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The relationship between visual attention and prospective memory

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THE RELATIONSHIP BETWEEN VISUAL ATTENTION AND PROSPECTIVE MEMORY

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ABSTRACT

The current study examined the role of attention in prospective memory. Prospective memory refers to the ability to form an intention to do something in the future, such as email a colleague, and additionally remembering to do so at the appropriate moment. Theories of prospective memory retrieval suggest that attention is required to complete an intention. However, the exact role of attention and whether it is *always* required remains unclear. One challenge in examining the allocation of attentional resources in prospective memory is that a direct measure of these resources does not exist. The current study attempted to address this issue by introducing methods applied in the area of visual attention (i.e., eye tracking). The results of the current study suggest that attentional resources beyond those required for the ongoing task were not necessary to complete the intention. In addition, the methods employed shed new light on the relationship between visual attention and the cognitive resources deployed in a prospective memory task.

Chapter 1 Introduction

Prospective memory (PM) refers to our ability to form an intention to do something in the future, such as pick up laundry from the dry cleaners, and additionally remember to do so at the appropriate moment, for example on the way home from work. The importance of PM is evident in our ability to remember to take medications, to deliver a message to a friend, or to remember to drop off your child at daycare. The consequences of forgetting to carry out an intention can range from being a nuisance in your day to something more severe such as death. In 2003, a UC Irvine professor forgot to drop his son off at daycare and instead went to work and mistakenly left his son in the back seat of the car. His son later died due to heat exhaustion (Carey, 2003; Cowan, 2005). This unfortunate case is an example of how dire the consequences of forgetting to carry out an intention can be. How is it that we can forget such an important task just as easily as we can forget a trivial task? What is it that allows us to remember, at the appropriate moment, that we need to fulfill an intention? What is it that prompts us to recall an intention once that moment has passed? Researchers that study PM are concerned with these issues and the cognitive processes that underlie them.

To better understand the issues surrounding PM, researchers conduct experiments in both natural settings and laboratory settings. Through research three types of PM intentions have been identified, time-based, activity-based, and event-based intentions (e.g., Kvavilashvili & Ellis, 1996; McDaniel & Einstein, 2007). In time-based tasks individuals are required to carry out the intention at a specific time, such as in three minutes or today at 6:00 pm. Activity-based intentions are to be completed following another task. The third and most widely studied type of intention requires one to complete the intention when an external cue is presented, from here forward called the PM cue. For example, it may be the case that you need to deliver a message to a friend and decide that the appropriate time to do so will be when you see him at a dinner party tonight. Seeing your friend (PM cue) in the appropriate setting (dinner party) signals you to tell him the message. In laboratory versions of PM tasks participants are usually occupied by an ongoing task after they receive the PM intention. This is done to simulate the task demands of everyday life, such as engaging in a conversation with others at the dinner party. The current study focuses on laboratory event-based PM tasks and the role of attention in these tasks.

The role of attention in event-based PM tasks is of major debate among theorists. One view suggests that success in event-based PM tasks requires the allocation of attentional resources to monitor the environment for the PM cue and subsequently retrieve the intention from memory. If these resources are not employed, the cue will be missed and the intention will not be carried out at the appropriate moment (e.g., Guynn, 2003; Smith, 2003). In contrast, others suggest that the conditions of the task set determine whether these resources are required to fulfill the intention. For example, the characteristics of the PM task, the characteristics of the ongoing task in which the PM task is embedded and individual differences can all affect whether cognitively demanding attentional resources or more automatic processes can be used to fulfill the intention (McDaniel & Einstein, 2000). Researchers have found contradicting results regarding the use of these resources under almost identical experimental conditions. Therefore, these theories and the potential issues surrounding them warrant further discussion.

Chapter 2 Theories of Prospective Memory

2.1 Monitoring in Prospective Memory

2.1.1 Preparatory Attentional and Memory Theory

Smith and colleagues have argued that attentional resources are always used in PM tasks to monitor for the PM cue (Smith, 2003; Smith & Bayen, 2004; Smith, Hunt, McVay & McConnell, 2007). These attentional resources have been labeled preparatory processes, in the Preparatory Attentional and Memory Processes Theory (Smith 2003; Smith & Bayen, 2004). This label is intended to reflect the fact that these processes are thought to prepare the individual to complete an intention. In addition to preparatory processes, automatic processes that aid in the detection of the PM cue and completion of the intention may also occur. However, complete reliance on automatic processes will not result in successful completion of an intention. In laboratory PM tasks, the participant's performance in an ongoing task provides a measure of preparatory processes. For example, Smith (2003) found that participants who had to complete a PM task in addition to making lexical decisions (determining if presented letter strings formed valid English words or nonwords) were significantly slower at making these decisions than participants who only completed the lexical decision task (LDT). Critically, response latencies on non-PM cue trials in the LDT were longer for participants with a PM intention. It is important to note that PM trials were excluded because participants are expected to slow down when the PM cue is presented. Presentation of the cue is likely to initiate retrieval of information related to the cue in addition to any thoughts related to the ongoing task, thus slowing the participants' responses on these trials (e.g., Marsh, Hicks, Cook, Hansen, & Pallos, 2003).

The results also showed a relationship between PM performance and response latencies in the LDT: PM participants who were faster in the LDT showed poorer PM performance. The results suggested that when participants did not take the time to properly engage preparatory processes to monitor the environment for the PM cue, they were more likely forget to perform the PM action upon presentation of the cue. In addition, participants who showed the most accurate PM performance also scored higher on a counting span task, a measure of working memory capacity (Case, Kurland & Goldberg, 1982). These results suggested the PM task required attentional resources that were more readily available for participants with high working memory capacities. Together they suggest that preparatory monitoring processes are required to successfully fulfill an intention and that these processes are drawn from a pool of limited attentional resources.

Smith et al. (2007) meticulously investigated numerous conditions, recognized by others (e.g., Einstein, McDaniel, Thomas, Mayfield, Shank, Morrisette & Breneiser, 2005), as suitable for evoking spontaneous detection of the cue and retrieval of the intention. They examined conditions where preparatory processes are not theoretically required to complete an intention. In these experiments participants completed two blocks of the ongoing task and were either assigned to a control group or PM group. Participants in the control group were never given an intention. In contrast, those assigned to the PM group received an intention after completion of the first block. They were told they would have to complete the intention during the second block of the ongoing task. A depiction of the experimental design can be found in Table 1.

Smith et al. (2007) consistently found a cost of having to complete an intention. Specifically, control participants improved from Block 1 to Block 2 in the ongoing task by reducing their response latencies. In contrast, participants in the PM groups did not show these practice effects, instead their reaction time performance remained the same across the blocks. The authors argued that participants in the PM groups were using limited resources to monitor for the cue which prevented them from improving in the ongoing task. However, it is noteworthy to mention that the cost of maintaining an intention systematically decreased when an increasing number of conditions thought to evoke automatic processing of the cue were met. Nonetheless, Smith and colleagues have taken painstaking effort to create conditions to eliminate preparatory attention, but have failed to do so, leading them to conclude that preparatory attentional resources are necessary to successfully complete intentions in event-based PM tasks.

Table 1
Experimental Design (Smith et al., 2007).

	Group Assignment	
	Control	*Prospective*
Block		
1	Lexical Decision Task	Lexical Decision Task
2	Lexical Decision Task	Lexical Decision Task And Prospective Task

2.1.2 Two-Process View

Similar to Smith (2003), Guynn (2003) suggested that attentional resources may be required to complete an intention, but that monitoring may occur in two forms, maintaining a retrieval mode and checking for the cue. Tulving (1983; 1998) coined the term “retrieval mode” to explain cognitive and neurocognitive functions that occur to treat stimuli as information to be retrieved. According to this view, a retrieval mode is a prerequisite for the actual retrieval process: retrieval of information cannot occur unless stimuli are demarcated as information to be retrieved and the individual is prepared to treat them as such. Guynn (2003) paralleled a prospective retrieval mode to Tulving’s (1983; 1998) retrieval mode, in that a prospective retrieval mode may serve as a prerequisite to identify stimuli as PM cues to prompt retrieval of the intention. Guynn (2003) refers to this as strategic monitoring which may involve maintaining an activated state of awareness to respond to PM cues *and* actively checking the environment for the cue (i.e., preparatory processes) where the former process may occur by itself or in combination with checking. The combination of the two processes is thought to occupy more attentional resources than simply maintaining a retrieval mode and thus will impose greater costs to the ongoing tasks.

Guynn (2003) created a novel design to explore whether monitoring exists in two forms. The ongoing task was a short-term memory task where participants were shown five words in a row for 5 sec and were given 4.5 sec to recall the words in the order they were presented (from left to right). In addition, participants performed a serial reaction time task where they pressed a key that corresponded to the on screen location of an asterisk. When the correct key was pressed the asterisk moved to one of three other locations on the computer screen. Participants were told to perform the asterisk task as quickly and accurately as possible while studying the words for the memory task. According to the authors, the serial reaction time task required attentional processes that are also engaged in strategic monitoring during PM tasks. Thus, performance on this task should be impaired when participants are given an intention. To assess strategic monitoring under these conditions, participants were instructed to press the *Enter* key if they saw a word that was a fruit during the memory task. Trials composed of the two ongoing tasks served as control trials and trials where a PM cue may appear constituted experimental trials. The number 2 was displayed at the top of the screen on control trials, indicating that only the two ongoing tasks were to be performed. The number 3 was displayed at the top of the computer screen on experimental trials, indicating that a PM cue may appear. The PM cue appeared on one sixth of the experimental trials. Participants then completed separate blocks of control only trials, experimental only trials and mixed trials.

