ABSTRACT

Investigating Prospective Memory Commission Errors

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Prospective memory (PM) is remembering to execute an intention in the future, such as remembering to buy bread on the way home from work. Commission errors occur when a completed or finished intention is erroneously re-executed. This dissertation investigated the influence of context and delay on commission error risk. In three experiments, participants encoded a PM intention (e.g. press "Q" when you see the target words *corn* and *dancer*). In Experiments One and Two, I manipulated the context of the PM procedure where participant's encountered target words (practice block, active block, or neither) before being instructed that the PM intention was finished. The target words were re-presented in a following finished block. In Experiment One, participants who did not execute the intention during the procedure were significantly more likely to make commission errors compared to participants who executed the intention in the active block. Experiments One and Two also demonstrated that executing the PM intention in a practice context did not decrease commission error risk to the same extent as executing the PM intention in the active context. In Experiment 3, I manipulated the temporal delay between the presentation of the finished instructions and the finished block. Significant

differences in commission error risk were not observed between participants with a ten minute delay and participants with a 48 hour delay, but commission error risk was high in both conditions. My experiments highlight the importance of executing a PM intention in the appropriate context before it is finished, especially because an unexecuted PM intention may remain accessible for a minimum of two days. These findings further our understanding of the Zeigarnik effect and of spontaneous retrieval theories of prospective memory.

Investigating Prospective Memory Commission Errors

by

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A Dissertation

Approved by the Department of Psychology and Neuroscience

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Submitted to the Graduate Faculty of
Baylor University in Partial Fulfillment of the
Requirements for the Degree
of

Doctor of Philosophy

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August 2016

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ACKNOWLEDGMENTS

I am grateful to my advisors Dr. Charles A. Weaver and Dr. Michael K. Scullin, for their advisement throughout my tenure at Baylor. Dr. Weaver and Dr. Scullin are the unsung heroes of my graduate career, their constant assistance, flexibility, and patience (and exceedingly high standards) helped me to grow from a young college student to a strong researcher and colleague. I would like to thank the additional members of my dissertation committee, Dr. Sara Dolan, Dr. Gary Elkins, and Dr. Tony Talbert, for providing me with helpful feedback regarding my dissertation and my future research career. I would like to thank the faculty, administration, and graduate students of the Baylor Psychology and Neuroscience department, for their support and compassion. Thank you for always welcoming me into your offices and giving me honest, tough, and very valuable advice. Finally, I would like to thank, from the bottom of my heart, the Scullin labmates, for giving me a home, #teamScullinforever. There's a million things I haven't done, but just you wait!

DEDICATION

To Mom, Dad, Theresa, Elizabeth, and all of my wonderful friends inside and outside of the department, words cannot express my gratitude for your unconditional love and support, and to Travis, the ever-favorite object of my heart, for helping me to remember (see what I did there?) to put life into perspective

CHAPTER ONE

Introduction

Prospective memory (PM) is remembering to carry out an intended action at an appropriate point in the future and in the absence of any explicit reminder to do so. Prospective memory is crucial for normal functioning; people form and remember to carry out PM intentions on a daily basis (Crovitz & Daniel, 1984; Kliegel & Martin, 2003). The consequences of failing to perform a PM intention may sometimes be minimal. For example, a forgotten trip to get milk at the grocery store after work can be made the next day. On the other hand, more severe failures in prospective memory, such as failing to take required medication, can result in injury (Osterberg & Blaschke, 2005). One subset of prospective memory failures is the failure to remember that the PM intention has already been completed, such as taking a second dose of medication upon encountering the bottle later that day. These *commission errors* also vary on a spectrum of importance. It may be embarrassing to send the same email more than once, but it can be dangerous to take a blood pressure pill twice in one morning. Prospective memory researchers are beginning to examine factors that influence commission error risk, such as whether the prospective memory intention is executed in the appropriate time or place (*context*), and how long a completed prospective memory intention remains accessible after it is finished, cancelled, or suspended (*delay*) (Bugg & Scullin, 2013; Scullin, Bugg, & McDaniel, 2012; Scullin & Bugg, 2013).

The study of prospective memory is important because what is learned is applicable to everyday life. Prospective memory research is relevant in healthcare and medical practices (Parker, Garry, Einstein, & McDaniel, 2011) and in the workplace (Dismukes, 2012; Loft, 2014; Loft, Pearcy, & Remington, 2011). The proposed experiments aim to examine whether *context* or *delay* influence the development of commission errors. To better explain how prospective memory commission errors are formed, I will first broadly review the prospective memory literature, including how encoding and retrieval processes support prospective memory (Chapter 1). Next, I will present a summary of the commission error literature and my research questions. I will place specific focus on the role of *context* and *delay* in affecting risk for commission errors (Chapter 2). Finally, I will present my experiments (Chapters 3-5).

An Introduction to Prospective Memory Literature

Prospective Memory Tasks

Prospective memory (PM) differs from retrospective memory (RM) in various ways. Retrospective memory emphasizes memory for events that have previously occurred, whereas prospective memory focuses on intended future events (memory for the future) (Baddeley, Eysenck, & Anderson, 2009). A failure of retrospective memory may include failing to remember a phone number for a friend, whereas a prospective memory failure involves forgetting to call a friend at a prescheduled time.

Researchers should be aware of the key characteristics of prospective memory tasks prior to the development of prospective memory related experiments or procedures. First, a prospective memory intention must be consciously formed, at least initially. For example, “I need to remember to press the enter key when I see the target word” is forming a prospective memory intention, whereas “I remembered to press the enter key when I saw the target word” is recalling a retrospective memory. Second, in most prospective memory tasks, the execution of the PM intention is delayed, sometimes significantly. Third, prospective memory retrieval cues appear as a natural part of another task or situation, eliminating the need for the intention to be retrieved for the subject to complete the experiment. Prospective remembering is self-initiated and involves consciously interrupting an ongoing task to execute an intention. In a retrospective memory task, a retrieval cue demands a response and prompts the participant to remember their instructions before moving forward with the experiment (Graf & Uttl, 2001).

In order to measure prospective memory successes and failures, there needs to be a constrained window of opportunity in which the PM intention can be appropriately performed and the time frame for response execution is limited. An intention to remember to buy milk after work involves the window of the time it takes to drive home from work. If this intention is not fulfilled during the drive home from work, then it is considered a failed intention. However, the intention to read a book involves a vague window of time of however long it may take to read a book. If the intention is not fulfilled within the next month or year, it is not necessarily considered a failed intention (McDaniel & Einstein, 2007).

Prior to the development of laboratory-based prospective memory tests (Einstein & McDaniel, 1990), prospective memory was measured using self-reports and semi-naturalistic tasks. Participants were asked to remember to call the researcher at a certain time in the future or mail postcards on certain days (Meacham & Leiman, 1982; Moscovitch, 1982; West, 1988). Einstein and McDaniel (1990) created a laboratory paradigm that measures prospective memory accuracy and retrieval (see also

Kvavilashvili, 1987). They introduced the paradigm in an experiment examining differences in prospective memory performance between younger and older adults. Participants learned a short-term memory task (ongoing task), and then were told that the experimenters were also interested in their ability to remember to do something at a particular point in the future. Participants encoded the PM intention to press the F1 key when the cue word “rake” appeared during the ongoing task. The cue word appeared three times over forty-two test trials. Participants in the no-aid condition read only the prospective memory instructions: “press the F1 key for “rake.” Participants in the external-aid condition were given thirty seconds to create a memory aid using a pile of school supplies. After a brief delay, participants performed the short-term memory ongoing task trials. There were no significant differences in prospective memory accuracy between younger and older adults (Einstein & McDaniel, 1990). Einstein and McDaniel (1990) concluded that their prospective memory paradigm allowed for researchers to identify variables that may affect prospective memory performance.

Most laboratory prospective memory experiments use variations on the initial prospective memory procedure (Einstein & McDaniel, 1990; Kvavilashvili, 1987). Participants learn an ongoing task, encode a PM intention, and are distracted briefly so the intention is not maintained in working memory. Prospective memory accuracy is determined by examining the mean proportion of hits (cue key presses when the cue word appears) during the ongoing trials. Researchers can also examine reaction times on the ongoing trials to assess how participants are allocating their attentional resources between the ongoing and PM intentions. “Costs” are reductions in ongoing task performance (typically observed as increased reaction times though sometimes as decreased accuracy)

(Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). The basic prospective memory procedure established by Einstein and McDaniel (1990) is used to examine changes in accuracy and reaction time across multiple types of prospective memory, including event-based, time-based, and activity-based prospective memory.

Types of Prospective Memory

Prospective memory can be subdivided into two types: event-based and time-based. Event-based prospective memory involves remembering to perform an action when triggered by an environmental cue. For example, the event (e.g., seeing the grocery store) provides the cue to perform a given action (e.g., buying some fruit). Remembering to perform a given action at a particular time is time-based prospective memory, such as "I need to remember to check the oven every five minutes so the cookies do not burn" (Baddeley et al., 2009). Event-based tasks are more likely to be completed than time-based tasks because event-based PM intentions are triggered by external PM cues, whereas time-based PM intentions require participants to generate their own internal PM cues to trigger the memory (Sellen, Louie, Harris, &Wilkins, 1997).

The present experiments focus on event-based prospective memory. Event-based prospective memory can further be broken down by type of cue. Salient and strongly associated PM cues are more likely to prompt retrieval of a PM intention than non-salient or weakly associated PM cues. In a laboratory setting, a salient PM cue would be presented on a different color background than the ongoing task items, whereas a non-salient PM cue would be presented on the same color background as the ongoing task items. An example of a strongly associated PM cue and action would be the intention to stop at the grocery store on the way home to buy bread, whereas an example of a weakly associated PM cue and action would be the intention to stop at the grocery store on the way home and buy shoe polish (McDaniel et al., 2004).

PM cue effectiveness is also determined by cue focality. A focal PM cue is one in which the properties of the cue that were encoded alongside the PM intention are similar to the properties that are being processed during the ongoing task. Consider a PM intention to press a certain key when a cue word appears during an ongoing lexical decision task. Identifying a cue word requires the same processes as identifying whether a string of letters is a word or a nonword, thus making the cue word *focal* to the ongoing lexical decision task. On the other hand, a nonfocal PM cue is a PM cue that does not share the same features as the ongoing task. Identifying a cue syllable (e.g. “tor” in the word, “tortoise”) requires different processes as identifying whether a string of letters is a word or a nonword, thus making the cue syllable *nonfocal* to the ongoing lexical decision task (Einstein & McDaniel, 2005, Experiments 1 and 2).

Categorizing each PM intention into specific types may be helpful. Consider the example of remembering to go to the grocery store. In the midst of a busy day, the PM intention may be reformed to include a specific time that the trip will be made (time-based) or the next time one sees a grocery store sign (event-based). A PM intention can be formed under one of the two broad formats just identified, and the probability of completion could depend on the manner in which the PM intention is encoded, the strength of the retrieval cues, and the interaction between the current context and the type of PM intention formed (see Marsh et al., 2006).

Prospective Memory Encoding

Before we are able to understand commission errors, we need to first understand the four stages of a prospective memory intention: encoding, delay, retrieval, and execution (Ellis & Milne, 1996). Commission error risk can be increased or decreased by manipulating aspects of any or all of the four stages. A prospective memory intention begins at encoding. In the next section, I will discuss variables that influence the strength of the encoding of a prospective memory intention, such as good planning, subconscious priming, specific PM cues, and encoding strategies. A strong prospective memory intention may be less susceptible to deactivation after it has been finished, which may increase the risk of commission errors.

Planning

The degree of planning involved for successful prospective memory retrieval is dependent on the characteristics of the PM task, such as the complexity of the task (Kvavilashvili & Ellis, 1996), the simplicity or difficulty of the decision to pursue the PM intention, and the importance of the PM intention. Marsh, Hicks, and Cooks (2006) conducted an experiment in which participants encoded a PM intention to press a cue key if they saw an animal word. One group of participants was also informed that animal words would appear in the last phase of three phases of ongoing tasks: Phase 1 was a lexical decision task, Phase 2 was questionnaire tasks, and Phase 3 was another lexical decision task. The other group was not alerted to when the animal cues would appear. With their knowledge, participants in the awareness condition could plan how they were going to remember to execute the PM intention. Participants who planned how they would execute the upcoming PM task only showed slower reaction times (costs) to the lexical decision trials in Phase 3, whereas participants in the no awareness condition showed costs in all phases of the experiment. Participants strategically restricted their monitoring to the context in which animal words were expected, as well as potentially formulated a plan to conserve resources appropriately.

Additionally, overall prospective memory performance is dependent on the quality of the plan (Kliegel et al., 2000). Kliegel et al. (2005) provided adults in a pre-planning condition with guidance as to how to formulate plans for a complex task. Participants with planning aid instructions were significantly more likely to incorporate noticing the PM cue into their plans. Fifty percent of these participants showed a higher likelihood of remembering to initiate the complex task than the 30% who did receive aid who also initiated the task (Kliegel et al., 2005).

Encoding

Successful execution of a PM task is not only reliant on good planning. Good prospective memory performance can also be linked to the strength of the encoding of the prospective memory (Einstein, Smith, & McDaniel, 1997; Mantyla, 1993). Encoding is the forming of a PM intention, with specific emphasis placed on the PM cues and actions associated with the intention. Within the encoding stage, researchers have examined variables such as priming effects (Mantyla, 1993), typicality and specificity (Ellis & Milne, 1996), performance predictions and task expectations (including metacognitive processes; Rummel & Meiser, 2013), context (Kuhlmann & Rummel, 2014) and cue saliency (Scullin et al., under review; Trawley et al., 2014). Manipulations such as the familiarity or distinctiveness of a retrieval cue and category-exemplar relations appeared to exert influence on delayed intention performance. In summary, the type of cue used to encode and retrieve a prospective memory intention influences whether the intention will be retrieved, which is important in understanding why some intentions are retrieved even when the task is finished.

Implementation Intentions

A helpful encoding strategy for good prospective memory performance is the use of implementation intentions (Gollwitzer, 1999). When individuals typically form PM intentions they may be general, non-committal ideas such as “I intend to write a dissertation proposal.” Implementation intentions convert non-committal ideas into specific achievable goals using the format “When Situation X arises, I will perform Response Y.” In the case of writing one’s dissertation, an implementation intention would be, “When I sit down at my computer at 1pm, I will write the paragraph on implementation intentions.” Gollwitzer and Brandstaetter (1997) demonstrated that standard PM intentions accompanied by implementation intentions are more effective than standard PM intentions alone. They asked participants to write a report about how they spent their Christmas Eve and submit it to the researchers within 48-hours of the event. The participants who wrote down the specific time and place at which they were going to write the report were significantly more likely to submit the completed report in the requested time period compared to the control participants (Gollwitzer, 1993).

Sheeran and Orbell (1999) and Milne, Orbell, and Sheeran (2002) provided additional evidence for the effectiveness of implementation intentions in remembering a prospective memory. Sheeran and Orbell (1999) encouraged one group of participants to form a general PM intention to take a vitamin C pill each day for three weeks. Another group of participants used implementation intention encoding to plan when and where they would take the vitamin C pill each day. Participants who formed implementation intentions were more likely to take their pills than participants who formed standard PM intentions. Milne, Orbell, and Sheeran (2002) instructed college students to remember to perform at least twenty minutes of exercise during an upcoming week. The group of participants who formed implementation intentions was significantly more likely to exercise than the group who formed standard PM intentions. Thus, boosting the strength of encoding can improve performance of naturalistic PM intentions.

Theoretical explanations for the effectiveness of implementation intention encoding suggest that it improves retrieval by strengthening the link between the PM cue and the intended action (McDaniel & Scullin, 2010). Despite evidence against automatic retrieval, implementation intention encoding remains not only an effective way of improving prospective memory performance (Gollwitzer, 1999; Liu & Park, 2004), but also of increasing commission error risk (Bugg et al., 2013)

Prospective Memory Retrieval Theories

Now that we have a basic knowledge of the ways in which a prospective memory intention is encoded, we can discuss how a prospective memory intention is retrieved. Prospective memory retrieval is self-initiated (i.e., not explicitly prompted as in free recall and recognition tests). In this next section, I will discuss the primary theories of prospective memory retrieval. Prospective memory theories differ on whether retrieval is hypothesized to be solely dependent on controlled processing (attentional monitoring), primarily dependent on automatic processing (spontaneous retrieval view), or on a combination of controlled and automatic processing (multiprocess framework). Retrieval is an important component of my dissertation because I am examining how the context in which the PM intention is retrieved and executed influences later commission error risk. An understanding of the retrieval mechanisms that support prospective memory accuracy can assist with the prevention of commission errors.

Preparatory Attentional and Memory Processes Theory (PAM)

Attentional monitoring theories state that the retrieval of a PM intention is dependent on our monitoring the environment for PM cues. These controlled monitoring processes require the use of attentional resources that are usually dedicated toward efficiently executing the ongoing task. In a laboratory setting, evidence of monitoring is observed when participants are slower to complete ongoing task trials. Monitoring for target words during active blocks often results in accurate intention execution. However, some PM researchers (Smith, 2003) believe that inaccurately monitoring during the finished block may result in commission errors.

