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Comparing Time and Event Based Prospective Memory: Effects of Delay

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Prospective memory (PM) is the act of remembering to perform a future intention (Einstein & McDaniel, 2005). Time-based PM is remembering to retrieve that future intention at or after a specific time has elapsed. Event-based PM is remembering to retrieve the future intention when a specific cue or event is encountered (Sellen et al., 1997). The current project was designed to compare time- and event-based PM performance within a laboratory context. Previous research suggests that time-based tasks are more difficult to carry out because a decrease in performance (or PM cost) is often found when compared to event-based tasks (e.g., Sellen et al., 1997). All participants completed a lexical decision task as the ongoing task. Participants in the event-based condition were asked to respond to a specific type of word for the PM task, and participants in the time-based task were asked to respond after a specific time has elapsed for the PM task. Delay between instruction and presentation of PM cue were manipulated in a completely between-subjects design. Higher performance was found in the event-based task, as predicted. The event-based task, however, resulted in an increased cost to the ongoing task speed. Isolated RT trials showed monitoring for both time- and event-based tasks at the 1 and 3 min delays and only monitoring for the time-

based task at the 6 min delay. Clock checking patterns resembled a “J” shaped curve where more clock checking appeared as the target time approached. Clock checking patterns is yet another way to assess monitoring for time-based tasks. Overall, time-based tasks are more difficult to complete but event-based tasks require more monitoring or cognitive resources. It is still unclear whether time-based tasks utilize the Multiprocess Model as the event-based tasks do.

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EFFECTS OF DELAY

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A.C.

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CHAPTER I

THE PROBLEM AND ITS BACKGROUND

Statement of the Problem

Prospective memory (PM) is the act of remembering to perform a future intention (Einstein & McDaniel, 2005). This type of memory is different from typical retrospective memory because it is "remembering to remember" to do something (Sellen, Louie, Harris, & Wilkins, 1997, p.484). There are two different types of PM, time-based and event-based.

Definition of Terms

Time-based PM is remembering to retrieve the future intention at or after a specific time has elapsed (Sellen et al., 1997). A few examples include: going to your dentist appointment at the correct time or picking up your children after school has let out. Event-based PM is remembering to retrieve the future intention when a specific cue or event is encountered (Sellen et al., 1997). Examples of this type of PM include: emailing a coworker when you arrive at the office or picking up stamps on your way home. The most important feature of a PM task is that there is no explicit reminder to carry out the intention. There is no automatic prompt telling you to go to your dentist appointment or to email your coworker. Instead, you have to retrieve the intention on your own (or with the use of external aids) and complete the action at the correct time or in the correct context (Kvavilashvili & Fisher, 2007).

CHAPTER II

REVIEW OF RELATED LITERATURE

General Literature Review

Theories of Prospective Memory

Because mechanisms involved in PM may be different from retrospective memory, retrieving a PM intention is not the same as remembering something in the past; thus, the theoretical explanations of PM are different from those proposed for retrospective memory. In current research, PM researchers are testing theoretical descriptions of how we retrieve prospective memories (Einstein & McDaniel, 2005). According to some views of PM (e.g., Smith, 2003), to keep the intention in mind, constant rehearsal in the form of monitoring for the PM cues or time will take place until the intention is retrieved. Monitoring is cognitively taxing and consumes a large portion of our capacity and ability to manage other cognitive information. Evidence supporting monitoring in PM often includes a PM cost where monitoring for the future intention interferes with successful completion of other tasks (e.g., reaction times slow down or accuracy decreases on these other tasks, presumably because of monitoring for the PM task).

Successful PM remembering is often a result of the strength between the cue and memory trace. PM remembering will be more difficult when the cue does not directly interact with the memory trace (Kliegel, McDaniel, & Einstein, 2008). To explain how we can often keep several future intentions in mind and successfully retrieve them while completing intermittent tasks, Einstein and McDaniel (2005) proposed the Multiprocess View that includes both spontaneous retrieval and monitoring. Spontaneous retrieval describes the act of the intention almost "popping" into one's head. Something in the environment (e.g., someone we encounter during the day) could cue our intention to retrieve a future action. The Multiprocess View proposes that various cognitive processes can contribute to successful PM retrieval, including automaticity and monitoring (Einstein & McDaniel, 2005). Monitoring is often used for short-term retrievals, whereas spontaneous retrieval is more efficient for long-term intentions. It is advantageous to free up cognitive resources until absolutely necessary to retrieve the intention. Spontaneous retrieval can also prompt momentary monitoring until the PM intention is completed. This model of PM has been supported for event-based PM (e.g., Einstein et al., 2005; McDaniel & Einstein, 2000; Scullin, McDaniel, Shelton, & Lee, 2010), but it has not yet been well-tested for time-based PM. In fact, this is a general trend in current laboratory research in PM: time-based PM has not been as fully investigated as event-based PM.

Although research that has investigated time-based PM in laboratory studies is scarce, some of the studies that have been conducted suggest that time-based tasks are more difficult for individuals to complete successfully when compared to event-based tasks (Kliegel et al., 2008; McDaniel & Einstein, 2007). Because they are tied to a specific cue, event-based tasks lend themselves to spontaneous retrieval when one encounters that cue and require less effort for the individual to retrieve. In time-based tasks, however, time needs to be strategically monitored for successful completion. Suppose that, to mail a birthday card, you need to pick up stamps before the post office closes in two hours, but you have a few other things to accomplish before you can make it to the post office. There are no reliable internal cues for when two hours has elapsed so you would have to monitor the intention and strategically check the clock to make it to the post office in time. You would not necessarily need to be constantly monitoring that intention because the environment will facilitate the remembering and spontaneous retrieval will take place. When cues are not readily available, like in time-based tasks, we are left to our own devices and expected to keep the intentions in mind.

The descriptive model that is prevalent in time-based PM research is the Test-Wait-Test-Exit (TWTE) model proposed by Harris (1984). Constant monitoring is too cognitively taxing and Harris proposed that we use periodic monitoring for strategic allocation of cognitive resources. The initial "test" comes early after the intention is placed in mind because responding to the intention late often has bigger consequences than being too early. The initial testing phase involves assessing whether or not it is appropriate to retrieve the intention (e.g., checking the clock to see if it is too early to leave for the movie). Showing up early to a movie has fewer consequences than being 30 min late. The initial test may reveal that it is too early to retrieve the intention and a period of waiting occurs until the next "test" phase. One will continue testing and waiting until it is appropriate to retrieve the intention during the "exit" phase where the intention is completed and monitoring is no longer necessary.

Time-based PM research has tested this model by having participants complete an ongoing task in addition to a time-based task where they can periodically check a clock or stopwatch. Forcing the clock checking to be an overt behavior, the researcher can record how often and when the participant is monitoring the time. With the lack of reliable cues in time-based PM tasks, clock checking must be initiated by the individual because the task is not as easily supported by the environment. Even with the TWTE model, participants need to start the initial monitoring and keep the intention available to remember to continue checking the clock. Time-based tasks rely on self-initiation and this limitation could be a possible explanation for some individual differences (Kliegel et al., 2008; Kvavilashvili & Fisher, 2007; McDaniel & Einstein, 2007). When attending to a time-based task, you need to keep the intention in mind as well as remembering to check the clock for the time. Event-based tasks often only have one cue and can rely on environmental support for retrieval cues. Having a clock in the environment can serve as a cue for time-based tasks but one must remember to check the clock; the clock is not going to prompt you to remember the intention. Time-based tasks rely on self-initiated processes so this could explain the decrease in performance found in previous studies compared with event-based tasks (Kvavilashvili & Fisher, 2007; Sellen et al., 1997), as well as the increase in PM costs found in some studies (see further discussion below) for time-based tasks. The next section will review studies that support this claim as well as further illustrate these differences between the two types of PM tasks.