According to Gyunn's predictions, if strategic monitoring involves two processes, checking for the cue should *only* occur when the cue is expected to appear, i.e., on experimental trials. In contrast, evidence of maintaining a retrieval mode should occur any time an intention is given. Thus performance in the serial reaction time task should be affected on control and experimental trials in the mixed block and all trials in the experimental only block. Accuracy and reaction time in the serial reaction time task were best in the control only block, intermediate in the mixed block and worst in the experimental only block. Because performance was significantly worse on all experimental trials, the results established that participants only check for the cue (perform a search for a fruit word) when they are in a context where they expect the cue to appear. In contrast, participants seemingly maintained a retrieval mode for the duration of the experiment anytime they were given an intention, regardless of context and expectation as shown by the intermediate performance in control trials of the mixed block.

Guynn's results suggest that monitoring is not one-dimensional, and that task demands will affect the extent to which different monitoring processes are engaged. Importantly, Guynn did not investigate whether automatic processes can also be used to complete an intention. Furthermore, evidence for the mental processes that compose strategic monitoring are inferred and not directly measured. In summary, the results do suggest that monitoring is a two process function, but they leave unclear the role of automatic processes in event-based PM tasks and the precise roles of the checking and maintenance functions.

2.2 The Multiprocess View

In contrast to Smith's (2003) theory, McDaniel and Einstein (2000) identified several conditions that are likely to reduce or eliminate the use of attentional monitoring processes in event-based PM tasks. The qualities of the PM task, the qualities of the ongoing task in which the PM task is imbedded, the amount of planning involved, and individual differences can all affect the extent to which monitoring or automatic processes will be used to complete the PM task. For example, monitoring should be reduced when there is less importance on the PM task compared to when the PM task is very important. In comparison, when the ongoing task is very difficult or engaging, there are likely to be fewer resources available to monitor the environment. Thus, the degree to which participants are occupied by the ongoing task will also affect the amount of monitoring found in the experiment. To reflect their belief that some conditions require the use of attentional resources and that others do not, they refer to their framework as the multiprocess view.

Although the multiprocess view generally describes conditions that theoretically should reduce or eliminate the need for attentional monitoring, it does not identify exact conditions that will lead to automatic processing or spontaneous retrieval of the cue versus those that always require attentional resources. Einstein et al. (2005) attempted to disentangle these conditions. Specifically, they investigated the effects of 1) cognitive load by presenting either one or six cues, 2) importance by placing moderate or high importance on the prospective task, and 3) focal versus nonfocal processing. Focal processing occurs when the ongoing and PM tasks require similar cognitive processes. For example, focal processing is expected to occur when detection of the cue is semantic and the ongoing task also requires semantic processing. In contrast, nonfocal processing would occur if detection of the PM cue requires processing the physical characteristics of the stimuli and the ongoing task requires semantic processing (e.g., Marsh, Hicks, & Hancock, 2000). Focal processing is predicted to eliminate the need for attentional resources because detection of the PM cue should not require attentional resources beyond those needed to complete the ongoing task. Consistent with their predictions, Einstein et al. (2005)

found that focal processing, moderate emphasis on the PM task, and decreasing the cognitive load associated with the PM task (i.e., making the task easier) all reduced or eliminated the cost associated with having an intention, as measured by response latencies in the ongoing task and prospective performance. Participants in these conditions were not significantly slower in the ongoing task compared to when there was no intention. In addition, prospective performance was equivalent across the conditions. For example, performance in the moderate and high emphasis conditions corresponded with each other. The authors suggested that the pattern of results showed that participants were not monitoring for the cue and were able to automatically and spontaneously retrieve the intention. However, monitoring and automatic processing was inferred from the reaction time data and prospective performance.

To directly test for spontaneous retrieval, the authors compared processing of the PM cues when the intention to respond to them was suspended, to a condition where participants were never given an intention to respond to the cues. The rationale was that spontaneous retrieval should occur even when the ongoing task conditions do not meet the criteria to carry out the intention. Participants in this experiment completed two blocks of trials. In a control block they were given a target word and told to remember it for a later memory test. In a separate PM block, they were also given a target word, but told that they should press a button (Q) on the keyboard if they encounter it during an imagery rating task. In the PM block participants completed an LDT and were told to ignore all other task demands and to respond as quickly as possible during the LDT. Importantly, the PM target unexpectedly appeared during the LDT instead of during the expected imagery rating task. Participants were significantly slower to respond on these surprise trials when they were given an intention to respond to the target even though they were instructed to ignore the PM task until the imagery rating task. Einstein et al.

(2005) proposed that the slowing experienced on the surprise trials in the LDT were due to participants spontaneously retrieving the intention when the PM cue was encountered. This spontaneous retrieval interfered with ongoing performance on that trial. Notably, latencies on nontarget trials in the LDT were not statistically longer in the PM block than in the control block, suggesting that having an intention did not result in the engagement of monitoring processes throughout the task as would be predicted by preparatory attention theory.

The results from this study demonstrated that PM retrieval can occur even when an intention is not an active part of the task and therefore when monitoring is neither necessary nor engaged. These results are in direct contrast to those obtained by Smith and colleagues (2003; Smith & Bayen, 2004; Smith et al., 2007). Considering the results surrounding monitoring in event-based PM tasks, the question remains as to why some find evidence of it and others do not.

2.3 The Issue of Discrepant Findings

It is clear that preparatory attention theory and the multiprocess view make different predictions regarding the importance of attentional resources in event-based PM tasks; however, the discrepant findings surrounding the actual use of these resources is a major issue for PM researchers. Smith and colleagues have consistently found evidence of monitoring when participants were given an intention to do something in the future (2003; Smith & Bayen, 2004; Smith et al., 2007). Monitoring, measured indirectly as a cost to the ongoing task in which the PM task was embedded, was observed even when precaution was taken to ensure the “best” chances of evoking spontaneous processing of the cue (Smith et al., 2007). Conversely, others have shown that the amount of monitoring devoted to complete an intention can be reduced or even eliminated (Einstein et al., 2005).

Therefore, the first goal of the current proposal is to further specify conditions under which monitoring versus spontaneous processes occur in PM tasks. The major difference between the two prominent views of event-based PM surrounds the attentional resources allocated to monitoring. For this reason alone, determining the conditions that will reliably support spontaneous processes will help to advance theories of event-based PM. One issue surrounding the discrepant finding is the complexity of PM tasks. A second issue that is not always considered in PM tasks is the participant's perceptions of the PM task and ongoing task and a third issue may be the use of a noisy dependent measure of monitoring . I will discuss each of these issues in more detail in the following sections.

2.3.1 The Complex PM Task

According to Ellis (1996), there are several stages involved in fulfilling a PM intention. The first stage is the creation of an intention or task to complete in the future such as picking up laundry from the cleaners. An intention may be self-initiated or it may be created by someone else for you to complete. The second stage is the retention interval. Using the dry cleaning example, this could be the period between when you wake up and form the intention, and when you leave work. The third stage is the performance interval. This refers to the context or point in time when the intended action should be carried out, after work in the example. Once the performance interval is identified, the fourth stage requires steps to start and execute the intention. In the example, this would involve taking the route to the cleaners (initiation of the intention) instead of the normal route home. On the way to the cleaners you must then remember to stop and pick up the clothes (execution of the intended action) rather than continuing on the route. The fifth stage involves evaluating the outcome to prevent repeating completed intentions or to ensure that postponed or uncompleted intentions will be fulfilled in the future or cancelled.

As is clear from Ellis' description of the different stages involved in PM tasks, successfully completing an intention is complex. This complexity also makes it difficult to measure the many cognitive processes that may be involved. Although Smith and colleagues and McDaniel and Einstein and colleagues have attempted to replicate each other, slight differences in the experimental design may have artificially contributed to some of the discrepant results. For these reasons it is essential to design experiments that can tease apart the processes involved in the different stages of a PM task.

2.3.2 Attention Allocation Policy

A second potential issue that is not typically addressed in the literature is that of the participant's perception of the task set. Marsh et al. (2005) attempted to clarify how this may also affect monitoring. Upon receiving the instructions for the experiment, it is likely that participants estimate the difficulty of having to detect the PM cues(s) while additionally performing the ongoing task. Based on this initial assessment of the task set, participants decide how much attention should be directed toward the ongoing task. The authors refer to this assessment as "attention allocation policy". They further suggest it is likely that participants may adjust their attention policies throughout the course of the experiment as they gain familiarity with the task. Importantly, any costs associated with maintaining an intention are thought to be influenced by the participant's perception of the task set.

It may be the case that previous studies did not take into account participants' expectations of the task set, which have contributed to the contrasting findings in the literature. One possibility is that evidence of automatic processing was found in conditions where participants allocated the majority of their resources to the ongoing task because they expected that they could automatically detect the PM cue or that the PM task was less important (as in the moderate emphasis condition of Einstein et al., 2005). In contrast, it is possible that participants were reluctant to allocate their attention to the ongoing task even when the multiprocess view predicts automatic processing of the PM cue, because the task set was not viewed as suitable for relying on automatic processes. It need not be the case that people always explicitly evaluate the difficulty of the task set to determine how to allocate their attention. In some circumstances, people may have a *feeling* regarding how to approach the task, or as they gain experience in the task, they may naturally alter how they allocate attention within the task set (Hicks, Marsh, & Cook, 2005; Marsh et al. 2005). Marsh et al. (2005) suggested that even when retrieval conditions are theoretically appropriate to initiate automatic processes, some people may choose to allocate more attention to the PM task than is actually needed. In some cases, the use of average response latencies as an estimate of monitoring may reflect individual differences in attention allocation policies. In fact, Einstein et al. (2005) created a single PM condition and divided participants in this condition into subsets of those whose responding in the ongoing task slowed when they were given an intention and those whose responding sped up compared to when there was no intention. They found that PM performance was equivalent for the groups and that performance in the ongoing task was not sacrificed for those who were faster in the ongoing task. These results suggested that there are some individual differences that may reflect differences in participant strategies or ability that may not be accounted for in most studies of prospective memory.

