THE EFFECTS OF CONTEXT EXPECTATION ON OLDER AND YOUNGER ADULTS' PROSPECTIVE MEMORY PERFORMANCE

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CHAPTER I

INTRODUCTION

Prospective memory refers to memory for actions to be carried out in the future. Examples of prospective memory are remembering to go to a doctor's appointment or remembering to meet for a study group. As can be seen from these examples, the importance of researching prospective memory is easily recognized given that prospective memory is an integral part of everyday life for adults of all ages. Thus, it is important to study factors that positively and negatively impact older and younger adults' prospective memory performance.

Context is one factor that may influence prospective memory performance across the lifespan. The encoding specificity principle is a general framework for understanding how contextual information affects retrospective memory (Tulving & Thomson, 1973). The encoding specificity principle states that memory is better when the context at encoding is reinstated at retrieval. For example, retrieval of information is better if participants are tested in the same room they studied in relative to being tested in a room different from that of learning (McDaniel, Robinson-Riegler, & Einstein, 1998). Context-dependent memory is a term that is often used interchangeably with encoding specificity. Context effects have only been minimally studied in relation to prospective memory. Researchers in this area have looked at context reinstatement (McDaniel et al., 1998; McGann, Ellis, & Milne, 2002; McGann, Ellis, & Milne, 2003), task appropriate processing (Marsh, Hicks, & Hancock, 2000; Meier & Graf, 2000), and context expectations (Cook, Marsh, & Hicks, 2005; Nowinski & Dismukes, 2005). However, the extent to which context-dependence influences prospective memory is still unclear. Further, none of the three lines of research have examined the impact of context-dependence on age-related differences in prospective memory performance. In particular, older adults rely heavily on prospective memory for independent living. Thus, studying context-dependence in prospective memory may afford older adults a valuable heuristic for improving prospective memory success rates.

The present research is designed to examine the impact of context expectation on age-related differences in prospective memory performance. The introduction is organized as follows. The first section will provide background information on the distinction between retrospective and prospective memory. The second section will briefly discuss context-dependent memory research on retrospective memory. A detailed description of the prospective memory literature examining the effects of context-dependence will follow. The third section will address current models of prospective memory. Also outlined is the research examining the impact of context-dependence on prospective memory performance. The fourth section will provide a brief overview of age-related differences in prospective memory research. Finally, specific aims of the current research will establish a rationale for studying the impact of context expectation on age-related differences in prospective memory performance, and outline the specific hypotheses of the proposed research.

Review of Literature

Memory research has largely focused on studying retrospective memory (RM), or remembering the past. Prospective memory (PM), memory for future intentions (Brandimonte, Einstein, & McDaniel, 1996), has become a recent interest among memory researchers. The increased research attention in PM may be explained by the pertinence of prospective memory to daily living. That is, research has shown that half the errors in a given day are prospective in nature (Crovitz & Daniel, 1984). Although the number of published studies has risen sharply in the last two decades (McDaniel & Einstein, 2007), some memory researchers strongly oppose PM as a concept and have been outwardly critical of PM as a new and different memory system.

The Distinction between RM and PM

The distinction between RM and PM appears to be both prominent when cursorily examined and subtle when more closely inspected. Widely studied memory systems such as semantic, procedural, and episodic memory are all examples of RM. PM is characterized by remembering to complete a task in the future. Examples of PM are taking medications and keeping appointments. A gross examination of the two types of memory suggests that differences are easily discerned. However, closer inspection of the underlying components of PM reveals that successful PM performance hinges on both RM and PM. That is to say, there is a RM and a PM component in any PM task (Einstein, Holland, McDaniel, & Guynn, 1992). For example, once an intention to deliver a message to a colleague has been formed, the agent must remember the RM component of what the message entails and the PM component of delivering the message upon encountering that colleague.

Most researchers have accepted the distinction between RM and PM. However, there are some staunch adversaries who have suggested that the identification of PM as a separate memory system is frivolous and useless (Crowder, 1996; Roediger, 1996). Both Crowder (1996) and Roediger (1996) have advocated that PM is nothing more than a type of episodic memory, and since such is the case, the excitement and research are both premature and unwarranted. Crowder (1996) proposed that PM is an oxymoron because the word memory refers to the past. He further stated that, "The loss of the term prospective memory would leave us better off, not impoverished" (p. 144). The anti-PM sentiment expressed by Crowder (1996) and Roediger (1996) stemmed from their point of view that PM is not governed by any special principles that are not also applicable to RM. In other words, PM is subject to the same principles as episodic memory and does not yield any information that suggests that PM is a separate memory system from episodic memory.

Despite the criticisms of Crowder (1996) and Roediger (1996) there is evidence that supports the distinction between RM and PM. Graf and Uttl (Graf & Uttl, 2001; Uttl, 2006; Uttl, Graf, Miller, & Tuokko, 2001) have championed the effort to substantiate PM as separate and distinguishable from episodic memory. They have argued that PM is distinct from episodic memory in at least two respects. First, PM requires conscious control to interrupt ongoing activities. Second, an individual can remember to fulfill an intention, but forget what the intention entails. If PM was simply a case of episodic memory, there would be no need for conscious control to interrupt ongoing activities. Further, all PM errors would be instances of forgetting the content of the intention instead of forgetting to complete the intention. The ability of an individual to have unsuccessfully completed an intention because the individual forgot *to* complete the intention but remembered the content of the intention supports the distinction between RM and PM. That is, participants who remember *that* (content of intention or RM component) they have to complete an intention but forget *to* (completion of intention or PM component) complete the intention validate PM as different from episodic memory.

Cementing the distinction between RM and PM is important for all researchers of PM. However, it is also important for PM researchers to keep in mind that PM has an RM component. The RM component is the part of the intention that relates to the content of remembering what completion of the intention entails. The PM component relates to remembering to put the intention into action. The RM component of PM will certainly allow PM to function on many, if not, as Roediger (1996) suggests, all the same principles by which RM is governed. The RM component is most important in that it provides a common element between RM and PM that researchers can focus on to compare and contrast the two types of memory. However, more research will need to be conducted before the issue of distinguishing between RM and PM can be resolved. The next section will briefly address past research that has examined PM using RM-based principles and will then present in more depth the RM-based principle on which the current research is based.

Principles shared between RM and PM

Divided attention (Cherry, 1953, Craik, Govoni, Naveh-Benjamin, & Anderson, 1996) and depth of processing (Craik & Lockhart, 1972) are examples of principles that RM and PM have in common. Divided attention occurs when two tasks are performed simultaneously. When attention is divided, often times neither task is performed optimally. A germane example to current society is talking on the phone while driving. Driving performance is lower while talking on the phone relative to driving while not talking on the phone (Horrey & Wickens, 2006; Lesch & Hancock, 2004; Strayer, Drews, & Johnston, 2003). Likewise, divided attention has been shown to have a negative impact on participants' recall and recognition performance (Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik et al., 1996); memory performance was lower when participants tried to learn information while simultaneously performing a second task.

Under the cognitive rigors of divided attention, participants performing PM tasks have also shown performance decrements (Einstein et al., 1992; Einstein, McDaniel, Manzi, Cochran, & Baker, 2000; Einstein, et al., 1998; Einstein, Smith, McDaniel, & Shaw, 1997). In addition to remembering to fulfill a PM intention embedded in an ongoing task, Einstein, McDaniel, Richardson, Guynn, and Cunfer (1995) assigned participants to either a high or low cognitive load condition. An additional working memory task was added to the ongoing and PM tasks in the high load condition. This additional working memory task consisted of listening to and comprehending an auditorially presented passage. Einstein et al. found that participants in the high load condition were unable to focus on both the ongoing and working memory tasks and eventually focused solely on the ongoing task with the embedded PM task. Even though statistical analyses could not be performed because participants were unable to complete both the ongoing and working memory tasks, it was clear that cognitive load significantly affected the participants to the point where they were unable to perform all three (ongoing, PM, working memory) tasks simultaneously.

Another principle on which both PM and RM function is depth of processing. Craik and Lockhart (1972) presented their levels of processing (LOP) framework as a potential explanation for differences in RM performance. The LOP framework states that the more deeply information is processed, the more likely it will be later recalled. Processing information at a deeper level is a function of more semantic or cognitive analyses at encoding. The effect of depth of processing has been documented for memory for pictures/faces (Bower & Karlin, 1974; Burgess & Weaver, 2003), memory for words (Craik & Tulving, 1975; Sauzeon, N'kaoua, Lespinet, Guillem, & Claverie, 2000), and false memories (Kronlund & Whittlesea, 2005; Thapar & McDermott, 2001).

Craik and Lockhart (1972) proposed that meaningful stimuli are processed at a deeper level and are better retained. PM researchers manipulated participants' perceived importance of the PM intention. Participants' perceived importance of the PM intention has an effect on the type of processing that is engaged (Meacham & Singer, 1977; Kliegel, Martin, McDaniel, & Einstein, 2001). That is, participants who perceive the intention to be of more (personal) importance presumably process the PM intention at a deeper level which manifests as a higher rate of successful future intention completion. In other words, even though participants are not instructed to process the information in a semantic manner, participants are processing the intention deeper because of its higher perceived importance. Research has shown that as perceived importance increased, participants were more likely to complete a future intention in a timely manner (Cigogna & Nigro, 1998; McDaniel & Einstein, 2000; Meacham & Singer, 1977). In contrast, when perceived importance was lower participants tended to be less accurate and timely in their PM responses (Kliegel et al., 2001).

Given that RM and PM both rely on principles such as divided attention and depth of processing, it is likely that all the principles that RM shares with PM have yet to be identified. Moreover, some of the shared principles that have been identified have not received adequate research attention. The role of context is one of the principles that has received little research attention in the field of PM, but has a solid foundation in RM research.

Encoding Specificity in RM

The influence of context on RM performance has been studied under the encoding specificity principle (Thomson & Tulving, 1970; Tulving & Pearlstone, 1966; Tulving & Osler, 1968). The encoding specificity principle states that an item can only be retrieved if it has been encoded in memory, and how it is retrieved depends on how the item was encoded (Tulving & Thomson, 1973). The bits of information that are associated with an item at the time of encoding can all be used as retrieval cues. One of the bits of information that also gets stored is the context in which the item was encoded. Thus, the context in which the item was encoded becomes an effective retrieval cue that people can use to help them to later recall the item from memory. For example, when a person goes into the kitchen but forgets for what purpose, the person can return to the room from which they came to help recall the original purpose for entering the kitchen.

Since the research of Tulving and Thomson (1973), encoding specificity has also been referred to as context-dependent memory (Craik, 1986; Godden & Baddeley, 1975) and task appropriate processing (Maylor, 1996; Roediger, Weldon, & Challis, 1989). Regardless of nomenclatorial differences, the research has shown that reinstating context has had a positive impact on participants' memory performance. For ease of interpretation in the current study, context-dependent memory is the preferred terminology and will be used henceforth.

A classic research study examining context-dependent memory was conducted by Godden and Baddeley (1975). Godden and Baddeley asked participants to learn lists of words either on dry land or underwater. After learning the lists of words, participants were asked to recall as many words from the lists as they could remember either on land or underwater. An examination of the number of words participants recalled revealed that when the context at encoding was reinstated at recall, participants recalled significantly more words than when the context at recall was different. In other words, if participants learned the lists of words underwater, they were able to recall more words when tested underwater than on dry land.

Godden and Baddeley (1975) showed that the physical context in which encoding took place was as an effective retrieval cue. However, further research extended the context-dependent memory beyond the physical environment at encoding. Geiselman and Glenny (1977) showed that contextual expectations about the to-be-recalled information present at encoding also served as effective retrieval cues. Geiselman and Glenny presented participants with word pairs on slides. Participants were asked to mentally rehearse one-third of the words pairs in a male voice, one-third in a female voice, and the remaining third in their own voice. At test, participants were auditorily presented with words spoken in a male or female voice and told to mark any word they recognized from the slides. The results showed that participants recognized more words when the sex of the voice in which the words spoken matched the sex of the voice in which participants had rehearsed them. In other words, words that participants were told to rehearse in a female voice were better recognized when the words were presented in a female voice at the time of retrieval.

The research of Gieselman and Glenny (1977) is important in understanding the impact of context on PM performance. By the very nature of PM, the retrieval context cannot be physically encoded at the time a future intention is formed. However, an expectation of the context in which the intention will be fulfilled is possible. Further, it is likely that performance on some PM tasks will benefit from an association with a future context. Going back to the example of giving a message to a colleague, the likelihood of successfully passing on the message may be increased by associating the intention with expecting to see the colleague in the future context of a faculty meeting.

Context-Dependent Memory in PM

Initially, PM was studied in naturalistic settings (e.g., Ceci & Bronfenbrenner, 1985; Levy, 1977; Levy & Clark, 1980) because laboratory-based research was not thought to be ecologically valid. However, Einstein and McDaniel (1990) later introduced a laboratory-based research paradigm that was designed to be analogous to real-world PM tasks. To make the PM task similar to situations that occurred in real life, the PM task was embedded in an ongoing activity. For example, an individual may need to remember to relay a phone message to a roommate. Encountering the roommate is the prospective cue which results in suspending the ongoing activity in order to remember the content of the message and to then relay the message.

The Einstein and McDaniel (1990) paradigm allowed researchers to exert more experimental control over the encoding and retrieval of the PM cue. The control over encoding and retrieval has allowed PM researchers to investigate the role of context in

PM performance. Marsh, Hicks, and Cook (2007) provide an excellent review of this body of literature. Even though the body of literature examining the impact of context on PM performance is sparse, four distinct foci have emerged: context reinstatement (McDaniel et al., 1998; McGann et al., 2002; McGann et al., 2003), output monitoring (Marsh, Hicks, Cook & Mayhorn, 2007; Marsh, Hicks, Hancock, & Munsayac, 2002), task appropriate processing (Marsh et al., 2000; Meier & Graf, 2000), and expected context (Cook et al., 2005; Nowinski & Dismukes, 2005). A brief discussion of each will follow.

Researchers have examined the impact of reinstating participants' environmental context (McDaniel et al., 1998, Exp. 2) and reinstating the semantic context of the retrieval cue (McDaniel et al., 1998; McGann et al., 2002; McGann et al., 2003) on PM performance. McDaniel et al. (1998, Exp. 2) studied the role of environmental context by manipulating the room in which participants learned and then performed the PM task. Half of participants learned the intention in room A and subsequently performed the PM task in room A. The remaining half of participants learned the intention in room A and then performed the PM task in room B. As has been found in RM research, participants performed better on the PM task when the environmental context was matched between encoding and retrieval relative to when the contexts at encoding and retrieval did not match.

Reinstating the semantic context of the retrieval cue has also been studied using homographs (McDaniel et al., 1998; McGann et al., 2002; McGann et al., 2003). Homographs are words that are spelled the same way but have different meanings (ex: wind, bear, mean). Using homographs, researchers have presented the cue word in the context of a sentence. The sentence provides semantic information so that participants will encode one specific meaning of the homograph (e.g., The man remembered that he was supposed to have wound his watch.). During the ongoing task the cue word was presented in sentences that provided three different types of semantic information relative to encoding. The three types of semantic information provided in the sentences were referred to as same, modulated, and different. The same and modulated conditions reinstated the same meaning presented at encoding. However, the modulated condition used a different context to reinstate the same meaning. Instead of specifically relating the cue word to a timepiece like same-sentences (e.g., If not wound regularly, the antique clock would run down.), modulated sentences reinstated the same meaning but in a different context (e.g., The spring was wound so tight that it broke.). In the different condition, the context of the sentence presented at retrieval changed the meaning of the homograph (ex: It was the subsequent error by Alex Gonzalez, not Steve Bartman's interference that had the diehard Cubs fan wound up.). Results from these studies (McDaniel et al., 1998; McGann et al., 2002; McGann et al., 2003) showed that PM performance was significantly higher when the context and meaning of the homograph were the same at encoding and retrieval relative to when one or both of them were different in the modulated and different conditions. Further, no significant differences between the modulated and the different conditions were observed (McDaniel et al., 1998; McGann et al., 2003). Even though the meaning was the same at encoding and retrieval in the modulated conditions, it is the context in which the PM cue was encoded that helped participants to successfully retrieve and complete the future intention more often. The results of this research are important because they show how much of an impact context can have on PM performance.