Investigating Prospective Memory in a Naturalistic Context

Initially, PM was examined in naturalistic settings where researchers could get a sense of how we retrieve PM demands in our daily lives. There can be severe consequences for failing to retrieve PM intentions in work, school, and everyday life. Naturalistic experiments are used to help mimic everyday retrieval, and typically in a naturalistic experiment, participants are given a task to complete sometime in the future, whether it be at a specific time or after an event has occurred. Participants go about their daily routines until the PM task needs to be retrieved (e.g., call the researcher on Sunday at 10:00 am or send the post card in after 5 days). Participants are discouraged from using external aids and are often asked to keep some kind of diary or record of their thoughts about the intention and when retrieval took place.

Sellen et al.'s (1997) study followed this model, but was unique because they used electronic badges to track when the participant thought of the future intention as well as when they retrieved the intention. These researchers were interested in examining the differences between time- and event-based PM within a naturalistic setting. Participants were selected from a workspace and asked to engage in specific PM tasks throughout their workday. Before conducting the experiment, participants wore the badges around for two weeks so that the badges did not serve as a cue on their own. When the experiment began, participants were asked to complete one PM task for one week each. In the event-based (or place) task, participants were asked to press their badge whenever they entered the common area of the workspace. In the time-based task, participants were asked to press their badge every two hours starting at 7:30, 8:00, 8:30

or 9:00 am. They were also asked to press their badges whenever they thought about the task. The following week, participants completed the other PM task (time-based or event-based) that they did not complete the first week.

Participants reported thinking about the time task more often than the event task, but had significantly lower performance for the time task. The event task was easier for the participants to remember and required fewer thoughts throughout the day. Participants rated the time task as more difficult because there was no reliable retrieval cue available as there was in the event task (e.g., entering the commons or walking by the commons). Only one participant showed higher performance in the time-based task than the event-based task. A post-experiment interview revealed that this participant had used an event that occurred at the same time each day, which triggered retrieval of the time-based task. Essentially, this participant turned the time-based task into an event-based task, which explains the atypical pattern of performance. From these results, we see that event-based tasks are often easier to carry out because they lend themselves to spontaneous retrieval from cues in the environment. Individuals do not need to constantly monitor the intention because they have an environmental cue that will support their remembering. After spontaneous retrieval of the intention, one may then monitor for a short period of time until the time or cue is encountered or the monitoring becomes too cognitively taxing. Thus, the time-based task does not have the same support from the environment. Participants in the Sellen et al. study were also thinking about the time task more often, suggesting that this task requires more strategic monitoring in order to keep the intention in mind and successfully retrieve it at the correct time. From Sellen et al.'s results, we see that time-based tasks may require more thoughts throughout the day.

Although Sellen et al.'s (1997) results suggested that time-based tasks rely on more internal monitoring; their study did not address the factors that influence this monitoring. More recent studies have investigated this question. For example, Kvavilashvili and Fisher (2007) were interested in whether thoughts of a PM intention were self-initiated or prompted by external/internal cues, while also comparing the differences between the two types of PM within a natural context. Their first study was conducted to examine whether time-based tasks are completed by deliberate, effortful, and self-initiated monitoring or sparked by incidental cues (either internal or external). Kvavilashvili and Fisher wanted to build upon the findings of Sellen et al. (1997) as well as investigate some discrepancies between lab-based experiments and naturalistic experiments.

Participants completed a naturalistic time-based task and were asked to call the researcher at a specified time. Kvavilashvili and Fisher (2007) also had participants report extensive details about when and where they were when the intention came to mind. Participants were asked to refrain from using external reminders such as notes, calendars, or alarms and to keep the diary out of sight (but accessible) so it did not serve as a reminder itself. When the call was ultimately made, participants were asked to rate their motivation level on a scale from 1 (not very motivated) to 7 (very motivated). Their second study included samples of both young and older adults to see if the findings could be replicated and generalized to other populations. Half of the participants from each age group were placed in the high-motivation condition and were told that it was very important for them to call within 10 min of their selected call time. The other subjects were placed in the low-motivation group and were asked to call within 10 min of their selected call time, with no extra pressure or importance placed on the task. To further understand the differences between time and event tasks, Kvavilashvili and Fisher (2007) conducted a third study that included two groups of young participants who either completed the standard time-based task (call the experimenter at a specified time) or an event-based task (call the experimenter after receiving a text message).

Results from their studies showed that no participant completely forgot to make the call, but there was variability in when the call was made: In Study 1, 59% remembered to call within 10 min of the target time (considered on time) and 41% were more than 10 min late (considered failed PM retrieval). Motivation was not found to be significantly different between those who remembered to call on time and those who were over 10 min late. Study 2 revealed that 78% of participants remembered to call within 10 min of target time and only 22% were more than 10 min late. The manipulation of motivation did not have a significant effect on PM performance such that those in the high motivation condition were not any more accurate in calling the researcher than those in the low motivation condition. Study 3's results showed that in the time-based condition, 53% of participants remembered to call within 10 min of target time and 47% were more than 10 min late with their call. In the event-based condition, 80% of participants responded on time (i.e., making the call within 10 min of receiving the text message) and 20% were over 10 min late. The participants who responded late all gave valid reasons for why they were unable to respond immediately to the text message. Thus, the event-based performance was extremely high, whereas time-based performance was significantly lower than that at around 50%, again illustrated the greater difficulty in completing a time-based task successfully.

Kvavilashvili and Fisher (2007) also examined the diaries kept by the participants during the experiment to get an idea of monitoring patterns throughout the span of the experiment. There has been some evidence to support a "J" shaped curve of monitoring for time-based PM tasks (Einsein et al., 1995; Kvavilashvili & Fisher, 2007; Park et al., 1997). Monitoring takes place over time delay, but increases as one gets closer to retrieving the PM intention. Also, thoughts of the intention often enter one's mind when completing mundane or "cognitively untaxing" tasks (as seen in Sellen et al., 1997, where participants reported thinking about the task in transition periods of their day). Interestingly, Kvavilashvili and Fisher (2007) found a "U" shaped pattern for rehearsals (i.e., monitoring) in the time-based condition and an inverted "J" shaped pattern in the event-based condition. A flat line was predicted for event-based tasks, because it was expected that monitoring would not change over time and there would not be an increase in monitoring at the beginning or end. Consistent monitoring was expected for event-based tasks because one can rely on other cues/events rather than increasing monitoring as time elapses. Although participants in the time-based condition reported rehearsing the intention more frequently overall, PM performance was significantly lower for time-based tasks. Self-initiated rehearsals were relatively low and not significantly different between the two groups, but the number of rehearsals with no apparent trigger was different between the two groups. A rehearsal with a trigger might be seeing a telephone and thinking about the task, whereas having the intention randomly popping into one's mind for no apparent reason is a rehearsal without a trigger. For both time- and event-based conditions, rehearsals with no apparent triggers (self-initiated) were significantly lower that triggered rehearsals. No significant differences were found between the groups but a trend toward time-based tasks having more non-triggered rehearsals emerged, a significant difference would suggest that time-based tasks are kept at a higher level in consciousness because there is no cue from the environment to aid retrieval, as in event-based tasks. More resources are needed to retrieve time-based tasks resulting in a higher resting threshold when one is not thinking about the intention. However, Kvavilashvili and Fisher's studies focused on naturalistic PM tasks, where the researchers did not have control over what the participants encountered in their environments that could serve as cues for retrieval. Thus, laboratory studies of PM tasks are important to allow control of the participants' environment as they attempt to retrieve the PM task.