One way to mitigate differences in allocation policies is to tell participants where their attention should be focused. This may not eliminate the effects of allocation policies but it is likely to attenuate these differences.

2.3.3 A Noisy Dependent Measure

Conservatively speaking, monitoring processes devoted to intentions are believed tap a pool of shared resources which reduces available resources for other tasks (e.g., McDaniel & Einstein, 2000; Smith, 2003). However, it is unlikely that the involvement of these attentional resources will always be under the participant's awareness (Smith, 2003; Smith et al., 2007). Because monitoring processes are often, if not always, unaware to the participant when they are employed, it is necessary to use a sensitive measure of monitoring. A measure that is commonly used to estimate monitoring is the average response latency in an ongoing task. This measure is thought to reflect the contribution of monitoring processes without relying on explicit measures such as prospective performance and ongoing task accuracy (Smith, 2003; Smith et al., 2007). However, it can be argued that response latencies do not directly measure the cognitive processes carried out in PM tasks. Marsh, Hicks, and Cook (2005) note that response latencies are sensitive enough to detect monitoring, but they may also tap attentional factors that are not directly related to the processes used to complete the intention or the ongoing task. For example, momentary lapses of intention (e.g., West & Craik, 1999) where attention is not directed at any part of the task set and stimulus-independent thoughts (Teasdale, 1989; Teasdale, Dritschel, Taylor, Proctor, Lloyd, Nimmo-Smith, & Baddeley, 1995) where unrelated thoughts come to mind may confound response latency data. Furthermore, Smith (2003) has argued that when monitoring is not found, either the dependent measure was not appropriate, or there was not sufficient power for detecting these processes (Smith et al., 2007).

Eye movement data may be able to detect off-task behaviors that would normally influence the response latency results in the form of noise. For example, off-task behaviors can be inferred from response latencies as longer reaction times for some trials, but because eye movement data is so rich (one can obtain speed of eye movements, number of fixations on and off the stimulus of interest, the duration of the fixations, ect.) they may provide a more accurate measure of these differences than response latencies. Because PM tasks are so complex and performance may be influenced by a number of variables, it can be difficult to differentiate monitoring processes from other cognitive processes. The second goal of the current study is to create a more direct measure of monitoring through the use of eye movement data. Research in the area of visual attention has shown that eye movements and visual attention are tightly linked (e.g., Hoffman, 1998; Irwin, 2004). If the attentional resources that are used in monitoring processes are similar to those used in visual attention, eye movements may provide a more accurate measure of attention than response latencies in an ongoing task by accounting for the influence of variables that typically contribute noise to the results.

Chapter 3 Visual Attention and Prospective Memory

3.1 Eye Movements as a Measure of Attention

Because the reported discrepancies regarding the use of monitoring processes occur under similar experimental conditions, a better way to account for and prevent them may be to create a more direct way to measure monitoring. Results from visual attention studies present a strong case for using eye movements as an estimate of attention. Irwin (2004) provides a summary of results supporting this notion. Basic support for this view comes from evidence showing that people tend to look at, or fixate, a stimulus in order to obtain information from it. One reason for this is that the human visual field is limited by physical properties of the eye as well as by cognitive capacity limits. Irwin (2004) notes that these limitations force us to direct visual our gaze and attention to specific stimuli or specific areas within the visual field.

A review of the literature by Corbetta (1998) revealed extensive evidence from psychological, functional anatomical, and cellular studies suggesting that the neural networks for directing attention and moving the eyes heavily overlap. The review included evidence that ruled out the possibility that visual attention and eye movements are completely independent functions; however, there was not enough evidence to conclude whether the two systems either partially overlap or are operated by the same mechanism. The findings from this review support the idea that eye movements and visual attention are related. Thus, if monitoring in prospective memory is considered to be an attention demanding function, measuring eye movements in a visually based PM task may provide a more direct measure of monitoring processes.

3.1.1 Covert vs. Overt Attention

One caveat to using eye movements as an estimate of attention is that attention can be focused in two ways: first, by overtly orienting attention (i.e., looking at the stimulus) or by covertly directing attention, meaning that attention is directed or guided without eye movements (e.g., Henderson, 2006; Hoffman, 1998; Irwin, 2004). Another way of stating this is that overt orienting occurs any time the head or eyes move to improve perception whereas covert orienting refers to changes or shifts in attention that are not a result of overt orienting. Both orienting mechanisms can occur reflexively, in response to stimulus presentation, or through a slower, more controlled response. Reflexive orienting typically occurs in response to stimuli presented in the periphery and automatically draws attention. In contrast, cues that evoke slower controlled responses are typically presented in the center of the screen and have some type of response goal associated with them. These cues are thought to be processed within conscious awareness and responding is voluntary (Johnson & Proctor, 2004). Both overt and covert orienting can occur in similar ways, but measuring each mechanism is slightly different.

Because overt attention necessarily requires one to move the eyes and in some cases the head, eye movements and fixations are justified measures of overt orientation. There are also data which suggested that covert visual attention can be measured through eye movement data. Covert attention is thought to affect the output of the visual system by directing attention to specific locations or items (Johnson & Proctor, 2004). For example, the benefit of covert attention can be seen in faster response latencies to locations where visual attention has been cued (cf., Johnson & Proctor, 2004, for a review) as well as in faster saccadic reaction times (cf., Hoffman, 1998, for a review). Saccades are brief eye movements that naturally occur about three to four times per second, and can be influenced by information in the periphery. For example, when reading it is common for saccades to be made to words that are about to be read. When such saccades occur, it allows readers to skip over high frequency short words (such as *if, the, or,* etc.), and allows the reader to recognize the next word faster than when saccades are suppressed by presenting one item or word at a time. This reduction in processing time for next-in-line items is thought to be a result of covert attention (Hoffman, 1998). Similar results have been obtained with other paradigms. In a cuing paradigm, validly cuing the location of a target led to shorter saccadic reaction times (saccades to the cued location are faster) to the target than when the cues were invalid (e.g., Belopolsky & Theeuwes, 2009; Posner, 1980). Thus, there is evidence that both overt and covert attention can be assessed through eye movements, overt through direct measures and covert through the influence of cues on processing speed.

Monitoring in prospective memory is thought to be an attention demanding strategy that, similar to visual attention, can be consciously employed at times and other times may occur through unconscious processing (Smith, 2003; Smith et al., 2007). Therefore, it is plausible that monitoring in a visual event-based PM task will be reflected by overt and/or covert shifts in visual attention that can be measured through eye movements. According to the Multiprocess View, salient PM cues such as those that seem to appear abruptly, should reduce or eliminate monitoring processes because they are noticed automatically and evoke spontaneous retrieval of the intention. Some support for this notion can be found in the literature on visual attention.

Early research seemed to suggest that the sudden appearance of a target (an onset) immediately captured attention (e.g., Jonides & Yantis, 1988; Yantis & Jonides, 1984). The results from these studies suggested that subjects were able to immediately recognize onset items, but needed to perform a serial self-terminating search for targets that did not have a sudden onset. Thus, it appeared that abrupt visual onsets were rapidly detected and likely automatically recruited visual attention. In aforementioned research, Yantis and Jonides required participants to make a saccade to detect the targets. The results further suggested that abrupt onsets captured attention which led to faster detection of cues by guiding eye movements to onset locations. In other words, when attention is captured, the oculomotor system and overt attention are likely to reflexively follow.

Yantis and Jonides (1990) set out to further test the role of stimulus onset in attentional capture by creating two necessary criteria for automatic capture: First, attention should be captured regardless of the difficulty of the task (load-insensitivity criterion), and second, attention should be captured regardless of whether the individual's goals coincide with the onset (intentionality criterion). The authors cite support for the load-insensitivity criterion, but neither prior research nor the results from their study supported the intentionality criterion. Abrupt onsets automatically captured attention regardless of the difficulty of the task, but when attention in their study was highly focused, the effect of onset was attenuated. These results suggested that when covert attention is focused elsewhere, overt attention may not be automatically captured by onsets. This finding is relevant to the current study because it suggests that a PM cue that abruptly appears may not reflexively capture attention as proposed by the multiprocess view. If this is the case, such a cue would not be sufficient to evoke spontaneous processing and thus, may not be a fair test of whether an intention can be completed without attentional resources.

However, research suggests that this may not present an issue for the current study. First, some research indicates that covert attention is responsible for the preparation but not execution of eye movements. This is referred to as premotor theory (Rizzolatti, Riggio, Dascola, & Umiltà, 1987; Rizzolatti, Riggio, & Sheliga, 1994). Second, Wu and Remington (2003) found that the effect of stimulus properties on both covert and overt attentional capture were not purely stimulus driven mechanisms, were sometimes differentially affected by stimuli, and can be modulated by top-down processes. However, stimuli with transient properties such as onsets did have similar effects on covert and overt attentional capture. This suggests that when there is a goal to attend to a transient stimulus property such as onset or a change in color, top-down processes encourage detection of the change and the onset will ensure that both attentional systems are captured similarly.

In summary, visual attention can be oriented in two ways, overtly and covertly. Although covert and overt attention may operate somewhat independently of each other, both can be assessed through eye movement data. Because monitoring is considered to be an attention demanding process, it is likely that monitoring in a visual PM task can be measured through overt and covert shifts in attention. Therefore, it is expected that eye movement data will provide a more accurate estimate of monitoring in a visual event-based PM task than current measures alone.