The preparatory attentional and memory processes (PAM) theory (Smith, 2003; Smith & Bayen, 2005) is one of the most influential theories regarding the processes underlying event-based prospective memory. According to the PAM theory, two processes are involved in successful prospective memory performance: a capacity-consuming preparatory process that monitors for the appropriate circumstance in which to execute the PM intention, and a retrospective memory process that assists with remembering the proper PM cues and the actions associated with the PM cues (Smith, 2003; see also Guynn, 2003). Controlled monitoring of the environment begins when the PM intention is encoded and is maintained until the required action is performed. Retrospective memory assists in the identification of PM cues and recollection of the intended action (Baddeley et al., 2009).

Smith (2003) showed evidence of preparatory attentional monitoring costs by comparing performance on an ongoing lexical decision task between groups that either performed the lexical decision task by itself (control condition) or had to simultaneously search for six PM cues (embedded prospective memory condition). Participants in the embedded prospective memory condition were slower to respond to non-cue filler lexical decision task words than participants in the control condition. Furthermore, longer lexical decision response times were correlated with better prospective memory accuracy. Participants devoted the majority of their attentional resources during the ongoing lexical decision trials to monitor for the embedded PM intention, indicating that PM retrieval may be a non-automatic preparatory process (Smith, 2003, see also Burgess et al., 2001; Smith & Bayen, 2004).

Examining the costs of attentional demands to the ongoing activity can provide evidence of monitoring for a PM intention. Because the PAM theory predicts that PM retrieval is a non-automatic process that will be superior when full attentional resources are available, prospective memory performance should decline if attention is divided between multiple ongoing tasks (McDaniel, Robinson-Riegler, & Einstein, 1998) or if more attention is demanded by the ongoing activity (cognitive load). Park et al., (1997) and Kidder, Park, Hertzog, and Morrell (1997) found that the inclusion of a second concurrent working memory task impeded performance on an event-based PM intention, suggesting that PM retrieval required attentional resources. Marsh and Hicks (1998) confirmed the importance of attentional resources in prospective memory retrieval by comparing prospective memory performance between participants executing one ongoing task and participants executing two ongoing tasks. Those in the dual-task condition showed more prospective memory failures than those in the one-task condition. Interestingly, prospective memory performance in the dual-task condition was dependent on the nature of the second ongoing activity (generating digits versus repeating words). Generating digits is thought to rely on attentional resources, whereas repeating words is a more automatic process (McDaniel & Einstein, 2007). Regardless of the secondary activity, constant monitoring for PM cues may be inconvenient. An alternative perspective is that spontaneous retrieval processes can trigger retrieval in the absence of continuous monitoring.

Spontaneous Retrieval Processes

It may be unrealistic to assume we are constantly monitoring for real world prospective memories at the expense of everyday ongoing tasks. The spontaneous retrieval theory (Einstein et al., 2005) has been proposed to account for PM retrieval when preparatory attentional resources are not being devoted to looking for PM cues (monitoring). Therefore, the spontaneous retrieval theory suggests that commission errors occur when participants are not monitoring during the finished block, but instead spontaneously retrieve the PM intention when they see a target word and do not inhibit execution.

Initial self-report prospective memory studies provided evidence in favor of the notion that prospective memory retrieval is possible without preparatory attentional processes. Einstein and McDaniel (1990) asked participants how they were able to remember to perform a PM intention during the prospective memory experiments. Many participants responded that the PM intention seemed to "pop" into their mind at certain points during the ongoing task. Reese and Cherry (2002) interrupted participants at various points of a PM intention task and asked what they were thinking about. Two percent of participants reported thinking about the PM intention (monitoring) whereas 69% of participants were thinking about the ongoing activity (not monitoring). In addition, participants showed decent prospective memory performance (about 60%), implying that good performance may be supported by spontaneous retrieval.

Additional objective behavioral data address the possibility that PM intentions do not always interfere with the ongoing task. Einstein et al. (2005, Experiment 3) tested the idea that prospective remembering can occur with no cost to the ongoing task (i.e., spontaneous retrieval in the absence of monitoring) by comparing performance between a one PM cue condition and a six PM cue condition (cf. use of six cue words in Smith, 2003). Significant costs to the ongoing sentence completion task (indicative of monitoring) were observed in the non-cue trials in the six-item condition, but not in the non-cue trials in the one-item condition. One limitation of this work was that the ongoing sentence completion task might not have been sensitive enough to detect potential costs. However, previous experiments involving quicker ongoing task responses also showed a lack of costs associated with the prospective memory task. Marsh, Hicks, Cook, Hansen, and Pallos (2003) used a much faster lexical decision ongoing task, which due to its sensitivity should pick up on monitoring that may not have been observed in the ongoing sensitive completion task. No significant costs to the ongoing lexical decision task were found in the one PM cue condition despite accuracy on 93% of the PM cue trials. These results support the theory that monitoring may not always be essential for successful prospective memory retrieval.

Spontaneous retrieval processes are also observed in conditions where PM cues are presented in unexpected contexts (e.g., when the PM intention is suspended or interrupted). Einstein et al. (2005; Experiment 5) had participants perform two ongoing tasks, an image rating task and a lexical decision task. Participants were told to only execute the PM intention during the image-rating task. The lexical decision block was between two image-rating blocks and PM cues were present in all three blocks. The PAM theory suggests that prospective memory retrieval would not occur during the lexical decision task because participants were not monitoring. The spontaneous retrieval view argues that in the absence of monitoring, retrieval can still occur because the PM intention will automatically stimulate retrieval processes. Furthermore, the involuntary retrieval of the PM intention will interfere with the speed of making a lexical decision when a PM cue is presented relative to when a control word is presented. Due to this intention interference, response times for PM cues during the lexical decision task will be significantly slower than reaction times for matched control words. Consistent with the assumptions of the spontaneous retrieval theory, Einstein et al. (2005) found response times for PM cues were significantly slower than they were for control words, suggesting that retrieval can occur without monitoring when the PM cue is presented.

Spontaneous retrieval is also more likely if the PM cue is focal, meaning there is a high overlap between the type of processing of the PM cue at encoding and the type of processing of the PM cue at retrieval (Marsh, Hicks, & Cook, 2005; McDaniel et al., 1998). Einstein et al. (2005; Experiments 1 and 2) provided empirical evidence for the correlation between PM cue focality and spontaneous retrieval processes. In Experiments 1 and 2, participants in the focal condition were asked to press a key when the word “tortoise” appeared in a category judgment task, whereas participants in the nonfocal condition were asked to press a key when the syllable “tor” occurred. The nature of the ongoing category judgment task encouraged participants to make judgments about entire words rather than syllables, and therefore influenced the retrieval strategy chosen to complete the PM intentions. Participants successfully completed the focal PM cue intention without any costs (spontaneous retrieval), whereas participants in the nonfocal PM cue condition showed significant costs to accuracy and reaction times on the ongoing task (monitoring). High levels of spontaneous retrieval can occur under the right task and cue conditions.

Reflexive associative mechanism. Multiple mechanisms have been proposed to account for our ability to spontaneously retrieve PM intentions. According to Moscovitch (1994), our memory works to provide reflexive associative memory processes that support spontaneous retrieval. When an association is formed between an action and a PM cue, the reflexive associative system delivers the intended action into consciousness if the PM cue is encountered outside of a retrieval mode. The system will reflexively initiate retrieval of the action, provided that there is a strong enough association between the action and PM cue.

McDaniel, Guynn, Einstein, and Brenesier (2004) tested the reflexive associative system by manipulating the degree to which a PM cue and action were associated. In their experiment, the PM intention was to write down response words whenever specific PM cue words were detected during an ongoing word-rating task. The PM cue-action pairs were either strongly associated (write “sauce” when you see “spaghetti”) or weakly associated pairs (write “church” when you see “spaghetti”). McDaniel et al. found that subjects were significantly more likely to remember to perform the PM intention when the cue word was highly associated with the response word (85%) compared to when the cue word was weakly associated with the response word (56%). If participants were monitoring throughout the experiment (checking for the cue), there would be no differences in accuracy between the conditions because the cues were identical for both the strong- and weak-association conditions. The researchers also tested the possibility that participants forgot the weakly associated word-pairs. A recall test showed that participants remembered all word-pairs throughout the experiment. Strongly associated cue-action pairs may stimulate the reflexive and associative retrieval of the PM intention when one is not in a retrieval mode (McDaniel & Einstein, 2007).

Discrepancy-plus-search mechanism. An additional mechanism proposed to support spontaneous retrieval processes is familiarity (Guynn & McDaniel, 2007). PM cues may seem more familiar than non-PM cues, either due to the higher activation and accessibility or the ease of processing of the PM cue. High familiarity of the PM cue may indicate that the PM cue is significant, which will initiate a search for the source of significance, and the PM intention will be retrieved and executed (Guynn & McDaniel, 2007). However, in some circumstances, familiarity may not increase the likelihood of successful prospective memory retrieval. For example, if I need to remember to deliver a message to a friend at work, my sense of familiarity for my friend will not activate a search for a PM intention because I am familiar with everyone else in the office as well.

Inferring that familiarity is required to search for a PM intention implies that the PM cue has already been detected, even though it may not have been. A more flexible explanation may be that a PM cue is recognized as significant because of its discrepancy.

According to the discrepancy-plus-search view (McDaniel & Einstein, 2000; Whittlesea & Williams, 2001a, 2001b), the presence of the PM cue creates a discrepancy in the expected fluency of ongoing task processing and actual fluency of ongoing task processing. A search is initiated to determine why the PM cue results in a discrepancy in processing. The perception of discrepancy and the basis for the discrepancy depends on the context in which the processing of the PM cue takes place. For example, if I need to remember to deliver a message to a work colleague, I may feel a sense of urgency and expectation when I see her at work. In an attempt to relieve this discrepancy, I will engage in a search for the cause of the discrepancy and may attribute it to my PM intention to deliver a message to her.

Discrepancy is also observed in laboratory prospective memory experiments. Prior exposure to the PM cues during encoding or practice trials results in an increased familiarity or feeling of discrepancy when those PM cue words are seen in the ongoing task, and following a search/attribution process, the PM intention to press a certain key when the PM cue words appear is retrieved (McDaniel & Einstein, 2007). Evidence for discrepancy-plus-search processes can be observed by creating discrepancy for non-cue items in an ongoing task. The quality of processing of the non-cue items creates a context in which the quality of processing of a particular PM cue becomes more or less discrepant.

McDaniel et al. (2004) manipulated the discrepancy of non-cue words presented in an ongoing word-rating task by exposing participants to both PM cue and non-cue words prior to the start of the PM phase. Previous exposure of both the PM cue and non-cue words reduced the difference in quality of processing and coherence between the two types of words (low discrepancy condition). Previous exposure to only the PM cues prior to the experiment created a sense of fluency in the PM cues that was discrepant from the quality of processing of the non-cues (high discrepancy condition). According to the discrepancy-plus-search view, PM performance should decline in the low discrepancy group because the PM cues no longer produce discrepancies during the ongoing task. PM performance declined in the low discrepancy group (see also Gao & Graf, 2005). Evidence of the discrepancy-plus-search view component of spontaneous retrieval processes is indicative that preparatory attentional monitoring processes are not always required for PM retrieval.

Multiprocess Theory

The multiprocess theory is comprised of three general assumptions (McDaniel & Einstein, 2000; Einstein et al., 2005). First, several different kinds of processes (monitoring and spontaneous retrieval processes) can support prospective remembering. Second, the type of retrieval strategy used and the effectiveness of that retrieval strategy are dependent on the characteristics of the PM intention, the demands of the ongoing task, and individual differences (Einstein et al., 2005; Experiment 4). For example, if participants expect the PM intention to be difficult or important, then they will be more likely to allocate more attentional resources to it (monitoring) (Einstein et al., 2005, Experiments 1 and 2; Harrison & Einstein, 2010; Harrison et al., 2013; Kliegel et al., 2004; Marsh et al., 2003; Marsh et al., 2006). Third, there is a bias towards reliance on spontaneous retrieval processes over monitoring (McDaniel & Einstein, 2000). Monitoring requires preparatory attentional resources that exact costs on the ongoing task. Costs can impair performance on the ongoing tasks that need to be completed during the delay between PM intention encoding and PM retrieval (Smith, 2003). Monitoring is also difficult to maintain over the retention intervals (McDaniel & Einstein, 2007). The presence of spontaneous retrieval processes when monitoring is discouraged (by explicitly telling participants to not respond to PM cues), is further validation of the multiprocess theory (Einstein et al., 2005; Experiment 5).

The multiprocess theory suggests that commission errors can occur by both types of retrieval processes (monitoring or spontaneous retrieval) and the type of retrieval process responsible for commission errors can be dependent on multiple factors, including the characteristics of the intention and the ongoing task. Therefore, it is important to present evidence for the multiprocess theory (Einstein et al., 2005; Scullin, McDaniel, Shelton, & Lee, 2010) and discuss how the two primary variables of my dissertation experiments, context and delay, have been shown to influence retrieval strategy and therefore, commission error risk.

In Einstein et al. (2005), monitoring costs were determined by averaging all ongoing task trials. Scullin, McDaniel, and Einstein (2010) argued that monitoring often waxes and wanes throughout the ongoing task, and therefore costs that are averaged across hundreds of trials may not necessarily indicate that monitoring was present at the moment the PM cue was processed (see also Loft & Yeo, 2007; West, Krompinger, & Bowry, 2005). Costs to the ongoing task trials that immediately followed the PM cues were examined to show that monitoring is functionally related to prospective memory retrieval. In addition, monitoring was experimentally prompted at designated points (proximal vs. distal to the target word) in the ongoing task by presenting stimuli associated with the prospective memory task. In Experiment 1, the stimuli presented were semantic associates/lures of the target words, and in Experiment 2, the focality of the PM cues and the background color of the screen were manipulated. If monitoring is always required for prospective remembering, participants should do best in conditions in which monitoring is induced proximal to the PM cue (either by semantic lures or by a background screen color). If spontaneous retrieval assisted in remembering, then participants should still recognize the focal PM cue and retrieve the PM intention. Participants relied on monitoring to execute the PM intention associated with the nonfocal cue, and on spontaneous retrieval to execute the PM intention associated with the focal cue, thus providing support for the multiprocess theory (see also Meier, von Wartburg, Matter, Rothen, & Reber, 2011).

Additional evidence from daily experiences and experimental studies (Scullin, McDaniel, Shelton, & Lee, 2010) confirm that unreinforced monitoring over a long period of time does not occur. Rather, monitoring is selectively engaged in contexts in which PM cues are expected. The Dynamic Multiprocess Theory (Scullin, McDaniel, & Shelton, 2013) proposes that the engagement of monitoring in a particular context will rely initially on spontaneous retrieval of the initial PM cue. Participants encoded a PM intention, completed a series of post encoding tasks, and then performed three ongoing (experimental) tasks after a 20 minute or 12-hour retention interval. Participants did not know in which ongoing experimental context the PM cue would occur. The PM cues were not presented until the end of the experimental block and they were presented infrequently within the three ongoing tasks. The results showed that participants did not allocate any attentional resources to monitoring throughout the ongoing task until the first PM cue was presented and the PM intention was spontaneously retrieved. Then, participants continued to monitor for the remainder of the ongoing task. Attention was flexibly allocated to monitoring in the context in which the PM cue was expected to occur (see also Kuhlmann & Rummel, 2014).

In addition to context, another PM characteristic that influences which retrieval strategy (monitoring or spontaneous retrieval) is used is the time between intention encoding and intention retrieval. Needing to remember a PM intention that will take place in a week may necessitate different retrieval processes than remembering a PM intention for two minutes. Previous research has shown that despite the increased effort to maintain the PM intention in working memory during brief delays, the PM intention can sometimes be lost after a few seconds (Einstein et al., 2000; McDaniel, Einstein, Stout, & Morgan, 2003), or a few minutes (Brandimonte & Passolunghi, 1994) either due to forgetting, an inability to monitor for the length of the delay, or a smaller frequency of presented PM cues (Loft & Yeo, 2007). On the other hand, other research (Guynn et al., 1998; Loft, Kearney, & Remington, 2008) has shown that participants were able to show similar levels of PM accuracy after a delay of up to thirty minutes between encoding and retrieval.

The most surprising finding regarding the role of delay in PM is that of Hicks, Marsh, and Russell (2000), who found that PM accuracy improved twice as much from a short delay (19%) to a delay of 15 minutes (36%). Hicks et al. concluded that increasing the delay might afford an opportunity for people to spontaneously rehearse the PM intention, or to be reminded of the PM intention. McBride, Beckner, and Abney (2011) manipulated delay, or when the PM cues were presented during the ongoing task, to examine when monitoring stops during the ongoing task. PM performance for nonfocal

PM intentions declined with longer delays (2 to 20 minutes; Experiment 1), and with more trials between encoding and PM cue presentation (40, 100, 200, 300, and 400; Experiment 2) due to a lack of monitoring during the ongoing task. Scullin and McDaniel (2010) examined the effect of delays as long as twelve hours. Their participants were more likely to remember to execute the PM intention in the short delay (20 minutes) wake and sleep conditions. Participants in the long delay (12 hour) sleep condition performed better than participants in the long delay wake condition, with no evident costs to the ongoing task. The influence of delay on PM retrieval and execution warrants further study, and doing so will be a focus of my dissertation research (Experiment 3).