The importance of context on PM performance can also be observed in terms of omission and commission errors. Errors of omission occur when the intention goes uncompleted and errors of commission occur when the PM intention is performed a second (or more) time(s) because the initial completion of the intention has been forgotten. Output monitoring involves remembering the outcome of a past future intention. Thus, examining output monitoring allows researchers to study omission and commission errors in PM.

Marsh and colleagues (Marsh et al., 2002; Marsh et al., 2007) have studied output monitoring through the re-presentation of PM cues. Participants were asked to press the "/" key when an animal word was presented on the screen. Half of these animal words were re-presented toward the end of the ongoing task. If participants remembered having responded to the PM cue earlier in the ongoing task, they were to press the "=" key. If they did not remember responding to it earlier, they were to press the "/" key to indicate it was the first response to the PM cue. Both Marsh et al. (2002) and Marsh et al. (2007) found that younger adults were more susceptible than older adults to commit errors of omission. That is, younger adults were more likely to think that they had responded to the re-presented PM cues earlier in the experiment when in fact they had not. Marsh et al. (2007, Exp 1) found that older adults were much less likely than younger adults to commit errors of commission. It was suggested that the age-related differences in errors of omission and commission were reflective of age-related differences in retrospective memory.

In relation to context, Marsh et al. (2002, Exp. 3) examined output monitoring when the ongoing task changed from rating words on pleasantness to rating words on imageability. The PM cues were initially presented during the pleasantness rating task and the re-presented PM cues were presented during the imageability rating task. The results showed that participants were more likely to forget having made the PM response to the PM cue when the context changed relative to when the context remained the same between the first and second presentation of the PM cues. The performance differences may also be due in part to the differences in how the words were processed in order to perform the pleasantness and imageability rating tasks. Thus, output monitoring decisions appear to also hinge on task appropriate processing.

In PM research, task appropriate processing refers to the degree of overlap between the type of processing used to identify the PM cue and the type of processing required to perform the ongoing task. Task appropriate processing was examined by having half of participants learn cues that required semantic processing to identify (ex: respond to animal words; Marsh et al., 2000; Meier & Graf, 2000) and the other half of participants learned cues that required structural processing to identify (ex: respond to words with ‘ee’ in them; Meier & Graf, 2000). After learning the PM cues, participants completed an ongoing task that either required semantic processing (making pleasantness ratings about each word; Marsh et al., 2000) or structural processing (counting the number of enclosed spaces in each word[1]; Meier & Graf, 2000). The results showed that PM performance was significantly higher when the type of processing required to perform the PM and ongoing tasks matched relative to when the PM and ongoing tasks required different types of processing (Marsh et al. 2000; Meier & Graf, 2000).

The research examining task appropriate processing has shown that the context in which a PM cue occurs can help participants be more successful at completing future intentions. Task appropriate processing turns context into an effective retrieval cue without participants specifically encoding context as a retrieval cue. This is important because it shows that under the right circumstances, context can be a highly effective PM performance aide even without effortfully processing it as such. The research on homographs also showed the effectiveness of context as a PM performance aide (McDaniel et al., 1998; McGann et al., 2002; McGann et al., 2003). Unlike with task appropriate processing, the role of context was made salient to participants. That is, participants encoded the PM cue in a very specific context and the results showed that performance was best when this context was reinstated at retrieval. One possibility for the results in the homographs studies is that learning the PM cue in such a way may have led to expectations about the presentation of the PM cue (e.g., in the same context as encoding). It is expectations about the context in which the PM cue will occur on which researchers have most recently focused.

Researchers investigating context expectations have examined PM performance when participants expect the PM cue to occur in a future context or expect the PM target to be presented in an upcoming task (Cook et al., 2005; Nowinski & Dismukes, 2005). At encoding, the presentation of the PM cue is associated with a specific task that will occur later in the experiment. Participants can then focus all their attention on monitoring for the PM cue during one specific task instead of throughout the experimental session. Monitoring occurs when participants allocate cognitive resources toward identifying the PM cue in order to successfully fulfill the intention. Thus, associating the PM cue with a future context may promote the fulfillment of the intention by using contextual cues to narrow the scope of the search for the PM cue(s).

Nowinski and Dismukes (2005) investigated differences in PM performance when there was an association between the PM cues and a future task and when there was no association. Two ongoing tasks were used in a within-subjects design. Participants were instructed to press a response key if they saw a word describing a fruit during task A or any other task. Emphasizing task A in the instructions like this created an expectation of the PM cue to occur in the context of task A. During the PM performance interval, participants alternated performing trials of task A and task B. The results showed that even though PM cues were presented during both task A and task B, participants were significantly more likely to fulfill the intention when the PM cues occurred during task A. Thus, it appears that forming an expectation about the context in which the PM cues occurs improves PM performance.

Cook et al. (2005) more thoroughly examined the impact of context expectation with the addition of an incorrect context expectation condition. Unlike Nowinski and Dismukes (2005), however, Cook et al. also used a time-based prospective memory (TBPM) task. TBPM is remembering to perform an intention in the future at a specific time or after a certain amount of time has elapsed (Einstein & McDaniel, 1990, Einstein et al., 1995). The typical TBPM paradigm requires the participant to make a PM response at designated times throughout the experiment or after a designated length of time (Cicogna, Nigro, Occhionero, & Esposito, 2005; Einstein et al, 1995; Hicks, Marsh & Cook, 2005).

Participants in Cook et al. (2005) were asked to press a target key during the sixth minute of a TBPM performance interval. Context expectation was created by dividing the performance interval into three phases and telling participants to expect the sixth minute to occur during the third phase of the performance interval. In the correct context expectation condition, the sixth minute occurred in the third phase. Incorrect context expectations were formed by lengthening the first phase of the experiment so that it included the sixth minute. Participants in the no context expectation conditions were told to respond during the sixth minute of the performance interval but were given no additional information about the phase in which the PM cue would occur.

Similar to previous research, Cook et al. (2005) reported that context can be used as an effective retrieval cue for retrieving and successfully completing intentions. When the TBPM cue occurred in the context that matched participants expectations (correct context expectation), performance was significantly better than having no context expectation at all. Although the benefits of context expectation were observed, the potential detriment of context expectation was also exhibited. That is, when the TBPM cue occurred in a context that did not match participants expectations (incorrect context expectation), performance was significantly worse than not having a context expectation. Cook et al. demonstrated that context expectation has the power to significantly improve successful TBPM intention competition, but can also have equally negative consequences.

Everyday life can be chaotic and daily schedules can rapidly change. The opportunity to fulfill an intention may be expected to occur in a certain context but may end up occurring in a different and unexpected context which may result in the opportunity being missed and the intention going uncompleted. Intentions left unfulfilled due to incorrect context associations may be trivial (e.g., mailing a postcard) or they may be of personal detriment (e.g., forgetting child at day care). Cook et al. (2005) focused on time-based intentions, but it is also important to further research this type of context expectation with event-based intentions (Nowinski & Dismukes, 2005) given that fulfilling both types of intentions is important for successful daily living.

Theories of Event-Based PM

Context-dependence in RM and principles shared between RM and PM have been presented. In addition, research examining the effects of context on PM performance has also been addressed. However, to further build the rationale for conducting the current study a better understanding of PM is necessary. Thus, a review of the PM literature is presented beginning with current theories and ends with age-related differences in PM performance.

The laboratory-based research paradigm developed by Einstein and McDaniel (1990) has been in use for less than twenty years. In this relatively short time, two prominent theoretical frameworks have been proposed to explain the underlying mechanisms of PM. These are the preparatory attention and memory (PAM) model (Smith, 2003; Smith & Bayen, 2004) and the multiprocess framework (Einstein et al., 2005; McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004). While neither one is wholly accepted over the other, they provide a foundation on which researches can build.

The PAM model was developed by Rebekah Smith (Smith, 2003; Smith & Bayen, 2004) in light of previous research (Kidder, Park, Hertzog, & Morrell, 1997; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). PAM proposes that cognitive resources are always necessary for successful PM performance (Smith, 2003; Smith & Bayen, 2004, 2005; Smith & Hunt, 2005). The PAM model posits that successful PM performance requires attentional resources throughout the performance interval (the length of time that the ongoing task with the embedded PM task takes to complete). That is, the PAM model maintains that resources devoted to searching for the PM cue are always in use regardless of whether the individual is aware of the monitoring process (Smith & Bayen, 2005). Smith and Bayen (2005) have provided evidence that both remembering to act and recalling the appropriate action require the use of working memory. In other words, the processes associated with successful PM performance are drawing from limited cognitive resources (Marsh, Hancock, & Hicks, 2002). Support for the PAM model is drawn from research indicating that successful PM performance is attained at a cost to the ongoing task (Kidder et al., 1997; Loft & Yeo, 2007; Marsh, Hicks, Cook, 2005; Park et al., 1997; Smith, 2003; Smith & Bayen, 2004, 2005, 2006). Cost to the ongoing task is defined as a decrease in performance and/or longer response latencies for the ongoing task in which the PM task is embedded relative to simply completing the ongoing task without an embedded PM task.

The multiprocess framework (Einstein et al., 2005; McDaniel & Einstein, 2000, McDaniel et al., 2004) is at odds with the PAM model in that the multiprocess framework advocates that recognition of the PM cue and retrieval of the PM action can *sometimes* occur spontaneously. That is, without placing a demand on cognitive resources that may otherwise result in a cost to the ongoing activity. In order to understand the position of the multiprocess framework in regards to the use of cognitive resources, a discussion of two possible ways individuals may engage in a PM task is necessary. First, individuals may consciously switch attention between the ongoing task (e.g., an STM recall task) and the PM task (e.g., pressing a key when a target word appears). In this instance, the individual has to consciously interrupt the ongoing task to switch attention toward monitoring for the PM cue. This approach requires strategic processing to monitor for the PM cue throughout the performance interval. The second approach is considered to be automatic because when a PM cue is encountered, it is processed without consuming resources (McDaniel & Einstein, 2000, 2005). Automatic processing of a PM cue does not require conscious switching of attention between the PM and ongoing tasks by the individual. In support of automatic processing, recent research (Cohen, Jaudas, & Gollwitzer, 2008; Einstein et al., 2005; McDaniel et al., 2004) has provided empirical evidence that successful PM performance can, under certain circumstances, occur without cost to the ongoing task.

The multiprocess framework posits that a variety of variables have an impact on whether individuals rely on monitoring or spontaneous retrieval to complete PM tasks. Some of the variables addressed in the multiprocess framework are: differences in importance placed on the PM task (Einstein et al, 2005, Exp. 1; Kliegel et al., 2001), target distinctiveness, association of the PM cue with the PM action, length of the delay between formation of intention and completion of intention (Brandimonte & Passolunghi, 1994), number of PM target events, type of ongoing task (focal vs. non-focal), and individual differences (i.e., working memory capacity; Smith & Bayen, 2005). There is also evidence that associating a PM intention with a future context influences participants’ decision to monitor for the PM intention (Cook et al., 2005, Marsh, Hicks, Cook, 2006).

The Cost of Context-Dependence in PM. Within the small body of PM research examining context, less than a handful of studies have examined how contextual association influences cost to the ongoing task. McDaniel et al. (1998) reported no differences in cost when the contextual association of homographs was manipulated. However, McDaniel et al. did not test participants in a control condition in which only the ongoing task was performed. In other words, a performance baseline was not obtained so that examining the cost of adding the PM task could not be addressed. Thus, this finding provides little in the way of helping to understanding how maintaining a context association with a PM intention impacts cost to the ongoing task.

Unlike McDaniel et al. (1998), McGann et al. (2002) included a control condition for the purpose of examining cost. McGann et al. (2002) tested typical PM task performance against performance when attention was divided while performing the PM task. Attention was divided by having participants complete an auditory recognition task at the same time as the PM task. Participants in the control condition performed only the auditory recognition task. The results showed that there was a cost to the auditory recognition task in the divided attention conditions relative to the control condition. The observed cost in this study is difficult to interpret because cost to the auditory recognition task is a function of performing two other tasks (the ongoing task and embedded PM task). The addition of a condition in which participants performed the auditory and ongoing tasks without the PM task could have been used as a comparison to investigate the cost of adding a PM task. Even though divided attention was required to simultaneously perform the auditory and ongoing tasks, it would have been more informative for our purposes to be able to quantify the cost of adding only a PM task in a divided attention paradigm.

McDaniel et al. (1998) and McGann et al. (2002) were unable to help illuminate the relationship between cost to the ongoing task and contextual association of the PM intention. However, Marsh et al. (2006) specifically examined this relationship. Like Cook et al. (2005), Marsh et al. (2006) split the ongoing task into three different phases. Half of participants were assigned to the control condition and completed all three phases of the ongoing task without a PM intention. The remaining half of participants were to form a future intention and were told they could expect the PM cues to occur in the third phase of the ongoing task. The ongoing task was a lexical decision task (LDT) in which participants made word/non-word judgments about stings of letters. An analysis of reactions times revealed that participants in the PM condition did not show any cost to the ongoing task in the first phase, but showed significant cost to the ongoing task in phase 3. In other words, participants only showed cost to the ongoing task when they were in the context in which they expected the PM cues to occur.

Based on these results, Marsh et al. (2006) suggested that associating a future intention with a particular context may be a way that people can avoid the extensive cost to everyday cognitive processing of having to monitor for PM intentions throughout the course of a day (Einstein, McDaniel, Williford, Pagan, & Dismukes, 2003). Given the potentially broad practical application of associating PM intentions with expected contexts, older adults are one group of individuals that may be able to benefit from this line of research. The very nature of performing a future intention during an ongoing task decreases the ability of older adults to be successful at PM tasks (Henry, MacLeod, Phillips, & Crawford, 2004). Therefore, anchoring the PM intention to an expected context may help older adults to successfully complete a higher proportion of everyday PM tasks.

Age-Related Differences in PM

Comparing older and younger adults' PM performance has been of interest since the seminal research on Einstein and McDaniel (1990). The development of PM abilities across the lifespan, theoretical understanding of PM, and practical applications of PM among older adults are part of the rationale for past research and the continued interest in age-related differences. PM is of practical importance for people of all ages, but it is especially important to older adults because of its role in maintaining social relations, independent living, and medication adherence (McDaniel, Einstein, & Rendell, 2008). Researchers have compared older and younger adults' PM abilities on both naturalistic and laboratory tasks in an effort to better understand and identify when and why age-related differences in PM performance occur.

Relatively few naturalistic studies of PM have been undertaken (e.g., Devolder, Brigham, & Pressley, 1990; Moscovitch, 1982; Rendell & Craik, 2000, Exp. 2; Rendell & Thomson, 1993; Rendell & Thomson, 1999, Exp. 1 & 2; West, 1988), but a majority of the ones that have usually focused on medication adherence (e.g., Carlson, Fried, Xue, Tekwe, & Brandt, 2005; Hertzog, Park, Morrell, & Martin, 2000; Kruse, Eggert-Kruse, Rampmaier, Runnebaum, & Weber, 1991; Leirer, Tanke, Morrow, 1994). Rendell and colleagues (Rendell & Craik, 2000, Exp. 2; Rendell & Thomson, 1993; Rendell & Thomson, 1999, Exp. 1 & 2) have used electronic logging devices to study older and younger adults' PM performance on naturalistic PM tasks. Participants' naturalistic PM performance was observed over the course of a week. Rendell and Thomson (1999) observed performance when participants were to complete one intention a day or four intentions a day. The results showed that older adults responded on time more often than younger adults in both the one and four intention conditions. Further, in comparing late responses, older adults' late responses were closer to the target time than were younger adults' late responses.

Rendell and Thomson (1999, Exp. 1 & 2) and Rendell and Craik (2000, Exp. 2) examined older and younger adults' ability to perform regularly occurring and irregularly occurring intentions. In the weeklong studies, participants were either given intentions that occurred at the same times every day to simulate taking medication or were asked to respond to intentions that occurred at different times each day to simulate the formation and completion of intentions that may arise through the course of a day. Both studies observed better performance by older adults on regularly and irregularly occurring intentions relative to younger adults. Also showing better PM performance by older adults and similar to Rendell and Thomson (1993), Rendell and Thomson (1999, Exp. 1) found that older adults' late responses were closer in temporal proximity to the target time than were younger adults' late responses.