3.2 Eye Movements as the New Measure of Monitoring

West, Carlson and Cohen (2007) applied logic from the visual attention literature to determine whether prospective performance was affected by a rich visual environment. Specifically, the authors examined the number of fixations to objects associated with a goal to respond, i.e., those with intentions (to determine how often objects were fixated), the duration of the first fixation (to determine the amount of initial processing on an item), and total fixation duration (to determine the full amount of processing given to displays with and without targets). Participants performed a visual search task where they were required to search for letters presented within a horizontal string of six letters. Participants determined whether the display contained a PM cue (M or D), a regular target (one of the remaining 18 consonants) or neither. PM cues were identified at the beginning of the experiment. Targets were identified at the beginning of each trial. There were 3 blocks of 76 trials. Each block consisted of 30 target-only trials, 30 distractor only trials, 8 prospective-only trials, and 8 target-plus-prospective trials. On target only and prospective only trials, a single target *or* PM cue was embedded among five distractors. On, target-plus-prospective trials, a single target *and* one PM cue appeared. On target-plus-prospective trials, participants were told to respond to the PM cue and *not* the target.

The results indicated that participants looked at PM cues the longest, distractors the shortest, and regular target looking times fell in between on all trial types (i.e., target only, prospective only, target-plus-prospective and distractor only). The authors suggest these looking times indicate the amount of online processing for each stimulus type. The authors were particularly interested in the total duration of fixations on PM cues and targets on target-plus-prospective trials. The results of this comparison showed that fixation durations were longest for the stimulus that participants responded to. In other words, when participants made a PM response they looked at the PM cue for a significantly longer duration than the target. In comparison, participants' fixation durations were significantly longer for targets when they incorrectly responded to the target over the PM cue. West et al. (2007) inferred that the retrieval of response information resulted in longer fixation durations for the stimulus type that was responded to, PM target or regular target.

One particular interest of this study was to determine to what extent a failure to fixate the PM target results in a failure to carry out the PM intention. The results showed that PM miss trials were not solely the result of not fixating the target. On prospective only and target-plus-prospective trials, the probability of fixating missed PM cues was greater than zero, suggesting that failing to complete an intention was caused by a failure to engage in strategic monitoring processes as well as failing to orient overt attention toward, i.e., look at, the PM cue. In other words, failing to complete the intention was not solely the result of not seeing the PM cue. Total fixation durations were also longer for PM hits than PM misses, bolstering the notion that monitoring processes were not engaged when the PM cue was missed even on trials where the cue was fixated. These results suggested that prospective performance in this paradigm not only relied on overt attention (fixating the cue) but also on attentional processes that bring the intention to mind when the PM cue is encountered. There is clearly a host of rich data to be obtained from eye movements to estimate the cognitive processes associated with prospective remembering. Importantly, these data show the value of implementing new techniques to measure the cognitive processes involved PM tasks.

However, the West et al. (2007) results do not provide insight into the effects of having an intention on the ongoing task before the PM cue has been encountered. There were several drawbacks to their design. First, there was no control comparison group. Smith (2003) argued that contrasting an intention group to a no-intention control is the comparison of interest when investigating the use of preparatory attention in a PM task. More specifically, the intention group may be slower, or in this case, likely show a different pattern of eye movements compared to the control group if monitoring resources are used. Second, the design encouraged monitoring because participants were required to search for two types of stimuli, regular targets and PM cues, on every trial. However, it is worth noting that West et al. (2007) were concerned with the extent to which a rich visual environment would affect prospective performance, not comparing the cognitive resources needed to complete an intention versus when no intention is given.

The work of West et al. (2007) clearly indicate that eye movement data accurately assess the cognitive processes employed in PM tasks and provide a more detailed account of these processes over conventional response latency measures. Specifically, eye movement data may allow a distinction to be made between different monitoring processes because eye movements are more directly related to monitoring for a visual cue than response latencies. As Guynn (2003) proposed, it is possible that monitoring involves both checking for the cue and maintaining a PM retrieval mode. For example, if response latencies in the ongoing task are longer for the PM group compared to a control group with no intention, but there are no differences in the number of times the groups look to the location where the PM cue is expected to appear, the results would bolster the notion that monitoring involves two processes. Specifically, this outcome would suggest that under the conditions of the experiment participants maintain a retrieval mode, but do not overtly check for the cue. Consequently, it is crucial to create a PM cue that appears in a separate location than the ongoing task in order to dissociate the costs associated with checking for the cue and maintenance of a retrieval mode.

Chapter 4 Overview of the Current Study

In the previous sections of this document, the argument was made that monitoring in a visually based prospective memory task may be observed through shifts in visual attention. To make this point even more obvious, consider a time-based prospective memory task where one is required to carry out the intention at a specific time (noon) or within a specific time interval (the next ten minutes). In this situation, a direct measure of strategic monitoring, and overt orienting, is to evaluate how often an individual checks the clock to see whether they need to carry out the intention. Conversely, there may be times when an individual thinks about the intention and/or what time it may be without checking the clock. Results indicate that better prospective performance in this scenario is associated with an increase in clock checking, i.e., monitoring, in the time period before the intention should be executed (e.g., Ceci & Bronfenbrenner, 1985; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). The inclusion of eye movement data was expected to indicate whether monitoring in a visual event-based PM task operates in a similar fashion as it does in time-based PM tasks, where prospective performance inherently relies on monitoring. Importantly, the PM cue and the ongoing task in the current study appeared in different screen locations which allowed the cognitive processes related to the ongoing task to be separated from those related to the PM task.

4.1 Overview of the Ongoing Task

In the current study participants engaged in a lexical decision ongoing task (LDT) where they were asked to decide as quickly as possible without sacrificing accuracy whether presented letter strings form valid English words or nonwords. The LDT was centered horizontally either at the top or bottom of the computer screen which was divided into a three by three grid. The LDT was used as the ongoing task because it has been used in other PM studies and has been reported to be sensitive enough to detect monitoring. Participants engaged in two blocks of the LDT: A baseline block where they performed the LDT by itself and a performance block where they were additionally given an intention to complete while engaged in the LDT. On two trials during the baseline block, the grid opposite the LDT stimulus changed color. The change also occurred during the performance block and served as the PM cue. As previously mentioned, the screen locations of the PM cue and ongoing stimuli needed to be separated in an attempt to distinguish between the attentional resources allocated to each task. Figure 1 displays an example screen shot of the LDT slide on both regular and change trials.

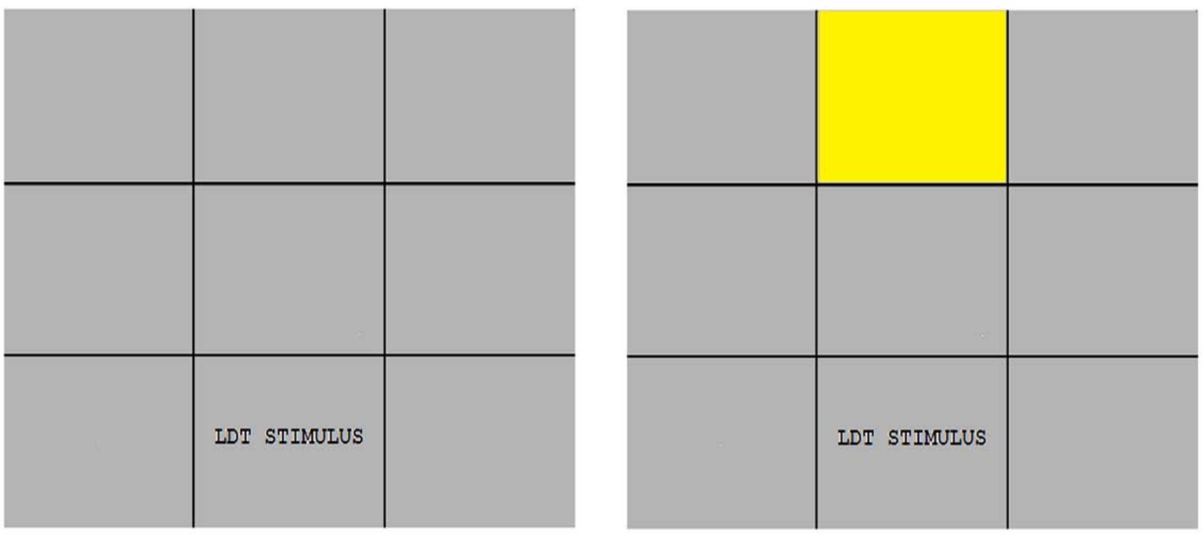

Figure 1
Example Lexical Decision Slide

4.2 Overview of the Prospective Task

Participants were given the intention to press a button each time the box opposite the LDT stimulus changed colors. One unique feature of the current design is that the location of the PM cue was well defined by the grid background and changes occurred within the participant's visual field. Thus, the changes could be detected without looking directly at the box. This feature is noteworthy because overtly orienting attention is not required to detect the change.

Therefore, when overt shifts in attention toward to color box occur they directly reflect checking for a change in the color box. Differences between the PM and control groups in eye movements toward the color box can be attributed to strategic monitoring in the form of checking for the cue.

Although attention can be focused overtly or covertly, the changes in the box color are assumed to engender transient properties, and thus are expected to capture both attention mechanisms (Wu & Remington, 2003) for the following reasons. First, changes in stimulus properties (color and luminance) of the color box are significant. Second, the box is large and noticeable changes in its properties should appear to be abrupt for this reason alone. Last, the change occurs very infrequently which should make the change feel salient to the observer. For similar reasons, the change is expected to encourage automatic processing of the PM cue because participants can rely on the experimental context to grab their attention and signal them to stop the current task and perform the prospective task instead of relying on attention demanding monitoring processes to search for the cue.