To conclude, the way in which a PM intention is encoded influences the way in which it is retrieved. For example, an intention that is encoded with focal or distinctive cues, a strong cue-target association, and good planning is likely to be retrieved using spontaneous retrieval processes. An intention that is encoded with nonfocal or nondistinctive cues, a weak cue-target association, and poor planning is likely to be retrieved using monitoring processes. Additionally, as I will elaborate below, how the PM intention is encoded and whether it is retrieved and executed influences whether it is deactivated. The deactivation of a PM intention is important because an intention that remains accessible despite being finished or executed may be erroneously re-executed, resulting in a commission error.

Prospective Memory Deactivation

Researchers have debated whether a PM intention remains active or is deactivated after it is finished or executed. First, I will present evidence for the deactivation of completed PM intentions. Then, I will present evidence against the deactivation of completed PM intentions.

Evidence for Deactivation

Considering the number of PM intentions that are not completed per day, it is unreasonable to assume that all of them are at a heightened state of activation. Marsh, Hicks, and Bink (1998) told participants that they would either perform actions from a script ("setting the table") or observe an experimenter performing the action script. Participants who performed the intended actions were significantly slower to respond to words from the execute script in a later lexical decision task than participants who did not perform the intended actions. During PM retrieval, slowed reaction times to target words may suggest spontaneous retrieval processes (Hicks et al., 2005; Marsh et al., 2003). The intentions had already been executed (performed), and the slowed reaction times to the target words suggest that the completed PM intentions appeared to have undergone inhibition (Goschke & Kuhl, 1993; Marsh, Hicks, & Bink, 1998). Dockree and Ellis (2001) used similar scripts to replicate the inhibition effect shown by Marsh et al. (1998). Participants encoded two scripts they were told were preparatory tasks for the next participant, and were then told one of the scripts was cancelled. A lexical decision task revealed that reaction times were faster to words from the to-be-performed script than words from the cancelled script, indicating that cancelled PM intentions may be deactivated. Once completed, the former to-be-performed PM intention showed less activation in a lexical decision task than neutral materials, providing evidence for the inhibition of completed PM intentions.

Scullin, Einstein, and McDaniel (2009) provided additional evidence for the deactivation of completed PM intentions (see also Meilan, 2008). Participants performed a PM intention alongside an ongoing image-rating task and were then told the PM intention was either suspended or finished before completing a lexical decision task. The suspended PM intention was spontaneously retrieved in the lexical decision task, but the finished PM intention was not. Finished PM intentions may be deactivated.

Cohen, Dixon, and Lindsay (2005; Experiment 2) used a Stroop task to test differences in deactivation between finished (perform the PM intention before the following Stroop task) and suspended PM intentions (perform the intention after the following Stroop task). Color naming was slower for words related to a suspended PM intention compared to words related to a finished PM intention, again suggesting that the suspended PM intention had been inhibited because participants were trying not to think of the intention-related words presented during the Stroop task (Marsh et al., 1998). After both PM intentions were completed, reaction times showed the levels of activation returned to baseline levels.

Evidence against Deactivation

It may seem as if there is evidence for some amount of deactivation of finished PM intentions, but other experiments show finished PM intentions remain at a heightened level of activation post completion. Cohen, Kantner, Dixon, and Lindsey (2011) found participants were unable to suppress intention-related processing when intention-related words appeared during a Stroop task. Reaction times were slowest to words from the PM intentions that participants were instructed to execute than reaction times to words from PM intentions that participants were instructed to ignore. However, reaction times to words from the PM intentions participants were told to ignore were also significantly slower than reaction times to control words. Even participants who knew they did not have to execute the PM intention still suffered interference, indicating the PM intention was not deactivated.

Nowinski, Holbrook, and Dismukes (2005) assessed PM intention activation across two phases of an experiment that participants believed to be two separate experiments (Part 1 and Part 2). In Part 1, participants completed a PM task and in Part 2, participants rated words (including target words from Part 1) as pleasant or unpleasant. Participants were slower to rate target words that appeared in Part 1 because of the lingering residual activation from the completed PM intention. The heightened accessibility of the completed PM intention resulted in the partial retrieval of PM target words from Part 1 of the experiment. However, it is also possible that the heightened activation observed from Experiment 1 to Experiment 2 was the result of participants holding their PM intentions for a long period of time (192 trials of semantic matching relative to receiving instructions and immediately performing the task) (see also Penningroth, 2011).

West, McNerney, and Travers (2007) gave participants a PM cue prior to a block of semantic judgment task trials and told participants to either perform the PM intention or forget about the PM intention for that block. During both perform and forget blocks, participants were slower to respond to the PM cue than the control word. However, West et al. (2007) did not have participants perform the PM intention at all prior to being told to perform or forget it. Technically then both PM intentions were “unperformed” PM intentions and showed the previously confirmed heightened levels of activation.

Penningroth (2011) observed sustained activation of completed PM intentions. Reaction times for PM scripts after completion were higher than neutral scripts. Penningroth attributed the sustained activation to delay. Participants waited three minutes between script instructions and script performance, whereas participants in Marsh et al. (1998) immediately performed the script after receiving performance instructions. Penningroth (2011) stated that it is possible that the longer PM intentions are held at a higher level of activation before completion, the more likely the PM intention is to show sustained activation after performance instead of inhibition (this would also explain the effects of Nowinski et al., 2005).

The literature is mixed in regards to what happens to finished PM intentions. Some findings provide support for the deactivation hypothesis (Bugg & Scullin, 2013; Marsh et al., 1998; Scullin, Einstein, & McDaniel, 2009) and some findings do not (Penningroth, 2011; Walser et al., 2012; West et al., 2007). Failure to deactivate finished PM intentions might result in commission errors. A commission error is the erroneous re-execution of a completed PM intention such as sending the same email twice in one morning. The next chapter will discuss commission errors in more detail, including the potential mechanisms that contribute to the development of commission errors and the variables that increase commission error risk.

CHAPTER TWO

Literature Review

Commission errors occur when a finished PM intention is re-executed. In a typical commission error experiment (Figure 1; Scullin, Bugg, & McDaniel, 2012; see also Scullin, Bugg, McDaniel, & Einstein, 2011; Scullin & Bugg, 2013; Walser et al., 2012), participants encode the PM intention (e.g., press the Q key when the word *corn* appears during a lexical decision task) and perform this PM intention during an “active” block of trials. Participants are then told that the PM intention is finished and that it no longer needs to be executed during later trials. In the “finished” block of trials, the word *corn* (the PM cue) is presented once or multiple times. A commission error occurs when the participant presses the Q key in response to the word *corn* during this finished block. Persisting spontaneous retrieval *without* a commission error (also indicative of a failure to deactivate the PM intention) occurs when participants respond slower to the word *corn* relative to matched control words during the finished block (Cohen et al., 2005). The ability to deactivate finished PM intentions is highly relevant because failure to disengage from finished PM intentions may incur not only commission errors, but may also impair the retrieval and execution of current and new goals (Scullin et al., 2011; Scullin et al., 2012; Walser et al., 2012).

Increasing Commission Error Risk

There are three ways of conceptualizing commission error risk. The first view, derived from PAM theory (Smith, 2003), argues that commission errors should occur because the monitoring process has not been discontinued upon PM intention completion and is present during the finished block. The second view was developed from evidence of an intention superiority effect (Goschke & Kuhl, 1993). The intention superiority effect is observed when unfinished PM intentions possess an elevated level of activation that increases their accessibility and likelihood of retrieval. Therefore, commission errors would be the result of persisting residual activation of a completed PM intention (Walser et al., 2012; 2014). The third view, the spontaneous retrieval theory, suggests that commission errors are the result of participants who are not monitoring during the finished block (as shown by equal reaction times to participants in a no PM control group) spontaneously retrieving the PM intention (Meiser & Rummel, 2012; Scullin et al., 2012).

Variables that encourage stronger PM intention encoding or spontaneous retrieval processes increase commission error risk. Commission error risk is particularly high when cognitive resources are impaired (Scullin et al., 2011; Penningroth, 2011). Specific variables that increase commission error risk are discussed below.

Implementation Intentions

Increasing the strength of encoding of a PM intention increases both the likelihood of successful retrieval and the risk of making a commission error. Bugg, Scullin, and McDaniel (2013) found that participants who used an implementation intention strategy (see Chapter 1) to encode a PM intention were twice as likely to make commission errors compared to standard encoding participants. Implementation intention encoding may increase the automatic processing of PM cues via strengthening the link between PM cue and action, which would make it more difficult to deactivate a finished PM intention.

Repeated Practice

Another way of increasing both the strength of the PM intention and susceptibility to commission errors is by forming a habitual response to the PM intention. Pink and Dodson (2013) encouraged half of their participants to develop a habitual response to eight prospective memory cues encountered ten different times throughout practice trials. The other half of participants encountered the eight PM cues one time only during the practice block. During the finished block, attention was divided by having some participants simultaneously perform a digit-monitoring task in which they listened to a series of digits and indicated the occurrence of three consecutive odd digits. The habitual condition demonstrated greater vulnerability to commission errors relative to the non-habitual condition, particularly when attentional resources were divided. Pink and Dodson (2013) concluded that PM intentions that have been executed and completed repeatedly are not deactivated, but remain in an active state.

Contextual Overlap and Cue Salience

Contextual overlap between the active block and the finished block, as well as highly salient PM cues can contribute to the development of commission errors by increasing the likelihood of spontaneous retrieval. Scullin et al. (2012) randomly assigned younger and older adults into one of three conditions, the non-salient-cue/contextual-match, the salient-cue/contextual-match, or the salient-cue/contextual-mismatch condition. Salient PM cues appeared against a colored (red or blue) background, whereas non-salient PM cues appeared against a black background. Non-cue words appeared on a black background. Participants in the contextual-match conditions performed the same ongoing task (lexical decision) in the active block and finished block, whereas participants in the contextual-mismatch condition performed a different ongoing task (image-rating) in the active block. The finished block included ten PM cues and ten salient control cues. As predicted, the salient-cue/contextual-match condition produced significantly more commission errors than the other two conditions. For participants in the contextual-match condition, the contexts were similar enough to promote automatic responding. In this case, features such as cue salience and contextual overlap stimulated spontaneous retrieval.

Impaired Executive Control

Scullin et al. (2011; 2012) provided initial evidence for the role of impaired inhibitory/executive control on commission error risk by comparing performance during a finished block (i.e., persisting spontaneous retrievals and commission error frequency) between older and younger adults. According to the inhibitory-deficit hypothesis (Hasher & Zacks, 1988), older adults should be less able to inhibit no longer relevant information than young adults. Inhibition-executive functioning was measured using the Stroop Task (incongruent color naming) and the Trail Making Test B. The researchers also measured processed speed using a simple color naming test and the Trail Making A test and covaried processing speed in their analysis to make sure that the effects observed were the result of inhibition. As predicted, older adults were more likely to continue to spontaneously retrieve their PM intentions and make commission errors during the finished block. Furthermore, poorer inhibitory/executive control scores were associated with greater risk for persisting spontaneous retrievals (Scullin et al., 2011) and commission errors (Scullin et al., 2012). Additional support for the role of inhibitory-executive functioning in commission errors comes from studies that looked at fatigue, a known correlate of executive dysfunction (e.g., van der Linden, Frese, & Meijman, 2003). Scullin and Bugg (2013) observed a positive association between an increase in reaction times across a 260-trial lexical decision block and commission errors. The increase in reaction times of participants who made commission errors was attributed to fatigue rather than to preparatory monitoring (cf. PAM theory) because the reaction time slowing during the finished block (468 ms) far exceeded what would be expected from monitoring (124 ms during active block). Fatigue impaired executive control and inhibition of the execution of the PM intention, thus increasing commission error risk.

Decreasing Commission Error Risk

The previously presented experiments showed that some variables, such as contextual overlap and repeated practice, have the potential to increase commission error risk via spontaneous retrieval processes or impaired executive control. Recently, researchers have begun to investigate which variables decrease commission error risk, such as cognitive load, delay, cue exposure, and execution.

Cognitive Load

Walser et al. (2014) provided evidence against the conclusion that cognitive resources are necessary to prevent commission errors (cf. Munoz, 2014; Pink & Dodson, 2013). Walser et al. (2014) studied aftereffects, or slowed reaction times to PM cues, that indicate retrieval. They manipulated the type of processing in the interval between the finished PM intention instructions and the finished block: a low cognitive load control condition (read aloud individual letters from a letter string slowly), a high cognitive load condition (repeat letter strings backwards as fast and accurately as possible), and an intention reflection condition (PM intention rehearsal). If cognitive resources were necessary for PM intention deactivation, then participants in the high cognitive load condition should show *increased* aftereffects relative to the low cognitive load condition. By contrast, aftereffects were reduced after the high cognitive load condition compared to the low cognitive load control condition, suggesting that PM intention deactivation does not necessarily depend on free cognitive resources. Thus, according to Walser et al. (2014), increasing cognitive load during the delay between the presentation of the finished instructions and the beginning of the finished block may decrease commission error risk.

Delay

Previously, I discussed studies that examined the length of the retention interval between encoding and retrieval. Research has shown that a PM intention can be retrieved successfully even after long delays (Hicks et al., 2000; Guynn et al., 1998; Loft et al., 2008; McBride et al., 2011; Scullin & McDaniel, 2010). A primary factor of interest in the proposed experiments (Experiment 3) is the length of the delay interval between the finished instructions and finished block. Long temporal delays may have the potential to decrease commission errors because the executed or finished PM intention has been shown to decay over time (Walser et al., 2012). Scullin et al. (2011) measured delay by including two phases of an image-rating task prior to the lexical decision task in the finished block. Participants in the long delay condition encoded and only executed the

PM intention in the first phase of the image-rating task, whereas participants in the short delay condition encoded and only executed the PM intention in the second phase of the image-rating task. The main effect of delay was not significant.

Scullin and Bugg (2013) investigated the role of delay interval length on commission errors. Participants were randomly assigned to a short delay condition in which the cue was presented at Trial 40 (out of 260) of the finished block, a long delay condition in which the cue was presented at Trial 258, or a no PM control group. One quarter of participants made commission errors during the finished block and risk for commission errors did not significantly differ between short and long delay conditions. However, as described above, there was greater evidence for fatigue and fatigue-induced commission errors in the long delay condition than in the short delay condition.

Researchers have so far manipulated delay using either position of cue in block (Scullin & Bugg, 2013) or block length (Scullin et al., 2011). More importantly, aftereffects and commission errors have been observed after temporal delays of thirty seconds to ten minutes after the finished instructions (Bugg & Scullin, 2013; Walser et al., 2012). Although informative, these current delay experiments are not representative of the potential influence of long temporal delays on commission error risk (e.g. 48 hours).

Repeated Finished PM Cue Exposure

Commission error risk has also been shown to decrease with repeated finished PM cue exposure. Walser et al. (2014) manipulated the timeline between the active PM block and finished PM block to differentiate between whether the residual activation of the finished PM intention could be reduced with delay or with repeated finished PM cue exposure. Participants encoded a PM intention to respond to two PM cue exemplars (A and B) of the same category (shapes) during an ongoing digit parity judgment task (i.e., determining whether digits are odd or even). Then, participants were told the PM intention was finished, and completed two finished blocks. In Test Block 1, only exemplar A served as a finished PM cue, whereas in Test Block 2, both exemplars A and B were presented. Aftereffects were defined as slower reaction times to the PM cues in Test Blocks 1 and 2 (20 and 30 seconds after initially completing the PM task, respectively).

Experiments 1 and 2 showed that repeated exposure to A cues in Test Block 1 not only reduced aftereffects of A cues in Test Block 1, but also reduced aftereffects in the similarly categorized B cues in Test Block 2. Experiment 3 confirmed that aftereffects were reduced with repeated exposure of PM cues. Walser et al. (2014) manipulated the number of PM cue exposures during the finished block (4 or 12) and the length of the finished block (short: 48 trials or long: 144 trials). Aftereffects were reduced in conditions with twelve repeated PM cues compared to four. Conceptually, these experiments showed that repeatedly exposing participants to finished PM cues in the finished block decreased the effect that the PM cue had on PM intention retrieval. However, it may be argued that these experiments showed evidence of extinction learning rather than intention deactivation because whether participants initially executed the intention was not manipulated before repeated finished PM cue exposure.

Active Execution of the PM Intention

In 1927, Zeigarnik conducted an experiment in which she gave participants a series of small tasks to complete one at a time. Half of these tasks were interrupted before the participant could complete them. When later asked about the tasks, participants were significantly more likely to recall their interrupted tasks than their completed tasks. Zeigarnik concluded that the interrupted tasks were maintained at a higher level of activation due to the tension and perseverance that surrounds incomplete goals. Since the first observation of the "Zeigarnik effect", researchers have been interested in whether initially executing a PM intention helps with the deactivation of that intention. Execution of the PM intention in the practice or active blocks will be a primary factor of interest in proposed Experiments 1-3 (Goschke & Kuhl, 1993; Marsh et al., 1998; 1999).