Relative to the small number of naturalistic research examining age-related differences in PM, a much larger number of laboratory-based studies have been conducted (c.f., Henry et al., 2004). Researchers interested in age-related differences have examined PM by itself (Cherry & Lecompte, 1999; Einstein & McDaniel, 1990; Salthouse, Berish, & Sieldlecki, 2004) and in conjunction with aspects of cognition that range from the increased cognitive load associated with performing multiple tasks simultaneously (d'Ydewalle, Luwel, & Brunfaut, 1999; Einstein et al., 1995) to dividing attention between multiple tasks (Einstein et al., 1992; Einstein et al., 2000; Einstein, et al., 1998; Einstein et al., 1997) to examining working memory ability (Cherry & LeCompte, 1999; Logie, Maylor, Sala, & Smith, 2004; Maylor, 1998; West & Bowry, 2005). A theme common to a vast majority of PM research investigating age-related differences is that older adults perform worse than younger adults on laboratory PM tasks. That is, when laboratory-based PM tasks are performed, research has repeatedly shown that older adults are unable to match the PM performance of their younger adult counterparts.

The Paradox. A paradox of age-related differences exists between naturalistic and laboratory-based research. Older adults routinely perform equal to or better than younger adults on PM tasks in naturalistic studies. To the contrary, younger adults usually perform significantly better than older adults on laboratory-based PM tasks. Researchers acknowledge that the paradox exists (Henry et al., 2004; Rendell & Craik, 2000; Rendell & Thomson, 1999), but very little is known about the potential underlying mechanisms.

What little is known about the paradoxical findings in the PM literature centers around age-related declines in cognitive resources. Craik and Byrd (1982) proposed that older adults experience RM declines due to age-related losses in processing resources. RM is an essential component of PM, which means that if RM abilities are reduced due to age-related factors, then it is likely that PM abilities will similarly be affected (Einstein & McDaniel, 1996). Strong support for the idea that lower PM performance by older adults is due to a reduction in cognitive resources can be found in laboratory-based PM research that has observed equal PM performance by older and younger adults.

A small section of the PM literature has not found significant performance differences between older and younger adults on PM tasks (e.g., Cherry & LeCompte, 1999; Einstein & McDaniel, 1990; Einstein, et al., 1995, Exp. 2; Reese & Cherry 2002; Rendell & Craik, 2000, time check task Exp. 2; Vogels, Dekker, Brouwer, & de Jong, 2002, word comparison task, pictures task), but even these findings demonstrate the importance of cognitive resources to PM performance. These studies attenuated age-related differences by slightly modifying the ongoing task to equate the cognitive demands of the ongoing task for older and younger adults. In particular, Cherry and LeCompte (1999), Einstein and McDaniel (1990), and Reese and Cherry (2002) adjusted word set length in an STM task that served as the ongoing task in which the PM task was embedded. Younger adults were presented with word lists of 4-9 words and older adults were presented with lists between 3-8 words. This modification to the ongoing task reduced the cognitive demand of performing the ongoing task for older adults by reducing the number of words they were to recall. The shorter and longer word sets were assumed to place equal cognitive demand on older and younger adults, respectively. Without such an adjustment, older adults would have had to work harder than younger adults to achieve the same performance on the ongoing task. In turn, older adults would have had fewer resources to allocate toward the PM task relative to younger adults. However, the slight accommodations to the ongoing task resulted in equivalent PM performance between older and younger adults (Cherry & LeCompte, 1999; Einstein & McDaniel, 1990; Reese & Cherry, 2002).

The observation of equal performance between older and younger adults when cognitive demands have been decreased for older adults supports the idea that older adults have a reduced allotment of cognitive resources from which to draw (Craik, 1986). That is, older adults were most likely able to devote a similar amount of resources toward the PM task because the adjustment to the ongoing task helped to equate the amount of resources both older and younger adults had to allocate toward the ongoing task.

Given what is currently known about the impact of age-related decline in cognitive resources on PM performance, why do older adults outperform younger adults on naturalistic PM tasks? Rendell and Craik (2000) put forth three potential explanations. First, there is much less time to complete tasks in the laboratory. Often, only a few seconds are provided before a PM response is considered a “miss”. Naturalistic tasks, however, provide much larger windows in which the participant can respond. Remembering to call for a doctor’s appointment after lunch will be considered correct in performed anytime between the end of lunch until the close of the doctor’s office. Second, PM tasks associated with successful daily living are fundamentally different than laboratory-based PM tasks. Naturalistic tasks are typically set up to be analogous to daily living [e.g., the regularly occurring intentions in Rendell & Thompson (1999) and Rendell & Craik (2000)] whereas laboratory tasks are more directed toward examining the underlying cognitive reasons that older and younger adults differ. Last, older adults may structure their lives to enhance support from their environments to compensate for fewer cognitive resources (Craik, 1986). It is not that older adults necessarily have rigid daily routines, but they may be more likely to schedule daily activities in a manner that will allow them to anchor future intentions to those activities.

For example, an older adult may plan to eat lunch at a certain time because it will then coincide with the next time to take medication.

Structuring daily activities to anchor them to future intentions is a way that older adults can take advantage of context as a memory aide. Using context in this way should help older adults compensate for fewer cognitive resources by providing a highly salient retrieval cue. A highly salient retrieval cue may help older adults compensate for age-related declines in self-initiated cueing. Because it is more difficult for older adults to self-cue (Craik, 1986), establishing salient external memory cues may help older adults perform equal to or better than younger adults in the real world. If older adults are already using context to their advantage in the real world, then associating future intentions with an expected context should also improve older adults' PM performance in the laboratory. The effective use of context expectations by older adults should attenuate age-related differences obtained in past laboratory-based research.

In summary, both context and age have been researched to help understand how they impact PM performance. However, the relationship between context and age has yet to be directly examined in PM. Given the positive influence of context on PM performance for younger adults (Cook et al., 2005; Marsh et al., 2006) and how older adults may use context to their advantage in the real world (Rendell & Craik, 2000; Rendell & Thompson, 1999), associating a future intention with an expected context should improve older adults' PM performance on laboratory PM tasks. The current research will be the first empirical study to directly examine how context expectations influence age-related differences in PM performance. Further, the research examining age-related differences in cost to the ongoing task is both sparse and inconsistent (Bastin

& Meulemans, 2002; d'Ydewalle, Bouchaert, & Brunfaut 2001; McDaniel & Einstein, 2005; Park et al., 1997). Thus, this research will also add to what is currently known about age-related differences in how maintaining a PM intention influences cost to the ongoing task.

Specific Aims

There are two primary aims of the current study. The first aim is to examine the impact of context expectation on age-related differences in prospective memory. Cook et al. (2005) investigated the impact of both correct and incorrect context expectations on participants' PM performance. However, they examined time-based PM and the sample was comprised solely of younger adults. While Nowinski and Dismukes (2005) examined event-based prospective memory, they too sampled only younger adults. To extend the PM research on context expectations, the current study will use an event-based PM task and will include older adult participants to examine age-related differences. The PM task will require participants to press a response key (F6) on the computer keyboard whenever a target event occurs (the presentation of a fruit word). The effects of context expectation on PM will be examined by manipulating the context in which participants expect the PM cues to occur during the ongoing task. To create different contexts within the ongoing task, the trials of the ongoing task will be divided evenly and a filler task will be presented between the two halves. It will be explained to participants in the expectation conditions that they should expect the PM cues to occur either before or after the filler task. Participants who will not told be to expect the PM targets in a specific context will be instructed to press the target key anytime a fruit word is presented on the computer screen.

Within this aim there are three specific hypotheses. First, in conjunction with past research (e.g., Cherry & Lecompte, 1999; Einstein & McDaniel, 1990; Salthouse et al., 2004) a main effect of age group is expected. Older adults' mean PM performance is anticipated to be significantly lower than younger adults' mean PM performance. Next, similar to the findings of Cook et al. (2005), a significant effect of context expectation is expected. Participants who will hold correct context expectations about the PM targets are expected to perform significantly better on the PM task than participants who will hold no context expectations about the PM targets. In turn, participants with no context expectations are expected to show significantly higher PM performance than participants who hold incorrect context expectations about the presentation of the PM targets. Finally, age group is expected to interact with context expectation. The age group by context expectation interaction is anticipated because it is hypothesized that a correct context expectation should benefit the PM performance of older adults more than it will benefit the PM performance of younger adults.

The second aim of the current study is to examine age-related differences in the amount of cost to the ongoing task that is associated with expecting PM cues to occur in a specific context. This aspect of the current research is largely modeled after Marsh et al. (2006). Marsh et al. found that when the PM intention occurred in an expected context, cost to the ongoing task was only observed in the context in which the PM cues were expected to occur. Cost to the ongoing task was assessed by comparing participants' average reaction times to the ongoing task trials in the correct context condition to their average reaction times when performing the ongoing task without an embedded PM task. Similar cost-based results are expected to be obtained in the current research.

Aim two also contains three specific hypotheses pertaining to participants' response latencies. First, a main effect of age group is expected. The mean response latencies for older adults are expected to be longer than the mean response latencies of younger adults. The second hypothesis is based on the context expectations about target presentation. That is, cost to the ongoing task is predicted to occur when participants are expecting PM targets to appear but not occur when participants are not expecting the PM targets to appear. Past research has shown that the addition of a PM task increases response latencies (e.g., Smith & Bayen, 2004, 2005, 2006). Thus, it is thought that participants should take longer to respond to the block of trials in which the PM task is embedded than the other two blocks of LDT trials (baseline and non-PM block) in the correct and no context expectation conditions. Marsh et al. (2006) observed cost to the ongoing task only in the expected context. Thus, the incorrect context expectation conditions are not expected to show a cost to the ongoing task. Finally, it is expected that age will interact with context expectation. This hypothesis predicts that compared to younger adults, older adults should show more cost to the ongoing task than younger adults in the correct context expectation conditions. In contrast, the amount of cost to the ongoing task is not expected to differ between the age groups in the incorrect context expectation conditions.

In summary, this study is expected to extend the research on PM by examining age-related differences in PM performance and cost under both correct and incorrect context expectations. Specifically, associating a PM intention with a future context should help participants be more successful at fulfilling those intentions. Examining older and younger adults' PM performance under different context expectations will add to what is already known regarding age-related differences and the effects of context in the PM literature. Confirmation of the outlined predictions will provide the first examination of cost to the ongoing task for older and younger adults for both correct and incorrect context expectations.

CHAPTER II

METHOD

Participants

Participants included 120 community dwelling older adults (M_{age} = 75.55, *SD* = 8.21) and 120 younger adults (M_{age} = 19.92, *SD* = 1.50). Older adults were recruited from local civic groups and senior centers and were remunerated with ten U.S. dollars. Older adult participants ranged in age from 60 to 95 years and there was an imbalance in gender with 39 men (M_{age} = 73.92, *SD* = 8.49) and 81 women (M_{age} = 74.86, *SD* = 8.11) participating. Within the older adult population women outnumber men so this gender imbalance was not anomalous. Younger adults were recruited from introduction to psychology courses at Oklahoma State University and were compensated with partial course credit. Younger adult participants ranged in age from 19 to 26 years of age and gender was balanced with 60 men (M_{age} = 19.87, *SD* = 1.23) and 60 women (M_{age} = 19.97, *SD* = 1.74) participating.

Within each age group, participants were randomly assigned to one of three conditions: correct context expectation, no context expectation, and incorrect context expectation. Two (age group: old, young) x 3 (context expectation: none, incorrect, correct) factorial ANOVAs were conducted on self-perceived health, educational attainment, verbal ability, prescription and non-prescription medications, the two working memory measures, and vision to determine pre-experimental equivalence. Younger adults (M = 1.71, SD =.68) reported their current health as significantly higher than older adults (M = 1.93, SD =.73), $F(1, 234) = 6.09$, $p = .04$, partial $\eta^2 = .03$. Older adults (M = 2.98, SD =.3.11) reported taking more non-prescription medications than younger adults (M = .26, SD =.62). A significant age-group by context expectation condition interaction was observed for education, $F(2, 234) = 3.61$, $p = .029$, partial $\eta^2 = .03$. Subsequent analyses showed that older adults in correct context (M = 5.55, SD = 1.04) and no context expectation (M = 5.63, SD = 1.17) conditions reported significantly higher educational attainment than all other conditions. Means in the remaining four conditions ranged from 4.9 to 5.0.

A significant age-group by context expectation condition was also observed for prescription medications, $F(2, 234) = 4.17$, p =.017, partial $\eta^2 = .03$. Older adults (M = 4.74, SD = 3.79) reported taking more prescription medications per day on average than younger adults (M = .50, SD = .94), $F(1, 234) = 147.93$, $p < .001$, partial $\eta^2 = .39$. In each context expectation condition older adults took more prescription medications than younger adults. Further, older adults in the correct context expectation condition (M = 6.03, SD = 4.29) reported taking significantly more medications per day than the older adults in the incorrect context expectation condition [M = 4.43, SD = 3.23; $t(78) = 2.57$, $p = .012$, $\eta^2 = .08$] and older adults in the no context expectation condition, albeit marginally [M = 3.76, SD = 3.51; $t(78) = 1.88$, $p = .063$, $\eta^2 = .04$].

Two measures of working memory were administered. The Backward Digit Span (BDS; Wechsler, 1955) test required participants to listen to and immediately recall in reverse order progressively longer sequences of single-digit numbers presented at the rate of one per second. Participants received one practice trial followed by two trials of two, two trials of three, two trials of four, and so forth, up to a maximum of two trials of eight-digit sequences. Testing proceeded until two consecutive trials within a given sequence length were missed. The Size Judgment Span (SJS; Cherry & Park, 1993) test required participants to listen to progressively longer sequences of words. The words included in the SJS test were ones that can be easily visualized and differ with respect to physical size (e.g., frog, hairpin, piano). Participants were asked to recall the words in order of their physical size, from the smallest to the largest item (e.g., hairpin, frog, piano). Participants were given two practice trials followed by the presentation of three trials of two words, three trials of three words, three trials of four words, and so forth up to a maximum of three trials of eight words. Testing proceeded until three consecutive trials within a sequence length were missed. The working memory measures were scored by giving full credit to sequence levels in which two trials were correctly recalled, and half credit to sequences in which only one trial was correctly recalled. Pre-experimental equivalence was achieved on participants' performance on the BDS task, $F < 1$. However, a significant age-group by context expectation condition was observed for performance on the SJS task, $F(2, 234) = 4.42$, $p = .013$, partial $\eta^2 = .04$. This interaction was due to younger adults performing significantly better in the correct context expectation condition ($M = 4.78$, $SD = .71$) than both the incorrect ($M = 4.41$, $SD = .72$) and no context expectation conditions ($M = 4.35$, $SD = .51$).

Participants also completed the Gardner and Monge (1977) 30-point Word Familiarity Survey. They chose a synonym for each given word from five choices. Participants were allotted one point for each correct choice for a total of 30 possible points. Pre-experimental differences were not observed for context expectation but were obtained between age-groups, $F(1,234) = 77.66$, $p < .001$, partial $\eta^2 = .25$. Older adults (M =17.71, SD = 5.57) performed better on the vocabulary measure than did younger adults (M =12.7, SD = 3.68).

Participant's vision was also tested. Participants stood ten feet from an eye-chart and read subsequently smaller lines of capital letters. The vision of younger adults (M = 12.32 ft, SD = 5.00 ft) was significantly better than the vision of older adults (M = 15.36 ft, SD = 5.66 ft), $F(1, 233) = 19.89$, $p < .001$, partial $\eta^2 = .08$. In addition, a main effect of context expectation was also observed, $F(2, 233) = 3.49$, $p = .032$, partial $\eta^2 = .03$. The vision of participants in the correct context expectation conditions (M =12.81 ft, SD = 3.47 ft) was significantly better than the vision of participants in the no context expectation conditions (M =15.00 ft, SD = 7.16 ft). The two variables did not produce an interaction, $F(2, 233) = 2.10$, $p = .125$, partial $\eta^2 = .02$, observed power = .43. Cell means for all demographic and individual difference measures can be found in Table 1.

Materials

Demographic Information. Participants completed a demographic questionnaire soliciting information regarding age, educational attainment, occupational status, and marital status. The demographic questionnaire also contained three questions related to self-perceived health from the Older American Resources and Services Multidimensional Functional Assessment Questionnaire (OARS; Duke University Center for the Study of Aging and Human Development, 1975).