Investigating Prospective Memory in a Laboratory Setting

A typical lab experiment first engages participants in an ongoing task to model tasks completed in everyday life. To examine attending to and retrieving PM intentions, an additional task is included while also completing the ongoing task to model PM tasks as they occur in everyday life. Researchers can then compare both accuracy and reaction times between conditions when no PM task is present and when the participants have an additional task to complete (Einstein & McDaniel, 2005). Completing this procedure in the lab allows for control over use of external aids and more controlled comparisons of time- and event-based tasks.

In an example of a time-based PM study in the lab, Huang, Loft, and Humphreys (in press) studied whether we internalize the intention in a time task and keep the intention in mind by monitoring or externalize the process by relying on environmental support and spontaneous retrieval. In time-based tasks, clock checking is a way to externalize the intention and minimize the need for internal control over the intention; thus, these researchers recorded how often and when participants checked the clock in the task. All participants completed two blocks of a lexical decision task. The subjects in the PM conditions were asked to make a single response when 11 min had elapsed in the second block of trials. A single response was used to mimic a realistic time-based task within a lab setting (e.g., you only have one chance to take the cookies out of the oven at the right time or they will burn). In Experiment 1, participants were either given an unexpected reminder of the PM task 6 min into the second block or no reminder at all. A control group was also included that completed the blocks of trials with no PM intention. All subjects were allowed to check the clock as many times as they felt necessary by pressing the space bar that revealed a hidden clock on the computer screen.

Huang et al. conducted two additional experiments to discourage clock checking and increase internal control, as well as to induce the possibility of a PM cost (i.e., increase in reaction times or decrease in PM accuracy). The goal was to increase the PM cost to determine if internal control is cognitively taxing and results in a cost to the ongoing task from the additional PM task. Half of the participants were discouraged from excessive clock checking. All participants in Experiment 3 were told that a reminder would be present in the second block of trials, but only half of the participants actually received that reminder.

Results revealed no significant differences between the clock checking conditions for ongoing task or PM task accuracy. Clock checking occurred more frequently after the 6 min mark, regardless of whether they received a reminder or not, than before 6 min had elapsed. There was, however, significantly more clock checking after 6 min for participants who received the reminder than those who did not receive the reminder. Clock checking and PM accuracy were positively correlated for both PM conditions, suggesting that clock checking increased the likelihood that participants successfully performed the PM task. No significant differences were found between the reminder and no reminder conditions for ongoing or PM task performance. A significant cost for the PM conditions was found when participants were discouraged from checking the clock. Increased costs were found because participants who were discouraged from clock checking had to rely on internal processes rather than having support from the environment.

Overall, Huang et al. (in press) concluded that when external control is increased and internal control is decreased (such as when subjects can rely on clock checking), no costs are found. In contrast, when internal control increases and external control is decreased (such as when clock checking is discouraged), significant costs are found. Time-based tasks rely on internal control for successful completion, and these results show that this type of task is dependent on clock checking to reduce costs. This pattern of efficient monitoring is supported by the TWTE model (Harris, 1984) and reduces interference of the PM task to the ongoing task. As the results of Huang et al. demonstrate, there are costs in both maintaining a time-based future intention as well as keeping an internal record of the passage of time. When the intention can be externalized, the task becomes easier and requires fewer cognitive resources.

CHAPTER III

RESEARCH DESIGN

Statement of the Problem

Although researchers have begun to investigate time-based tasks in the lab as Huang et al. (in press) did, we know significantly less about time-based PM and what contributes to the difference in performance from event-based PM that is often found. Time-based PM has been examined only more recently in the lab and has not been extensively or directly compared to event-based PM. Thus, the current project was designed to compare time- and event-based PM performance and their cost on an ongoing task within a laboratory context. Performance on time-based tasks is typically lower than performance on event-based tasks, suggesting that time-based tasks are more difficult to complete (Kvavilashvili & Fisher, 2007; Sellen et al., 1997). The lower performance in conjunction with more frequent thoughts about time-based tasks found in past studies supports this suggestion. In the current study, this suggestion was further tested by comparing PM cost for time- and event-tasks over the time course of the PM task. Participants completed a lexical decision task in addition to a time or event-based PM task and delay of PM cue presentation was manipulated. PM cost was measured by an increase in reaction time when the additional PM task is present compared with the baseline block of trials. Clock checking behavior also shows monitoring for the intention, and it was recorded in all time-based conditions.

To mimic everyday PM tasks, a single PM response was made by participants in an event- or time-based task with length of delay manipulated for these tasks. The manipulation of delay allowed for an examination of monitoring over time for both time- and event-based tasks. Both types of PM tasks were embedded within the same ongoing task to allow for a more controlled comparison of these tasks than has been done in studies looking at naturalistic PM tasks.

Hypotheses

Hypothesis 1: In regards to PM accuracy, I hypothesized that participants would have higher performance when completing an event-based PM tasks than time-based PM tasks. Both Sellen et al. (1997) and Kvavilashvili and Fisher (2007) found significantly higher performance for naturalistic event-based tasks than time-based tasks. I hypothesized that the same pattern would occur in the current study for the event-based task as compared to the time-based task, because participants will not need to monitor the intention as often for the event-based task. They can rely on an external cue to facilitate their memory with less PM cost. Thus, I also expected higher PM cost overall for the time-based than the event-based task. This result would be consistent with results in past studies (Kvavilashvili & Fisher, 2007; Sellen et al., 1997) showing more frequent thoughts about the time-based task. In addition, as the delay from instruction for the PM task and retrieval of the PM task increases, accuracy will decrease in both time and event-based tasks types (McBride, Beckner, & Abney, 2012; McDaniel & Einstein, 2007). The longer a PM intention needs to be kept in mind, the harder it is to retrieve successfully, especially for time-based tasks where spontaneous retrieval is less likely.

Hypothesis 2: Monitoring for the PM task in both task types was expected to take place initially, but because it consumes too many resources, I expected monitoring to decrease with longer delays. This result was reported by McBride et al. (2012) for an event-based PM task. I hypothesized that time-based PM tasks would result in a higher PM cost than the event-based PM tasks and as the delay increases, the cost will decrease as monitoring diminishes. I expected that PM cost will decrease when the delay is increased because, overall, less monitoring will occur over time. However, I expected monitoring would persist longer for the time-based task, resulting in an interaction for PM cost between type of PM task and delay. In general, time-based PM tasks are more difficult and require more resources, and should therefore show greater PM cost than event-based tasks (Huang et al., in press). Thus, for time-based tasks, participants should monitor for the PM task longer, resulting in higher reaction times in the PM block of the experiment. Participants might also forget about the intention all together, resulting in a missed PM retrieval. Thus, I hypothesized that delay would decrease accuracy for time-based tasks, because there is a lower chance of spontaneous retrieval and monitoring often stops after a short period of time.