Due to contradictions to the multiprocess view, the proposed design may reduce monitoring, but may not eliminate it. First, the PM task is not focal to the ongoing task. Detecting a perceptual change in the color box requires cognitive processes different from those needed to determine if letter strings create English words. Therefore, attentional resources are required to stop the cognitive processes in operation for the ongoing task in order to initiate the cognitive processes needed to complete the PM task. Second, the PM instructions generally state to press a button anytime the color box changes colors as opposed to telling them to press a button anytime the color box changes to red or blue. Typically, specifying the PM cue should facilitate automatic processing of the cue because it precisely defines the moment when the PM cue will appear (McDaniel & Einstein, 2000; 2007). For instance, instructing participants with an LDT ongoing task to press a button when they encounter the word rabbit should facilitate automatic processing of the PM cue compared to instructing them to press a button anytime they encounter an animal word. The latter instructions require two steps: determine if the stimulus is a word, and if it is a word, further determine if it represents an animal. Specific instructions, however, only required one step: determine if the presented item is "rabbit".

Despite the predictions of the multiprocess view, changes in the color box are expected to automatically draw attention, and in doing so spontaneously initiate cognitive processes related to the intention (e.g., retrieval of the action). Changes in the color box are salient and distinct from the other components of the experiment. Distinct cues are predicted by the multiprocess view to aid in spontaneous retrieval (McDaniel & Einstein, 2000; 2007). The visual attention research and results from pilot data suggest that the salience of the cue may supersede the issue of having nonfocal tasks. The results of a pilot experiment showed that 98% of participants noticed that the box changed colors. Additionally, the majority of participants were able to correctly recall the colors that appeared and the number of times it changed. The participants were not warned about the changes, yet were accurately able to report them. These findings establish that the changes automatically captured attention.

Likewise, the specificity of the PM instructions should not present a problem for the current study. Using specific instructions to respond to a semantic cue is thought to reduce monitoring because it reduces the cognitive load associated with detecting the PM cue. In contrast, leaving the color change unspecified actually makes the PM task easier. Instructing participants to respond to any color change allows them to respond anytime there is a change. In this case, specifying that they respond to red increases the cognitive load associated with the PM task because participants need to remember to attend to the change, and also to discriminate between different changes in order to only to respond to red. General instructions may reduce the load associated with detecting a perceptual change, and for this reason, should reduce monitoring. Finally, in the current study participants experienced the change during the baseline block. According to Marsh, Hicks and colleagues, attention allocation policies are thought to be heavily influenced by experience with the task set (Hicks et al., 2005; Marsh et al., 2005). Thus, experience with the color change should alert participants to the ease with which changes can be detected allowing them set an attention allocation policy that discourages the use of monitoring processes.

The final component to the prospective task was an emphasis manipulation that was included to address individual differences in attention allocation policies. There were three PM groups each with different instructions about which task, ongoing or PM, was most important. The first group was a standard PM group instructed to respond to changes in the box color. In addition, there was an ongoing emphasis group instructed to respond to changes in the box color, but to place importance on the LDT. In contrast, the final PM group, the prospective emphasis group, was instructed to respond to changes in the box color, but to place importance on remembering to carry out the intention. Placing emphasis on the ongoing task was expected to reduce monitoring for the PM cue. Conversely, placing emphasis on the PM task should increase monitoring because available resources should be devoted to the PM task (e.g., Einstein et al., 2005; McDaniel & Einstein, 2000). The emphasis manipulation was implemented to investigate the boundaries surrounding the use of monitoring processes and to alleviate the nuisance effects that one’s perception of the task set may have on monitoring. For example, instructing participants to place emphasis on one task over the other may eliminate the propensity to allocate attention to both the ongoing and PM tasks. The emphasis manipulation should reduce individual differences in how people choose to allocate attention, and thus allow for a purer measure of monitoring that is not muddled by participant expectations. Lastly, there was a no-intention control group which never received an intention against which all the other groups were compared.

4.3 Dependent Measures

The dependent measures for the current study were prospective performance, accuracy and average response latencies in the LDT, eye movements, and a set of measures that were used to predict prospective memory performance and monitoring. Prospective performance assessed whether the emphasis manipulation differentially affected prospective memory in the current design. Accuracy, response latencies, and eye movement data from the LDT assessed monitoring processes. As previously mentioned, response latencies do not allow the two monitoring processes, checking for the cue and maintaining a retrieval mode, to be easily dissociated. Eye movements were included to directly assess checking behaviors, while evidence of a retrieval mode can be inferred from both response latencies and eye movement measures when overt checking did not occur. Comparing response latencies in the ongoing task while excluding trials where the color box was looked at were expected to indicate whether participants given an intention instantiated a retrieval mode without the influence of potential checking processes (Guynn, 2008). However, excluding trials where the color box was looked at was not necessary, because most participants never fixated the color box, even when it changed colors. The final set of measures were included to assess whether differences in working memory capacity, the ability to inhibit irrelevant information, and perceptions of the task set can predict prospective performance and the engagement of monitoring processes. Refer to

Appendix A for the list of dependent variables and measures and the cognitive processes each assessed.

Chapter 5 Predictions

The main goal of the current study was to determine whether an intention can be completed without sacrificing performance in an ongoing task. To address the numerous counts of discrepant results reported in the literature regarding the issue, eye movements were included as a novel and more direct measure of attention. Predictions regarding the use of attention in the current study are discussed within the frameworks of Preparatory Attentional and Memory Processes Theory and the multiprocess view. Both views predict similar performance in the baseline block for all groups because the instructions were the same up to thas point.

5.1 Preparatory Attention Predictions

According to Preparatory Attentional and Memory Processes Theory, attentional resources are required to successfully fulfill a PM intention. As a result, participants in the PM groups were expected to show costs to the ongoing task that the control group does not experience. First, the PM groups should show similar or slower response latencies in the performance block compared to the baseline block. In contrast, the control group may show improvement in the performance block of the LDT in the form of faster response latencies compared to their baseline performance. Second, costs to the ongoing task are also expected to manifest in the eye movement data. For example, the response latency costs expected for the PM groups may be a result of PM participants requiring longer fixation durations and/or simply making more fixations before giving a response. In other words, having an intention is expected to slow the cognitive processes used to make lexical decisions resulting in less efficient processing of the LDT stimuli evidenced by the eye movement results. Because the PM emphasis instructions implicitly encourage monitoring, this group may show greater costs to the ongoing task in both response latencies and eye movements than the other PM groups. Essential to these predictions is that all of the PM groups are expected to show costs to the ongoing task that the control group does not experience.

The costs of monitoring to the ongoing task as a result of having an intention are also expected to conversely benefit PM performance. When these resources are not effectively devoted to the PM task, participants will fail to complete the intention. Consequently, the emphasis instructions are expected to influence PM performance. For instance, the ongoing group may devote too much of their resources to the ongoing task leaving an insufficient amount for monitoring processes, the outcome being poorer prospective performance for this group compared to the other PM groups. Altogether, the PM groups are expected to show costs to the ongoing task and a supplementary benefit to the PM task as a result of engaging in monitoring processes.

Theories of working memory suggest that one of its functions is to control attention. Those who are higher in working memory capacity tend to exhibit better control of attention (Baddeley, 2007; Cowan, 2005; Unsworth & Engle, 2007). Following this line of reasoning, working memory capacity should predict prospective performance. As previously noted, Smith (2003) found that participants higher in working memory capacity were more likely to complete an event-based PM task. Operation span (Ospan) was included as a measure of working memory capacity which should be positively correlated with prospective performance replicating Smith (2003). Ospan has been shown to be a reliable and valid measure of working memory capacity (Klein & Fiss, 1999).

Performance in the current study may also be influenced by individuals' abilities to inhibit irrelevant information. Specifically, irrelevant thoughts that occur due to mind wandering or other distractions may tap into the pool of limited attentional resources (e.g., Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Smallwood & Schooler, 2006). In comparison, they may result from a failure to control attention and maintain focus on the relevant task (McVay & Kane, 2010). Thus, participants who are better able to ignore thoughts not related to the task set were expected to show better prospective performance and LDT performance. The Stroop task requires participants to respond to the printed color of items (e.g., the color blue) while trying to ignore what is written (e.g., the word red). The written information is irrelevant, but difficult to ignore because reading is the more common and stronger process (e.g., Friedman & Miyake, 2004; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; MacCleod, 1991). As such, the Stroop task was included as a valid and reliable measure of inhibition (Friedman & Miyake, 2004; Miyake et al., 2000). The relationship with Stroop performance was expected to be borne out in PM accuracy, LDT response latencies and eye movement measures. Participants who experienced greater difficulty inhibiting distracting thoughts were expected to display poorer PM performance, longer response latencies in the LDT, and it was presumed that these participants would make longer and possibly more fixations per trial. Furthermore, this relationship was expected to be indicative of monitoring and should be stronger, in the PM groups. Research also suggests that individuals higher in working memory capacity are better able to ignore irrelevant information (Kane & Engle, 2003). Thus, Ospan performance was expected to correlate with Stroop performance and eye movement measures predicted to indicate off-task thoughts.

Although participants were given instructions to reduce the influence of task set perceptions, it was unclear whether such instructions would eliminate their influence. After participants completed the performance block of the LDT they completed a brief post-experiment questionnaire to directly evaluate their subjective experiences. In particular, the post-experiment questionnaire evaluated participants' perceptions of difficulty and importance of the LDT and PM tasks. PM participants who judged the task set as more difficult were expected to be more likely to engage in monitoring processes. Similarly, those who placed importance on the PM task were expected to monitor and as a result, display better PM performance.

5.2 Multiprocess View Predictions

According to the multiprocess view, the distinctiveness of the PM cue and prior experience with this change in the baseline block should automatically set in motion retrieval processes concerning the relevance of the cue when it appears. This was expected to come about regardless of whether participants anticipated the cue or not (e.g., Einstein et al., 2005; McDaniel & Einstein, 2007). As a result, PM performance was expected to be very high and evidence of monitoring was not predicted to be found in the current study. Therefore, emphasizing the importance of one task over the other was not predicted to affect PM performance. Consistent with these predictions, Einstein et al. (2005) found that emphasizing the PM task did not benefit performance when the PM task did not require monitoring.