Lexical Decision Task. Participants judged letter strings as words or non-words. All stimuli were medium frequency (20-25 ppm) words between four and six letters long

(Allen, Madden, Weber, & Groth, 1993; Lien et al., 2006) taken from Francis and Kucera (1982). Half of the stimuli were modified by replacing one or two letters to make non-words (e.g., huke from home). The presentation of words and non-words was presented randomly save for the three prospective memory targets, which were presented at predetermined times.

A fixation point (+) was presented for 500ms (Allen, Madden, & Crozier, 1991; Giffard, Desgranges, Kerrouche, Piolino, & Eustache, 2003; Robert & Mathey, 2007) followed by the to-be-judged stimulus. Participants were to press the key labeled ‘YES’ or the key labeled ‘NO’ if they judged the stimulus to be a word or a non-word, respectively. Following their responses to the letter strings, participants were presented with a blank screen until the next trial began with the onset of the fixation point. Each lexical decision trial lasted for a total of 3000ms. The amount of time that the blank screen was presented for each trial was dependent on how long it took participants to respond to each letter string ([3000ms – (500ms + response time)]; Hicks et al. 2005). The Hicks et al. lexical decision protocol was employed because of the control it allowed over the presentation of the prospective memory targets. In other words, because every lexical decision trial was the same length the presentation of the prospective target words within the lexical decision task (LDT) was temporally identical for all participants.

Prospective Memory. The prospective memory test was embedded within the LDT. For all participants, prospective memory targets were three different (Cohen et al., 2008) fruit words (e.g., apple, grape, pear) and the response to the target events was to press the F6 key. When participants identified a fruit word, they were instructed to first press the F6 key on the computer keyboard and then respond to the lexical decision stimulus.

States Task. Participants were provided with a blank map of the United States of America and were asked to write the full name of the state on the corresponding state on the map. Participants were provided with a pencil and were told they could begin when they were ready. After a maximum of five minutes the task was terminated by asking the participants to please stop working.

Recognition Task. The stimuli were fifty words presented on the computer screen one at a time at a rate of two seconds per word. Participants were told to study the words as carefully as they could because later on they were going to be asked to recognize them. Following the presentation phase participants were provided with a paper list of 100 words. Each word was followed by the words 'YES' and 'NO'. Participants were asked to circle YES if they recognized the word from the list they had studied or circle NO if they did not recognize it from the list they just studied.

Letter Cancellation Task. The letter cancellation task was presented in the middle of the lexical decision trials that made up the ongoing task. That is, the first half the ongoing lexical decision trials were presented, then the letter cancellation task followed by the second half of the lexical decision trials. Participants were provided with a highlighter, and a sheet of paper on which a variety of capital letters were randomly distributed. Participants were asked to locate and highlight as many of the capital 'A's as they could find. Participants received up to four different sheets, subsequent sheets increased in density of letter distribution.

Importance Measure. Participants were asked to complete two questions that asked them to rate how much importance they placed on the LDT (e.g., Quickly and accurately responding to each letter string) and on the prospective memory task. Ratings were made on a Likert-type scale that ranged from 1 (little importance) to 7 (a great deal of importance).

Strategy Assessment. Participants were asked an open-ended question (Ex: Was there anything you did during the course of today's experiment to help you to remember to press F6 when you saw the fruit words?) at the end of the experiment where they were given the opportunity to describe any strategies they may have used while performing the PM task.

Vision Test. Participants were required to complete a vision test. Standing ten feet from the eye-chart, participants were asked to read subsequently smaller lines of letters. When participants failed to correctly identify all letters of a line, the task was stopped. Participants were scored on the last line they correctly identify.

Design

The overall design of the experiment was a 2 (age group: old, young) x 3 (target expectation: none, phase 1, phase 3) x 2 (target occurrence: phase 1, phase 3) between-subjects factorial design. Within each age group, an equal number of participants were assigned to each of the target expectation and target occurrence conditions.

Procedure

Upon arriving at the laboratory, participants were seated at a computer. Participants completed the consent form and demographics questionnaire. Next, participants were instructed on how to perform the LDT and then completed ten practice trials. Participants were then asked to complete a set of 50 lexical decision trials to obtain baseline reaction time estimates. At three seconds per trial this set of lexical decision trials took 2.5 min to complete.

Once participants had completed the control block of lexical decision trials, participants were informed of a secondary interest in their ability to remember to do something in the future. At this point they were presented with the prospective memory instructions. They were told that later on they would be completing two more sets of lexical decision trials that would be separated by a one-minute break. The two lexical decision sets and the one-minute break will henceforth be referred to in terms of phases. The first set of lexical decision trails will be phase 1, the one-minute break will be phase 2, and the second set of lexical decision trials will be phase 3. Phases 1 and 3 contained twice as many trials as were used to obtain baseline estimates. At a rate of 3 sec per trial, each phase took participants 5 min to complete. Within a phase, the prospective memory targets were always presented as the 40^{th}, 67^{th}, and 94^{th} trials. The combined time of all three phases comprising the ongoing task was 11 minutes.

All participants were told to press the F6 key whenever they were presented with a word that was a fruit. For half of the participants in all conditions the target events occurred in phase 1 (before the one-minute break) and the other half occurred in phase 3 (after the one-minute break). Participants in the correct context expectation condition were correctly informed that they should expect the prospective cues in one of either phase 1 or phase 3. In this condition prospective cues were presented in the phase in which participants were told they should expect them, either phase 1 or phase 3. Participants in the no context expectation condition did not receive any indication as to which of phase 1 or phase 3 that they should have expected the prospective cues to be presented. Participants in the incorrect expectation condition were incorrectly lead to believe that the prospective cues will occur in phase 1 or phase 3. In this condition prospective cues were presented in the opposite phase from which participants were told they should have expected them. If a participant was told to expect the prospective cues to be presented in phase 3, the prospective cues were actually presented in phase 1 and vice versa. This deception regarding in which phase to expect the PM targets was necessary to create an incorrect context expectation for participants in the incorrect context expectation conditions.

Following the PM instructions, participants were asked to complete the states task, the recognition task, and all three phases of the LDT with the embedded prospective memory task. The cancellation task, phase 2, was completed during a short break between the two LDT blocks, phase 1 and phase 3. Upon finishing phase 3, participants were immediately asked to recall the target response and the target event category (fruits). Then, the importance questionnaire was completed followed by the open-ended strategy question. Next, the vocabulary questionnaires and the working memory measures were completed. The experimental session concluded with a vision test followed by debriefing.

CHAPTER III

ANALYSES

All analyses involving factorial ANOVAs, one-way ANOVAs, or *t*-tests compared group means. When analyses compared more than two groups or conditions, post-hoc analyses were conducted to determine which conditions statistically differed, if differences occurred. Reported analyses have been organized as they apply to the specific aims of the current study. Unless otherwise noted, an alpha of .05 was used for determining statistical significance.

Aim One

PM performance. PM performance was scored as the proportion correct out of three possible opportunities. Thus, a participant could receive one of four possible scores, 0, .33, .67, or 1.00. PM responses were scored as correct if participants pressed the F6 key during the lexical decision trial in which the PM cue was presented or during the fixation point of the following trial (e.g., Marsh, Hicks, & Watson, 2002; Smith, Hunt, McVay, & McConnell, 2007).

Analyses. A 2 (age group: old, young) x 3 (context expectation: correct, none, incorrect) between-subjects factorial ANOVA was conducted on the PM proportion scores.[2] Six older adults and 15 younger adults were removed from all analyses. All removed participants were from the incorrect context expectation condition. These participants were removed because their responses to post-test questions indicated that they chose not to press F6 in response to the PM targets because the PM targets did not appear in the phase in which they were instructed to expect them.[3] Cell means can be found in Table 2.

For the analysis of PM performance the assumption of homogeneity of variance was violated, Levene's $F(5, 213) = 6.17$, $p < .000$. Instead of adopting a more stringent level of significance for the omnibus analysis, follow up significance tests using specific error terms were conducted. Significance was determined at $\alpha = .05/k$ where k was equal to the number of significance tests performed.

The first hypothesis was that a main effect of age group would be observed with younger adults performing better than older adults on the PM task. The analysis resulted in a failure to reject the null hypothesis, $F < 1$. There was no difference between older ($M = .36$, $SD = .44$) and younger ($M = .33$, $SD = .39$) adults' PM performance.

In the second hypothesis it was hypothesized that there would be significant differences in PM performance across the three context expectation conditions. A significant effect of context expectation was obtained, $F\ (2, 213) = 10.19$, $p < .001$, partial $\eta^2 = .09$ (see Figure 1). For the main effect of context expectation the homogeneity of variance assumption was not met, Levene's $F(2, 216) = 10.44$, $p < .001$, and independent t-tests were conducted at $\alpha = .05/k$ where $k = 2$ to examine differences between context expectation conditions. Participants with correct context expectations ($M = .49$, $SD = .43$) performed significantly better than participants with no context expectations ($M = .34$, $SD = .40$), $t(158) = 2.28$, $p = .024$, $\eta^2 = .03$. In addition, participants with no context expectations performed significantly better than participants with incorrect context expectations (M = .18, SD =.33), $t(135.13) = 2.62$, p = .010, η^2 = .05. This analysis illustrates the positive and negative effects of context expectation. That is, relative to no context expectation, performance was better when the PM targets were presented in the context in which participants had expected them to appear and PM performance was worse when the PM targets were presented in a context in which participants did not expect them to appear.

Finally, it was hypothesized that age would interact with context expectation. It was anticipated that a correct context expectation would benefit the PM performance of older adults more than it would benefit the PM performance of younger adults. In addition, an incorrect context expectation was expected to be less of a detriment to older adults' PM performance than to younger adults' PM performance. Support for this hypothesis was not obtained due to a failure to reject the null hypothesis, $F < 1$. Thus, context expectation did not differentially impact older and younger adults' PM performance. Relative to maintaining no context expectations, correct and incorrect context expectations had the same degree of positive and negative impact, respectively, on older and younger adults' PM performance.

In summary, there were no differences in PM performance between older and younger adults. Context expectation, however, did significantly impact PM performance. A medium to large effect was obtained for context expectation (partial η^2 = .09). Context expectation accounted for nine percent of the variance in PM performance differences. PM performance was highest when context expectations were correct and lowest when context expectations were incorrect.

Aim Two

Cost. Cost to the ongoing task was assessed by separately examining both speed (e.g., Cohen et al., 2008; Marsh et al., 2006) and accuracy (e.g., Loft, Humphreys, & Whitney, 2008; Loft, Kearney, & Remington, 2008; Meiser & Schult, 2008). Participants' reaction times to the trials of the lexical decision task were used to measure speed. The ability of participants to correctly discern words and non-words was used as the measure of accuracy. Accuracy was quantified by dividing correct responses by the total number of responses, which yielded a proportion score for each participant.

There is variation in the literature regarding the manner in which response latency data has been trimmed for analysis. Four different methods of data trimming were initially undertaken (Marsh et al., 2006; Smith & Bayen, 2004, 2006). All four methods resulted in the same pattern of significant effects. Ultimately, the data were trimmed in the same fashion as Marsh et al. (2006) because the current research was designed to replicate and extend their work. Prior to analysis, all response latencies derived from incorrect lexical decisions were removed and accounted for 5.6% of the data. Then, response latencies above or below 2.5 standard deviations from a participant's mean were removed and accounted for 2.8% of the remaining latencies.

Overall analyses. As with the PM analyses, aim two analyses were reduced by collapsing the target expectation and target occurrence variables into one context expectation variable. Thus, a 2 (age group: old, young) x 3 (context expectation: correct none, incorrect) x 3 (LDT block: baseline, no PM embedded, PM embedded) split-plot ANOVA was conducted to examine participants' response latencies. Cell means can be found in Table 3.

The assumption of homogeneity of variance was violated, Mauchly's $W = .82$, $\chi^2(2) = 42.18$, $p < .001$; thus, the multivariate approach toward analyzing the split-plot ANOVAs was adopted because of the sensitivity of pairwise comparisons to the sphericity assumption. Further, Levene's test of equal variances was also significant, smallest Levene's $F(5, 2213) = 3.88$, $p = .002$. Significance tests were again conducted with specific error terms. Significance was determined at $\alpha = .05/k$ where k was equal to the number of significance tests conducted. All latencies have been reported in milliseconds.

The first hypothesis predicted longer mean response latencies for older adults than mean response latencies of younger adults. A significant main effect of age group supported this hypothesis, $F(1, 213) = 129.74$, $p < .001$, partial $\eta^2 = .38$. Older adults (M = 902 ms, SD = 169 ms) on average took longer to respond to LDT trials than younger adults (M = 682 ms, SD = 109 ms).

The predicted context expectation by LDT block interaction was also obtained, Wilks' $\lambda = .94$, multivariate $F(4, 424) = 3.09$, $p = .016$, partial $\eta^2 = .03$. Follow-up analyses were conducted to determine if the pattern of means supported the hypothesis that cost to the ongoing would occur when participants were expecting PM targets to appear but not when participants were not expecting the PM targets to appear. Three 2 (context expectation) x 3 (LDT block) factorials were conducted to examine interaction components using $\alpha = .05/k$ where $k = 3$ to determine significance. Each interaction component examined the three levels of LDT block at two levels of context expectation. Only the interaction component examining LDT block at correct and incorrect context expectations was significant, multivariate $F(2, 136) = 5.44$, $p = .005$, partial $\eta^2 = .07$.

The interaction components comparing incorrect and correct context expectations conditions with no context expectation conditions were not significant, multivariate $F(2, 136) = 2.22$, $p = .112$, partial $\eta^2 = .03$, observed power = .45 and multivariate $F(2, 157) = 1.92$, $p = .150$, partial $\eta^2 = .02$, observed power = .39, respectively.

In further probing the significant interaction component it was determined that the observed pattern of means was mostly in accordance with what was hypothesized. Paired sampled *t*-tests were conducted to examine response latencies between levels of LDT block. Significance was determined at $\alpha = .017/k$ where $k = 6$. None of the three pairwise comparisons conducted on response latencies for participants in the correct context expectation conditions were significant at the adjusted level of significance. Two of the three pairwise comparisons were, however, conventionally significant and are subsequently discussed because they demonstrated a trend in the hypothesized direction. Participants in the correct context expectation conditions showed a trend of cost from the baseline block of LDT trials ($M = 773$ ms, $SD = 184$ ms) to the blocks of LDT trials in which PM targets were embedded ($M = 806$ ms, $SD = 184$ ms), $t(79) = -2.03$, $p = .045$, $\eta^2 = .05$. In addition, participants' response latencies in the PM target embedded LDT blocks were also longer than for LDT trials in which no PM targets were embedded ($M = 775$ ms, $SD = 167$ ms), $t(79) = 2.29$, $p = .025$, $\eta^2 = .06$. This shows a trend of cost in the hypothesized direction because participants' response latencies were longer in the blocks in which the PM targets were expected and were presented than their response latencies for both the baseline and no PM target blocks of LDT trials.

Baseline latencies ($M = 818$ ms, $SD = 185$ ms) for participants in the incorrect context expectation conditions were significantly longer than latencies for the blocks in which PM targets were presented, (M = 786 ms, SD = 151 ms), $t(58) = 3.49$, $p = .001$, $\eta^2 = .17$. In addition, response latencies for blocks in which PM targets appeared were significantly shorter than response latencies in which PM targets did not appear (M = 803 ms, SD = 158 ms), $t(58) = -3.13$, $p = .003$, $\eta^2 = .15$. Participants' latencies for the baseline trials were not different from the latencies for the blocks in which no PM targets were presented, $t(58) = 1.61$, $p = .112$, $\eta^2 = .04$. Even though cost to the ongoing task was not observed relative to the baseline latencies, the fact that response latencies were significantly longer in the non-PM presentation blocks relative to the PM presentation blocks supports the hypothesis: responses latencies were hypothesized to be shorter when PM targets were not expected. For participants in the incorrect context expectation conditions, the phases in which the PM targets were presented were the phases in which the PM targets were not expected to occur. Conversely, the phases in which the PM targets did not appear were the phases in which participants in the incorrect context expectation conditions expected the PM targets to appear. Thus, for participants in the incorrect context expectation conditions, the observed pattern of longer latencies in the phases in which the PM targets were not presented relative to the shorter latencies in the phases in which the PM targets were presented is in line with the hypothesized pattern of response latencies. However, while cost was observed in the expected context, it was not observed relative to the baseline trials as hypothesized (see Table 3).