Hypothesis 3: In terms of monitoring patterns and clock checking, I hypothesized that the pattern will resemble a "J" shaped curve (i.e., some initial clock checking, then less clock checking as the task continues, but as the target time approaches, clock checking will increase, see Figure 1). Although Kvavilashvili and Fisher (2007) found a "U" and an inverted "J" shaped curve in time-based tasks, I expected that the lab setting would allow more accurate recording of when participants check the clock (or monitoring for the time), resulting in the typical "J" shaped curve found in other studies. Huang et al. (in press) found similar results in that after 6 min into the second block (over halfway to target time), clock checking increased. Thus, I hypothesized that as the participants check the clock and realize that the target time is approaching, they would check the clock more often, resulting in the "J" curve pattern for monitoring. I only predicted this shape for the longer delays, because the 1 min time delay is too short for many clock checks to occur.

Collection of the Data

Participants

Two hundred and ninety-three participants were recruited from Illinois State University and received course credit for their participation in the study. Upon entering the lab, participants were randomly assigned to one of seven conditions. Participants either completed an event-based PM task or a time-based PM task with a 1, 3, or 6 min delay in when the response is required. The control group had no PM instruction given (and thus no delay condition to consider). A total of 39 participants' data was excluded from analyses for various reasons: did not remember PM task (n = 12), did not understand PM task (n = 6), did not understand ongoing task (n = 3), low ongoing task accuracy (n = 8), made several PM false alarms (n = 3), experimenter error (n = 3), outside distraction (n = 3), and slow performance resulting in an increased delay (n = 1). The analyses include 254 participants' data.

Materials and Design

A 2 (PM Task: Event or Time) X 3 (Delay: 1, 3, or 6 min) between-subjects design was used. A control group was included that does not receive the PM task.

Two hundred and twenty-five words were selected from the ELP (English Lexicon Project) website all containing two syllables with the length ranging from five to seven letters (50 words of each length). The first set of stimuli consisted of 75 words and 75 nonwords, which were put in a random order for the set of baseline trials (i.e., Block 1) in the experiment. The second set of stimuli consisted of 125 words and 125 nonwords, which were presented in random order for the set of experimental trials (i.e., Block 2). Nonwords from the second set of stimuli were adapted from words in the first set of stimuli and vice versa. For example, a random vowel in a word from one was changed to create a nonword for the second set (e.g., “English” becomes “Englosh”). Each block began with five practice trials using additional words chosen from the ELP and were excluded from analysis. The event-based PM cue was the flower word “daisy”. The cue was presented once in Block 2, regardless of the type of PM task assigned (event- or time-based). To record key press reaction times and correct responses, Super Lab 4.5 was used on a Macintosh computer.

Procedure

Upon entering the laboratory, participants were randomly assigned to one of the 7 conditions: Event PM 1 min (n = 35), Event PM 3 min (n = 35), Event PM 6 min (n = 37), Time PM 1 min (n = 38), Time PM 3 min (n = 39), Time PM 6 min (n = 35), or Control (n = 35). All participants first received instructions for a lexical decision task, where they were asked to decide if each letter string presented is a word or not. They were asked to press the “w” key for word and the “n” key for nonword. Stimuli were presented one at a time in white in the middle of a computer screen with a black background. Before each letter string, a fixation cross appeared for 750 ms before the string was presented. Participants completed 5 practice trials before beginning the baseline phase of trials. All participants received the same stimuli in the baseline block in the same random order. The baseline phase consisted of 75 words and 75 nonwords.

After completing the baseline phase, participants in the Event PM conditions (either 1, 3, or 6 min delay) were asked to notify the researcher whenever they encountered a flower word by saying “flower word”. Depending on the condition, the PM cue “daisy” was presented on the 37^{th}, 111^{th}, or 221^{st} trial to match the Time PM conditions. The second block of trials consisted of 125 words and 125 nonwords.

Participants in the Time PM conditions (either 1, 3, or 6 min delay) were asked to notify the researcher by saying “time’s up” when an amount of time has elapsed, either 1 min, 3 min, or 6 min. There was a stopwatch available for the participant to check as a way to monitor the time. The stopwatch was placed behind the computer screen so that it is out of the subjects’ line of sight for the duration of the experiment. But subjects were shown where the stopwatch was located and told they may check the clock when necessary. The researcher took note of when the clock is checked and when the researcher notified the participant of the elapsed time. Following the completion of the study phase, the participants were asked what their tasks were (i.e., say “flower word” or notify research of the time). Failure to recall the instructions lead to exclusion from analysis. The subjects in the control condition completed the lexical decision task for both phases of the experiment without the added PM instructions.

CHAPTER IV

ANALYSIS OF THE DATA

Statistical Measures

PM accuracy, reaction times (RTs), and number of clock checks were recorded and analyzed. Since the event cue was only presented once in the second block, PM accuracy for event-based tasks was scored as either 0 or 1. Participants who correctly responded to the cue received a 1 (or a hit) and those who did not respond to the cue received a 0 (or miss). Similarly, since there was only one correct time for the participants to respond to the time-based cues, PM accuracy for the time-based task was also scored as a 0 or 1. The specific measure of accuracy used was as follows: if the participant responded within 10 s before or after the target time, they received a 1, and if they responded outside of that window, they received a 0. RTs were measured by the computer program and averages for each block were calculated. The researcher recorded when the clock was checked and those times are plotted onto a graph with time on the x-axis and the number of clock checks on the y-axis, see *Figure 1* for example.

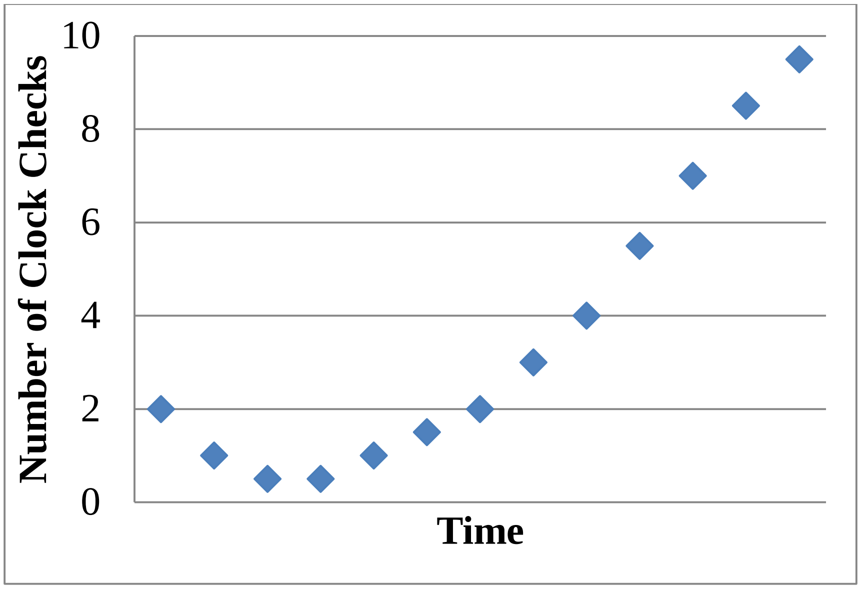

Figure 1. Example of "J" Shaped Clock Checking Curve

Statistical Analysis

Prospective Memory Accuracy

A one-way ANOVA was performed to analyze PM accuracy across task type and delay. Refer to *Figure 2* for a summary of the mean PM performance for each task type and delay. The results revealed a significant effect of task type, $F(1, 213) = 517.47$, $p < .001$, partial $\eta^2 = .77$, where overall, time-based tasks ($M = .68$) resulted in lower performance than event-based tasks ($M = .91$). Performance did not differ significantly for the different delays, $F(2, 213) = 1.23$, $p = .29$, partial $\eta^2 = .01$. The interaction between task type and delay was not significant, $F(2, 213) = 1.92$, $p = .107$, partial $\eta^2 = .02$. Although the interaction was not significant, a trend is emerging where in the event-based tasks, accuracy is decreasing with delay and in the time-based tasks, accuracy is increasing with delay.