Masicampo and Baumeister (2011a) hypothesized that our vigilant pursuit to accomplish unfulfilled goals occupies our limited attentional and working memory resources (akin to a Zeigarnik effect), therefore making unfulfilled goals more likely to cause interference on following unrelated tasks. Across five studies, Masicampo and Baumeister (2011a) showed that thinking about an unfulfilled goal (in these experiments, suppressing thoughts of a white bear) caused participants to perform poorly on later tests of fluid intelligence, impulse control, and on an anagram test that measured executive functioning. Task interference was resolved when participants returned to completed the previously unfulfilled goal (thinking about the white bear), as evidenced by equal performance on an anagram test compared to participants who did not suppress unfulfilled goals. In several follow-up experiments, Masicampo and Baumeister (2011b) addressed whether making a plan to achieve a goal could reduce the persisting cognitive activation of an unfulfilled goal. They asked participants to reflect on two important but unfinished tasks in their daily life. One group of participants then formed plans for how to complete their tasks (via implementation intention encoding) and the other group of participants wrote about tasks they had recently completed. Participants who formed plans for completing their tasks showed less interference on the later reading comprehension task than participants in the control group who did not form plans. Regarding the mechanism involved, Masicampo and Baumeister (2011a; 2011b) argued that reflecting on and committing to specific plans for attaining goals reduces the accessibility of the goals and allows for the reallocation of those executive resources toward other unrelated tasks. The drive to attain a goal is suspended once a plan is made and the goal-related cognitive activity can cease until resumed at a later time.

Bugg and Scullin (2013) investigated the influence of executing the PM intention in the correct context on the risk of commission errors. They asked participants to encode a PM intention and then presented the PM cue either zero or four times during the active block. They hypothesized that participants who executed the PM intention four times would be more likely to make commission errors to the cues in the finished block than participants who did not perform the PM intention (cf. commission error studies on habit formation; Pink & Dodson, 2013). Unexpectedly, the participants who executed the PM intention in the active block made no commission errors, whereas 56% of the participants who did not perform the PM intention made commission errors. Executing the PM intention during an active block facilitated its deactivation (Zeigarnik, 1938). In Experiment 3, participants encoded two PM cues (corn and dancer) but were presented with only one of the two cues during the active block. Both PM cues were presented in the finished block of PM intentions. Commission errors were marginally more frequent for the non-presented PM cue relative to the presented PM cue. Thus, deactivation appeared to be specific to the PM cue for which the PM intention was executed.

Besides the Zeigarnik effect, additional theories have been proposed to explain why executing a PM intention facilitates its deactivation. According to the episodic trace hypothesis (Hommel et al., 2001), an episodic trace is formed when an intention is executed (see also Hommel, 1998; Waszak & Hommel, 2007). Stop-tags are applied to episodic traces to facilitate the ability to withhold the executed PM response when the finished instructions are presented. When the PM response is not executed prior to the finished instructions, there are no episodic traces or stop-tags associated with the response that would assist with inhibition once the finished instructions are presented. Repeatedly performing the PM task results in a greater number of episodic traces, a better representation of the completed intention, and a more effective no-go memory to be used when encountering the finished PM cues. The deactivation view and the reconsolidation hypothesis (Nader & Hardt, 2009; Scullin et al., 2009) suggests that executing the PM intention destabilizes the PM target-action link, and repeatedly executing the PM intention (four times, in this case) sufficiently destabilizes the PM target-action link for deactivation at the presentation of the finished instructions.

The Proposed Experiments

I propose three experiments to investigate how PM intention execution, the *context* (block) in which the PM intention is executed and the *delay* between intention execution and the finished block influence the frequency of commission errors. I will measure commission errors by counting the number of responses made to finished PM cues in the finished block. I will make comparisons between PM cue and control trials for all conditions. By conducting these experiments, I aim to systematically investigate how PM performance and delay influence commission error risk.

There are gaps in the literature regarding the extent to which executing the PM intention can facilitate its deactivation. One gap in the literature concerns whether the simple, physical act of executing a PM intention is sufficient for intention deactivation. If so, then executing a PM intention during a practice block should have the same impact on commission error risk as performing a PM intention during an active block. In Experiments 1-3, I will therefore investigate if *when* a PM intention is executed—practice block or active block—influences its deactivation. If practicing and actively executing the PM intention both decrease commission error risk, then it can be concluded that merely physically executing the PM intention is the key to intention deactivation. Alternatively, if practicing and actively executing the PM intentions differ significantly in their effects on commission error risk, then it can be concluded that the *context* (block) in which the PM intention is executed is critical to intention deactivation.

A second gap in the literature concerns the role of delay (Experiment 3). In Experiment 3, I will assess commission error frequency after a 10-minute or a 48-hour delay. The role of an extended temporal delay in the development of commission errors is ambiguous. One study found no effect of delay on commission errors (Scullin et al., 2011), one study found commission errors occurred in varying delay conditions (Scullin & Bugg, 2013), and two studies found that commission errors occurred when delay interacted with other variables (Walser et al., 2012; 2014). None of these delay conditions were longer than ten minutes. Extending the length of time between the finished instructions and the finished block to 48-hours provides a much more definitive test of whether delay reduces commission error risk. Collectively, these experiments will inform theories of PM deactivation and may assist in the development of commission error prevention strategies.

CHAPTER THREE

Experiment One

Introduction

Previous work suggested that performing a PM intention during an active block reduced commission errors (Bugg & Scullin, 2013). In Experiment One, I investigated whether executing a PM intention during a practice block similarly reduces commission errors. Participants encoded a PM intention to press the Q key when cue words (e.g., corn and dancer) appeared during a lexical decision task. Then participants either executed the PM intention zero times (no-perform condition), two times in the practice block (practice condition), ten times in the practice block (repeated practice condition) or two times in the active block (active condition). Participants were then told that the PM intention is finished and no longer needs to be executed. They completed a finished block in which they were presented with cue words to measure whether risk of commission errors depended on prior practice or performance of the PM task.

Methods and Materials

Participants

I tested 98 Baylor University undergraduate students (M_{age} = 19.28, *SD* = 1.19; 72% female, 56% Caucasian). In Experiment 1, participants were randomly assigned to a no-perform condition (*n* = 24) or a practice condition (*n* = 24). The two supplemental groups—active condition and repeated practice condition—each included 25 undergraduate students and data collection was conducted after the no-practice and practice conditions were tested. Sample sizes were based upon the effect sizes reported by Bugg and Scullin (2013). Additional information regarding the required sample size and the power analysis for Experiment 1 can be found in Appendix A.

Participants reported engaging in moderate or vigorous exercise for 20 or more minutes roughly 3 times a week, rated their health to be O.K. to good (3.76 out of 5), and slept for an average of 6.75 hours (SD = 1.56) the night before the experiment. There were no group differences in these measures (largest F = 1.71, p = .17 for sleep time). The groups were also similar in vocabulary scores, gender, race/ethnicity, and years of formal education (starting with high school), but there was an unexpected difference in age across the groups, F (3, 94) = 3.68, p = .02, η^2 = .11. The age difference was descriptively very small (i.e., less than 1 year difference; $M_{no\text{-}perform}$ = 19.17; $M_{Practice}$ = 18.96; M_{Active} = 19.04; $M_{Repeated}$ = 19.92) and age within this limited range sample did not correlate with commission error risk (ρ = .126, p = .22). Therefore, I assume the group difference reflects Type I error, or is otherwise inconsequential to the main analyses.

Materials

Demographic Questionnaire. Assesses basic demographic characteristics such as gender, age, race, and level of education completed.

Encoding form. A form on which participants wrote down the cue key and cue words to confirm understanding of the PM intention.

Post-Experimental Questionnaire. Checks participants' understanding of the instructions for the experiment. The questionnaire asks them to recall the ongoing lexical decision task instructions, the cue key, and the cue words. The questionnaire also asks participants whether they believed that the PM intention was finished upon receiving the finished instructions, whether they continued to think about the PM intention after its completion (0 = *never*, 2 = *rarely*, 5 = *sometimes*, 8 = *frequently*, 10 = *always*), and if they have any other comments.

Experimental Design

I manipulated the number of PM cues presented during the practice and active blocks between participants (see Table 1). During the practice block, participants in the no-perform and active conditions saw zero PM cues whereas participants in the practice condition saw two PM cues (each cue once). During the active block, participants in the no-perform and practice conditions saw zero PM cues whereas participants in the active condition saw two PM cues (each cue once).

Table 1

Number of PM cues presented by condition and block in Experiment One

Condition	Practice	Active	Finished
No-perform	0	0	10
Practice	2	0	10
Repeated Practice	10	0	10
Active	0	2	10

Dependent Measures

Commission errors. A commission error was defined as an erroneous prospective memory response (Q press) to a PM cue (or control) trial or within three trials after the PM cue (or control) trial in the finished block. Late responses (i.e., Q presses on post-cue trials) were acceptable because it is possible for a participant to retrieve the PM intention during the PM cue trial but not execute the action until the response to the PM cue has already been made (e.g., Scullin & Bugg, 2013). Commission errors were further broken down into whether commission errors were made (Yes/No), how many commission errors were made (the total number of Q presses in the finished block), and which type of commission errors were made (cue, control, or filler trials). However, total number of commission errors is typically not as strong of a discriminating variable as commission error risk, see Scullin et al., 2012, and Scullin & Bugg, 2013, for further evidence and discussion).

Reaction times. Mean reaction times for PM cue and control trials in the finished block were compared across groups. Slower reaction times to PM cue trials relative to control trials indicate spontaneous retrieval. Mean reaction times for non-cue trials in the finished block were also compared across groups to examine whether monitoring differed across all conditions.

Procedure

The procedure is depicted in Figure 1. I first introduced participants to the lexical decision (ongoing) task in which they had to indicate whether strings of letters (presented on the computer screen) were words or non-words by pressing 1 (Y) or 2 (N) on the keyboard. To acquaint them with this task, participants performed ten lexical decision practice trials. After each trial, participants received feedback regarding their speed and accuracy. All words appeared in white typeface against a black background. Then participants encoded the PM intention to press the Q key if they saw either of two PM target words during the lexical decision task trials (in one counterbalance condition the target words were corn/dancer, and in the other counterbalance they were fish/writer).

The PM targets were always presented on a red background (or a blue background in a second, counterbalanced, condition; following Scullin et al., 2012). The experimenter confirmed understanding of the PM task by having participants write down their PM target words and response key before proceeding to the Practice-PM block.

As shown in Figure 1, the Practice-PM block included 10 lexical decision trials (with speed and accuracy feedback). In the no-perform condition, participants completed the Practice-PM block with zero PM targets. In the practice condition, participants completed the Practice-PM block with two PM targets. In the active condition, participants completed the Practice-PM block with zero PM targets. In the repeated practice condition, participants completed the Practice-PM block with 10 PM targets. 50 lexical decision trials were used to accommodate the larger number of PM target presentations.

All participants then completed a demographics form and a vocabulary test before moving onto the Active-PM Block. The Active-PM Block included 72 lexical decision trials in the no-perform condition, practice condition, and repeated practice condition. In the active condition, participants additionally saw the PM targets twice (each target word once).

Following completion of the Active-PM Block, participants were given the following instruction (capitalized for emphasis): “Please note that you no longer need to press Q in the presence of target words. That task is finished and should not be performed again.” After a brief vocabulary test and lexical decision delay interval, participants began the Finished-PM Block. All participants completed 260 lexical decision trials, with 10 interspersed PM target words (five times for each target) and 10 interspersed control words (i.e., the two words not used as PM targets, presented on the other red/blue background color). Following the Finished-PM Block, participants completed a post-experimental questionnaire to assess their recollection of the target word and key, whether they believed the “finished” instructions, and how often they continued to think about the PM task after it was finished. When time permitted, participants (n = 85) also completed the reading span task (Unsworth, Heitz, Schrock, & Engle, 2005) to determine whether our experimental and supplemental groups differed in working memory capacity and whether working memory capacity negatively correlated with commission errors (cf. Walser et al., 2014).

Statistical Analysis

Following previous work (Bugg & Scullin, 2013), my primary measure was risk for commission errors, defined as the percentage of participants who made at least one commission error, that is, a Q press during the Finished-PM block. I conducted Chi-Square Tests of Independence to examine differences in commission error risk between conditions. The magnitude of these differences was determined using phi (ϕ) (small effect = .01, medium effect = .03, and large effect = .05; Cohen, 1988) Independent samples t-tests were conducted to examine the relationship between Practice- and Active-PM block performance and commission error risk. I used the Levene’s Test of Equality of Variances to correct for unequal variances. For my secondary measures, I conducted an analyses of variance (ANOVA) to determine whether working memory capacity and/or ongoing task performance during Active-PM or Finished-PM blocks differed across groups. I also conducted Spearman’s rank order correlation to determine the relationship between age and commission error risk. Statistical significance was inferred by a $p < .05$, and a p value from .05 to .10 would be considered marginally significant and treated cautiously.

Results

Commission Errors

Commission error risk across groups is displayed in Figure 2. In Experiment 1, commission error risk was high in both the no-perform and practice conditions, and these two groups did not differ statistically, $\chi^2 = 1.34$, $p = .25$, $\phi = -.167$. Increasing the number of opportunities to practice the PM intention appeared to have no effect on reducing commission errors; commission error risk was nearly identical between the practice condition and the repeated practice condition, $\chi^2 = 0.17$, $p = .68$, $\phi = -.059$. Thus, practice did not deactivate the intention and reduce commission errors.

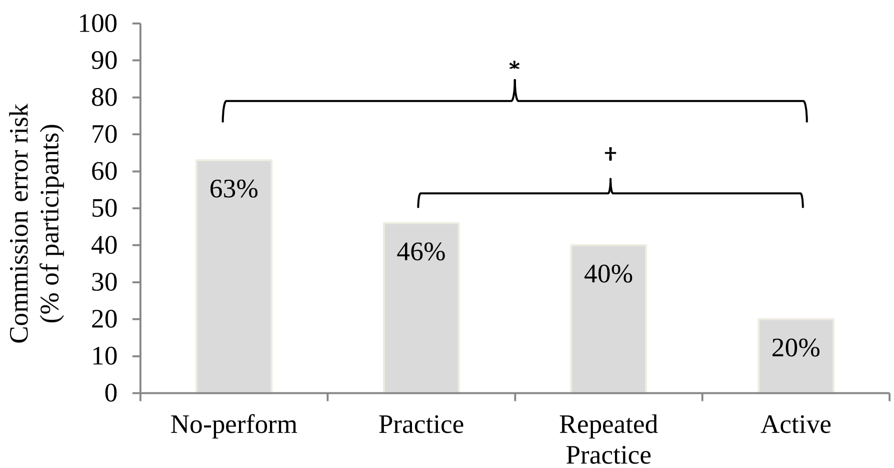


Figure 1. Commission error risk across conditions in Experiment 1

Next, in an attempt to replicate Bugg and Scullin's (2013) findings of PM deactivation under conditions of two performance opportunities (rather than four opportunities), I examined whether the active and no-perform conditions differed in commission error risk. As illustrated in Figure 2, and consistent with my prediction, there was a robust group difference between the active condition and the no-perform condition, $\chi^2 = 9.16$, $p < .01$, $\phi = -.432$. Furthermore, consistent with the above analyses suggesting that practice does not reduce commission error risk, the active condition tended to show lower risk for commission errors than the practice, $\chi^2 = 3.72$ $p = .05$, $\phi = -.275$, and repeated practice conditions, $\chi^2 = 2.38$, $p = .12$, $\phi = -.218$. Given the nominal trends in the repeated practice condition (relative to active and no-perform conditions), one might be tempted to conclude that repeated practice reduces, at least to a small degree, commission error risk. However, the benefits of repeated practice should not be overestimated due to the lack of statistical differences, disproportionate number of performance opportunities (10 versus 2 in the active condition), and the large effect sizes observed between the active and no-perform condition.

PM Performance

The mean proportion of Q presses and mean reaction times and accuracy (standard deviations in parentheses) for non-PM lexical decision trials across conditions is shown in Table 2 There was no association between the number of Q presses and subsequent commission error risk, ($t < 1$). Given the use of a salient target cue, we expected participants to press the Q key on almost every target opportunity, but a post-hoc inspection of the individual target trials showed that participants often did not press the Q key on the first target presentation in the practice (66%), repeated practice (68%), and active (40%) conditions. The reason for this is unclear, but may have to do with initial confusion over whether they could make the PM response after making the ongoing task response (cf. Ihle, Hering, Bisiacchi, Mahy, & Kliegel, 2013). However, responses occurring on the feedback screen were not recorded for the practice and repeated practice condition so individuals who made the ongoing response first and then the PM response would have been scored as “missing” the target word for that practice trial. Importantly, Practice-PM block performance did not significantly influence commission error risk for participants in the practice condition or the repeated practice condition, (*ts* < 1), nor did accuracy on the first target trial response in the practice, χ^2 = 0.08, $p = .77$, ϕ = -.059, or repeated practice, χ^2 = 1.10, $p = .29$, ϕ = -.210, conditions.

Table 2

Mean proportion of Q presses and mean reaction times and accuracy (standard deviations in parentheses) for non-PM lexical decision trials across conditions.