The third hypothesis predicted an interaction that would show that compared to younger adults, older adults would show more cost to the ongoing task in the correct context expectation conditions. Further, the amount of cost to the ongoing task was not expected to differ between the age groups in the incorrect context expectation conditions. The data did not support this hypothesis, multivariate $F < 1$.

Proximal analyses. In light of recent research (Scullin, McDaniel, & Einstein, 2010), the response latency data have been analyzed in an alternative manner. The second approach to analyzing participants' response latencies is based on the premise that averaging across all LDT trials in a performance interval may dilute the estimate of cost to the ongoing task. That is, if response latencies from trials in which monitoring did not occur are averaged with latencies from trials in which monitoring did take place, the mean estimate of cost will be biased downward. Thus, such an analysis may not detect any effects involving cost to the ongoing task. From this, Scullin et al. (2010) found that when prompted to monitor for the PM targets, cost to the ongoing task was observed when averaging only the five LDT trials directly preceding the presentation of the PM targets. Scullin et al. referred to this as proximal analysis. Data from the current research were analyzed via proximal analysis to investigate effects of cost that the overall analysis may not have detected.

There were three differences in how the proximal analysis was conducted relative to the overall analyses. First, only response latencies preceding correct responses to the PM targets were included. According to PAM theory, monitoring is required throughout the performance interval to be able to respond to a PM cue. If a participant did not correctly respond to a PM cue, it is possible that monitoring was not taking place. Thus, only latencies preceding PM hits were analyzed. While every participant was afforded three PM opportunities, if a participant responded correctly to only one trial, only the five latencies preceding the PM 'hit' were averaged. Of the 225 participants, only 100 participants recorded a PM hit. If a latency within the five trials preceding a PM hit was missing because the participant did not respond, the proximal average was based on the number of non-missing latencies. Across 100 participants who recorded a PM hit, there were 228 total PM hits. For only 2 of the 228 PM hits were the number of latencies averaged across less than three. Second, it was of concern that trimming the data as did Marsh et al. (2006) may have removed some latencies proximal to the PM targets that may have been reflective of cost to the ongoing task. Therefore, the proximal analysis was applied to the untrimmed response latency data. Finally, Scullin et al. (2010) compared their proximal latency means to the corresponding set of LDT trial response latencies from the blocks of LDT trials with no embedded PM task. The current experiment was designed to estimate cost by comparing latencies in PM-embedded LDT blocks with latencies from the baseline blocks. The following proximal analysis includes mean latencies from all three blocks. However, only the last 15 latencies from the baseline block of LDT trials were averaged across to obtain each participant's baseline latency estimate. This sub-sample of baseline latencies was used because it represented the most stable pattern of response latencies within the baseline block of LDT trials for both age groups (see Figure 2).

A 2 (age group: old, young) x 3 (context expectation: correct, none, incorrect) x 3 (LDT block: baseline, no PM embedded, PM embedded) split-plot ANOVA was conducted to examine participants' proximal response latencies. The results showed that only the main effects of age and LDT block were significant, $F(1, 94) = 37.78$, $p < .001$, partial $\eta^2 = .26$ and multivariate $F(2, 93) = 3.16$, $p = .047$, partial $\eta^2 = .06$, respectively.

The main effect of age is due to longer mean response latencies by older adults (*M* = 891 ms, *SD* = 156 ms) compared to younger adults (*M* = 692 ms, *SD* = 96 ms).

The assumption of homogeneity of variance was violated, Mauchly's *W* = .88, $\chi^2(2) = 12.17$, *p* = .002, thus an alpha correction of $\alpha = .05/k$ where $k = 3$ was used for determining the significance of the pairwise comparisons that probed the main effect of block. The comparison between the baseline trials and the PM embedded trials yielded a significant difference in response latency, $t(99) = -2.94$, $p = .004$, $\eta^2 = .08$. Participants' reaction times were significantly longer for the trials in the PM block (*M* = 824 ms, *SD* = 198 ms) than were the response latencies for the baseline trials (*M* = 769 ms, *SD* = 182 ms). The mean latency for the no PM block was not significantly different than either the baseline or PM block latencies, $t(99) = -1.65$, $p = .102$, $\eta^2 = .03$ and $t(99) = -1.97$, $p = .052$, $\eta^2 = .04$, respectively. Thus, cost was observed in the PM blocks in comparison to the baseline latencies but not in comparison with the latencies in the non-PM block as found in Scullin et al. (2010). Cell means for the proximal analysis can be found in Table 4.

To summarize, older adults took significantly longer to respond to lexical decision stimuli than did younger adults. The obtained age-related difference in response latency produced a very large effect (partial $\eta^2 = .38$). Differences in age accounted for 38% of the variance in response latencies. In addition, for all participants response latencies were higher when the PM targets were expected to appear and lower when the PM targets were not expected to appear. The effect of context expectation on response latencies was small and only accounted for three percent of the variance in response latencies ($\eta^2 = .03$).

Accuracy. A participant's accuracy score was a proportion of the number of correct responses divided by total number of trials attempted. The accuracy data were also trimmed prior to analyses. Any trial that was yoked with a response latency that was above or below 2.5 standard deviations was removed. This process yielded the removal of 2.2% of the data. The data trimming procedure did not change the pattern of results relative to no data trimming. Nonetheless, analyses were conducted using the trimmed data.

Overall analyses. For the second part of aim two a 2 (age group: old, young) x 3 (context expectation: correct, none, incorrect) x 3 (accuracy block: baseline, no PM embedded, PM embedded) split-plot ANOVA was conducted to examine potential differences in cost to the accuracy of the ongoing task.

No hypotheses were formed regarding participants' accuracy because both age groups were expected to perform near ceiling (e.g., Allen et al., 1991; Balota & Ferraro, 1996) which would limit variability and, in turn, the detection of significant effects. Thus, significant findings are presented independent of hypotheses. The assumption of homogeneity of variance was violated, Mauchly's $W = .97$, $\chi^2(2) = 6.92$, $p = .031$; thus, the multivariate approach toward analyzing the split-plot ANOVAs was once again adopted.

The analysis yielded only two significant effects. First, the main effect of accuracy block showed that participant's accuracy for the lexical decision trials differed across the three blocks of lexical decision trials, baseline, no PM, and PM, multivariate $F(2, 212) = 34.60$, $p < .001$, partial $\eta^2 = .25$. Paired-samples *t*-tests were conducted with $\alpha = .05/k$ where $k = 3$ used to determine significance. Two of the three paired-samples *t*-

tests were observed to have been significant. Participants' baseline accuracy (*M* = .93, *SD* = .05) was significantly lower than participants' accuracy for both the no PM (*M* = .95, *SD* = .05) and PM blocks (*M* = .95, *SD* = .05), $t(218) = -6.62$, $p < .001$ $\eta^2 = .17$ and $t(218) = -8.65$, $p < .001$, $\eta^2 = .26$, respectively. Participants' accuracy performance did not significantly differ from the no PM to the PM blocks of trials, $t(218) = -1.34$, $p = .181$, $\eta^2 = .01$.

The second significant effect was a two-way interaction between age and LDT block, multivariate $F(2, 212) = 5.00$, $p = .008$, partial $\eta^2 = .05$. This interaction reflects that older and younger adults differed in how accurate their responses were across the three blocks of LDT trials. The interaction was probed by comparing older and younger adults' accuracy performance for each block of LDT trials. Independent *t*-tests were conducted with $\alpha = .05/k$ where $k = 3$ was used to determine significance. The interaction appears to have been due to a significant difference in accuracy performance between older (*M* = .95, *SD* = .04) and younger (*M* = .94, *SD* = .04) adults during the no PM block, $t(217) = 2.53$, $p = .012$, $\eta^2 = .03$. Significance values for the other two comparisons were *p*'s > .070. Means for can be found in Table 5.

Proximal analysis. A proximal analysis was also conducted to examine the cost of adding a PM task to performing the ongoing task accurately. A 2 (age group: old, young) x 3 (context expectation: correct, none, incorrect) x 3 (accuracy block: baseline, no PM embedded, PM embedded) split-plot ANOVA was conducted (see Table 6 for cell means). The only significant effect was a main effect of accuracy block, multivariate $F(2, 93) = 5.34$, $p = .006$, partial $\eta^2 = .10$.

Due to a violation of the homogeneity of variance assumption, Mauchley's W = .79, $\chi^2(2) = 22.23$, $p < .001$, pairwise comparisons were conducted at $\alpha = .05/k$ where k = 3 was used to determine significance. The main effect of accuracy block was due to a significant difference in accuracy between the baseline (M = .93, SD = .04) and PM blocks (M = .96, SD = .07) , t(99) -4.03, $p < .001$, $\eta^2 = .14$. Accuracy in the no PM block (M = .95, SD = .07) did not significantly differ from the baseline or PM blocks, t(99) -1.51, $p = .133$, $\eta^2 = .02$ and t(99) -1.33, $p = .188$, $\eta^2 = .02$, respectively.

In summary, participants responded more accurately to the LDT trials comprising the two phases of the ongoing task than they did for the baseline LDT trials During the block in which the PM targets did not appear (i.e., the No PM block) the lexical decisions of older adults were more accurate than those of younger adults.

CHAPTER IV

DISCUSSION

The primary goals of this experiment were to corroborate Cook et al. (2005) and Marsh et al. (2006) and extend their findings by establishing that context expectation would also benefit older adults' prospective memory performance. In turn, relative to younger adults, cost to the ongoing task was also anticipated to be higher for older adults when the PM targets were expected to appear. In general, empirical evidence was obtained that supported these goals. That is, relative to no context expectations, PM performance was significantly higher when context expectations were correct and PM performance was significantly lower when context expectations were incorrect and this was true for both older and younger adults. In conjunction with the PM results, the pattern of means for cost showed that response latencies were higher when PM targets were expected than when they were not expected for both age groups.

Aim One

Aim one centered on examining PM performance between age groups and across context expectations. The discussion has been organized as follows. First, three potential explanations are discussed as to why the hypothesized age-related differences in PM performance were not observed. The second part of the discussion for aim one is centered around how the observed impact of context expectation on older and younger adults may be applied to the PM performance paradox.

The data were expected to yield a main effect of age group. Younger adults were expected to perform significantly better on the PM task than their older adult counterparts. However, the results showed that there was no age-related difference in PM performance. Three potential explanations that may explain the lack of age-related differences in PM performance are subsequently discussed. These three explanations focused on perceived importance of the PM task, the degree of focality of the PM task, and exemplar typicality of the PM targets.

The first potential explanation for why older adults performed equivalently to younger adults may have been due to a difference in how important the PM task was to each age group. Research examining task importance has observed that higher importance has a positive impact on PM performance (Cigogna & Nigro, 1998; McDaniel & Einstein, 2000). Older (M = 6.27, SD = .99) and younger adults (M = 6.12, SD = 1.04) reported the ongoing task to be equally important, $t(217) = 1.08$, $p = .282$, $\eta^2 = .01$. Older adults (M = 4.96, SD = 2.23), however, reported the PM task as significantly more important than younger adults (M = 3.85, SD = 2.31), $t(217) = 3.59$, $p < .001$, $\eta^2 = .06$.

The PM data were re-analyzed with PM importance as a covariate. The results showed a marginally significant age-related difference in PM performance, $F(1, 212) = 3.60$, $p = .059$, partial $\eta^2 = .02$, observed power = .47. Once the variance from importance ratings was removed, younger adults performed significantly better than older adults on the PM task. Estimated marginal means for younger and older adults were M = .38, SE = .03 and M = .30, SE = .03, respectively. Thus, compared to younger adults, older adults perceived the PM task as being more important, and this difference in importance seems to at least partially explain why age-related differences in PM performance were not observed in this experiment.

A second potential explanation is that it has been shown that age-related differences in PM performance have been attenuated when focal PM tasks were used relative to when non-focal PM tasks were used (c.f., Kliegel, Jager, & Phillips, 2008, but see Einstein et al., 1995). Recently, focal and non-focal PM tasks have been equated to task appropriate processing (Marsh et al., 2006, but see McDaniel et al., 2008). In this view, focal PM tasks are tasks in which the processes necessary to complete the ongoing task are the same processes that are involved in processing the defining features of the PM cues. In contrast, non-focal PM tasks are tasks in which the processes necessary to complete the ongoing task are not the same processes involved in processing the defining features of the PM cues (Kliegel et al., 2008). The current research used categorical cues which should have placed more demand on self-initiated cueing (McDaniel et al., 2007). The use of categorical cues was expected to exacerbate age-related differences in PM performance because of older adults' reduced ability to self-cue (Craik, 1986). However, in the current study the processes involved in performing the LDT and PM tasks were the same. Therefore, even though the PM cues were categorical, the focality of the PM task may have been high and resulted in the lack of observed age-related differences in PM performance. High focality of the PM task potentially explains the equal PM performance between the two age groups.

The typicality of the exemplars from the taxonomic category of fruit may be yet another reason why age-related differences were not observed. An exemplar is a typical instance of a category (e.g, an emerald is an instance of a gemstone). Exemplars can range from high typicality (diamond) to low typicality (opal). The use of typical exemplars as PM cues has been shown to yield higher PM performance in both older (Cherry et al., 2001, Exp. 3; Mantyla, 1994) and younger adults (Nowinski & Dismukes, 2005; Penningroth, 2005) relative to the use of atypical exemplars. Mantyla (1994) obtained a statistically significant age by typicality interaction. Mantyla showed that older adults' PM performance benefited significantly more than younger adults' PM performance from the use of typical exemplars relative to atypical exemplars as PM targets.

The PM targets in the current study were fruit words chosen from Battig and Montague (1969). Apple, pear, and grape (1^{st}, 3^{rd}, & 6^{th} exemplars respectively) were chosen from the taxonomic category of fruit. Orange and peach (2^{nd} and 5^{th} exemplars, respectively) were omitted because in addition to fruits they are also colors. Banana (4^{th} exemplar) was also avoided because of repetition of letters. None of the other LDT stimuli contained structural characteristics similar to banana; thus, it was thought that banana would be of higher salience as a PM target relative to the other two targets.

In light of the results of Mantyla (1994), it could have been that the use of three of the most typical exemplars in the taxonomic category of fruit was of more benefit to older adults' PM performance than to younger adults' PM performance. This differential effect of the typicality of the PM targets may also help to explain the absence of age-related differences in the current research.

As hypothesized, the data also yielded a reliable effect of context expectation. Past research has shown the effects of context expectation on younger adults' PM performance (Cook et al., 2005; Nowinski & Dismukes, 2005), but the current study is the first to examine the impact of context expectation on older adults' PM performance. Even though there was not a significant interaction of age group and context expectation, the results of the current study are still informative and exciting.

The effect of context expectation shows that correct and incorrect context expectations similarly influence the PM performance of older and younger adults. That is, the PM performance of both older and younger adults was significantly higher when the PM targets appeared during the phase in which they were expected. When the PM targets appeared in a phase that differed from when participants were told they could expect them to appear, PM performance was significantly worse for both age groups.

It has been hypothesized that older adults are better at naturalistic PM tasks because they effectively use context both as a means to limit their reliance on self-initiated cuing and also to provide a salient cue to increase the likelihood of successfully completing future intentions (Henry et al., 2004). The current study, however, found that older and younger adults were able to use context to improve their PM performance equally well. If older and younger adults similarly benefit from context expectations, then the use of context as a memory aide alone is an insufficient explanation. Therefore, attenuated age-related differences in PM performance in naturalistic studies may partially be due to older adults understanding that context *can* be used as an effective memory aide. In other words, older adults may have had experiences that solidified context as an effective strategy for remembering to accomplish to-be-completed tasks. Alternatively, younger adults may not realize the utility of context as a viable PM strategy.

Aim two

When performance on a task suffers because a PM task is embedded in it, the change in performance without the PM task to the addition of the PM task is called cost to the ongoing task. Cost to an ongoing task has thus far been assessed by measuring two behaviors, speed and accuracy. Regardless of how cost is observed, longer response latencies or reduced accuracy, it is thought that cost to the ongoing task is the manifestation of participants strategically monitoring for PM cues. That is, participants are actively engaged in determining if they have encountered the point at which they are to perform the PM response. Thus, participants were using resources that would have been directed toward performing the ongoing task and applying those resources toward monitoring for the PM cue(s). The reduced pool of resources applied to performing the ongoing task resulted in lower performance or cost to the ongoing task.