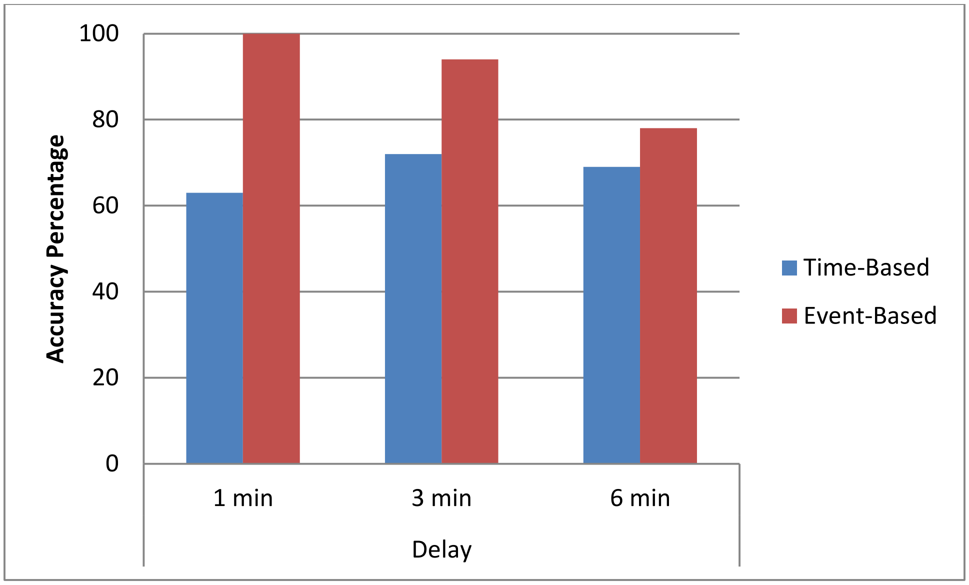

Figure 2. PM Accuracy with Delay

Prospective Memory Cost

An initial 3 X 3 ANOVA on Baseline Block RTs with task type and delay as factors revealed a significant difference between conditions, $F(2, 315) = 3.89$, $p = .02$. Because of these significant differences, basic difference scores could not be used to measure PM cost. Instead, an ANCOVA with the Baseline Block RTs as a covariate and PM Block RTs as the DV was used for RT analyses. Refer to *Figure 3* for a summary of the mean RTs for each task type and delay. The results yielded a significant difference for task type, $F(2, 315) = 26.89$, $p < .001$, partial $\eta^2 = .15$. The higher cost was found in event-based tasks ($M = 779$ ms) rather than the time-based task ($M = 697$ ms), which was originally hypothesized. As expected, the control group had the fastest overall RTs ($M = 676$ ms). Post hoc analyses revealed that when compared to controls, RTs were not significantly different in the time-based tasks, $t(215) = 1.59$, $p = .078$. However, RTs were significantly different in the event-based tasks when compared to controls, $t(210) =$

6.35, $p < .001$. There was no significant effect of delay, $F(2, 314) = 1.67$, $p = .19$, partial $\eta^2 = .10$. The interaction between task type and delay was not significant, $F(4, 314) = 1.04$, $p = .39$, partial $\eta^2 = .13$.

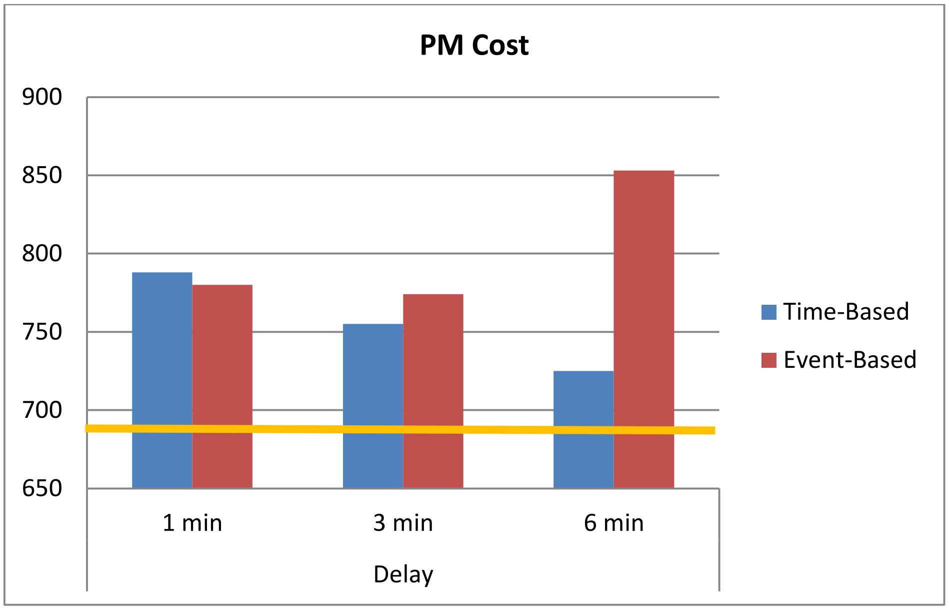

Figure 3. Mean RTs for Each Task Type and Delay (line denotes Control RTs)

To assess a PM cost for the trials immediately before the target time or cue was presented, the 25 trials preceding the target were isolated and analyzed. This was important to see if monitoring is occurring immediately before the target time or word was reached. An ANCOVA revealed a significant effect of task type, $F(2, 314) = 10.45$, $p < .001$, partial $\eta^2 = .06$, where a higher cost was found for the event-based task (M = 799 ms) compared to the time-based task (M = 762 ms). There was also a significant effect of delay, $F(2, 314) = 9.80$, $p < .001$, partial $\eta^2 = .06$, as well as a marginally significant interaction, $F(4, 314) = 2.35$, $p = .054$, partial $\eta^2 = .03$.

A simple effects analysis was used to break down the significant interaction between task type and delay for the 25 trial RTs. The analyses revealed that at the 1 min delay, there was a significant difference between the time and event condition (*p* = .02) as well as a significant difference between time and control (*p* = .050). There was also a significant difference between event and control (*p* < .001). At the 3 min delay, the control and event conditions were marginally different (*p* = .051). At the 6 min delay, the control and time conditions were significantly different (*p* = .01). *Table 1* shows the mean RTs at each condition and delay for the 25 trials before the PM target.