	Q presses		RT (ms)		Accuracy		Working Memory
Condition	Practice	Active	Active	Finished	Active	Finished	Reading Span
No-Perform	-	-	741 (134)	549 (70)	0.83 (.09)	0.92 (.04)	57.96 (11.61)
Practice	0.46	-	827 (155)	590 (105)	0.82 (.07)	0.90 (.10)	54.61 (9.65)
Repeated Practice	0.81	-	786 (109)	588 (74)	0.84 (.05)	0.92 (.03)	54.50 (11.73)
Active	-	0.68	817 (202)	597 (112)	0.78 (.09)	0.92 (.06)	57.29 (8.84)
F value	6.67		1.52	1.36	3.16	0.56	0.62
p value	.002		.214	.259	.028	.645	.602

Post-Experimental Questionnaire

Data from the post-experimental questionnaire indicated that 94% of participants believed the experimenter instructions that the PM task was finished. All but one participant recalled that the target key was Q, and 92% of participants accurately recalled both target words. Removing participants who did not believe that the PM intention was finished when receiving those instructions or those who forgot the PM words or action did not alter the above conclusions regarding commission errors.

Participants in the no-perform condition were significantly more likely to continue to report that they thought about the PM task (*M* = 6.0, out of 10), compared to participants in the other three conditions (*M* = 3.6, out of 10), F (3, 93) = 3.25, $p = .03$, $\eta^2 = .09$. These results are consistent with Zeigarnik's (1938) theorizing, but may also simply reflect that there were the most commission errors in the no-perform condition (subjective ratings were collected *after* the Finished-PM Block phase, see Figure 1).

Ongoing Task Performance

To determine whether the groups differed in monitoring strategy (attention allocation), we analyzed ongoing task performance (Park et al., 1997; Smith, 2003). Mean accuracy and reaction times on non-PM lexical decision trials are presented in Table 1.

In the Active-PM Block (i.e., when participants expect to see PM targets), there was not a main effect of group on ongoing task response times, ($F < 1$), but there was a main effect on ongoing task accuracy, F (3, 94) = 3.16, *MSE* = .018, $p = .03$, $\eta^2 = .09$. Participants in the active condition were less accurate than participants in the no-perform, practice, and repeated practice groups (*ps* = .015, .062, and .006, respectively). The latter three conditions did not differ from one another (smallest $p = .38$). The worsened Active-PM Block ongoing task accuracy in the active condition (i.e., the group that actually saw the PM target cues) most likely reflects that participants change their attention allocation policies (or monitoring strategies) upon seeing PM cues during Active-PM Blocks (Cohen et al., 2011; Scullin et al., 2013; Smith, 2003). Most relevant to determining whether differential attention allocation explained the group differences in commission errors *in the Finished-PM Block*, we did not observe significant group differences in ongoing task accuracy or mean reaction times across the four conditions, ($Fs < 1$).

Working Memory Capacity

The groups did not differ in reading span scores, ($F < 1$). Total reading span score did not differ depending on whether an individual made a commission error, ($t < 1$) (cf. Walser et al., 2014).

Discussion

The main objective of Experiment 1 was to determine whether initially practicing a PM intention has the same deactivating effects (i.e., reduced commission errors) as initially performing a PM intention (during an Active-PM Block). The results suggest that practicing a PM intention may be insufficient for deactivating the intention. Making the PM response during the Active-PM Block reduced commission error risk more than making the PM response during the Practice-PM block.

My findings suggest an exception to the general rule that the more times one initially executes a PM intention (or the stronger the initial encoding), the greater the risk is for later commission errors (Bugg et al., 2013; Muñoz, 2014; Pink & Dodson, 2013). The no-perform condition, which included zero targets during Practice- and Active-PM blocks, demonstrated the highest risk for commission errors. Participants in the no-perform condition may have been more likely to experience the Zeigarnik effect (1938), which refers to experiencing intrusive thoughts about an unfinished PM intention and a persistent compulsion, tension, or need that dissipates only after completing the PM intention (see also Marsh et al., 1998, 1999; Masicampo & Baumeister, 2011; Weiner, Johnson, & Mehrabian, 1968). The unfulfilled intentions may have increased the accessibility of the PM intention (i.e., Zeigarnik's, 1938, account), which thereby made participants more susceptible to erroneous spontaneous retrievals during the Finished-PM Block (McDaniel & Einstein, 2000; Walser et al., 2012). The ongoing task performance data supported this spontaneous retrieval interpretation because there were no group differences in Finished-PM Block accuracy or response time.

The absence of group differences in ongoing task performance (during the Finished-PM Block) indicated that either all groups were monitoring at a similar level or that no groups were monitoring at all (which, by current theories, implicates that retrieval was spontaneous; Scullin et al., 2013). I favor the latter interpretation of no monitoring during the Finished-PM Block because previous research has consistently indicated that participants do not monitor during contexts in which prospective memory cues are not expected (Kuhlmann & Rummel, 2014; Marsh et al., 2006; Scullin et al., 2013), including during Finished-PM Blocks (Scullin & Bugg, 2013). Thus, a reasonable explanation for the heightened risk for commission errors in the practice conditions is that increased accessibility (due to the incomplete PM intention) led to a greater likelihood of erroneous spontaneous retrievals during the Finished-PM Block.

The differences in commission error risk between the practice, repeated practice, and active conditions may also be attributed to Zeigarnik effects. Indeed, it is possible that practiced PM intentions share the same characteristics of an unfulfilled PM intention because practicing an intention may be psychologically (and theoretically) different compared to actively executing the PM intention. Participants in the practice and repeated practice conditions *expected* to execute the PM intention during the Active-PM Block

(Marsh et al., 1998), but their intention to do so was left unfulfilled, despite having *physically* pressed the Q key during a Practice-PM block. Thus, response execution (i.e., pressing Q) should not be conflated with PM intention fulfillment.

CHAPTER FOUR

Experiment Two

Introduction

In Experiment One, I observed a difference in commission error risk between participants in the active condition and participants in the no practice, practice, and repeated practice conditions. Participants who actively executed the PM intention (active condition) were less likely to make one or more commission errors compared to participants who practiced responding to the PM cue (practice and repeated practice conditions). The data showed that the *context* (block) in which the PM intention is executed might influence commission error risk.

Conversely, one potential limitation of Experiment One was that participants, regardless of condition, demonstrated overall low PM accuracy (in the practice and active block). Approximately 66% of participants did not perform the PM task on the first cue opportunity. Additionally, participants only saw the PM cues twice (one time for each cue) during their respective practice or active blocks. Bugg and Scullin (2013) presented participants with four PM cues (two times each) and observed higher PM accuracy and lower commission error risk (in the active condition). To ensure that participants pressed the target key to both cue words, participants in Experiment Two saw four PM cues in their respective practice or active blocks.

The purpose of Experiment Two was to investigate whether the contextual block (practice or active) in which the PM intention is executed influences commission error risk (Scullin et al., 2012) when there were four presentations of two PM cues (each cue twice) instead of two presentations (each cue each) (Experiment 1; Scullin & Bugg).

Methods and Materials

Participants

Forty-eight Baylor University undergraduate students (Mage = 19.13, SD = .90; 71% female, 56% Caucasian) were randomly assigned to the practice condition (*n* = 24) or the active condition (*n* = 24). Participants reported engaging in moderate or vigorous exercise for 20 or more minutes roughly 3 times a week, rated their health to be O.K to good (3.90 out of 5), and slept an average of 6.69 hours (*SD* = 1.57) the night before the experiment. There were no group differences in these measures (largest *F* = 2.09, *p* = .16, for health limits). The groups were also similar in vocabulary score, age, gender, race/ethnicity, and years of formal education (starting with high school). Additional information regarding the required sample size and the power analysis for Experiment 2 can be found in Appendix A.

Materials

The materials in Experiment 2 were identical to those in Experiment 1.

Experimental Design

I manipulated the number of PM cues presented during the practice and active blocks (see Table 3). Participants in the practice condition saw four PM cues (each cue twice) in the practice block before completing the active block (zero PM cues). Participants in the active condition saw four PM cues (each cue twice) in the active block prior to completing a practice block (zero cues). After finishing the active block of lexical decision trials, all participants then saw the finished instructions and completed the finished block.

Table 3

Number of PM cues presented by condition and block in Experiment Two

Condition	Practice	Active	Finished
Practice	4	0	10
Active	0	4	10

Dependent Measures. The dependent variables in Experiment 2 were identical to those in Experiment 1.

Procedure

The procedure for Experiment 2 was the same as in Experiment 1 (Appendix B), with the exception of two changes. Participants saw four PM cues (two times each) during the practice or active blocks depending on their condition (see Table 3). In the practice condition, participants completed 20 lexical decision trials (instead of 10) to accommodate the larger number of PM cue presentations.

Statistical Analyses

The statistical approach was the same as described in Experiment 1. I conducted a Chi-Square Test of Independence to assess the difference in commission error risk between the practice condition and the active condition. I also conducted independent samples t-tests to assess differences in accuracy and reaction times on non-target lexical decision task trials between the practice condition and the active condition.

Results

Commission Errors

Commission error risk across the practice and active groups is displayed in Figure 2. Relative to commission error risk in Experiment 1, commission error risk was low in both the practice and active conditions; 16% of participants in the practice condition made one or more commission errors compared to 4% of participants in the active condition. The context in which the intention was executed (practice or active block) did not appear to influence commission error risk when there were four presentations of two PM cues (each cue twice), $\chi^2 = 2.01$, $p = .16$, $\phi = -.205$.

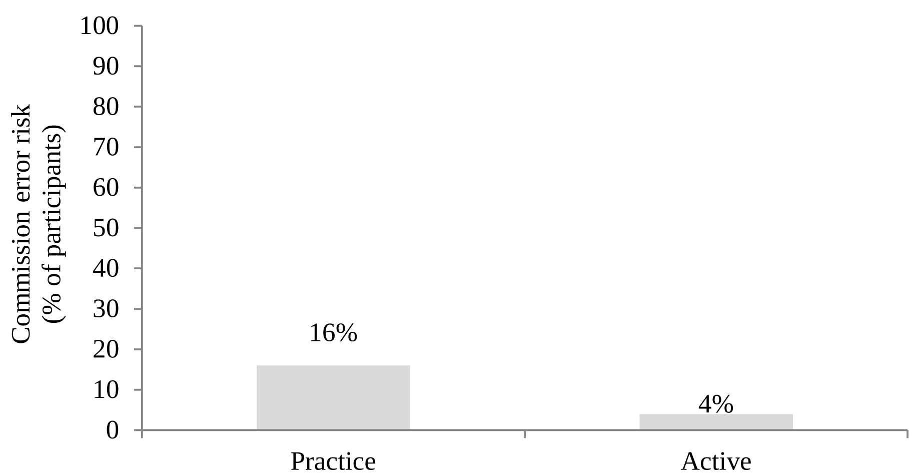


Figure 2. Commission error risk across conditions in Experiment 2

PM Performance

The mean number of Q presses and mean reaction times and accuracy (standard deviation in parentheses) for non-PM lexical decision trials across conditions is shown in Table 4). Participants in the practice condition pressed the Q key a mean of 1.71 times (out of 4; 43%), whereas participants in the active condition pressed the Q key a mean of 3.29 times (out of 4; 82%); t (46) = -4.51, $p < .01$. There was no significant correlation between number of accurate Q presses (1.71 times in the practice block and 3.29 times in the active block) and subsequent commission error risk, $r(46) = -.12$, $p = .42$; ($t < 1$). A post-hoc inspection of the individual target trials showed that 58% of participants in the practice condition and 79% of participants in the active condition pressed the Q key to the first target trial in their respective blocks, $\chi^2 = 2.42$, $p = .12$, $\phi = .225$. Accuracy on the first target trial did not significantly influence commission error risk for participants in either condition, $\chi^2 = 0.20$, $p = .66$, $\phi = .060$.

Table 4

Mean number of Q presses and mean reaction times and accuracy (standard deviations in parentheses) for non-PM lexical decision trials across conditions.

	Q presses		RT (ms)		Accuracy		Working Memory
Condition	Practice	Active	Active	Finished	Active	Finished	Reading Span
Practice	1.71	-	766 (144)	610 (222)	0.82 (.08)	0.91 (.01)	16.96 (7.01)
Active	-	3.29	859 (196)	641 (215)	0.83 (.06)	0.90 (.01)	15.96 (6.78)
t value	-4.51		-1.67	-0.49	-0.48	0.39	0.49
p value	.001*		.103	.624	.636	.693	.624

Post-Experimental Questionnaire

Data from the post-experimental questionnaire indicated that all participants remembered the Q key, 98% of participants remembered both target words, and 92% of participants responded that they believed the instructions that the PM task was finished. Removing participants who did not believe the PM intention was finished when receiving those instructions or those who forgot the PM words or actions did not alter the above conclusions regarding commission errors. There were no significant differences in likelihood of continuing to think about the PM instructions after the task was completed between participants in the active condition (*M* = 4.75 out of 10) and participants in the practice condition (*M* = 5.26 out of 10); ($t < 1$).

Participants who made one or more commission errors were also significantly more likely to think about the PM task after it was finished, (*M* = 7.60, *SD* = 1.67) compared to participants who made no commission errors, (*M* = 4.69, *SD* = 2.61); t (46) = -2.42, $p = .02$.

Ongoing Task Performance

In the Active-PM block, the practice and active conditions did not differ in their mean response times on non-target lexical decision task trials, or mean accuracy on non-target lexical decision task trials, (*ts* < 1). In the Finished-PM block, the practice and active conditions did not differ in mean response time on non-target lexical decision task trials, or mean accuracy on non-target lexical decision task trials, (*t*s < 1)

Mean response time on non-target lexical decision task trials in the finished block was significant correlated with commission error risk, $r(46) = .297$, $p = .04$, and total number of commission errors, $r(46) = .300$, $p = .04$. Participants who made one or more commission errors ($n = 5$) were significantly slower to respond to non-target lexical decision task trials in the finished block (*M* = 812.88, *SD* = 446.38) compared to participants who did not make commission errors (*M* = 604.06, *SD* = 170.13); t (46) = -2.11, $p = .04$.

Working Memory Capacity

The groups did not differ in reading span scores, ($t < 1$) Total reading span score did not differ depending on whether an individual made a commission error, ($t < 1$)

Discussion

I did not observe significant differences in commission error risk between participants who practiced the PM intention and participants who actively executed the PM intention. Presenting participants with four PM cues (two times each) resulted in high PM accuracy in the active condition and low commission error risk in both the practice and active conditions. The low commission error risk observed in the active condition is a replication of the previous finding of Bugg and Scullin (2013). Executing a PM intention in the appropriate context (the active block) facilitated deactivation. However, the low commission error risk observed in the practice condition is a new observation that requires more explanation.

Context may assist with the reduction of commission error risk, but it may not be as influential of a variable as the number of times a PM intention is executed (Bugg & Scullin, 2013). Participants in both conditions executed the PM intention at least twice (M = 2.50 out of 4) before the finished instructions were presented. Executing the PM intention has been shown to reduce Zeigarnik effects and therefore the likelihood of spontaneously retrieving the PM intention during the finished block. If participants were spontaneously retrieving the PM intention, I would except to observe slowed reaction times to target word trials compared to control word trials. I observed no differences in reaction times to target words and control words between participants who made one or more commission errors and participants who did not make a commission error.

Instead, my data show that the participants who made one or more commission errors were significantly slower to respond to non-target lexical decision task trials in the Finished-PM block than participants who did not make commission errors. Participants may have monitored for target words throughout the Active-PM block, as evidenced by the high mean reaction times to the non-target lexical decision task trials (~800 ms). Participants who did not make commission errors showed significantly reduced reaction times to non-target lexical decision task trials from the Active-PM block (~800 ms) to the Finished-PM block (~600 ms). The reduction in response times indicates that the PM intention may have been deactivated because participants were no longer monitoring for the target words.

Participants who made one or more commission errors were unchanged in their reaction times to non-target lexical decision task trials from the Active-PM block (~800ms) to the Finished-PM block (~800ms). The high mean reaction times across blocks suggests that the PM intention may not be deactivated because participants were still monitoring for the target words. Participants who made one or more commission errors reported being significantly more likely to think about the PM task after it was finished than participants who did not make one or more commission errors, and it is possible that they forgot that the PM intention was finished.

The context in which a PM intention is executed does not seem to influence commission error risk as much as how many times the intention is executed. Increasing the number of cue presentations from two in Experiment 1 to four in Experiment 2 successfully demonstrated the influence of cue exposure and intention execution on reducing commission error risk.

CHAPTER FIVE

Experiment Three

Introduction

Experiments One and Two showed that the context in which a PM intention is executed does not influence commission error risk as much as the number of opportunities to execute the PM intention. I have demonstrated that context is a weak moderator of intention deactivation. I will now manipulate a variable that may have more potential to contribute to deactivation: delay.

