects of reminders on time-based PM. For example, in the Huang et al. (2014), in some conditions the researchers allowed frequent clock checks and gave an explicit reminder about the task. The results showed that when clock checking was not discouraged and when explicit reminders were given, there was no cost from a time-based PM. But the researchers found that when internal control is increased (clock checking and reminders were limited/absent), costs from PM performance also increased. Further, Cook et al. (2005) showed that the use of explicit reminders increased time-based PM performance by increasing clock checks. The current results supported these findings, showing no decline in performance between 1- and 6-day delays when an explicit reminder was given by the experimenter. However, when implicit reminders were given, the delay effect seen in Experiment 1 was replicated.

Post-study questionnaire data from the current experiments suggest that participants thought about the task often during the delay interval, with just over 77% in Experiment 1 and more than 86% in Experiment 2 thinking about the task at least once per day. Thus, internal reminders likely contributed to the high completion performance in the current study. However, despite these frequent thoughts about the task and the experimenter-initiated reminders provided in Experiment 2, "on-time" performance was less than 50% in every condition across the study. This result indicates a high difficulty level for accurate performance of a naturalistic, time-based PM task, despite moderate levels of motivation reported (see Table 1 for mean motivation ratings).

Schnitzspahn et al. (2020) reported higher levels of performance (above 50%) for similar naturalistic time-based PM tasks (call or text the experimenter) at 1- and 3-day delays using a 10 min window to measure performance accuracy. However, participants were completing several tasks in their study, including lab-based tasks in an initial session, a naturalistic event-based task, and reporting of naturalistic self-assigned tasks. Thus, their participants may have been more motivated to complete the tasks (they only reported task importance ratings on a 3-point scale for their tasks) or thought of the study more often due to the number of tasks they were assigned. PM performance in the current study was more comparable to that reported by Jeong and Cranney (2019), who asked participants to send texts to the experimenters after 3- and 6-day delays, with half of the participants given an additional incentive for "on-time" performance (within 10 min of the scheduled time). Although their extra incentive participants showed a performance level of 57.5% accuracy across the two delays, the control participants' performance was only 26.7%, which is similar to the on-time performance seen in the current Experiment 1 at the 3- and 6-day delays.

Conclusions

In conclusion, this study contributes to previous literature on naturalistic time-based PM, which has been somewhat overlooked in the development of theoretical descriptions of PM (Rummel & Kvavilashvili, 2023). Delay effects are particularly important to examine in PM tasks, as mixed results have been reported for variable delays in laboratory studies and have rarely been compared in naturalistic studies of time-based PM. Further, a clear picture of the effects of delay on PM performance will aid in theoretical descriptions of naturalistic, time-based PM.

The current results provide further evidence that time-based PM performance does decrease when the length of delay increases. This study was also one of the first to examine different types of experimenter-initiated reminders in naturalistic time-based PM, showing that implicit reminders are less effective than explicit reminders. The results from this study are useful for understanding what may help or hinder time-based PM, specifically in younger adults. They also suggest that spontaneous retrieval may be less effective for time-based naturalistic tasks than for event-based tasks tested in previous studies.

Disclosure statement

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References

Anderson, F. T., & McDaniel, M. A. (2019). Retrieval in prospective memory: Multiple processes or just delay? *Quarterly Journal of Experimental Psychology*, *72*(9), 1–11. https://doi.org/10.1177/1747021819845622

Chen, Y., Lian, R., Yang, L., Liu, J., & Meng, Y. (2017). Working memory load reminder effect on event-based prospective memory of high- and low-achieving students in math. *Journal of Learning Disabilities*, *50*(5), 602–608. https://doi.org/10.177/0022219416668322

Conte, A. M., & McBride, D. M. (2018). Comparing time-based and event-based prospective memory over short delays. *Memory*, *26*(7), 936–945. https://doi.org/10.1080/09658211.2018.1432662

Cook, G. I., Marsh, R. L., & Hicks, J. L. (2005). Associating a time-based prospective memory task with an expected context can improve or impair intention completion. *Applied Cognitive Psychology*, *19*, 345–360. https://doi.org/10.1002/acp.1082

Devolder, P. A., Brigham, M. C., & Pressley, M. (1990). Memory performance awareness in younger and older adults. *Psychology and Aging*, *5*(2), 291–303. https://doi.org/10.1037/0882-7974.5.2.291

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

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science*, *14*(6), 286–290. https://doi.org/10.1111/j.0963-7214.2005.00382x

Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., & Breneiser, J. (2005). Multiple processes in prospective memory retrieval: Factors determining monitoring versus spontaneous retrieval. *Journal of Experimental Psychology: General*, *134*(3), 327–342. https://doi.org/10.1037/0096-3445.134.3.327

Guo, Y., Liu, P., & Huang, X. (2019). The practice effect on time-based prospective memory: The influences of ongoing task difficulty and delay. *Frontiers in Psychology*, *10*, 1–10. https://doi.org/10.3389/fpsyg.2019.02002

Guynn, M. J., McDaniel, M. A., & Einstein, G. O. (2001). Remembering to perform actions: A different type of memory? In H. D. Zimmer, R. L. Cohen, M. J. Guynn, J. Engelkamp, R. Kormi-Nouri, & M. A. Foley (Eds.), *Memory for action: A distinct form of episode memory?* (pp. 25–48). Oxford University Press.