Table 1

Mean RTs (ms) for 25 Trials Before PM Target

	PM Condition		
Delay	Time	Event	Control
1 min	791**	865***	730***
3 min	743*	742*	680*
6 min	776**	725	695**

* $p < .10$ ** $p < .05$ *** $p < .01$

Accuracy and Reaction Time Correlations

To assess whether ongoing task speed was related to PM task accuracy, correlations between Block 2 RTs and PM accuracy as well as the 25 trials RTs and PM accuracy were analyzed for each task and at each delay. There was no significant relationship between PM block RTs and PM performance for the time-based task at the 1 min delay ($r = .27$, $p = .11$), 3 min delay ($r = .22$, $p = .18$), or 6 min delay ($r = .16$, $p = .37$). There were also no significant relationships between PM block RTs and PM performance for the event-based tasks at the 3 min delay ($r = .18$, $p = .31$), or 6 min delay($r = .02$, $p = .92$). However, there was a significant relationship between the 25 trial RTs and PM performance for the time based task at the 1 min delay (r = .45, p = .005) and 3 min delay (r = .38, p = .02). There was no significant relationship at the 6 min delay, r = .16, p = .35. In regards to the event-based tasks and 25 trials, there was no significant relationship at the 3 min delay (r = .18, p = .30) or 6 min delay (r = -.12, p = .49). Because PM performance was at ceiling for the event-based task at the 1 min delay, correlations could not be performed for either block 2 RTs or the 25 trial RTs and the relationship was not tested.

Clock Checking

A stopwatch was provided for participants to check the time during the PM phase of the time-based conditions. Researchers recorded the number of times and when the clock was checked. The results showed that the clock was checked more often as delay increased, $F(2, 105) = 15.56$, $p < .001$, where the clocked was checking on average 1.30 times in the 1 min delay, 2.24 times in the 3 min delay, and 2.65 times in the 6 min delay. As hypothesized, clock checking behavior increased as the target time approached. The number of clock checks over the time course was recorded and is presented graphically. Refer to *Figure 4* for clock checking patterns over the 1 min time course, *Figure 5* for the 3 min time course, and *Figure 6* for the 6 min time course. *Figure 7* shows all 3 delays presented on one graph for clock checking patterns. There are clear peaks at the target time which shows that clock checking increased at the target times approached.

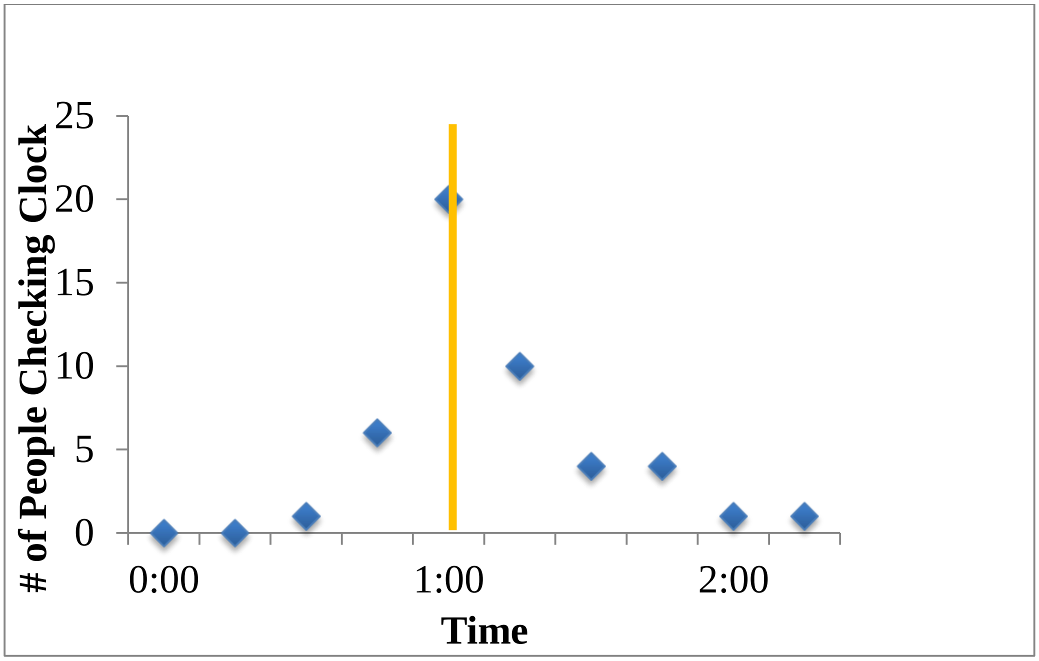

Figure 4. Clock Checking Pattern for Time-based 1 min Delay (Vertical Line Denotes Target Time)

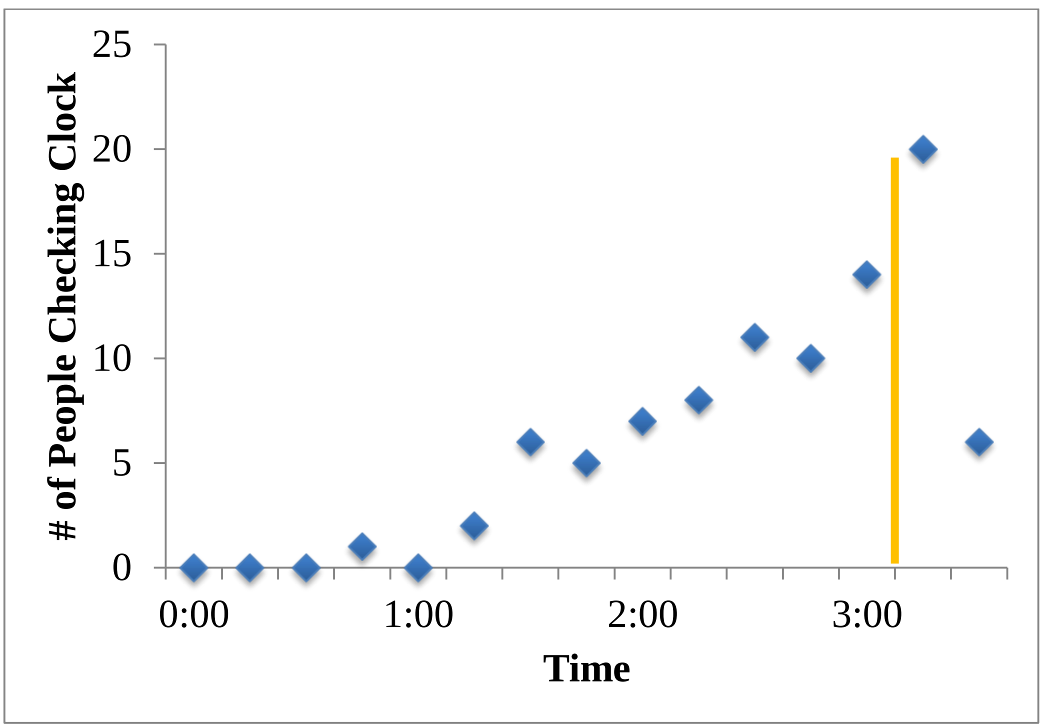

Figure 5. Clock Checking Pattern for Time-based 3 min Delay (Vertical Line Denotes Target Time)