Response latency: overall analysis. There were two primary findings for the response latency data. First, older adults took significantly longer on average to respond to the LDT trials than did younger adults. Given the age-related declines in cognitive resources for older adults (Craik & Byrd, 1982) this finding aligned perfectly with what was expected: younger adults were expected to respond significantly faster on average to LDT trials than older adults.

The second finding showed that longer response latencies were observed in phases when the PM targets were expected relative to the response latencies in phases in which PM targets were not expected. This second finding showed a trend that corroborated past research (Marsh et al., 200). Marsh et al. (2006) showed that relative to no expectations about the PM targets, cost to the ongoing task was higher when participants expected the PM targets to be presented. The current study was unable to observe cost to the ongoing task in the no context expectation conditions. However, response latencies for participants in the correct context expectation conditions showed a trend of being higher in the phases in which participants expected the PM targets to appear relative to the phases in which participants did not expect them to appear. In addition, participants in the incorrect context expectation conditions showed a significant increase in mean response latency from when the PM targets were not expected to when the PM targets were expected.

The current study was designed to compare response latencies from the PM and no PM blocks to the average latencies obtained for the baseline block of LDT trials. However, the mean latencies for the baseline trials were quite noisy. When the analysis was instead conducted as a 3 (context expectation: correct, none, incorrect) x 2 (LDT block: no PM embedded, PM embedded) a significant result was obtained for the LDT block by context expectation condition, $F(2, 216) = 5.51$, $p = .005$, partial $\eta^2 = .05$. The pattern of means for this interaction is exactly what was expected (see Table 7).

This finding dovetails nicely with the results from the PM analysis. The current study used non-focal PM cues to which successful PM responses should have resulted in cost to the ongoing task (e.g., McDaniel & Einstein, 2000, 2005; Marsh et al., 2002; Scullin et al., 2010; Scullin, McDaniel, Shelton, & Lee, in press; Smith & Bayen, 2004, 2005, 2006). If it is assumed that cost is due to monitoring and cost has been shown to increase in an expected context, then the latency data should correlate highly with the PM data. This is exactly what was observed. In other words, cost was observed in the pattern it should have been given the PM data. Longer response latencies and the highest PM performance were observed in the PM block of the correct context expectation conditions and shorter response latencies and the lowest PM performance were observed in the PM block of the incorrect context expectation conditions. Stated more directly, these results show that participants largely based their monitoring strategies on the expectation of when the PM targets were to appear.

Response latency: proximal analysis. Recent research has questioned the prevailing method of assessing cost to the ongoing task (Scullin et al. 2010). Marsh, Hicks, Cook, Hanson, and Pallos (2003) suggested that the use of categorical cues, as in the current study, likely requires participants to engage in cost producing monitoring strategies. Unlike Scullin et al. (2010), however, the participants in the current study were not cued to monitor at a specific point during the PM performance interval. Therefore, while the proximal analysis was conducted on the latency data, it was not expected to yield any results over and above the overall analysis. The results of the proximal analysis yielded an age main effect and a main effect of LDT block. The main effect of block was due to a significant cost to the ongoing task in the PM blocks relative to the baseline and no PM blocks. In conclusion, for the data of the current study the proximal analysis was no more informative than the overall analysis.

As previously discussed, there was quite a bit more variance in the latency data for older adults. For each age group, LDT trials were divided into blocks of ten and a mean score obtained (see Figure 2). A visual inspection of thes data revealed two stark differences between the latency data for the two age groups. First is the difference between older and younger adults in the pattern of latencies across the baseline trials. Younger adults' response latencies virtually leveled off after the first 20 trials whereas older adults continued to produce shorter and shorter latencies across all but the last 10 baseline trials.

The current methodology only allowed participants 10 practice trials before beginning the block of baseline trials. The number of practice trials in past research has ranged from 24 (Balota & Ferraro, 1996) to 900 (Ratcliff, Thapar, Gomez, & McKoon, 2004). Ten practice trials were chosen for three specific reasons: to keep the length of the experimental session reasonable, to keep participant disinterest in the LDT to a minimum, and to minimize fatigue. The experimental session took just over an hour and participants were required to perform the LDT for a total of 13 min. However, it is clear that the ten practice trials prior to beginning the baseline trials were insufficient for older adults. A caveat of the current study is that the unreliable baseline estimate for older adults may be a potential reason as to why the age by context expectation interaction for cost to the ongoing task was not observed as expected.

Accuracy. The accuracy data were not expected to yield any significant effects, but a significant interaction between accuracy and age was obtained. This interaction was due to older adults responding more accurately than younger adults to the LDT trials when no PM task was embedded. However, because the mean differences are quite small it is important to use caution when interpreting the significant effects involving accuracy. The mean differences were very small and were most likely significant because of the large number of participants. To that end, a discussion of these significant findings has been forgone.

Implications

Theoretical. The current research has shown that context expectation is another principle by which retrospective and prospective memory function similarly. Context was shown to benefit PM performance here as it has been shown to benefit RM performance (Gieselman & Glenny, 1977; Godden & Baddely, 1975). Thus, the effects of context expectation on PM performance supports the position of Crowder (1996) and Roediger (1996) that PM is just a type of episodic memory. To the contrary, although older adults always have problems with RM because of declines in cognitive resources (Craik & Byrd, 1982; Einstein & McDaniel, 1996), they performed equally as well as younger adults on the PM task across all context expectation conditions.

In terms of the response latency data, there are at least two potential implications for theory development. First, the arguments of Scullin et al. (2010) for using proximal analysis to measure cost are understood. However, such an analysis needs to be founded theoretically before being implemented in any research. Scullin et al. prompted their participants to monitor for the PM cue and then measured the cost elicited by the prompt. For their purposes, this analysis was beneficial. For research embedding non-focal PM cues in an ongoing task and does not prompt participants to monitor, proximal analyses did not provide any advantage over traditional cost analyses. In fact, proximal analysis may prevent such research from observing cost to the ongoing task. Marsh et al. (2003) suggested that spontaneous remembering will not be observed when the PM targets are categorical. In addition, Reese and Cherry (2002) found that participants, old and young, do not often think about the PM task during PM performance intervals. If thinking about the PM task is highly related to monitoring, cost is more than likely going to be observed when participants are monitoring for categorical cues, but it is difficult to tell when participants may monitor. Even if the central tenet of PAM theory, that successful PM performance requires attentional resources throughout the performance interval, is most appropriate, the amount of cost on any given ongoing trial may fluctuate. Therefore, limiting the search for cost to only a few trials directly preceding the PM target presentation would be ineffectual at providing an accurate estimate of cost.

Second, the unreliability of the older adult response latency data means that any interpretation of that data should be done so with extreme caution. It should be noted, however, that because the current work constitutes one of the first empirical PM studies to examine cost in an older adult sample, it is of pragmatic importance to future research as a potential foundation on which to develop new methods and refine current theories for this area of research. That is, research needs to be conducted to identify methods that are better suited for assessing cost to the ongoing task in older adult samples. Such methods need to establish high reliability while taking in to account the practical concerns that are associated with testing older adult participants.

Practical. A majority of prospective memory errors, such as social obligations, have few if any serious repercussions outside of personal embarrassment. However, a percentage of prospective memory failures do carry very serious consequences for both older and younger adults. Failing to remember to lock the doors at night, turn off appliances, and take medication are all examples of potentially detrimental PM failures. Any strategy that can be shown to effectively reduce the rate of such PM errors is of practical importance. The results of the current study provide just such a strategy with two comporting practical implications. This strategy is associating a future intention with an expected context.

Of primary interest is that the rate of successful PM completion was higher when PM cues were expected to occur in a certain context. This means that both older and younger adults may be able to successfully complete a higher number of future intentions each day if those intentions are associated with the context in which they are to be performed. A practical application would be educate older and younger adults on how often PM errors occur (Crovitz & Daniel, 1984) and explain how they can use context to reduce the numbers of PM errors. That is, it would be recommended to them to think about the context in which they expect the opportunity to fulfill the intention to occur. Mentally anchor the expected context with opportunity for completing the intention. Then, when the associated context is encountered, it should help to cue them to either begin monitoring for the opportunity to fulfill the intention or complete the intention outright. Therefore, associating an expected context with a future intention will help increase rates of PM success.

Not only is successful PM performance important but so is the cost imposed on ongoing tasks by the addition of PM tasks. Research has shown that dual-task performance is more difficult or costly for older adults than it is for younger adults (c.f., Riby, Perfect, & Stollery, 2004; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003). A practical concern for older adults is their ability to perform ongoing tasks at a high level while monitoring for when it is appropriate to fulfill a future intention (e.g., take medication or attend a grandchild's birthday party). Marsh et al. (2006) reported that younger adults showed cost to the ongoing task in the context in which the PM task was expected to occur, but did not show cost to the ongoing tasks outside of the expected context. The cost data obtained in the current study shows a similar trend. A PM strategy that decreases the amount of cost to ongoing tasks while maintaining a high level of PM success is enticing. Such value is easily observed when discussing meeting real world deadlines. For example, more attention can be devoted to writing a report if monitoring for a PM cue is only required in a specific context. The benefit of increased attention to the ongoing task is that the deadline is more likely to be met because the initial work will be of higher quality, and in turn, less time will be spent on revisions.

Limitations

There were two main limitations of the current study. The first limitation of the study has to do with how context expectations were instructionally manipulated. Participants were told to first press the response key whenever a PM target was presented on the screen. It was then explained to participants the phase in which they could expect the PM targets to appear. This approach to creating expectations was rather direct. It may have been more prudent to create context expectations in a more subtle manner. Although a less direct approach may have helped to avoid the removal of the participants from the incorrect context expectation condition, it may have also eliminated the observed effect of context expectation.

A second limitation of the current study was that older adults were not provided with sufficient practice for the LDT. Older adults showed large decreases in mean response latency across the block of baseline LDT trials. Further, decreases in mean response latencies were observed for the first 130 (of 200) trials of the ongoing task. Had older adults been provided with more practice trials prior to beginning the baseline LDT trials, their response latencies may have been more reliable and age-related differences in cost may have been observed. Increased reliability of older adults' response latencies may have also been able to inform the PM results.

Future directions

Although the current research has shown that context expectations affect older and younger adults similarly in the laboratory, future research needs to focus specifically on examining these same variables in naturalistic settings. That is, the extent of the impact that context expectation may have on PM performance in naturalistic settings cannot be determined without future research. Similar to the current study, research needs to be undertaken in which context expectation is manipulated in a naturalistic setting. At the very least participants' PM performance should be compared between correct context expectations and no context expectations. Such a line of research should help to better understand age related differences in the real world and ultimately help clarify the PM performance paradox.

While the lack of age-related differences in PM is exciting from a theoretical and cognitive aging perspective, explaining such findings is problematic given the current state of prospective memory research. Cognitive aging PM researchers have been and continue to be interested in the variables and interactions that result in age-related difference, or the lack thereof. However, it is difficult to extrapolate from and make inferences based on past research when there is very little consistency in the methods used to examine the variables of interest (e.g., PM performance and cost the ongoing task) among PM researchers. The scientific revolution that was prospective memory resulted in a massive research endeavor; however, now is the time to fill in the gaps and systematically identify the mechanisms and principles of PM. The difficulty in explaining the results of the current study makes salient the shortcomings of PM research to explain results that are atypical.

Finally, there is a general lack of consistency in the PM literature. PM tasks can vary in such ways as the type of PM cue, the type of PM task (event- or time-based), the number of PM target. However, the importance lies within the interaction of the PM task and the ongoing task. PM research would greatly benefit from comparing PM performance and cost across a number single-parameter changes in either the PM or ongoing task. An example relating to the current research is how the addition of a PM task impacts cost to the LDT task in the older adult population. A single parameter change may include but not be limited to, randomizing the length of time the focal point is presented, increasing the number of practice trials, and perhaps using different inter-trial intervals for older and younger adults. Such an undertaking would help to answer a number of questions that have gone unanswered in the current research. Questions such as was the pattern of latencies in the older adults sample due the LDT not being demanding enough. If the LDT was not demanding enough, was the pattern of latencies due to older adults adjusting their monitoring strategies as the performance interval progressed? Programs of research with these types of goals, while decidedly not sexy, could have a profound effect on current PM theories (Ellis & Freeman, 2007). It would help to determine the validity of age-related differences in cost under PAM theory and also benefit the mulitprocess framework by identifying more PM and ongoing task combinations that may allow participants to automatically process PM cues.

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FOOTNOTES

[1]Closed spaces refer to letters such as Ps, Qs, or O's etc… For example, the word 'people' has five enclosed spaces.

[2]Context expectation was initially observed via an interaction between the two variables of target expectation and target occurrence. Thus, the analysis was conducted as a 2 (age group: old, young) x 3 (target expectation: none, phase 1, phase 3) x 2 (target occurrence: phase 1, phase 3) between-subjects factorial ANOVA. This analysis was subsequently reduced by collapsing the target expectation and target occurrence variables into one context expectation variable. Such collapsing was performed because it is a more direct test of the hypothesis and it enhances ease of interpretation. The results of the original analysis have been included in Appendix A.

[3]Immediately following phase 3 participants answered questions about the PM task. One of these questions was, "Was there ever a time that you saw a fruit word but did not think that you were supposed to press F6?" If participants answered 'Yes' to this question, the experimenter followed up with, "Why didn't you think that you were supposed to press F6?" Participants who were removed from analysis answered this question with an answer similar to following participant's quote:

> Because you told me that the fruit words that I was supposed to press F6 to were going to be *after* the break and not before. So, I left the fruit words before the

break like pear and apple alone and just press yes when I saw them.

The inclusion of these participants in the analysis of PM performance did not change the pattern of significant effects.

[4] The results of statistical tests found significant but not related to the hypotheses of aim two have been presented in Appendix B.

TABLES

Table 1

Demographic and Health Information

	Context Expectation Condition					
	Correct		None		Incorrect	
	Old	Young	Old	Young	Old	Young
Age						
M	72.6	20.10	76.49	19.92	74.58	19.85
SD	7.49	1.53	8.67	1.25	8.17	1.70
Vocabulary						
M	17.90	12.80	18.78	12.58	16.45	11.73
SD	5.36	3.29	5.95	3.97	5.24	3.74
Health Q. 1[a]						
M	2.05	1.78	1.88	1.60	1.88	1.75
SD	.75	.53	.72	.67	.72	.81
Health Q. 2[b]						
M	2.03	1.23	1.78	1.33	1.68	1.38
SD	.70	.48	.73	.53	.66	.49
Health Q. 3[c]						
M	1.53	1.83	1.43	1.75	1.30	1.95
SD	.72	.50	.64	.59	.52	.64

Education[d]						
M	5.55	5.00	5.63	4.88	5.00	4.98
SD	1.04	.39	1.17	.56	1.04	.42
Backward Digit Span[e]						
M	4.18	4.80	4.40	4.85	4.29	4.51
SD	.94	1.32	.84	1.00	.91	.99
Size Judgment Span[f]						
M	3.90	4.78	4.10	4.35	3.89	4.41
SD	.68	.71	.65	.51	.70	.72
Prescription Meds						
M	6.03	.48	4.43	.35	3.78	.68
SD	4.29	.85	3.23	.58	3.51	1.27
Non-prescription Meds						
M	2.38	.38	3.55	.13	3.00	.28
SD	1.94	.77	4.27	.34	2.61	.64
Recognition[g]						
M	1.26	1.49	1.29	1.26	1.23	1.41
SD	.53	.72	.59	.38	.59	.61
Vision[h]						
M	13.35	12.28	16.93	13.08	15.80	11.62
SD	2.97	3.88	7.46	6.38	5.14	4.40

Note. n = 240, 40 per cell. [a]Health at the present time on a 4-point Likert Scale (1 = *excellent* to 4 = *poor*). [b]Health prevents activites (1 = *not at all* to 3 = *a great deal*). [c]Health compared to others (1 = *better* to 3 = *poorer*). [d]Years of education (1 = *less than 7th*, 2 = *7th to 9th grade*, 3 = *10th to 11th grade*, 4 = *high school degree*, 5 = *partial college or specialized training*, 6 = *college degree*, 7 = *graduate degree*). [e,f] Measures of working memory. Scores range from 2 to 8. [g]Recognition scores were calculated as d' ($Z_{\text{False alarms}} - Z_{\text{Hits}}$). [h]Vision estimates are presented in feet.