The response latency results and eye movement results were predicted to be similar for all of the groups in both blocks of the task with the exception of the PM emphasis group. Because emphasizing the PM task promotes monitoring, this group alone may show costs to the ongoing task. In their Experiment 1, Einstein et al. (2005) tested performance under conditions where monitoring was not theoretically needed to complete the PM task. The authors found no significant differences between a moderate PM emphasis condition and the no intention control condition; however, responding was significantly longer when high importance was placed on the PM task. Therefore, latencies in the control and ongoing emphasis groups were anticipated to be similar, but like Einstein et al. (2005), latencies yielded by the PM emphasis were expected to be longer than the control and ongoing emphasis conditions. One caveat to these predictions is that experiencing the PM cue color change during the baseline block may mitigate the effect of the emphasis instructions. If this is the case, then all of the PM groups should show ongoing performance comparable to that of the control group's performance. The predictions regarding the eye movement results were similar to the response latency predictions: All of the groups were expected to show similar eye movement results with the possibility that the PM emphasis group's results may diverge.

Stroop and Ospan performance were not predicted to correlate with PM performance because the current PM task theoretically did not require attentional resources beyond those needed to complete the ongoing task. However, Stroop and Ospan performance were expected to correlate with each other because they measure related cognitive processes (Kane & Engle, 2003). Similarly, post-experiment reports of difficulty and importance should not predict PM performance because the distinctness of the cue was expected to overpower the influence of participant perceptions of the task set. Even if participants did not appreciate the salience of the PM cue, the cue should still capture attention and assure the completion of the intention. In contrast, there may be some evidence of monitoring if participants whose post-experiment results indicate they placed high importance on the PM task, resulting in an unnecessary allocation of attention to the PM task. In the unlikely event that it occurs, any evidence of monitoring should correlate with Ospan performance, Stroop performance, task set difficulty and importance of the PM task. Note that in contrast to the predictions made by Preparatory Attention and Memory Processes Theory, monitoring processes were not expected to be related to PM performance. Under the current predictions, the employment of monitoring processes would be superfluous.

Chapter 6 Experiment

6.1 Method

6.1.1 Participants

Participants were drawn from the Department of Psychology's subject pool at Louisiana State University and were awarded partial course credit or extra credit for their participation. Two hundred eleven students participated in either a behavioral only version or an eye tracking version of the experiment. The behavioral only version was included to remain consistent with the methods that are traditionally used in PM studies. The stimuli in the eye tracking version were presented in the same manner as the behavioral only version, but responses were recorded using a controller instead of the keyboard. The behavioral only version was included to ensure that the response latency results obtained from the eye tracking version were not simply an artifact of the response mechanism. Of the 211 participants, 149 (control $n = 37$, ongoing emphasis $n = 38$, no emphasis $n = 38$, PM emphasis $n = 36$) completed a behavioral only version of the tasks where eye movement methods were not included. The remaining 62 students (control $n = 17$, ongoing emphasis $n = 15$, no emphasis $n = 15$, PM emphasis $n = 15$) participated in the eye tracking version of the experiment where eye movements were recorded during the baseline and performance LDT tasks.

6.1.2 Design and Materials

6.1.2.1 Ongoing Task

The ongoing task was an LDT. A pool of 138 medium frequency words was selected from the Kučera Francis (1967) word compendium to be used in the LDT. Each word in the LDT had a nonword counterpart. Procedures implemented by Smith and colleagues were used to create pronounceable nonwords by moving the first syllable of each word to the end of the word

(Smith 2003; Smith et al., 2007). Words that appeared when the box color changed did not have a nonword counterpart, resulting in a total of 272 stimuli. Each LDT stimulus was presented in either the bottom or top third of the screen and was centered horizontally. Each item appeared in black Courier New 18 point font on a gray background. The background display was composed of nine grids. Participants in the behavioral only version made their LDT responses using a computer keyboard. Participants who participated in the eye movement version responded using an EyeLink button controller which is similar to a video game controller. All items were counterbalanced across participants. The order of presentation was randomized anew for each participant.

6.1.2.2 PM task

After the baseline block, participants in the PM groups were given the PM instructions to respond anytime the box opposite the LDT stimulus changed colors. Therefore, the color change/PM cue appeared in either the top or bottom third of the screen and was centered horizontally. Each box created by the grid background subtended 8.17° of visual angle. On color change/PM trials the entire box opposite the LDT stimulus changed green once and yellow once at baseline. The box changed red once and blue once in the performance block. Different colors were used on the change trials to account for potential differences in saliency of the change from one color to the next and thus, differences in detecting the change itself. There were no differences in participants' abilities to detect the changes as evidenced by the response latency results, eye movement results, and explicit reports from the post-experiment questionnaire. The reported results were collapsed across this factor. On non-change trials the box was gray like the rest of the background. The color changes subtended such a large area (about one ninth of the entire screen) to ensure that the change was distinct and could be detected without looking directly at the change area to discourage monitoring. The color box changed back to gray on the trial following the change.

6.1.2.3 Eye Movement Data Collection

The eye movement data were collected using an EyeLink II eye tracker. Eye movements were recorded at a rate of 500 Hz from a single eye with an accuracy of 0.5°. The EyeLink II cameras were calibrated before the baseline and performance blocks. Following the calibration tasks the computer selected the eye with the least amount of error to track throughout the task. Eye position data were recorded every 3.0 msec. Information about the specifications of the EyeLink II can be found at http://www.sr-research.com/EL_II.html.

6.1.2.4 Predictor Measures

The Operation Span (Ospan) task is a measure of working memory capacity that has a processing component and a memory storage component. Ospan is thought to be a valid measure of how much information an individual can store in a short term memory store, or working memory capacity, because the processing component prevents the use of strategies such as rehearsal (e.g., Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005). For this reason, the Ospan task was included as a measure of working memory capacity. In this task participants were required to determine whether simple mathematical statements (e.g., 2 + 5 = 7) were true or false. Half of the statements were true and the order of true and false statements was random. Following each problem, participants were shown a letter they were to remember. Participants were presented with 3 to 7 math problem/letter displays per trial. At the end of each trial, participants were shown a display with a series of 12 letters. They were required to indicate in serial order which letters were presented during that trial. Participants performed a practice block of 22 trials followed by 15 experimental trials (3 trials at each length: 3 to 7). Participants performed the math problems at their own pace; however, if they took longer than their average response time during the practice phase, the trial was counted as an error.

The ability to control attention by inhibiting irrelevant information was measured using a computerized version of the Stroop task. In this task, participants were given three different trial types. In one type they were shown color words that were presented in a different color creating incongruent trials (e.g., GREEN presented in blue color). On other trials they were shown an asterisk that presented in one of six colors (red, green, blue, orange, yellow, or purple). Finally, the last trial type consisted of neutral words presented in one of the six colors. Participants were required to state out loud the color of each stimulus as quickly and accurately as possible. Each trial began with a white fixation point on a black screen presented for 500 ms, followed by presentation of the trial stimulus (color word, asterisk, or neutral word). The stimuli remained on the screen until the participant made a response. After a response was given, the screen remained black for 1000 ms before the beginning of the next trial. There were 60 asterisk trials, 60 color word trials, and 60 neutral word trials, with the different trial types mixed throughout the task. The order of trials was pseudorandom, such that the color on one trial was not related to the word or the color on the trial that immediately precedes it. The trials were also fixed such that no single trial type (e.g., asterisk) appeared more than three trials in a row. To facilitate selection process with such few possible selections because of the randomization criteria, the program was written such that it created 90 trials that met the criteria and then repeated the sequence once. A similar design was previously used and shown to measure individual differences in the ability to ignore distracting information (Friedman & Miyake, 2004).

Participants completed a brief demographics questionnaire on the computer to screen for colorblindness and other known visual impairments. The demographics questionnaire also recorded responses to other variables that may have influenced performance such as the number of medications the participants were taking and how much caffeine was consumed before entering the experiment session. The final task in the experiment was the paper and pencil post-experiment questionnaire designed to assess participants' perceptions of the task set. Please refer to Appendix B for a list of the statements included in the demographics questionnaire and refer to Appendix C for a list of the statements included in the post-experiment questionnaire.

6.1.3 Procedure

When participants entered the experiment they first completed the computer based demographics questionnaire, which took about three minutes. Only participants with normal to corrected vision participated in the study. Colorblind participants were permitted to participate but their Stroop results were not included in the data. Immediately following the demographics questionnaire, participants performed the Ospan task followed by the baseline block of the LDT, the Stroop task, performance block of the LDT, and finally the post-experiment questionnaire.