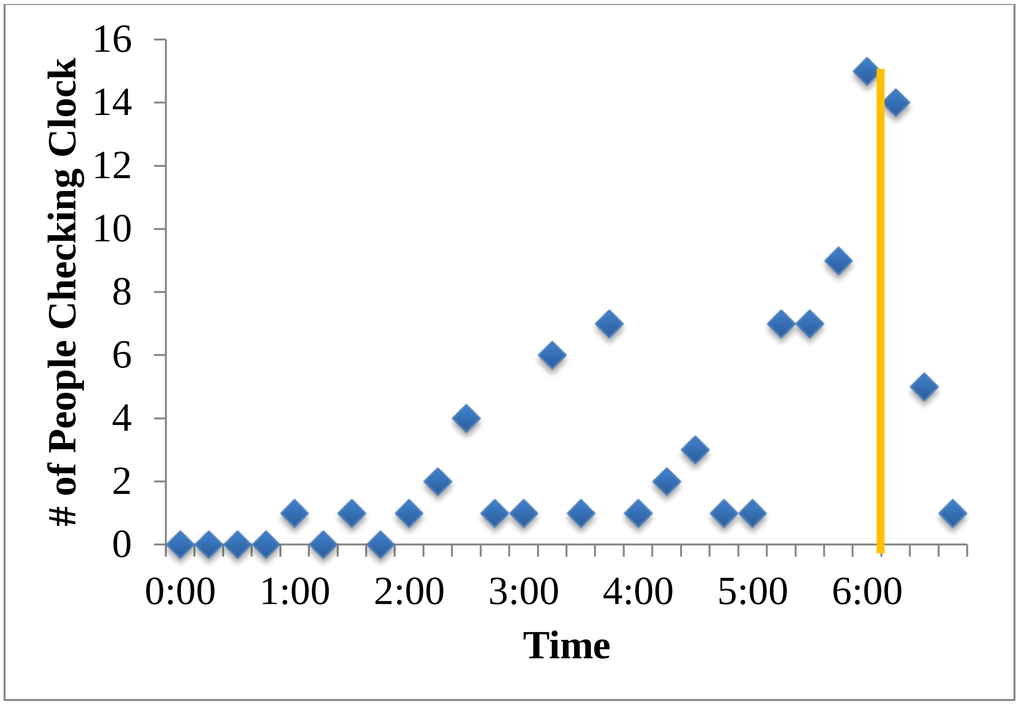

Figure 6. Clock Checking Pattern for Time-based 6 min Delay (Vertical Line Denotes Target Time)

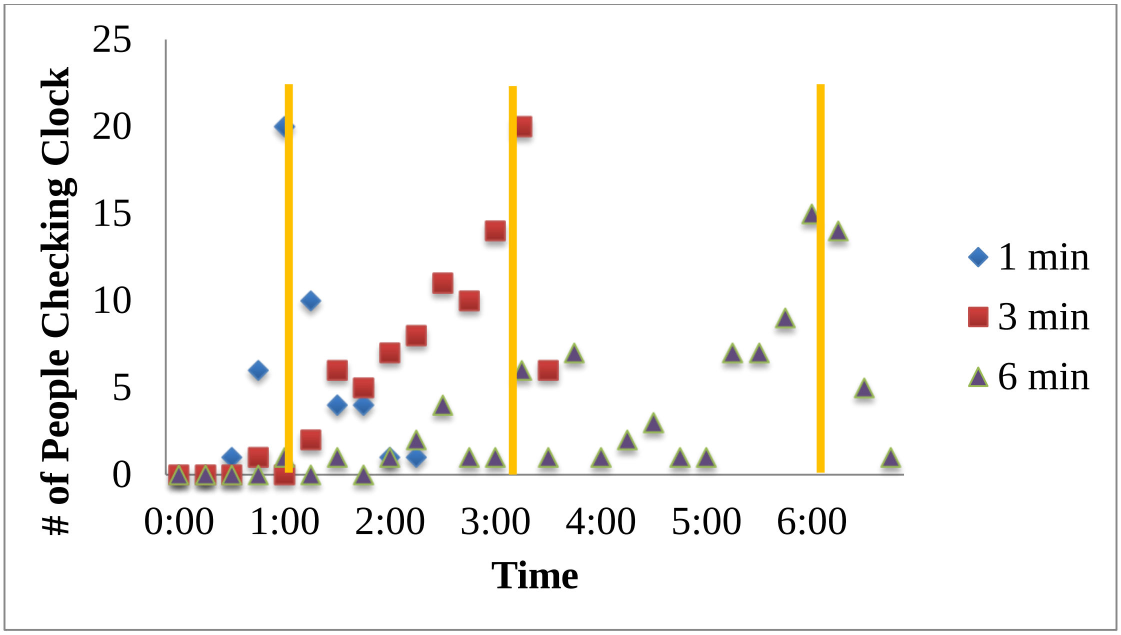

Figure 7. Clock Checking pattern for all Delays of Time-Based Task (Vertical Lines Denote Target Times)

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Research Problem, Method, and Findings

The current study was designed to compare event-based and time-based PM tasks. Few studies have compared these task types in a laboratory setting. Based on past studies (e.g., Kvavilashvili & Fisher, 2007; Sellen et al., 1997), my first hypothesis stated that event-based tasks would result in higher PM performance over all. When compared to event-based tasks, performance was significantly lower in the time-based condition. On average, time-based performance was below 70%, whereas, event-based performance was above 90%. These results suggest that time-based tasks are more difficult to complete successfully without additional aids. A possible reason for these results is that the time-based task is self initiated, whereas in the event-based task, if participants forgot about the task, they may have been suddenly reminded, by spontaneous retrieval, of the additional task when the word was presented on the screen. I also hypothesized that delay would affect PM performance in that as delay increases, performance will decrease. The data did not support this hypothesis as there were no significant differences in performance across delays. However, there was a trend in PM performance and delay across task types in that as delay increased, PM accuracy decreased for the event-based task. Whereas, as delay increased, PM performance increased for the time-based task. Perhaps more data would support a significant interaction between task type and delay for PM accuracy. The hypothesized interaction was not supported either and I will discuss some possible explanations for this surprising finding.

Another way I assessed PM performance is through PM cost by mean RT data. My second hypothesis stated that overall, time-based tasks would produce more cost to the ongoing task and show slower RTs than the event-based tasks. There were differences in RTs across task type, but the difference was found but in the opposite direction. Participants were slower in the ongoing task when they were asked to complete the event-based PM task than the time-based task. The data here suggest that event-based tasks are more cognitively taxing and require more resources than originally predicted. Park et al. (1997) found that event-based tasks consume more attentional resources and create an increased cost when compared to time-based tasks. The data suggest that time- and event-based PM tasks require different amounts of attention for successful PM retrieval. The current results, as well as Park et al.'s, support that event-based tasks require more continuous attention, whereas time-based tasks require the central executive to direct "short bursts" of attention to monitor the time. An increased cost for event-based tasks was found and attributed to continuous attention necessary to retrieve the intention. This is in line with the current results as well. Because participants did not know when the target word would be presented, it slowed down their RTs. The time-based tasks only require participants to worry about the task for a short period of time and once the target time was reached they knew the additional task was over. Participants in the event-based task were not aware of the fact that there was only one target word so they continued to monitor the PM task. This may also be the reason no significant interaction between task and delay was found.

Although performance was higher for the event-based task, we can see from the RT data that it was at a cost to the ongoing task speed. Correlations were performed to see if there was a significant relationship between ongoing task speed and PM accuracy. The data does not support a trade-off between speed and accuracy. There was no evidence to suggest that monitoring contributed to the higher performance for event-based tasks. Although subjects seemed to be monitoring in this task, it was related to their higher performance. It is likely that spontaneous retrieval was supporting the higher PM performance in the event-based task rather than monitoring.