Table 2

Mean Prospective Memory Proportions: Age Group by Context Expectation.

	Older Adults	Younger Adults
Context Expectation		
Correct	.53 (.45)	.45 (.42)
None	.38 (.44)	.29 (.36)
Incorrect	.15 (.33)[a]	.21 (.33)[b]

Note. Standard deviations are shown in parentheses. [a] *n* = 34 and [b] *n* = 25 otherwise *n* = 40.

Table 3

Overall Analysis Mean Response Latencies (in milliseconds) for Age by Context Expectation by LDT Block

	Lexical Decision Task Block					
	Older Adults			Younger Adults		
	Baseline	No PM	PM	Baseline	No PM	PM
Context Expectation						
Correct						
M	884	869	898	662	681	713
SD	184	166	197	97	105	112
None						
M	970	939	945	643	672	667
SD	212	197	194	122	130	124

Incorrect						
M	904[a]	873[a]	860[a]	702[b]	709[b]	686[b]
SD	179	156	144	120	102	94

*Note: *n* = 40. [a] *n* = 34. [b] *n* = 25.

Table 4

Proximal Analysis Mean Response Latencies (in milliseconds) for Age by Context Expectation by LDT Block

	Lexical Decision Task Block					
	Older Adults			Younger Adults		
	Baseline[a]	No PM	PM	Baseline[a]	No PM	PM
Context Expectation						
Correct						
M	870[b]	912[b]	907[b]	677[b]	702[b]	762[b]
SD	171	208	239	87	146	151
None						
M	909[c]	903[c]	939[c]	629[c]	678[c]	698[c]
SD	231	161	207	93	95	121

Incorrect							
M	788[d]	779[d]	869[d]		718[e]	708[e]	747[e]
SD	131	141	129		103	84	98

*Note: [a] Included only the last 15 trials in the block. [b] $n = 25$. [c] $n = 18$. [d] $n = 6$. [e] $n = 8$.

Table 5

Overall Analysis Mean Accuracy Proportions for Age Group by Accuracy Block.

	Older Adults[a]	Younger Adults[b]
Baseline	.93 (.05)	.93 (.05)
No PM	.95 (.04)	.94 (.04)
PM	.96 (.04)	.94 (.05)

Note. Standard deviations are shown in parentheses. [a] n = 114. [b] n = 105.

Table 6

Proximal Analysis Mean Accuracy Proportions for Age by Context Expectation by Accuracy Block

	Accuracy Block					
	Older Adults			Younger Adults		
	Baseline	No PM	PM	Baseline	No PM	PM
Context Expectation						
Correct						
M	.93	.96	.96	.93	.93	.96
SD	.06	.05	.06	.04	.09	.07
None						
M	.93	.95	.95	.93	.94	.96
SD	.05	.06	.08	.06	.07	.06
Incorrect						

M	.93[a]	.96[a]	.97[a]		.93[b]	.92[b]	.93[b]
SD	.05	.06	.05		.04	.09	.09

*Note: n = 40. [a] n = 34. [b] n = 25.

Table 7

Mean Response Latencies for Context Expectation by Block (No PM vs. PM)

	No PM Block	PM Block
Context Expectation		
Correct[a]	775 (167)	806 (184)
None[a]	805 (214)	806 (214)
Incorrect[b]	803 (158)	786 (151)

*Note. Standard deviations are shown in parentheses. [a] n = 80. [b] n = 59.

FIGURES

Figure 1

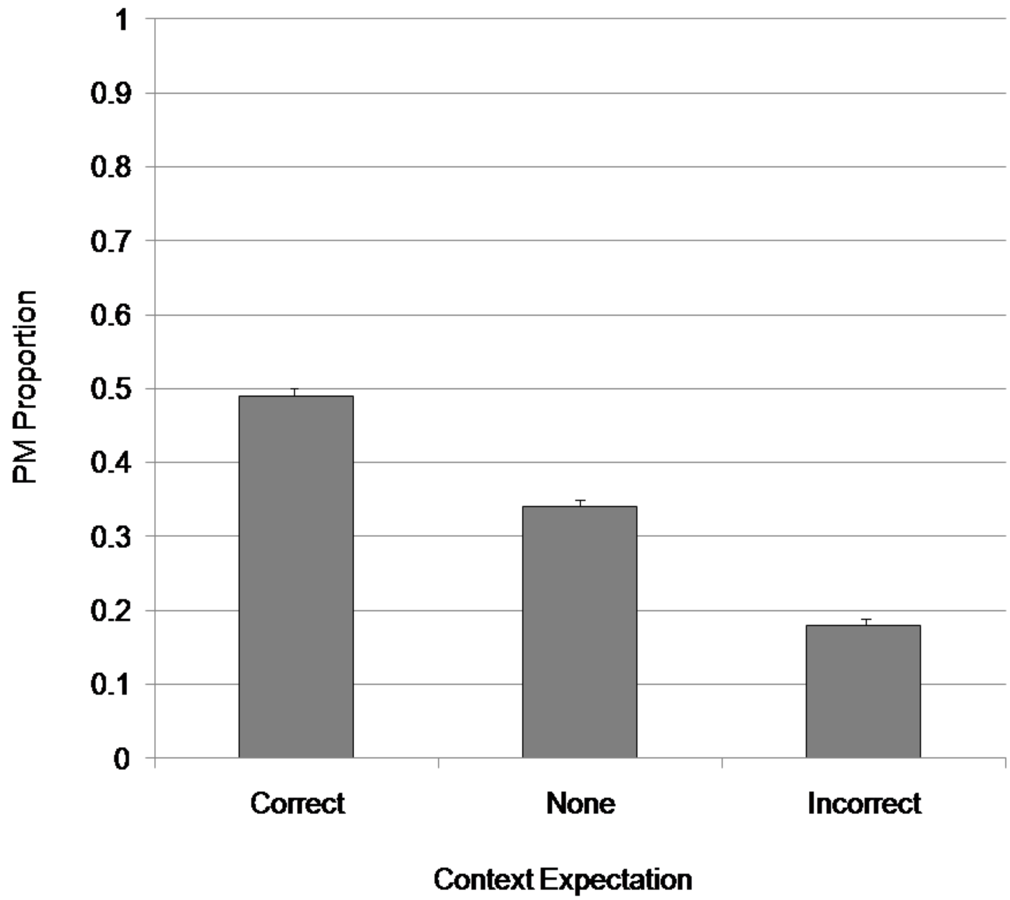
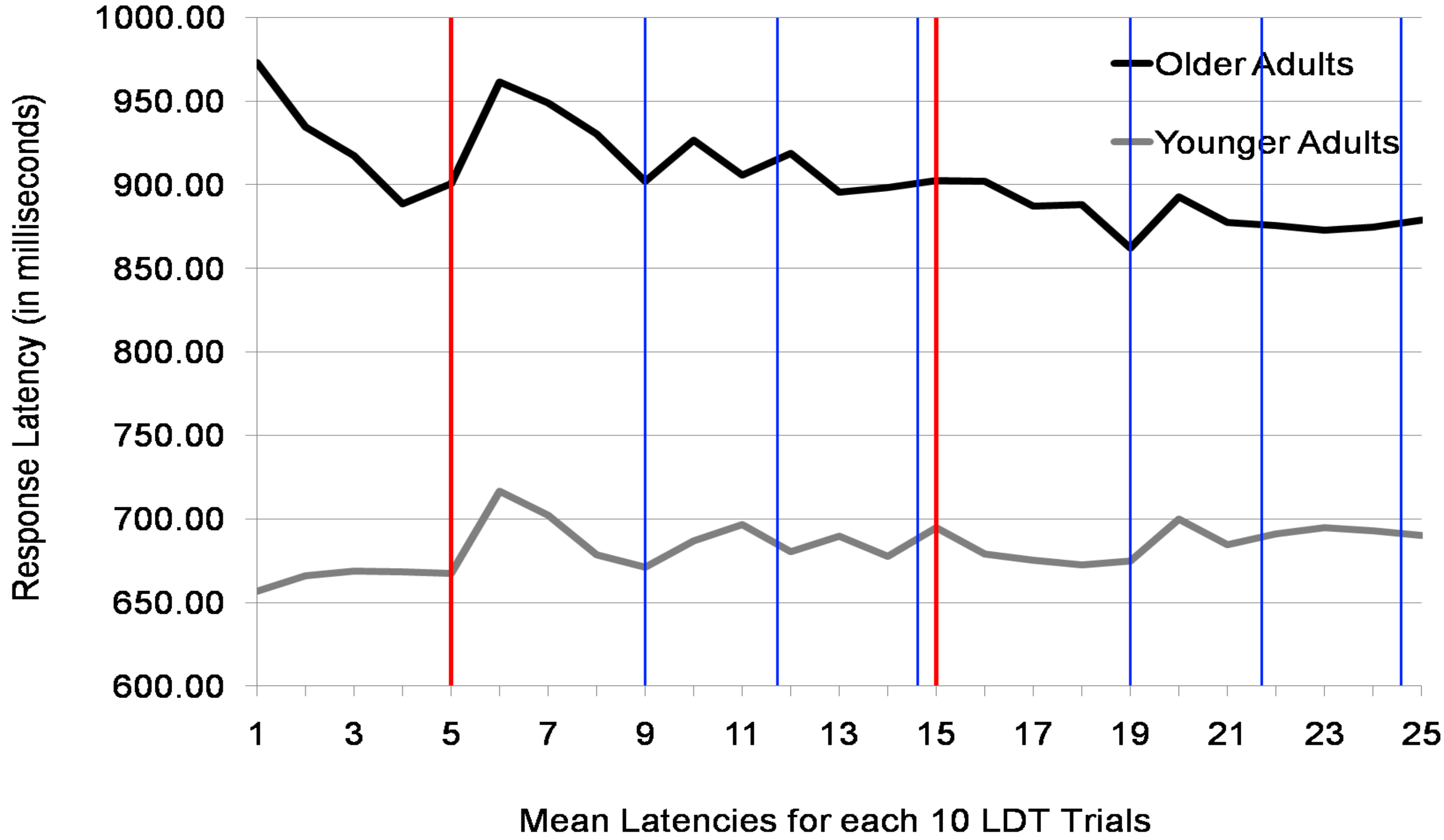

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PM Proportion
Correct
None
Incorrect
Context Expectation

Figure 2


Older Adults
Younger Adults
Response Latency (in milliseconds)
1000.00
950.00
900.00
850.00
800.00
750.00
700.00
650.00
600.00
1
3
5
7
9
11
13
15
17
19
21
23
25
Mean Latencies for each 10 LDT Trials

APPENDICES

APPENDIX A

EXPANDED AGE BY CONTEXT EXPECTATION ANALYSIS EXAMINING PROSPECTIVE MEMORY

A 2 (age group: old, young) x 3 (target expectation: none, phase 1, phase 3) x 2 (target occurrence: phase 1, phase 3) between-subjects factorial ANOVA was to be conducted on PM proportion data. Participants in the correct context expectation conditions were expected to perform better on the PM task than participants in the no context expectation conditions who would in turn perform better on the PM task than participants in the incorrect context expectation conditions. Group means can be found in Table A1.

The analysis yielded two significant two-way interactions. First, a significant interaction between target expectation and target occurrence supported the context expectation hypothesis, $F(2, 207) = 9.65$, $p < .001$ (Figure A1). This study was designed to demonstrate the effects of context expectation through this interaction. In probing the target expectation by target occurrence interaction the simple main effects of target expectation were conducted at each level of target occurrence using $\alpha = .05/k$ where $k = 2$ for determining significance. Both simple main effects of target expectation were significant, $F_{phase\ 1}\ (2, 110) = 4.92$, $p = .009$ and $F_{phase\ 3}\ (2, 103) = 5.71$, $p = .004$. Due to violations of the assumption of homogeneity of variance at both levels of target occurrence, pairwise comparisons were conducted with independent *t*-tests so that the standard error terms would be unique to the groups compared (Keppel & Wickens, 2004). In addition, an alpha correction of $\alpha = .025/k$ where $k = 2$ was used for determining significance. The adjusted degrees of freedom have been reported for all pairwise comparisons in which the assumption of equal variances was not met.

In the conditions in which the PM targets were presented in phase 1, there was no difference in the PM performance of participants expecting the PM targets in phase 1 (*M*

= .45, *SD* = .42) and the PM performance of participants with no context expectation (*M* = .34, *SD* = .40), *t*(78) = 1.17, *p* = .25. Further, PM performance of participants with no context expectations did not statistically differ from that of participants expecting the PM targets to appear in phase 3 (*M* = .16, *SD* = .34), *t*(70.99) = 2.09, *p* = .041. Thus, for participants who were presented with the PM targets in phase 1, a correct context expectation was not a significant advantage relative to not having a context expectation, nor was incorrect context expectation a significant detriment to PM performance relative no context expectation.

In the conditions in which the PM targets were presented in phase 3, there was no difference in the PM performance of participants expecting the PM targets in phase 1 (*M* = .19, *SD* = .33) and the PM performance of participants with no context expectation (*M* = .33, *SD* = .40), *t*(64) = -1.49, *p* = .141. In addition, the PM performance of participants with no context expectations was not statistically different from the PM performance of participants who expected the PM targets to be presented in phase 3 (*M* = .53, *SD* = .44), *t*(78) = -2.04, *p* = .045.

Thus, for participants who were presented with the PM targets in phase , an incorrect context expectation was not a significant detriment to performing the PM task relative to not having a context expectation, nor was a correct context expectation a significant advantage in successfully performing the PM task relative to not having a context expectation.

In order to better understand the target expectation by target occurrence interaction, PM performance was also compared between levels of target occurrence across levels of target expectation. Thus, an alpha of $\alpha = .05/k$ where $k = 3$ was used for determining significance. When the PM targets were expected to be presented in phase 1, participants performed significantly better when the PM targets were presented in phase 1 (M = .45, SD =.42) relative to when they were presented in phase 3 (M = .19, SD = .33), $t(61.83) = 2.76$, $p = .008$. Participants in the no context expectation conditions did not differ in PM performance when the PM targets were presented in phase 1 (M = .34, SD =.40) or phase 3 (M = .33, SD =.40), $t(78) < 1$. Finally, when the PM targets were expected to be presented in phase 3, participants performed better on the PM task when PM targets were presented in phase 3 (M = .53, SD =.44) relative to phase 1 (M = .16, SD =.34), $t(70.59) = -4.01$, $p < .001$. These simple main effects tests show that when an expectation about context in which the PM task will occur is formed, PM performance is much better when that expectation is met relative to when it is not met. However, if no expectation about context is formed, PM performance does not differ by presenting the PM targets in different contexts.