Following the Ospan task, participants received instructions for the LDT. They were told to decide as quickly as possible whether each letter string created a valid English word or a nonword. Participants in the eye tracking version of the study responded to words by pressing the right trigger button on the EyeLink controller with their right index finger and pressing the left trigger button with their left index finger to indicate the current stimulus was a nonword. Participants in the behavioral version responded to by pressing the "F" or "J" keys on the keyboard respectively marked "NW" for nonword and "W" for word with either their left or right index fingers. Participants in both versions of the task were told to keep their index fingers poised over the nonword and word response keys. Each trial in the eye tracking version began with a drift correction that lasted about 250 ms, followed by a 500 ms fixation display. The drift correction accounts for errors between what the EyeLink II recorded and actual eye movements and fixations. During the drift correction, participants looked at the center of a target on the screen and pressed the large round button on the EyeLink controller so the EyeLink II could calculate x-y coordinates corresponding to the location of the pupil. The fixation display appeared as soon as the EyeLink II registered a recording. An asterisk appeared on the fixation display in the same location as the drift correction target. This was also the same location at which each LDT stimulus appeared. The fixation display served to keep participants focused in the location of the LDT and as a brief filler display because the EyeLink II did not record eye movement data for about 500 ms following a drift correction. In the behavioral version, there was no need for a drift correction so the fixation display appeared for 750 ms to try to equate the time between the start of the trial and presentation of the LDT stimulus. The LDT stimuli appeared as soon as the fixation display disappeared in both versions of the task. The LDT stimuli remained on the screen until participants made a response. Once a response was given a screen with the word "NEXT" automatically appeared. Participants in the eye tracking version were required to press the large round button on the EyeLink II controller with their left thumb when the word "NEXT" appeared to end each trial. In the behavioral version, participants pressed the spacebar when the word "NEXT" appeared. Each of the trial stimuli, drift correction target, fixation asterisk, LDT stimulus and "NEXT", appeared in the same location. Figure 2 shows an example of a full LDT trial when there is no color change.

The color box changed colors on trials 41 and 82 in the baseline block upon presentation of the LDT slide (refer to Figure 3). On change trials the entire box opposite the LDT stimulus changed colors (refer to Figure 1). The color change remained on the screen through the presentation of the "NEXT" slide. The color box changed back to gray upon presentation of the drift correction that began the following trial. Participants were not made aware of the of the color changes prior to the outset of the baseline block. To obtain an adequate measure of LDT performance participants completed 102 baseline trials.

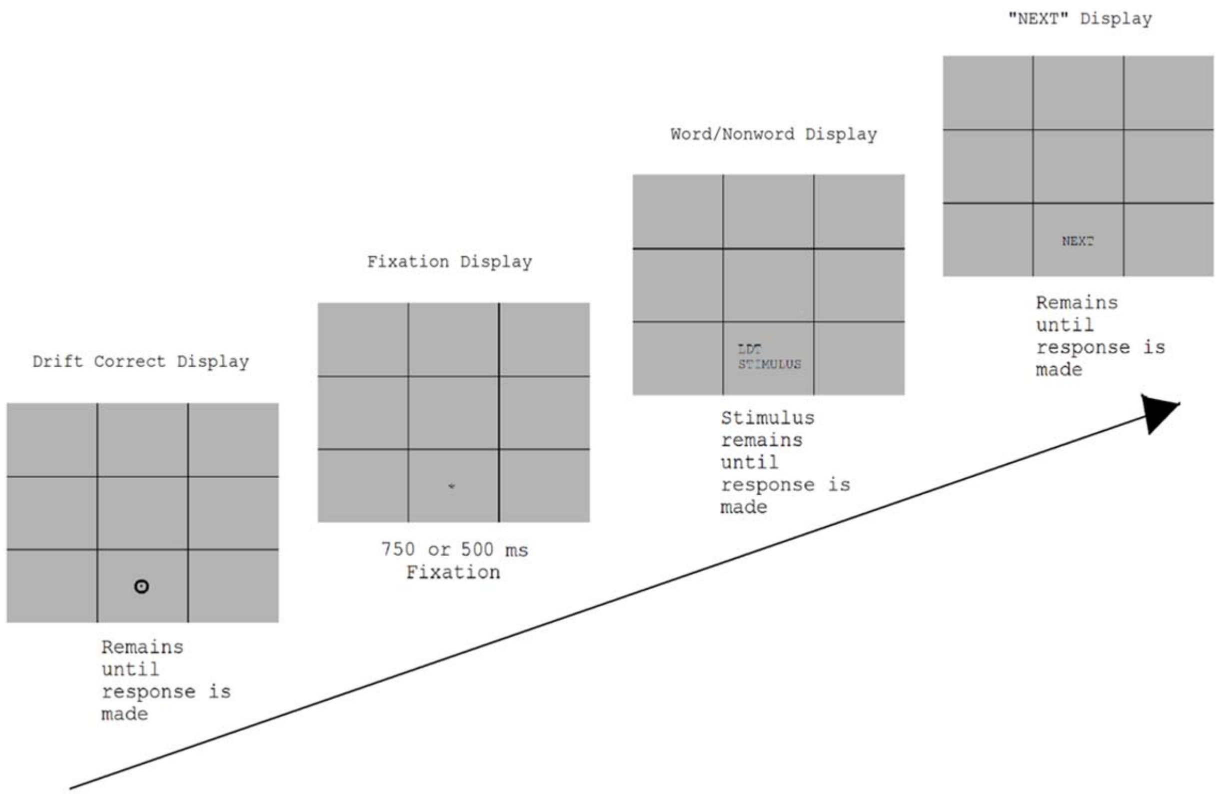

Figure 2
Lexical Decision Trial Schematic. The drift correction only appears in the eye tracking version of the study.

At the end of the baseline block the participants were informed that the experimenters were concerned with their ability to perform different cognitive tasks. At this point the PM groups were given instructions to respond to the PM color change cue. The control group was made aware of the changes, but they were instructed to ignore them (Refer to Appendix D). After receiving the performance block instructions each participant engaged in 12 practice LDT trials where the color change/PM cue appeared three times to familiarize participants with the PM response or making LDT responses in the face of color changes.

After the practice trials participants engaged in the Stroop task. The Stroop task not only served as a measure of inhibition, but it also served to prevent the intention from remaining in working memory when participants began the performance block. It is typical to include another task at this point to help avoid ceiling effects (e.g., Brandimonte & Passolungi, 1994; Einstein & McDaniel, 1990).

Participants began the performance block of the LDT following the presentation of the Stroop task. They were reminded which keys (or triggers) corresponded to their word/nonword decisions and of their "NEXT" response, but they were not reminded about the color changes or their significance. The methods were the same as the baseline block with the exception of the total number of trials, the trials where the changes occurred, and the colors that appeared. In the performance block there were 170 LDT trials, the change trials/PM cue appeared on trials 75 and 150, and the box changed to red and blue. Following the performance block, participants completed the post-experiment questionnaire and then were debriefed and thanked for their participation.

6.2 Behavioral Results and Analyses

The Type I error rate for each of the reported analyses was set at $\alpha = .05$. One participant each from the ongoing and no emphasis groups was dropped from the behavioral only condition because they were missing performance block data due to an experimenter error. One participant was dropped from the control group in the eye tracking condition due to an issue that occurred while calibrating the cameras.

6.2.1 LDT Accuracy

Accuracy in the LDT was calculated as a percent correct score for word trials. This measure did not include the two color change or PM trials. One participant in the PM emphasis group from the behavioral only condition was excluded because his or her accuracy results were two standard deviations below the group's mean. In the eye tracking condition, one participant in each of the PM groups and two participants in the control group were not included in the analyses because their accuracy results were below two standard deviations of their group's mean. Table 2 shows the accuracy data from the baseline and performance blocks for the behavioral only and eye tracking conditions. Separate 4 X 2 mixed factorial Analyses of Variance (ANOVA) were performed on the behavioral only condition accuracy results and the eye tracking condition accuracy results. Group (control, ongoing emphasis, no emphasis, PM emphasis) served as the between-subjects variable and block (baseline, performance) served as the within-subjects variable. The behavioral only condition results yielded a main effect of block $F(1, 142) = 61.96$, $p < .01$, $\eta_p^2 = .30$. There was no effect of group $F(3, 142) = 1.16$, $p > .05$, $\eta_p^2 = .02$, nor was there an interaction between block and group $F(3, 142) = 1.54$, $p > .05$, $\eta_p^2 = .03$. The eye tracking condition accuracy results were similar to those of the behavioral only condition. There was a main effect of block $F(1, 52) = 27.20$, $p < .01$, $\eta_p^2 = .34$, no effect of group $F(3, 52) = 1.83$, $p = .15$, $\eta_p^2 = .10$, but the interaction was significant $F(3, 52) = 3.42$, $p = .02$, $\eta_p^2 = .17$. The outcome of simple effects tests using a Bonferroni correction showed that LDT accuracy declined in the performance block for all of the groups except the no emphasis group. The results from both conditions suggest that accuracy declined slightly in the performance block; however accuracy was not affected by the PM instructions. These results are not surprising because making lexical decisions at one's own pace is a fairly easy task. Thus, LDT accuracy is not likely to be sensitive enough to detect any influence from the PM task. For this reason, no further accuracy analyses will be discussed.

Table 2
LDT Proportion Correct Scores. Values in parentheses represent one standard error of the mean.

	LDT Accuracy	
	Baseline	*Performance*
Behavioral Only Condition		
Control (*n* = 37)	.99 (.003)	.97 (.003)
Ongoing Emphasis (*n* = 37)	.99 (.003)	.96 (.005)
No Emphasis (*n* = 37)	.98 (.003)	.97 (.004)
PM Emphasis (*n* = 35)	.99 (.002)	.97 (.006)
Eye Tracking Condition		
Control (*n* = 14)	1.00 (–)	.99 (.002)
Ongoing Emphasis (*n* = 14)	.99 (.003)	.98 (.006)
No Emphasis (*n* = 14)	.99 (.005)	.99 (.004)
PM Emphasis (*n* = 14)	~1.00 (.002)	.98 (.006)

6.2.2 Response Latencies in the LDT

The response latency measures from the LDT were expected to be sensitive enough to detect the influence of the PM instructions, if there were any to detect. The first response latency measure compared the average median latencies from the baseline and performance blocks. Latencies in the baseline block were taken from the end of the block and included the trials following the second color change. This interval was used to ensure that participants had ample opportunity to familiarize themselves with the task. The interval preceding the appearance of the first color change/PM cue in the performance block was expected to provide the best opportunity to discover evidence of monitoring. Once participants have had the opportunity to complete the intention, there may no longer be a need to devote resources to this task. Hence, evidence of monitoring is not likely to be found once the cue has been presented. The second set of response latencies compared performance on the single trial preceding the change, the trial where the change/PM cue occurred, and the trial following the change. These variables were examined to determine whether the color change captured attention and whether its effects lasted beyond the change trial. The response latency measures were analyzed separately for the behavioral only and eye tracking conditions and only included trials where a correct response was given.