In the general PM literature, delay refers to the period of time in between intention encoding and intention retrieval (also known as the retention interval). In my Experiment Three, delay is defined as the period of time between the reading of the finished instructions and the re-presentation of the finished PM cues during the finished block of trials. Methodological differences in previous experiments have prevented researchers from reaching a definitive conclusion about how delay influences commission error risk. Walser et al., (2012) presented participants with twelve PM cues throughout a long finished-PM block and observed decreased aftereffects of the PM intention. Scullin et al. (2011) manipulated the number of tasks participants completed before executing the PM intention, and found no difference in commission error risk between participants who completed one block of trials (short delay) and participants who completed two blocks of trials (long delay). Scullin and Bugg (2013) manipulated the position of the PM cue during the finished-PM block and observed no difference in commission error risk between participants who saw the PM cue early in the block and those who saw the PM cue late in the block.

My experiment is the first to examine commission error risk after extending the delay between the finished instructions and the finished block to 48 hours. Participants were randomly assigned to a normal delay condition (about 10 minutes), and a 48-hour delay condition. In order to show a potential effect of an extended delay on commission error risk, I needed to ensure the participants in my normal condition were at a high risk of making commission errors. The Experiment Three procedure followed the same procedure as the no-perform (Zeigarnik) condition in Experiment One.

I can make competing predictions about my results based on previously established retrieval and deactivation theories. The residual activation theory (Walser et al., 2012) suggests that commission error risk will be higher for participants in the normal delay condition because the unexecuted PM intention will have decayed after 48 hours. On the other hand, the tenacity of the unexecuted intention (Zeigarnik, 1938) may last for a longer period of time than previously studied. Strong focal PM cues may trigger the spontaneous retrieval of the finished PM intention and increase commission error risk in both the normal and 48-hour delay conditions.

Methods and Materials

Participants and Design

I tested 64 Baylor University undergraduate students (M_{age} = 19.35, *SD* = 2.36; 73% female, 55% Caucasian). Participants were randomly assigned to the normal delay condition (*n* = 32) or the 48-hour delay condition (*n* = 32). Sample sizes were based upon the effect sizes reported by Walser et al. (2012). Participants slept for an average of 6.77 hours (*SD* = 1.12) the night prior to the experiment, rated their health to be O.K. to good (3.64 out of 5), and reported engaging in moderate or vigorous exercise for 20 or more minutes roughly 3 times a week. There were no group differences in these measures (largest $t = 1.35$, $p = .18$ for medication). The groups were also similar in vocabulary scores, gender, race/ethnicity, and years of formal education (starting with high school) ($t < 1$). Additional information regarding the required sample size and the power analysis for Experiment Three can be found in Appendix A.

Materials.

The materials in Experiment Three were identical to those in Experiments One and Two.

Experimental Design

I manipulated the delay between the finished instructions and the finished block (normal or 48-hour delay). Participants in the normal delay condition completed the practice and active blocks and then had a normal (ten minute) delay between the finished instructions and the finished block. Participants in the 48-hour delay condition completed the practice and active blocks, read the finished instructions, and returned to the lab two days later to complete the finished block. The statistical approach was the same as described in Experiment One.

Dependent Measures.

The dependent variables in Experiment Three were identical to those in Experiments One and Two.

Procedure

The procedure for the delay conditions in Experiment Three was the same procedure as the no-perform condition in Experiment One (see Appendix B). Participants were randomly assigned to a normal delay condition or the 48-hour delay condition. Participants in the normal delay and the 48-hour delay conditions encoded a PM intention and completed the prospective memory practice and active blocks, in which they were exposed to zero PM cues. All participants then read the finished instructions. Participants in the normal delay condition completed a vocabulary test and the finished block. The delay between finished instructions and the finished block was roughly ten minutes (as in Experiments One and Two). After completing the finished block, participants in the normal condition completed the post-experimental questionnaire.

Participants in the 48-hour delay condition completed a vocabulary test and were instructed to return to the laboratory 48 hours later for their second session. Participants in the 48-hour delay condition were told they would be completing additional forms and memory tests in their delayed second session. All participants returned for a second session exactly 48 hours later, in which they completed the finished block of trials, the post-experimental questionnaire, and a series of self-report questionnaires that asked about their memory and sleep patterns.

Statistical Analyses

Following my previous two experiments, my primary measure was risk for commission errors, defined as the percentage of participants who made at least one commission error, that is, a Q press during the Finished-PM block. I used Chi-Square tests of independence to compare commission error risk between the normal delay condition and the 48-hour condition. Independent samples t-tests were conducted to examine differences between conditions in ongoing task performance and reaction times during the Active-PM and Finished-PM block.

Results

Commission Errors

Commission error risk across both groups is displayed in Figure 3. Commission error risk was high in both the normal delay and 48-hour delay conditions: 72% of participants in the normal delay condition made one or more commission errors compared to 78% of participants in the 48-hour delay condition. The two conditions did not differ statistically, $\chi^2 = 0.33$, $p = .56$, $\phi = -.072$. As previously observed in Bugg and Scullin (2013), not having the opportunity to execute the PM intention before the intention is finished increases the risk of commission errors (i.e. the Zeigarnik effect). However, the present study also shows that an unexecuted finished PM intention can remain accessible and therefore susceptible to commission error risk for at minimum 48 hours.

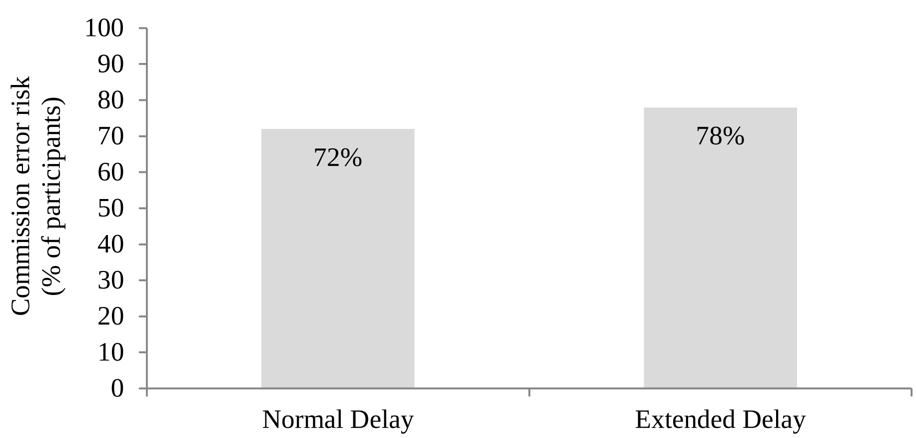


Figure 3. Commission error risk across conditions in Experiment 3

Ongoing Task Performance

The mean reaction times and accuracy (standard deviation in parentheses) for non-PM lexical decision trials across conditions is shown in Table 5). In the Active-PM block, significant differences in mean response times on non-target lexical decision task trials or mean accuracy on non-target lexical decision task trials were not observed between the normal delay and 48-hour delay conditions, (*t*s < 1). In the Finished-PM block, the normal delay and 48-hour delay conditions did not differ in mean accuracy on non-target lexical decision task trials, (*t* < 1). However, participants in the 48-hour delay condition showed significantly slower mean response times on non-target lexical decision task trials, t (62) = -2.37, p = .02. Neither commission error risk nor total number of commission errors were significantly correlated with mean response time on non-target lexical decision trials in the active or finished PM blocks, (*r* < 1).

Table 5

Mean number of Q presses and mean reaction times and accuracy (standard deviations in parentheses) for non-PM lexical decision trials across conditions.

	RT (ms)			Accuracy	
Condition	Practice	Active	Finished	Active	Finished
Normal delay	731 (566)	754 (134)	580 (107)	0.80 (.08)	0.91 (.08)
48-hour delay	858 (894)	841 (222)	645 (112)	0.81 (.08)	0.93 (.04)
t value	-0.68	-1.90	-2.37	-0.79	-0.88
p value	.501	.063	.021*	.430	.386

Post-Experimental Questionnaire

Data from the post-experimental questionnaire indicated that 98% of participants remembered the Q key, 91% of participants remembered both target words, and 72% of participants believed the experimenter instructions that the PM task was finished. Of the eighteen participants who did not believe the experimenter instructions, twelve were from the normal delay condition and six were from the 48-hour delay condition, and this group difference was not significant, $\chi^2 = 2.78$, $p = .09$. Removing the participants who did not believe the PM intention was finished when receiving the instructions or those who forgot the PM words or actions did not alter the above conclusions regarding commission errors (65% of participants in the normal delay condition made one or more commission errors compared to 73% of participants in the 48-hour delay condition, $\chi^2 = 0.35$, $p = .55$). There were no significant differences in likelihood of continuing to think about the PM instructions between participants in the normal delay condition (5.22 out of 10) and participants in the 48-hour delay condition (5.63 out of 10; $t < 1$).

Participants who made one or more commission errors were not significantly more likely to think about the PM task after it was finished ($M = 5.71$, $SD = 2.67$) compared their non-commission error counterparts, ($M = 4.56$, $SD = 3.37$; $t < 1$).

Discussion

The primary finding of Experiment 3 is that an unexecuted PM intention may remain active and accessible for a minimum of 48 hours. The present experiment is the first to observe the extent of the tenacity and perseverance of an unexecuted but finished PM intention (Zeigarnik, 1938). Additionally, the present experiment may serve to elucidate theories of intention deactivation and commission error risk. For example, Walser et al. (2012) found no evidence of the residual activation of a completed PM intention lasting longer than seconds to minutes. In this case, we may have observed activation lasting for a minimum of 48 hours.

The spontaneous retrieval view (Scullin & Bugg, 2013) does not directly comment on the duration by which *finished* PM intentions can be spontaneously retrieved. There is evidence for spontaneous retrieval of active PM intentions 12 hours later (Scullin & McDaniel, 2010) and 7-days later (Kvavilashvili & Fisher, 2007). Additionally, spontaneous retrieval relies on the strength of the cue-action link formed during PM intention encoding. A strong, salient, or focal cue will trigger the retrieval of the associated action from long-term memory (Beck, Ruge, Walser, & Goschke, 2014; Einstein et al., 2005; Moscovitch, 1994). Long-term memory capacity is unlimited (Miller, 1956). By this logic, the strong, salient, PM cues (Scullin et al., 2012) could have triggered the spontaneous retrieval of the associated action even after an extended delay.

Alternatively, the high risk of commission errors observed in the 48-hour delay condition might be explained by the monitoring theory. The monitoring view predicts that commission errors will emerge if preparatory monitoring processes are not deactivated upon intention completion (Smith, 2003). In addition, encountering contexts previously associated with PM intentions can sometimes spontaneously trigger monitoring (Scullin et al., 2013). Participants in the 48-hour delay showed evidence of monitoring because they were significantly slower to respond to non-target lexical decision trials in the finished PM block than participants in the normal delay condition. One interpretation of the observed monitoring may be that the participants in the 48-hour delay condition forgot that the PM task was finished. Although 80% of participants in the 48-hour delay condition reported that they believed the finished instructions from the previous session, this does not mean they did not forget them when they returned for their second session and saw the first target word.

Previous researchers have observed aftereffects and commission errors after temporal delays of thirty seconds to ten minutes after an executed PM intention was finished (Scullin et al., 2011; Scullin & Bugg, 2013; Walser et al., 2012). Bugg and Scullin (2013) and I (Experiments 1 and 2) observed Zeigarnik effects in our respective experiments; participants who did not execute their intention prior to reading the finished instructions made commission errors when the finished block was presented ten minutes later. I also found that participants who did not execute their intention prior to reading the finished instructions made commission errors 48 hours later. Collectively, my findings suggest that the Zeigarnik effects surrounding unexecuted PM intentions result in the intention remaining accessible two days after it was instructed to be finished.

CHAPTER SIX

Conclusion

I conducted three experiments to investigate how the context in which a PM intention is executed and the delay between the finished instructions and the finished block influenced commission error risk. In Experiment 1, I showed that practicing the intention prior to finishing the intention facilitated intention deactivation, but not to the same extent as actively executing the PM intention. In Experiment 2, I showed that the context in which the PM intention is executed (practice or active block) may not influence commission error risk as much as the number of times the intention is executed (two to four times). I concluded that context is a weak moderator of commission error risk and may need to interact with other variables (including number of times the intention is executed) to fully reduce commission error risk. In Experiment 3, I confirmed the significance of executing a PM intention in the appropriate context by demonstrating that an unexecuted intention can remain accessible for 48 hours after instructions that it was finished. I will now discuss how the results of these experiments inform theories of PM deactivation and of commission error risk.

The Mechanisms Underlying Deactivation of Completed Intentions

A fundamental observation from the present experiments is the importance of executing an intention prior to being instructed to finish it. Unexecuted intentions remain active and increase commission error risk. My findings offer evidence for the deactivation of executed intentions provided the intentions are executed in the appropriate context and more than one time. Previous researchers have provided support for the deactivation hypothesis (Bugg & Scullin, 2013; Cohen et al., 2005; Dockree & Ellis, 2001; Marsh et al., 1998; Scullin et al., 2009; West et al., 2007), but the underlying mechanisms of intention deactivation remain debated.

Scullin et al. (2009) and Bugg and Scullin (2013) suggest that executed PM intentions exhibited less activation than unexecuted intentions because unexecuted intentions possess a tenacity and perseverance that persists even after the intention is finished (Zeigarnik, 1938). Experiments 1 and 2 further the understanding of this Zeigarnik effect to include that the intention needs to be executed in the appropriate context in order for the tenacity and perseverance to be fully reduced. Zeigarnik effects might increase the likelihood of the spontaneously retrieving the intention during the finished block and therefore the risk of commission errors.

A modern explanation for my findings can be provided by the episodic-trace hypothesis (Hommel et al., 2001). Participants who repeatedly executed the intention had a greater number of episodic traces associated with the intention than participants who did not execute the intention (Walser et al., 2012). The episodic traces help to destabilize the intention for deactivation when the finished instructions are presented (Hommel et al., 2001). The more times an intention is executed (up to four times in Experiment 2) creates more episodic traces to assist with deactivation (Nader & Hardt, 2009; Scullin et al., 2009).

Why does executing the PM intention in an active context reduce commission error risk more than executing the intention in a practice context? First, it is possible that participants in the practice conditions may have expected to continue to execute the PM intention throughout the remainder of the experiment and the intention remained at a heightened level of tenacity, perseverance, and activation (Marsh et al., 1998; Zeigarnik, 1938). Second, participants in the practice condition may have viewed “practicing” the intention as an opportunity to plan how they will execute the intention later in the experiment (Masicampo & Baumeister, 2011). Planning may have reduced some of the tenacity and accessibility of the unexecuted intention, but not enough to prevent commission errors. Third, participants in the practice condition may not have executed the intention enough times to create a rich representation of the intention being fulfilled to destabilize the intention when the finished instructions were presented. As a result, deactivation was not successful (Hommel et al., 2001; Nader & Hardt, 2009; Scullin et al., 2009).

My findings from Experiments 1 and 2 specify a key aspect of intention deactivation. The PM intention needs to be executed multiple times in the appropriate context (in this case, the active block) to effectively reduce commission error risk. My findings regarding the practice and active conditions also further the previous understanding of spontaneous retrieval processes. A strong link between the PM cues and the PM intention has been shown to support spontaneous retrieval of the intention (Einstein & McDaniel, 1990; Einstein et al., 2005; Reese & Cherry, 2002). It appears that executing the intention in a practice context may encourage the maintenance of the cue-action link and the possibility of spontaneous retrieval. Executing the intention in the active context multiple times weakens the cue-action link and decreases the likelihood of spontaneous retrieval.

Future research should examine the psychological and theoretical differences between executing an intention in a practice context or an active context. Researchers can examine whether participants believe the practice context to be a learning experience or an opportunity to form a plan for execution by incorporating questions throughout the present experiment that ask participants what is currently on their mind. Depending on what participant's report about the intention after executing it in a practice block, we can determine how context influences intention deactivation, if at all.

The Influence of Delay on Unexecuted Intentions

I provided a more definitive test of whether delay reduces commission error risk by extending the length of time between the presentation of the finished instructions and the finished block to 48 hours. I did not give participants the opportunity to execute the encoded PM intention prior to the finished instructions because I wanted to test how long an unexecuted intention would remain accessible. Without any practice or experience withholding a response in the practice or active block of the procedure, all participants, regardless of the delay condition, showed a high risk of commission errors.

In Experiment 3, I observed the interesting and novel possibility that the tenacity and perseverance of an unexecuted intention (Zeigarnik effect) is capable of persisting for a minimum of 48-hours. Spontaneous retrieval processes may only have been partly responsible for the retrieval of the highly accessible finished intention because participants in the 48-hour delay condition also showed evidence of monitoring during the finished block. The dynamic multiprocess theory (Scullin et al., 2013) suggests that monitoring in a particular context (in this case, block) relies initially on the spontaneous retrieval from the first PM cue, and then persists throughout the remainder of the block.

The highly accessible unexecuted intention may have been spontaneously retrieved when the first target word was presented and participants may have continued to monitor throughout the remainder of the block because they expected target words to occur (Smith et al., 2003). Participants should not have executed the intention because of the previous finished instructions but they may have either forgotten the instructions or assumed that the intention should be executed regardless (because they were used to responding to the salient background of the target words). Future researchers may want to ask participants to write out the finished instructions after they have completed the finished block but before the post-experimental questionnaire to make sure that they were understood and not forgotten.