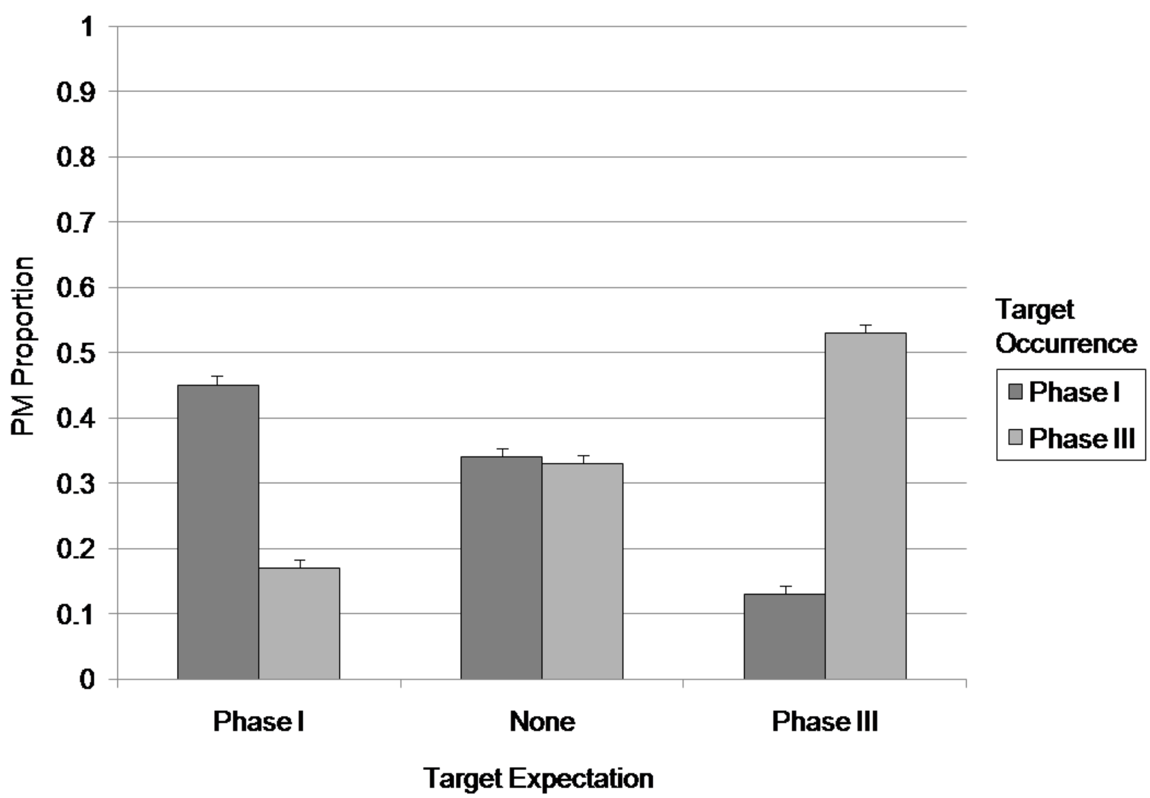
The age group by target occurrence interaction was also significant, $F(1, 207) = 3.91$, $p = .049$, partial $\eta^2 = .02$ (Figure A2). Because the homogeneity of variance assumption was violated, simple main effects were analyzed with unique error terms and with an alpha correction of .05/k. There were two simple main effects tests conducted, thus $k = 2$ which resulted in significance being evaluated at $\alpha = .025$. The PM performance of older adults who were presented with the PM targets in the phase 1 (M = .40, SD =.45) was not statistically different from the PM performance of older adults who were presented with the PM targets in phase 3 (M = .33, SD =.43), t <1. Further, the PM performance of younger adults who were presented with the PM target in phase 1 was not lower than the PM performance of younger adults presented with the PM targets in phase 1 (M = .42, SD =.41), $t(95.13) = -2.25$, p = .027.

Table A1

Mean PM Performance for Older and Younger Adults across Target Expectation and Target Occurrence Conditions

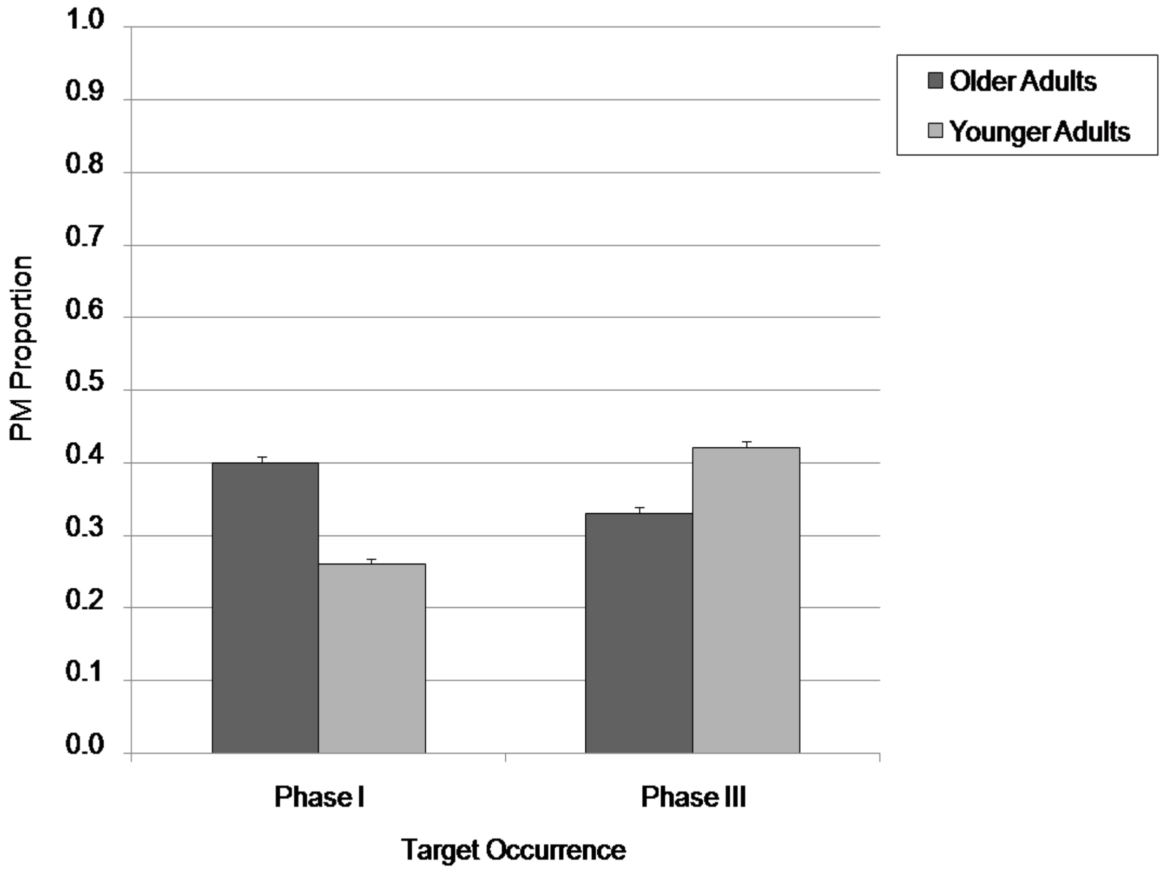
	Target Expectation					
	Old			Young		
	Phase I	None	Phase III	Phase I	None	Phase III
Target Occurrence						
Phase I						
M	.55	.45	.13	.35	.23	.13
SD	.45	.45	.33	.38	.33	.30
Phase III						
M	.12	.32	.50	.22	.35	.55
SD	.29	.38	.45	.31	.38	.44

Figure A1.



1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PM Proportion
Phase I
None
Phase III
Target Expectation
Target Occurrence
Phase I
Phase III

Figure A2.


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PM Proportion
Older Adults
Younger Adults
Phase I
Phase III
Target Occurrence

APPENDIX B

SIGNIFICANT EFFECTS THAT DID NOT SPECIFICALLY TEST THE HYPOTHESES OF AIM TWO

The omnibus 2 (age group: old, young) x 3 (target expectation: none, phase 1, phase 3) x 2 (target occurrence: phase 1, phase 3) x 3 (response latency: baseline, phase 1, phase 3) split-plot ANOVA yielded two significant interactions that were not related to the hypotheses presented in the specific aims section. See Table B1 for a list of all the effects.

The first significant effect was a two-way interaction between age group and target expectation, $F(2, 207) = 3.53$, $p = .031$, partial $\eta^2 = .03$. Response latencies across target expectation conditions differed for older and younger adults. Neither of the simple main effects of target expectation was significant, largest $F(2, 111) = 2.49$, $p = .088$, partial $\eta^2 = .04$. In light of the non-significant simple main effects, interaction contrasts were turned to for identifying the source of the interaction. Based on the table of means (see Table B2) it was determined that two interaction contrast analyses were to have been conducted. Due to the assumption of homogeneity of variance having been violated for the omnibus analysis [Mauchly's $W = .85$, $\chi^2(2) = 25.28$, $p < .001$ and smallest Levene's $F(11, 207) = 2.08$, $p = .023$], interaction contrasts were conducted with $\alpha = .05/k$ where $k = 2$ for determining significance. The first interaction contrast examined older and younger adults who either did not have a specific phase expectation of when the PM target or who expected the PM targets to appear in phase 1. The interaction contrast was not significant, $F(1,142) = 3.34$, $p = .07$, partial $\eta^2 = .02$, observed power = .44. The second interaction contrast examined older and younger adults who either did not have a specific phase expectation of when the PM target or who expected the PM targets to appear in phase 3. The interaction contrast analysis proved have been significant, $F(1,149) = 5.24$, $p = .024$, partial $\eta^2 = .03$. Thus, the age-group by target expectation interaction was due to a change in the magnitude of mean response latencies between older and younger adults with not specific phase expectations for when the PM targets would be presented and who expected the PM targets to be presented in phase 3.

The second significant interaction unrelated to the aim two hypotheses was between the variables of latency and target expectation, Wilks' $\lambda(4,412) = 4.40$, $p = .002$, partial $\eta^2 = .04$. Initially, the 3 x 3 interaction was decomposed into interaction components that were conducted with $\alpha = .05/k$ where $k = 3$ used to determine significance. Conducting pariwise comparisons of target expectation at every level of latency made the most sense for the purposes of the current experiment. That is, it of interest to see how the latencies of participants in the different target expectation conditions fluctuated across the blocks of LDT trials. First, the interaction of participants in the none and phase 1 target expectation conditions across latency did not yield a significant interaction, Mauchly's $W = .86$, $\chi^2(2) = 19.16$, $p < .001$, multivariate $F < 1$. Next, were the participants in the none and phase 3 target expectation were examined. The interaction term was statistically significant, Mauchly's $W = .65$, $\chi^2(2) = 65.58$, $p < .001$, multivariate $F(2,150) = 8.28$, $p < .001$, partial $\eta^2 = .10$. The final interaction component examined compared the participants in the phase 1 and phase 3 target expectation conditions and was significant, Mauchly's $W = .88$, $\chi^2(2) = 16.85$, $p < .001$, multivariate $F(2,136) = 8.27$, $p < .001$, partial $\eta^2 = .11$. Participants in the phase 3 target expectation condition significantly differed from the other two target expectation conditions and those two conditions themselves did not statistically differ. Given the results, the phase1 and none target expectation conditions were collapsed prior to conducting interaction contrasts.

The interaction contrasts were conducted using $\alpha = (.05/k)/k$ where $k = 3$ for determining significance. The first interaction contrast compared the participants in the two target expectation conditions across latencies for the baseline and phase 1 LDT trials and was not significant, $F < 1$. Nor was the interaction significant when comparing across latencies for the baseline and phase 3 LDT trials, $F(1,217) = 6.55$, $p = .011$, partial $\eta^2 = .03$, observed power = .72. The final interaction contrast comparing the two target expectation conditions across phase 1 and phase 3 latencies was significant, $F(1,217) = 14.21$, $p < .001$, partial $\eta^2 = .06$. Follow-up pairwise comparisons were conducted to identify the source of the latency by target expectation interaction. It was shown that the interaction was due to the a significant decrease in latencies for participants in the phase 1 and none target expectation conditions from phase 1 ($M = 826$, $SD = 214$) to phase 3 ($M = 789$, $SD = 185$) whereas participants in the phase 3 target expectation condition show no change in latency from phase 1 ($M = 772$, $SD = 158$) to phase 3 ($M = 780$, $SD = 140$), $t(145) = 4.80$, $p < .001$ and $t(72) = - 1.16$, $p = .248$, respectively. Latency means can be found in Table B3.

Table B1

Analysis of Variance Results for Response Latency

Source	*df*	*F*	*p*	partial η^2	1-β
Age Group[a]	1, 207	126.23	< .001	.38	-
Target Expectation	2, 207	1.59	.210	.15	.33
Target Occurrence[a]	1, 207	6.74	.010	.03	-
Latency[a]	2, 206	7.64	.001	.07	-
Latency x Age Group[a]	2, 206	9.70	< .001	.09	-
Latency x Target Expectation[b]	4, 412	4.40[c]	.002	.04	-
Latency x Target Occurrence	2, 206	< 1	-	-	-
Age Group x Target Expectation[b]	2, 207	3.53	.031	.03	.65
Age Group x Target Occurrence	1, 207	< 1	-	-	-
Target Occurrence x Target Expectation	2, 207	<1	-	-	-
Age Group x Target Expectation x Target Occurrence	2, 207	< 1	-	-	-
Latency x Age Group x Target Expectation	4, 412	< 1[c]	-	-	-
Latency x Age Group x Target Occurrence	2, 206	< 1	-	-	-
Latency x Target Expectation x Target Occurrence[a]	4, 412	1.53[c]	.192	.02	.47
Age Group x Target Expectation x Target Occurrence x Latency	4, 412	1.24[c]	.292	.01	.39

*Note: [a] Effects that test the specific hypotheses of aim two. [b] Results have been presented in Appendix B. [c] Wilks λ is reported instead of multivariate F.

Table B2.

Mean Reaction Times (in Milliseconds): Age Group by Target Expectation.

	Target Expectation		
Age Group	Phase I	None	Phase III
Older Adults			
M	894	947	863
SD	174	187	134
Younger Adults			
M	706	664	683
SD	109	121	91

Table B3.

Mean Reaction Times (in Milliseconds): Latency by Target Expectation.

	Target Expectation		
Response Latency	Phase I	None	Phase III
Baseline			
M	821	807	767
SD	210	238	157
Phase I			
M	832	821	772
SD	201	225	158
Phase III			
M	788	790	780
SD	164	201	140

APPENDIX C

IRB

Oklahoma State University Institutional Review Board

Date:	Thursday, January 22, 2009
IRB Application No	AS0892
Proposal Title:	Word Judgments and Memory
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 1/21/2010

Principal Investigator(s):

Terrence Kominsky
116 N. Murray
Stillwater, OK 74078

Celinda Reese-Melancon
116 N. Murray
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

VITA

Terrence K. Kominsky

Candidate for the Degree of

Doctor of Philosophy

Dissertation: THE EFFECTS OF CONTEXT EXPECTATION ON OLDER AND YOUNGER ADULTS' PROSPECTIVE

Major Field: Lifespan Developmental Psychology

Biographical:

Personal Data:

Born in Salt Lake City, Utah, on November 9, 1980, the son of Larry and RaeAnn Kominsky.

Education:

Completed the requirements for the Doctor of Philosophy in Lifespan Developmental Psychology at Oklahoma State University, Stillwater, Oklahoma in May, 2010.

Completed the requirements for the Master of Science in Experimental Psychology at Oklahoma State University, Stillwater, Oklahoma in 2005.

Completed the requirements for the Bachelor of Arts in Psychology at the University of Sioux Falls, Sioux Falls, South Dakota in 2003.

Professional Memberships:

Association for Psychological Science
APSSC RiSE-UP Member (Aging)

American Psychological Association
APA Division 5 – Evaluation, Measurement, Statistics
APA Division 20 – Adult Development and Aging

Name: Terrence K. Kominsky Date of Degree: May, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: THE EFFECTS OF CONTEXT EXPECTATION ON OLDER AND YOUNGER ADULTS' PROSPECTIVE MEMORY PERFORMANCE

Pages in Study: 122 Candidate for the Degree of Doctor of Philosophy

Major Field: Lifespan Developmental Psychology

Scope and Method of Study:

The purpose of this study was to examine the impact of context expectation on cost to the ongoing task and the prospective memory (PM) performance of older and younger adults. Participants were randomly assigned to one of the following context expectation conditions: correct, incorrect, and none. Participants performed a lexical decision task (LDT) that was divided in two blocks of 100 trails. The PM task was embedded in the LDT task. Participants in the correct context expectation condition were presented with the PM targets in the LDT block they were told they could expect them. Participants in the incorrect context expectation condition were presented with the PM targets in the opposite LDT block they were told they could expect them. Participants in the no context expectation conditions were presented with the PM targets in one of the LDT blocks but were not explicitly told in which block they could expect them. Participants response latencies for the LDT trials were used to assess the cost of embedding a PM task in the ongoing LDT task. The amount of cost was determined by comparing participants' performance on the LDT with and without the embedded PM task.

Findings and Conclusions:

PM performance was significantly higher for participants who correctly expected a PM cue to appear in a specific context relative to the PM performance of participants who did not have a context expectation. Further, compared to no context expectation, PM performance was significantly lower when participants context expectations were incorrect. No age-related differences in PM were observed.

Due to the instability in the response latency data for older adults, the pattern of means for cost trended in the hypothesized direction. For both age groups in the correct context expectation condition, latencies were higher in the PM embedded block relative to the baseline LDT block but not the no PM block. In the incorrect context expectation condition, both age groups showed significant cost to the ongoing task in the PM embedded block relative to the no PM embedded block but not the baseline LDT block.

ADVISER'S APPROVAL: Celinda Reese-Melancon, Ph.D.