The data for the time-based task suggest that participants are using the Test-Wait-Test-Exit (TWTE) (Harris, 1984) strategy for monitoring the time-based task. Park et al. describe the short bursts of attention as a reason for a decreased cost compared with event-based tasks. The TWTE model is an efficient strategy of monitoring the time and is a possible reason for the decreased cost in the time-based tasks. The time-based tasks did produce lower performance but did not create an increased cost as originally hypothesized. McDaniel and Einstein (2007) discussed time-based tasks and the reliance on self-initiated remembering in these tasks. There are no readily available cues in the environment for the participants to use in remembering the time-based task so they must "remember to remember". The clock was out of sight for participants so they needed to remember to check the clock and remember the time at which they were to respond. Even if the participants were using the TWTE strategy, it is largely self-initiated and this is yet another possible reason for the low performance but decreased cost. Just as Sellen et al.'s (1997) results showed, there is no readily available cue for the time-based tasks. Participants in their study reported that the event-based task was easier to perform because there were environmental cues. Whenever they passed the common area, their memory was prompted through spontaneous retrieval. Time-based tasks lack an environmental cue to prompt spontaneous retrieval. The current results support this description of the tasks as well. The RT data results show that there was more monitoring in the event-based task condition but the delay by task type interaction was not significant.

To get a better idea of monitoring occurring in the PM task, the 25 trials before the target cue or time were isolated and analyzed. The same trials were also selected for the control condition to be compared. Here we saw an interaction of task type and delay in PM cost. At the 1 min delay, only the event-based task resulted in monitoring, as compared with the control condition. In the 3 min delay conditions, monitoring was found in both the time- and event-based tasks, when compared to controls. However, no significant difference was found between the time- and event-based conditions showing that monitoring was occurring at the same level for these tasks at the 3 min delay. At the 6 min delay conditions, monitoring was found in the time-based task, but not the event-based task. This is in line with the Multiprocess View proposed by Einstein and McDaniel (2005) where spontaneous retrieval can occur for event-based PM tasks, especially after a delay. This is also consistent with results reported by McBride et al. (2011). However, this result was only found in the current study when looking at the 25 trials leading up to the target cue or time, suggesting that monitoring is conducted consistently across the block of trials. Isolating the trials immediately before the PM cue or time occurs allows us to get a better idea of whether monitoring is occurring at that point and illuminates differences that were not initially found when averaging across the entire set of trials in the block.

In this study, an additional measure of monitoring through clock checking in the time-based tasks was included. Kvavilashvili and Fisher (2007) proposed a "J" shaped curve of clock checking behavior, meaning that as the target time approaches, clock checking behavior increases exponentially. Kvavilashvili and Fisher's results did not support the "J" shaped curve; instead they found more of an inverted "U" shape. However, their delays were longer (on the order of days) than the delays used in the current study. Thus, my third hypothesis was that a "J" shaped curve would be found for clock checking behavior in the time-based tasks in the current study with much shorter delays. I first analyzed how often the clock was checked by delay. The clock was checked more often in the longer delays and it was often more than halfway to the target time. Huang et al. (2014) also found similar results, where participants checked the clock more often after the halfway point in the second block of trials. When the number of clock checks is presented graphically, the "J" shaped curve begins to emerge. In the beginning of the time course, participants are not checking the clock, but as the target time approaches, an increase in clock checking is seen. I suggest that these results differ from those reported by Kvavilashvili and Fisher, because in the current study, there was less time for participants to start and stop thinking about the task as they naturally would have in a naturalistic task with longer delays. Measuring monitoring through the clock checking pattern is a way to show monitoring specifically for the time-based tasks in addiction to RT data. We can see exactly where this type of monitoring occurred over the time course of trials.

The clock-checking data also support a TWTE model of monitoring, because participants only monitored for short periods of time when they were checking the clock. Again, this explains a decreased cost for the time-based tasks. Participants know that time moves in a steady fashion so they can better estimate time passing than predicting when the PM cue will appear. These data suggest that time-based tasks require less continuous monitoring than the event-based tasks. Park et al.'s clock checking results also support the pattern of short bursts of monitoring, decreasing the overall costs in time-based tasks.

Limitations

There are few limitations of the current project. The design was conducted between subjects, and I think this reduced the validity of the comparison across time- and event-based tasks. Participants only completed one task at one delay and individual differences could be a potential confounding variable. A second experiment is in progress using the PM task as a within-subjects variable to control for this factor. The choice of delay is also a possible limitation because the results may only be generalizable to these relatively short delays. A longer delay may have made the task slightly more naturalistic in that it could be generalized to PM intentions that we carry out over week long periods. It is possible that they results and patterns of monitoring are subject to short delays only. Another limitation of the design would be the target word. Participants were asked to look for a flower word, "daisy", and respond. A handful of participants reported that they did not know any flowers or responded to the word “dozen” as an example of a “flower word”. Although only a small amount of data was excluded from analyses for this reason, the follow-up study is using animal words to clear up any confusion.

Recommendations of Future Research

The current project was designed to compare time- and event-based PM performance. Past research has shown that performance on time-based tasks is typically lower than performance on event-based tasks, suggesting that time-based tasks are more difficult to complete. Costs to the ongoing task for both time- and event-based PM across different delays were also compared. I initially hypothesized that a cost to the ongoing task was indicative of the decreased performance in time-based tasks. Although the data do not support this claim, there are several explanations for the results found. Future studies should continue to directly compare time- and event-based PM tasks both in and out of the laboratory. These studies can provide a further explanation for changes in performance as well as the interaction with increased delays.

REFERENCES

Einsein, G. O., McDaniel, M. A., Richardson, S. L., Guyunn, M. J., & Cunfer, A. R. (1995). Aging and prospective memory: Examining the influence of self-initiated retrieval processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*,996-1007.

Einstein, G. O., & McDaniel, M. A. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology, 14*, 127-144.

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science*, *14*, 286–290.

Harris, J.E., & Morris, P.E. (Eds.). (1984). *Everyday memory, actions and absent-mindedness*. London: Academic Press Inc. Ltd.

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

Huang, T., Loft, S., & Humphreys, M. (in press). Internalizing versus externalizing control: Different ways to perform a time-based prospective memory task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.

Kliegel, M., McDaniel, M.A., & Einstein, G.O. (Eds.). (2008). *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives*. New York: Taylor and Francis Group LLC.

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: General*, *136(1)*, 112-132.

McBride, D. M., & Abney, D. H. (2012). A comparison of transfer-appropriate processing and multi-process frameworks for prospective memory performance. *Experimental Psychology*, *59*, 190-198.

McBride, D.M., Beckner, J.K., & Abney, D.H. (2011). Effects of delay of prospective memory cues in ongoing task on prospective memory performance. *Memory & Cognition*, *39*¸1222-1231.

McBride, D. M., Coane, J. H., Drwal, J., & LaRose, S-A. M. (2013). Differential effects of delay on time-based prospective memory in younger and older adults. *Aging, Neuropsychology, and Cognition, 20*, 700-721.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology. 14*, 127-144.

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

Park, D. C., Hertzog, C., Kidder, D. P., Morrell, R. R., & Mayhorn, C. B. (1997). Effect of age on event-based and time-based prospective memory. *Psychology and Aging, 12*, 314-327.

Scullin, M. K., McDaniel, M. A., Shelton, J. T., & Lee, J. H. (2010). Focal/nonfocal cue effects in prospective memory: Monitoring difficulty or different retrieval processes? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36*, 736-749.

Sellen, A. J., Louie, G, Harris, G. E., & Wilkins, A. J. (1997). What brings attention to mind? An in situ study of prospective memory. *Memory, 5(4)*, 483-507.

Smith, R. E. (2013). 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*, 347-361.