Previous literature has shown spontaneous retrieval processes are responsible for retrieval of active intentions after delays as long as 7 days (Kvavilashvili & Fisher, 2007). The present study shows spontaneous retrieval processes are utilized to retrieve finished intentions after delays as long as 2 days. Future research should replicate the observed duration of Zeigarnik effects and stability of spontaneous retrieval processes and extend the present results by lengthening the amount of time for which a finished intention remains unexecuted.

Application and Future Direction

The observed endurance of unexecuted but finished intentions also has significant applied implications. Commission errors in naturalistic settings have already been shown to have relevance to medication adherence and health (Kimmel et al., 2007). I believe that research on practicing intentions and commission errors may have translational implications, particularly within contexts that require an extensive amount of repetitive training such as in the military or in law enforcement (Biggs et al., 2015). Consider, for example, soldiers who during basic training must remember and search for specific cues that may indicate that an IED is present (an overturned backpack, a large crowd of people) and quickly execute the appropriate associated response (clear away crowd, disarm IED). If my laboratory findings generalize to military settings (which certainly requires further research), then the implication would be that not having the opportunity to perform previously encoded intentions in an active duty context may significantly increase risk for commission errors (i.e., upon return from active duty). From a clinical perspective, the relevant future research question is whether an increased likelihood of spontaneously retrieving an unperformed intention may cause or intensify symptoms of post-traumatic stress disorder, including difficulty concentrating and scanning of the environment for threats (Berntsen, 2010; Berntsen & Hall, 2004; Baumann et al., 2013; Cottencin et al., 2006; McNally et al., 1998; Rubin & Berntsen, 2009). Thus, I recommend that future research evaluate whether Zeigarnik-like effects are implicated in conditions such as post-traumatic stress disorder (Horowitz, 1975).

Under Zeigarnik-like conditions in which there are erroneous spontaneous retrievals of finished intentions, commission errors may be avoidable by training response-inhibition (Scullin et al., 2011; 2012). Biggs et al. (2015) had participants undergo a simulated (gun) shooting environment in which participants actively trained to avoid shooting civilians via enhanced response inhibition, or in a control group, only practiced searching the environment for visual targets (i.e., training that was unrelated to the shooting task). During their post-training simulations, participants who completed the response inhibition training shot fewer civilians (but more correct targets) compared to their pre-training simulations. An interesting potential extension of the Biggs et al. (2015) finding would therefore be to determine whether individualized cognitive-based training can be applied to help participants inhibit PM commission errors. For example, Bugg, Scullin, and Rauvola (2016), tested the effectiveness of "forgetting practice" in reducing commission errors in older adults. After reading the finished instructions, one group of older adults received practice in not executing the no longer relevant intention (e.g.: not pressing the Q key in response to cue words) prior to the Finished-PM block. Forgetting practice significantly reduced commission errors, presumably by strengthening the association between the PM cues and the no-go response.

In everyday life, prospective memory commission errors are avoidable. The present experiments demonstrated a simple way to prevent commission errors: by executing a PM intention at the appropriate time or in the appropriate context before it is finished. If this is not possible, then the accessibility of the unexecuted PM intention can be reduced using strategies that weaken the likelihood of spontaneous retrieval and encourage better inhibition of the PM response (such as practicing forgetting the intention) (Bugg, Scullin, & Rauvola, 2016).

APPENDICES

APPENDIX A

Required Sample Size and Power Analysis

Experiment One

A post-hoc power analysis for a Chi-Square test of independence was conducted using PS- Power and Sample Size Calculation (Dupont & Plummer, 1990). The Type II error rate was set at b =.20 (power = .80) and Type I error rate at a = .05. The power analysis was based on the proportions and sample sizes provided by Bugg and Scullin (2013). Their sample size of 48 had sufficient power to show a large effect size (d = .64). The projected sample size needed for a medium effect size is approximately 72 participants for this between subjects design (n = 24). This proposed sample size will be more than adequate for the main objective of this study. For this design and sample size, power = 0.99.

Experiment Two

A post-hoc power analysis for a Chi-Square test of independence was conducted using PS- Power and Sample Size Calculation (Dupont & Plummer, 1990). The Type II error rate was set at b =.20 (power = .80) and Type I error rate at a = .05. The power analysis was based on the proportions and sample sizes provided by Bugg and Scullin (2013) and by the sample sizes provided by the Experiment One data. The projected sample size needed for a medium effect size was approximately 48 participants for this between subjects design (n = 24). This proposed sample size will be more than adequate for the main objective of this study. For this design and sample size, power = 0.91.

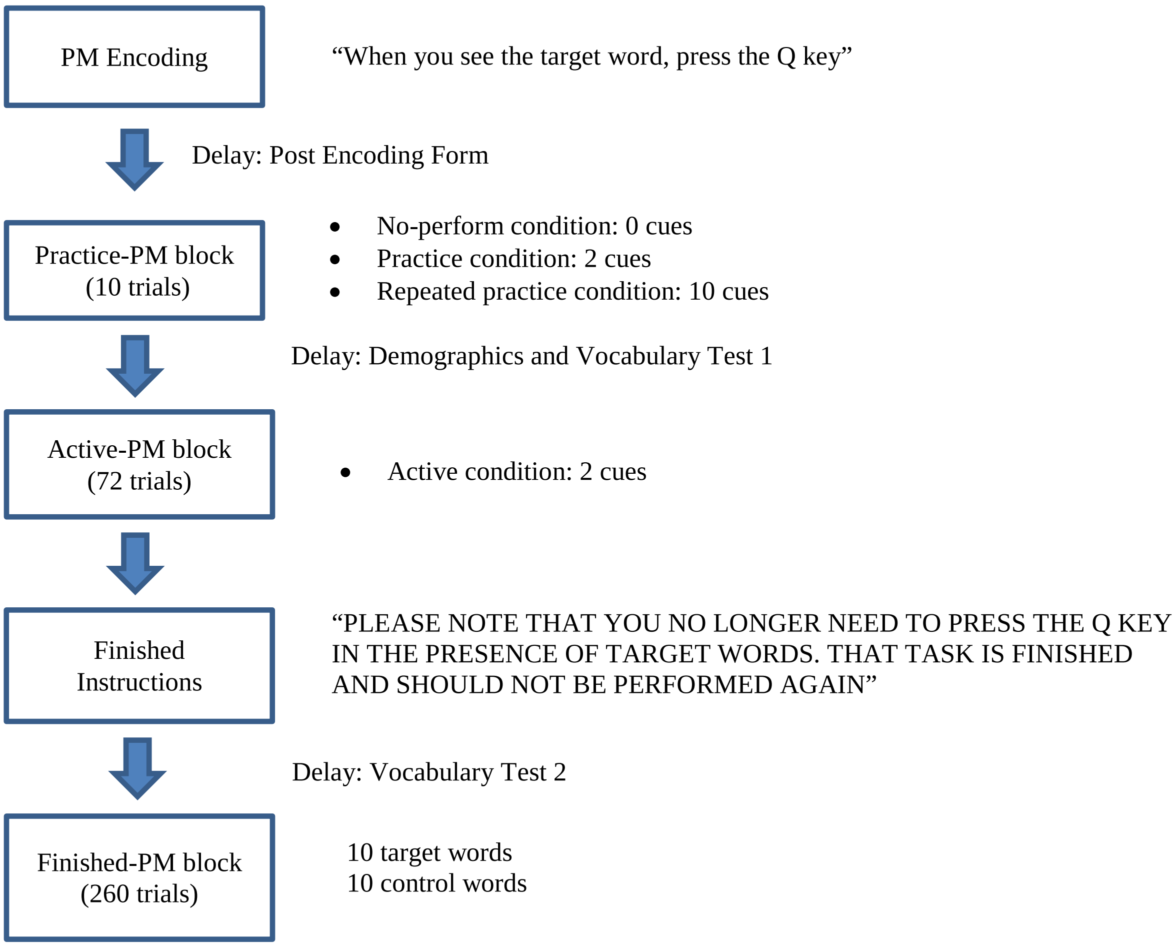
Experiment Three

A power analysis for a Chi-Square test of independence was conducted using PS-Power and Sample Size Calculation (Dupont & Plummer, 1990). The Type II error rate was set at *b* =.20 (power = .80) and Type I error rate at *a* = .05. The power analysis was based on the proportions and sample sizes provided by Walser et al., (2012) and by the sample sizes provided by the Experiment One data. A sample size of 12 had sufficient power (0.80) to show a large effect size (eta squared = .36). The projected sample size needed for a large effect size is approximately 64 participants (*n* = 32) for this between subjects design. This proposed sample size will be more than adequate for the main objective of this study. For this design and sample size, power = 0.98.

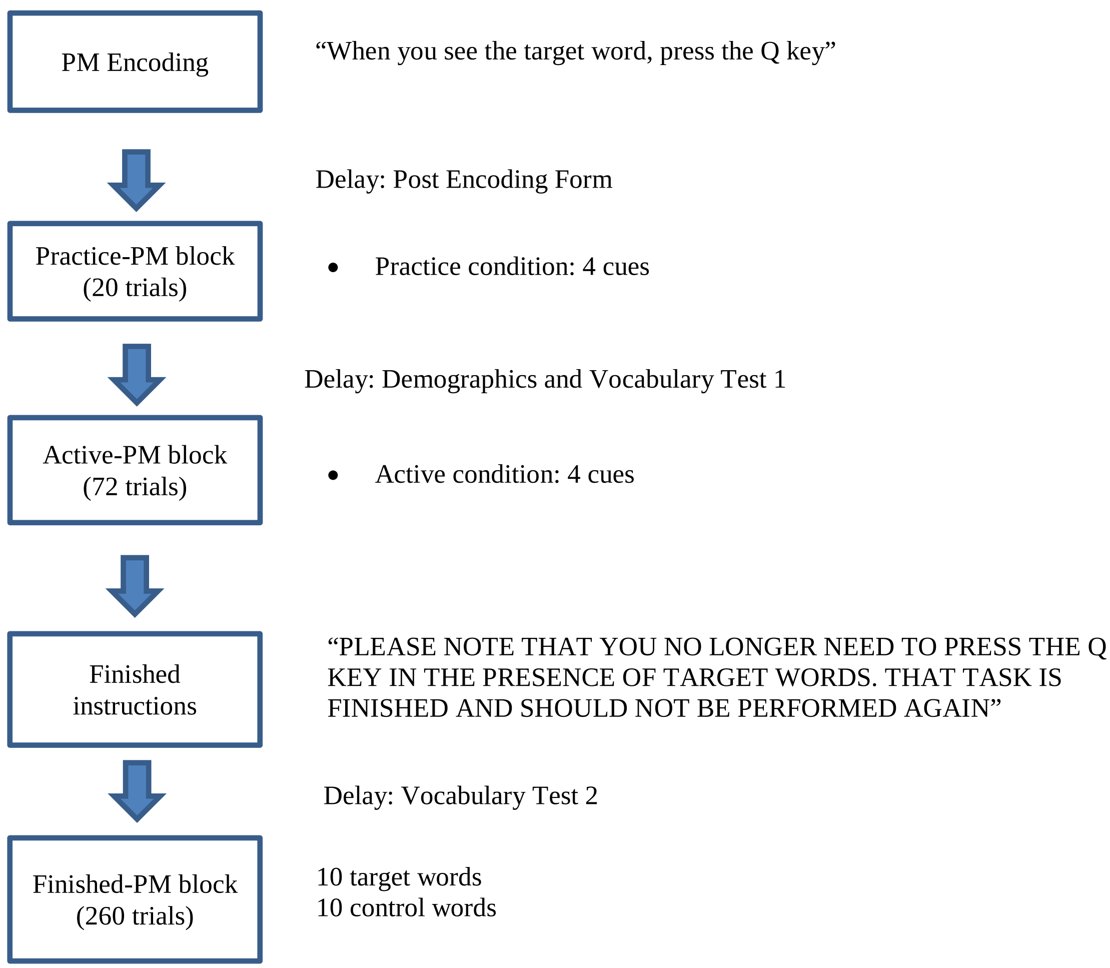
APPENDIX B

Figures

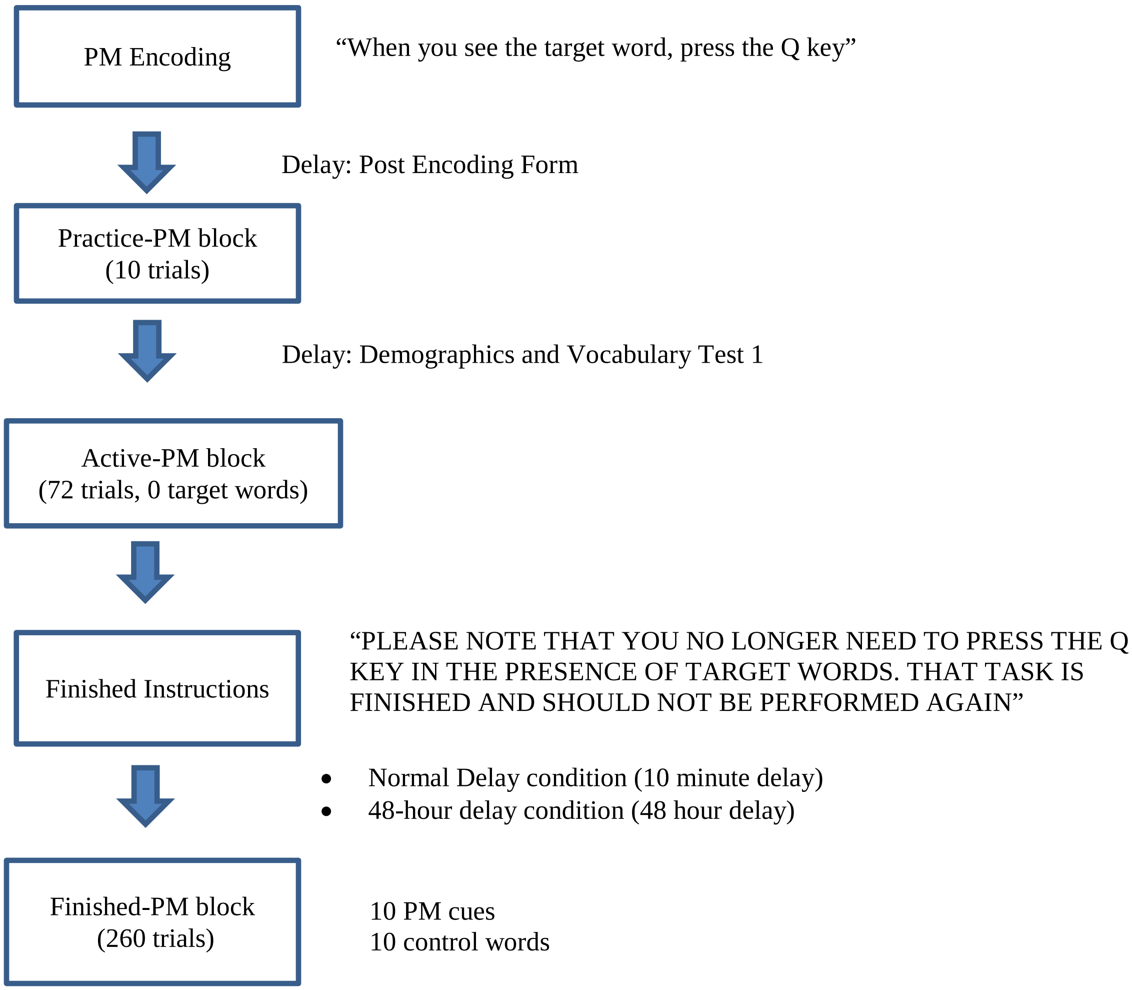
Experiment One Procedure



Experiment Two Procedure



Experiment Three Procedure



REFERENCES

Baddeley, A., Eysenck, M. W. & Anderson, M. C. (2009) *Memory*. New York: Psychology Press.

Baumann O. & Mattingley J. B. (2013). Dissociable representations of environmental size and complexity in the human hippocampus. *The Journal of Neuroscience, 33,* 10526-10533.

Beck, S. M., Ruge, H., Walser, M., & Goschke, T. (2014). The functional neuroanatomy of spontaneous retrieval and strategic monitoring of delayed intentions. *Neuropsychologia, 52,* 37-50.

Berntsen, D. (2010). The unbidden past: Involuntary autobiographical memories as a basic mode of remembering. *Current Directions in Psychological Science, 19*, 138-142.

Berntsen, D. & Hall, N. M. (2004). The episodic nature of involuntary autobiographical memories. *Memory & Cognition, 32,* 789-803.

Biggs, A. T., Cain, M. S., & Mitroff, S. R. (2015). Cognitive training can reduce civilian casualties in a simulated shooting environment. *Psychological Science, 26*, 1164-1176.

Brandimonte, M. A., & Passolunghi, M. C. (1994). The effect of cue distinctiveness and retention interval on prospective remembering. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 47*(A), 565-588.

Bugg, J. M., Scullin, M. K., & McDaniel, M. A. (2013). Strengthening encoding via implementation intention formation increases prospective memory commission errors. *Psychological Bulletin Review, 20*, 522-527.

Bugg, J. M. & Scullin, M. K. (2013). Controlling intentions: The surprising ease of stopping after going relative to stopping after never have gone. *Psychological Science*, *24*, 2463-2471.