Hicks, J. L., Marsh, R. L., & Russell, E. J. (2000). The properties of retention intervals and their affect on retaining prospective memories. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(5), 1160–1169. https://doi.org/10.1037/0278-7393.26.5.1160

Huang, T., Loft, S., & Humphreys, M. S. (2014). Internalizing versus externalizing control: Different ways to perform a time-based prospective memory task. *Journal of Experimental Psychology*, *40*, 1064–1071. https://doi.org/10.1037/a0035786

Jeong, J. M., & Cranney, J. (2019). Motivation, depression, and naturalistic time-based prospective remembering. *Memory*, *17*(7), 732–741. https://doi.org/10.1080/09658210903074673

Kvavilashvili, L., & Fisher, L. (2007). Is time-based prospective remembering mediated by self-initiated rehearsals? Role of incidental cues, ongoing activity, age and motivation. *Journal of Experimental Psychology*, *136*(1), 112–132. https://doi.org/10.1037/0096-3445.136.1.112

Laine, M., Jylkkä, J., Ritakallio, L., Eräste, T., Hangas, S., Hering, A., Zuber, S., Kliegel, M., Fellman, D., & Salmi, J. (2023). Spontaneous memory strategies in a videogame simulating everyday memory tasks. *Quarterly Journal of Experimental Psychology*, 1–15.

McBride, D. M., Coane, J. H., Drwal, J., & LaRose, S. M. (2013). Differential effects of delay on time-based prospective memory in younger and older adults. *Aging, Neuropsychology, and Cognition*, *20*(6), 700–721. https://doi.org/10.1080/13825585.2013.765937

McBride, D. M., & Flaherty, M. (2020). Comparing costs in time-based and event-based prospective memory. *Memory*, *28*(7), 918–925. https://doi.org/10.1080/09658211.2020.1798463

McBride, D. M., & Workman, R. A. (2017). Is prospective memory unique? A comparison of prospective and retrospective memory. In B. H. Ross (Ed.), *The psychology of learning and motivation. (Vol. 67)* (pp. 213–238). Elsevier Academic Press. https://doi.org/10.1016/bs.plm.2017.03.007

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

McDaniel, M. A., & Einstein, G. O. (2007). *Prospective memory: An overview and synthesis of an emerging field*. Sage Publications Inc.

Meacham, J. A., & Singer, J. (1977). Incentive effects in prospective remembering. *Journal of Psychology: Interdisciplinary and Applied*, *97*, 191–197. https://doi.org/10.1080/00223980.1977.9923962

Niedźwieńska, A., & Barzykowski, K. (2012). The age prospective memory paradox within the same sample in time-based and event-based tasks. *Aging, Neuropsychology, and Cognition*, *19*, 58–83. https://doi.org/10.1080/13825585.2011.628374

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

Rummel, J., & Kvavilashvili, L. (2023). Current theories of prospective memory and new directions for theory development. *Nature Reviews Psychology*, *2*, 4–54. https://doi.org/10.1038/s44159-022-00121-4

Schnitzspahn, K. M., Kvavilashvili, L., & Altgassen, M. (2020). Redefining the pattern of age-prospective memory-paradox: New insights on age effects in lab-based, naturalistic, and self-assigned tasks. *Psychological Research*, *84*, 11370–11386. https://doi.org/10.1007/s00426-018-1140-2

Scullin, M. K., McDaniel, M. A., & Shelton, J. T. (2013). The dynamic multiprocess framework: Evidence from prospective memory with contextual variability. *Cognitive Psychology*, *67*, 55–71. https://doi.org/10.1016/j.cogpsych.2013.07.001

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*(3), 347–361. https://doi.org/10.1037/0278-7393.29.3.347

Szarras, K., & Niedźwieńska, A. (2011). The role of rehearsals in self-generated prospective memory tasks. *International Journal of Psychology*, *45*(5), 346–353. https://doi.org/10.1080/00207594.2011.565342

Wójcik, M., Neckar, J., & Niedźwieńska, A. (2020). Predictors of everyday prospective memory performance: A superiority in the execution of event-based tasks over time-based tasks reverses in real-life situations. *Journal of Applied Research in Memory and Cognition*, *11*(2), 245–257. https://doi.org/10.1037/h0101872