Bugg, J. M., Scullin, M. K., & Rauvola, R. S. (2016). Forgetting no-longer-relevant prospective memory intentions is (sometimes) harder with age but easier with forgetting practice. *Psychology and Aging, 31*, 358-369.

Burgess, P. W., Quayle, A., & Frith, C. D. (2001). Brain regions involved in prospective memory as determined by positron emission tomography. *Neuropsychologia, 39,* 545-555.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd. ed). Lawrence Erlbaum Associates.

Cohen, A. L., Dixon, R., & Lindsay, D. (2005). The intention interference effect and aging: Similar magnitude of effects for young and old adults. *Applied Cognitive Psychology, 19*, 1177–1197.

Cohen, A. L., Kantner, J., Dixon, R. A., & Lindsey, D. S. (2011). The intention interference effect: The difficulty of ignoring what you intend to do. *Experimental Psychology, 58*, 425-433.

Cottencin, O., Vaiva, G., Huron, C., Devos, P., Ducrocq, F., Jouvent, R., ... & Thomas, P. (2006). Directed forgetting in PTSD: A comparative study versus normal controls. *Journal of Psychiatric Research, 40*, 70-80.

Crovitz, H. F., & Daniel, W. F. (1984). Measurements of everyday memory: Toward the prevention of forgetting. *Bulletin of the Psychonomic Soc*iety, 22, 413–414.

Dismukes, R. K. (2012). Prospective memory in workplace and everyday situations. *Current Directions in Psychological Science, 21*, 215-220.

Dockree, P. M. & Ellis, J. A. (2001). Forming and canceling everyday intentions: Implications for prospective remembering. *Memory & Cognition, 29*, 1139-1145.

Dupont, W. D., & Plummer, W. D. (1990). Power and sample size calculations: A review and computer program. *Controlled Clinical Trials*, 11:116-28.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 717–726.

Einstein, G. O., McDaniel, M. A., Manzi, M., Cochran, B., & Baker, M. (2000). Prospective memory and aging: Forgetting intentions over short delays. *Psychology and Aging, 15,* 671-683.

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

Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., & Morissette, N. (2005). Multiple processes in prospective memory retrieval: Factors determining monitoring versus spontaneous retrieval. *Journal of Experimental Psychology: General, 134,* 327-342.

Einstein, G. O., Smith, R. E., McDaniel, M. A., & Shaw, P. (1997). Aging and prospective memory: The influence of increased task demands at encoding and retrieval. *Psychology and Aging, 12,* 479-488.

Ellis, J. & Milne, A. (1996). Retrieval cue specificity and the realization of delayed intentions. *The Quarterly Journal of Experimental Psychology, 49A*, 862-887.

Gao, J., & Graf, P. (2005). *Retrieval processes for event cued prospective memory tasks.* Poster presented at the 2nd International Prospective Memory Conference, Zurich, Switzerland.

Gollwitzer, P. M. (1993). Goal achievement: The role of intentions. In W. Stroebe & M. Hewstone (Eds.), *European review of social psychology* (Vol. 4, pp. 141-185). Chichester: Wiley.

Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist, 54*, 493-503.

Gollwitzer, P. M., & Brandstaetter, V. (1997). Implementation intentions and effective goal pursuit. *Journal of Personality and Social Psychology, 73,* 186-199.

Goschke, T. & Kuhl, J. (1993). Representation of intentions: Persisting activation in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*, 1211-1226.

Graf, P. & Uttl, B. (2001). Prospective memory: A new focus for research. *Consciousness and Cognition, 10*, 437-450.

Guynn, M. J., McDaniel, M. A., & Einstein, G. O. (1998). Prospective memory: When reminders fail. *Memory & Cognition, 26*, 287-298.

Guynn, M. J. (2003). A two-process model of strategic monitoring in event-based prospective memory: Activation/retrieval mode and checking. *International Journal of Psychology, 38,* 245-256.

Harrison, T.L., Mullet, H.G., Whiffen, K.N., Outserhout, H., & Einstein, G.O. (2013). Prospective memory: Effects of divided attention on spontaneous retrieval. *Memory & Cognition, 42*, 212-224.

Harrison,T. L. & Einstein, G. O. (2010). Prospective memory: Are preparatory attentional processes necessary for a single focal cue? *Memory & Cognition*, *38*, 860-867.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation, Vol. 22* (pp. 193-225). New York: Academic 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*, 1160-1169.

Hicks, J. L., Marsh, R. L., & Cook, G. I. (2005). Task interference in time-based, event-based, and dual intention prospective memory conditions. *Journal of Memory and Language, 53*, 430-444.

Hommel, B. (1998). Automatic stimulus-response translation in dual-task performance. *Journal of Experimental Psychology: Human Perception and Performance, 24,* 1368-1384.

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences*, *24, 849 – 878.* http://dx.doi .org/10.1017/S0140525X01000103.

Horowitz, M. J. (1975). Intrusive and repetitive thoughts after experimental stress. *Archives of General Psychiatry, 32*, 1457-1463. doi:10.1001/archpsyc.1975.01760290125015.

Kidder, D. P., Park, D. C., Hertzog, C., & Morrell, R. W. (1997). Prospective memory and aging: The effects of working memory and prospective memory task load. *Aging, Neuropsychology, and Cognition, 4,* 93-112.

Kimmel, S. E., Chen, Z., Price, M., Parker, C. S., Metlay, J. P., Christie, J. D., . . . Gross, R. (2007). The influence of patient adherence on anticoagulation control with warfarin: Results from the International Normalized Ratio Adherence and Genetics (IN-RANGE) Study. *Archives of Internal Medicine, 167*, 229 –235. http://dx.doi.org/10.1001/ archinte.167.3.229

Kliegel, M., McDaniel, M. A., & Einstein, G. O. (2000). Plan formation, retention, and execution in prospective memory: A new approach and age-related effects. *Memory & Cognition, 28,* 1041-1049.

Kliegel, M., Martin, M., McDaniel, M. A., Einstein, G. O., & Moor, C. (2007). Realizing complex delayed intentions in young and old adults: The role of planning aids. *Memory & Cognition, 35*, 1735- 1746.

Kliegel, M. & Martin, M. (2003). Prospective memory research: Why is it relevant? *International Journal of Psychology, 38,* 193-194.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G. O. (2004). Importance effects on performance in event-based prospective memory tasks. *Memory, 12*, 553-561.

Kuhlmann, B. G. & Rummel, J. (2014). Context-specific prospective memory processing: Evidence for flexible attention allocation adjustments after intention encoding. *Memory & Cognition, 42*, 943-949.

Kvavilashvili, L. (1987). Remembering intention as a distinct form of memory. *British Journal of Psychology, 78,* 507.

Kvavilashvili, L., & Ellis, J. A. (1996). Varieties of intention: Some distinctions and classifications. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.) *Prospective memory: Theory and applications* (pp. 23-51). Mahwah, NJ: Erlbaum.

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*, 112-132.

Liu, L. L. & Park, D. C. (2004). Aging and medical adherence: The use of automatic processes to achieve effortful things. *Psychology and Aging, 19*, 318-325.

Loft, S. (2014). Applying psychological science to examine prospective memory in simulated air traffic control. *Current Directions in Psychological Science, 23*, 326-331.

Loft, S., Pearcy, B., & Remington, R. W. (2011). Varying the complexity of the prospective memory decision process in an air traffic control simulation. *Journal of Psychology, 19*, 77-84.

Loft, S., Kearney, R., & Remington, R. (2008). Is task interference in event-based prospective memory dependent on cue presentation? *Memory & Cognition, 36*, 139-148.

Loft, S., & Yeo, G. (2007). An investigation into the resource requirements of event-based prospective memory. *Memory & Cognition, 35,* 263–274.

Mantyla, T. (1993). Priming effects in prospective memory. *Memory, 1,* 203-218.

Marsh, R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*, 336-349.

Marsh, R. L., Hicks, J. L., & Bink, M. L. (1998). Activation of completed, uncompleted, and partially completed intentions. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 350-361.

Marsh, R. L., Hicks, J. L., & Bryan, E. S. (1999). The activation of unrelated and canceled intentions. *Memory & Cognition, 27*, 320-327.

Marsh, R. L., Hicks, J. L., Cook, G. I., Hansen, J. S., & Pallos, A. L. (2003). Interference to ongoing cognitive activities covaries with the characteristics of an event-based intention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 861-870.

Marsh, R. L., Hicks, J. L., & Cook, G. I. (2005). Task interference from prospective memories covaries with contextual associations of fulfilling them. *Memory & Cognition, 34*, 1037-1045.

Marsh, R. L., Cook, G. I., & Hicks, J. L. (2006). Task interference from event-based intentions can be material specific. *Memory & Cognition, 34*, 1636-1643.

Masicampo, E. J., & Baumeister, R. F. (2011a). Unfulfilled goals interfere with tasks that require executive functions. *Journal of Experimental Social Psychology, 47*, 300-311.

Masicampo, E. J., & Baumeister, R. F. (2011b). Consider it done!: Plan making can eliminate the cognitive effects of unfulfilled goals. *Journal of Personality and Social Psychology, 101*, 667-683.

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

McDaniel, M. A., Robinson-Riegler, B., & Einstein, G. O. (1998). Prospective remembering: Perceptually-driven or conceptually-driven processes? *Memory and Cognition, 26,* 121-134.

McDaniel, M. A. & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology, 14,* S127-S144.

McDaniel, M. A., Einstein, G. O., Graham, T., & Rall, E. (2004). Delaying execution of intentions: Overcoming the costs of interruptions. *Applied Cognitive Psychology, 18*, 533-547.

McDaniel, M. A., Guynn, M. J., Einstein, G. O., & Breneiser, J. (2004). Cue-focused and reflexive-associative processes in prospective memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 605-614.

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

McDaniel, M.A & Scullin, M. K. (2010). Implementation intention encoding does not automize prospective memory responding. *Memory & Cognition, 38,* 221-232.

McNally, R. J., Metzger, L. J., Lasko, N. B., Clancy, S. A., & Pitman, R. K. (1998). Directed forgetting of trauma cues in adult survivors of childhood sexual abuse with and without posttraumatic stress disorder. *Journal of Abnormal Psychology, 107*, 596-601.

Meacham, J. A., & Leiman, B. (1982). Remembering to perform future actions. In U. Neisser (Ed.), *Memory observed: Remembering in natural contexts* (pp. 327-336). San Francisco: Freeman.

Meier, B., von Wartburg, P., Matter, S., Rothen, N., & Reber, R. (2011). Performance predictions improve prospective memory and influence retrieval expectations. *Canadian Journal of Experimental Psychology, 65*, 8-12.

Meilan, J. J. G. (2008). Activation and deactivation processes in postponed intentions. *Psychologia, 51*, 1-10.

Meiser, T. & Rummel, J. (2012). False prospective memory responses as indications of automatic processes in the initiation of delayed intentions. *Consciousness & Cognition*, *21*, 1509-1516.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *The Psychological Review, 63*, 81-97.

Milne, S., Orbell, S., & Sheeran, P. (2002). Combining motivational and volitional interventions to promote exercise participation: Protection motivation theory and implementation intentions. *British Journal of Health Psychology*, ***7****,* 163-184.

Moscovitch, M. (1982). A neuropsychological approach to memory and perception in normal and pathological aging. In F. I. M. Craik & S. Trehub (Eds.), *Advances in the study of communication and affect: Vol. 8. Aging and cognitive processes* (pp. 55-78). New York: Plenum Press.

Moscovitch, M. (1994). Cognitive resources and dual-task interference effects at retrieval in normal people: The role of the frontal lobes and medial temporal cortex. *Neuropsychology, 8,* 524-534.

Munoz Gomez Andrade, A. (2014). Completing intended actions under divided attention: would I do it again if I had the chance? Unpublished thesis.

Nader, K., & Hardt, O. (2009). A single standard for memory: The case for reconsolidation. *Nature Reviews Neuroscience*, *10*, 224-234.

Nowinski, J. L., Holbrook, J, & Dismukes, R. K. (2005, May). *Effects of lingering intentions on subsequent tasks.* Poster presented at the American Psychological Society Conference, Los Angeles, CA.

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

Parker, S., Garry, M., Einstein, G. O., & McDaniel, M. A. (2011). A sham drug improves a demanding prospective memory task. *Memory, 19*, 606-612.

Penningroth, S. L. (2011). When does the intention-superiority effect occur? Activation patterns before and after task completion and moderating variables. *Journal of Cognitive Psychology, 23*, 140-156.

Pink, J. E. & Dodson, C. S. (2013). Negative prospective memory: Remembering not to perform an action. *Psychological Bulletin Review, 20*, 184-190.

Reese, C. M., & Cherry, K. E. (2002). The effects of age, ability, and memory monitoring on prospective memory task performance. *Aging, Neuropsychology, and Cognition, 9*, 98-113.

Rubin, D. C. & Berntsen, D. (2009). The frequency of voluntary and involuntary autobiographical memories across the lifespan. *Memory & Cognition, 37*, 679-688.

Rummel, J. & Meiser, T. (2013). The role of metacognition in prospective memory: Anticipated task demands influence attention allocation strategies. *Consciousness and Cognition, 22*, 931-943.

Scullin, M. K., McDaniel, M. A., & Einstein, G. O. (2010). Control of cost in prospective memory: Evidence for spontaneous retrieval processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36,* 190-203.

Scullin, M. K., Bugg, J. M., McDaniel, M. A., & Einstein, G. O. (2011). Prospective memory and aging: Preserved spontaneous retrieval, but impaired deactivation, in older adults. *Memory & Cognition, 39*, 1232-1240.

Scullin, M. K. & Bugg, J. M. (2013). Failing to forget: Prospective memory commission errors can result from spontaneous retrieval and impaired executive control. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*, 965-971.

Scullin, M. K., Einstein, G. O., & McDaniel, M. A. (2009). Evidence for spontaneous retrieval of suspended but not finished prospective memories. *Memory & Cognition, 37*, 425-433.

Scullin, M. K., Bugg, J. M., & McDaniel, M. A. (2012). Whoops, I did it again: Commission errors in prospective memory. *Psychology and Aging*, *27*, 46-53.

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?. J*ournal of Experimental Psychology: Learning, Memory, and Cognition*, *36*, 736-749.

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.

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

Sheeran, P., & Orbell, S. (1999). Augmenting the theory of planned behavior: Roles for anticipated regret and descriptive norms. *Journal of Applied Social Psychology, 29*, 2107-2142.

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*, 347-361.

Smith, R. E., & Bayen, U. J. (2004). A multinomial model of event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*, 756–777.

Smith, R. E., & Bayen, U. J. (2005). The effects of working memory resource availability on prospective memory: A formal modeling approach. *Experimental Psychology, 52*, 243-256.

Trawley, S. L., Law, A. S., Brown, L. A., Niven, E. H., & Logie, R. H. (2014). Prospective memory in a virtual environment: Beneficial effects of cue saliency. *Journal of Cognitive Psychology*, *26*, 39-47.

Van der Linden, D., Frese, M., & Meijman, T. F. (2003). Mental fatigue and the control of cognitive processes: effects of perseveration and planning. *Acta Psychologica, 113*, 45-65.

Walser, M., Goschke, T., & Fischer, R. (2014). The difficulty of letting go: Moderators of the deactivation of completed intentions. *Psychological Research, 78*, 574-583.

Walser, M., Fischer, R., & Goschke, T. (2012). The failure of deactivating intentions: Aftereffects of completed intentions in the repeated prospective memory cue paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*, 1030-1044.

Walser, M., Plessow, F., Goschke, T., & Fischer, R. (2014). The role of temporal delay and repeated prospective memory cue exposure on the deactivation of completed intentions. *Psychological Research, 78,* 584-596.

Waszak, F., & Hommel, B. (2007). The costs and benefits of cross-task priming. *Memory & Cognition, 35*, 1175-1186.

Weiner, B., Johnson, P., & Mehrabian, A. (1968). Achievement motivation and the recall of incompleted and completed exam questions. *Journal of Educational Psychology, 59,* 181-185.

West, R. L., McNerney, M. W., & Travers, S. (2007). Gone but not forgotten: The effects of cancelled intentions in the neural correlates of prospective memory. *International Journal of Psychophysiology*, *64*, 215-225.

West, R. L. (1988). Prospective memory and aging. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory: Current research and issues: Vol. 2. Clinical and educational implications* (pp.119-128). Chichester, UK: Wiley.

West, R., Krompinger, J., & Bowry, R. (2005). Disruptions of preparatory attention contribute to failures of prospective memory. *Psychonomic Bulletin & Review, 12*, 502-507.

Whittlesea, B. W. A., & Williams, L. D. (2001a). The discrepancy-attribution hypothesis: I. The heuristic basis of feelings of familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*, 3-13.

Whittlesea, B. W. A., & Williams, L. D. (2001b). The discrepancy-attribution hypothesis: II. Expectation, uncertainty, surprise, and feelings of familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*, 14–33.

Zeigarnik, B. (1938). On finished and unfinished tasks. In W. D. Ellis (Ed.), *A source book of Gestalt psychology* (pp. 300–314). London, England: Harcourt, Brace and Co.