6.2.2.1 Behavioral Only Condition

Average median response latencies (ms) to correct word trials were submitted to a 2 X 4 mixed factorial ANOVA with block (baseline interval 3, performance interval 1) as the within-subjects variable and group (control, ongoing emphasis, no emphasis, PM emphasis) as the between-subjects variable. Four outliers were removed from the control (n = 33) and no emphasis groups (n = 33), two were dropped from the ongoing emphasis group (n = 35) and one participant was dropped from the PM emphasis group (n = 35) because their latencies exceeded two standard deviations from their group's mean. There was a main effect of block $F(1, 132) = 8.69$, $p < .01$, $\eta_p^2 = .06$, no main effect of group $F(3, 132) < 1.00$, $p > .05$, $\eta_p^2 = .02$, and no interaction between block and group $F(3, 132) = 2.30$, $p > .05$, $\eta_p^2 = .05$. The main effect of block was a result of significantly faster response latencies during the performance interval compared to the baseline interval.

Although there was not a significant main effect of group, the PM groups displayed similar latencies during the performance block while the control was numerically faster. The control group's performance block results were faster both in comparison to the PM groups and to their baseline latencies. Separate one-way ANOVAs on the baseline and performance intervals did not yield any significant group effects, nor did a comparison of the difference scores. An Analysis of Covariance (ANCOVA) was performed on performance interval latencies with baseline interval latencies as the covariate in an attempt to account for the influence of baseline responding at performance. The results showed that baseline latencies were significantly related to performance block latencies $F(1, 135) = 143.93$, $p < .01$, $\eta_p^2 = .52$. The effect of group during the performance interval did reach significance $F(3, 135) = 4.40$, $p = .01$, $\eta_p^2 = .09$. Post-hoc comparisons on the estimated adjusted means for the performance interval using a Bonferroni correction for multiple comparisons revealed significant differences between the control and the ongoing emphasis groups and the control and the PM emphasis groups at $p < .05$, no other differences were significant. Thus, when the error variance is reduced by accounting for baseline performance the group differences were significant. The results of the ANCOVA suggest that the ongoing emphasis and PM emphasis groups engaged monitoring processes during the performance block, preventing them from improving to the same degree as the control group.

Table 3
Behavioral Only Condition LDT Response Latencies. The values are the average median response latencies (ms) to correct word trials during the third baseline interval and the first performance interval. The performance interval 1 estimated adjusted means from the ANCOVA were evaluated at baseline interval 3 = 635 ms. Values in parentheses represent one standard error of the mean.

	Behavioral Only Condition LDT Response Latencies (ms)			
	Baseline Block Interval 3	*Performance Block Interval 1*	*Estimated Adjusted Performance Means*	*Block Difference Scores*
Control (*n* = 33)	627 (15)	588 (11)	592 (9)	39 (11)
Ongoing Emphasis (*n* = 35)	632 (17)	631 (13)	632 (9)	1 (12)
No Emphasis (*n* = 33)	648 (21)	624 (15)	617 (9)	23 (13)
PM Emphasis (*n* = 35)	632 (12)	627 (10)	628 (9)	5 (11)

There is research from both laboratory settings and naturalistic environments suggesting that people sometimes use down time between tasks to remind themselves of uncompleted intentions (e.g., Hicks, Marsh, & Russell, 2000; Martin, Brown, & Hicks, 2011; Sellen, Louie, Harris, & Wilkins, 1997). In the current study, it was possible that participants viewed the "Next" response as downtime because the "Next" slide only served to tell participants to end the current trial and prepare for the following trial. As such, "Next" latencies were compared across the third baseline and first performance intervals. All of the comparisons failed to reach significance and the results will not be discussed further. There was no indication that participants used the "Next" response as time to reflect on the PM task or other thoughts (responses during both intervals were close to 200 ms).

The final response latency comparisons were made between the trials preceding the color change, the change trials and the trials immediately following the change. These trials were selected to compare performance during the brief window adjacent the change. The data only include participants who made correct LDT judgments on all three trial types. As a result, the number of participants included in the baseline block comparisons were slightly different from the previous latency comparisons, control $n = 36$, ongoing emphasis $n = 37$, no emphasis $n = 33$, PM emphasis $n = 34$. The change trial in the baseline block was unexpected, but the pre-change and post-change trials were similar to the other LDT trials.

Baseline latencies on the pre-change trial were very similar: all of the groups slowed when the change occurred and participants sped up on the post-change trial. This was confirmed by a 3 (trial type) X 4 (group) mixed factorial ANOVA with trial type as the within-subjects factor and group as the between-subjects factor. There was a significant effect of trial type $F(2, 272) = 59.24$, $p < .01$, $\eta_p^2 = .30$, a significant effect of group $F(3, 136) = 2.68$, $p = .05$, $\eta_p^2 = .06$, and no interaction $F(6, 272) < 1.00$, $p > .05$, $\eta_p^2 = .01$. Follow-up post-hoc tests were conducted using a Bonferroni correction. The results showed that the change trial was significantly slower than the pre-change and post-change trials (both significant at $p < .01$), and the pre-change trial was significantly faster than the post-change trial ($p < .01$). The post-hoc tests on the main effect of group suggest it was driven by differences between the no emphasis group and the control group ($p = .09$) and the no emphasis group and the PM emphasis group ($p = .11$), although the differences were not significant after being adjusted for multiple comparisons. The results demonstrate that participants performed similarly on the pre-change, change, and post-change trials at baseline. Importantly, everyone slowed significantly on the change trials suggesting they captured attention (refer to Figure 3).

Behavioral Only Condition Baseline Pre-change, Change, and Post-change Latencies

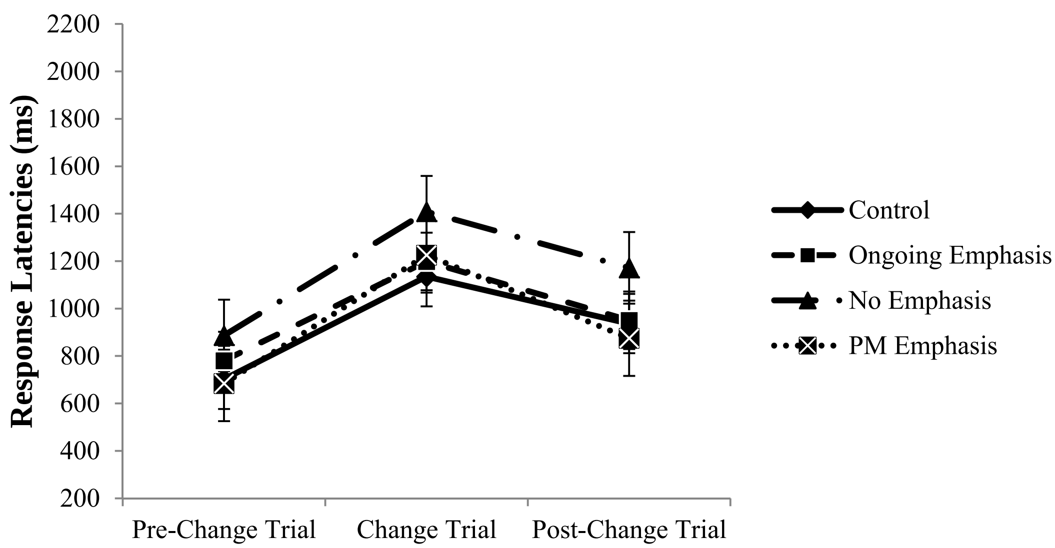

Figure 3
Behavioral Only Condition Baseline Pre-change, Change, and Post-change Latencies. Values are the average response latencies (ms) from the two pre-change, change, and post-change trials during the baseline block from the behavioral only condition. Error bars represent one standard error of the mean.

The same analyses were conducted for the performance block pre-change, change, and post-change trials. The data are shown in Figure 5. In contrast to the baseline block, participants were aware of the color changes that occurred during the performance block. Additionally, this change served as the cue for the PM groups to press the space bar after making their lexical judgments. As with the baseline block, the comparisons only included participants who made correct LDT judgments on all three trial types. Thus, the results exclude participants who made their PM responses early on the change trial (i.e., before making a lexical decision). The number of participants in each group were control $n = 32$, ongoing emphasis $n = 28$, no emphasis $n = 33$, and PM emphasis $n = 33$.

The performance results were similar to those obtained at baseline with the exception of the change trial. The 3 (trial type) X 4 (group) mixed factorial ANOVA yielded a significant effect of trial $F(2, 244) = 106.80$, $p < .01$, $\eta_p^2 = .47$, and a significant effect of group $F(3, 122) = 9.70$, $p < .01$, $\eta_p^2 = 19$. The main effect of trial arose because the pre-change latencies were significantly faster than both the change/PM trial and post-change latencies (both comparisons significant at $p < .01$). The change trial was also significantly slower than the post-change trial ($p < .01$). Although the main effect of group was significant at baseline, the effect size for the performance block results was triple the effect size produced at baseline. This finding was borne out in the post-hoc analysis results where the control group displayed significantly faster latencies overall than the ongoing emphasis, no emphasis, and PM emphasis groups (all comparisons, $p < .01$). In contrast to the baseline results, the main effects were qualified by a significant interaction $F(6, 244) = 6.71$, $p < .01$, $\eta_p^2 = .14$.

Behavioral Only Condition Performance Pre-change, Change, and Post-change Latencies

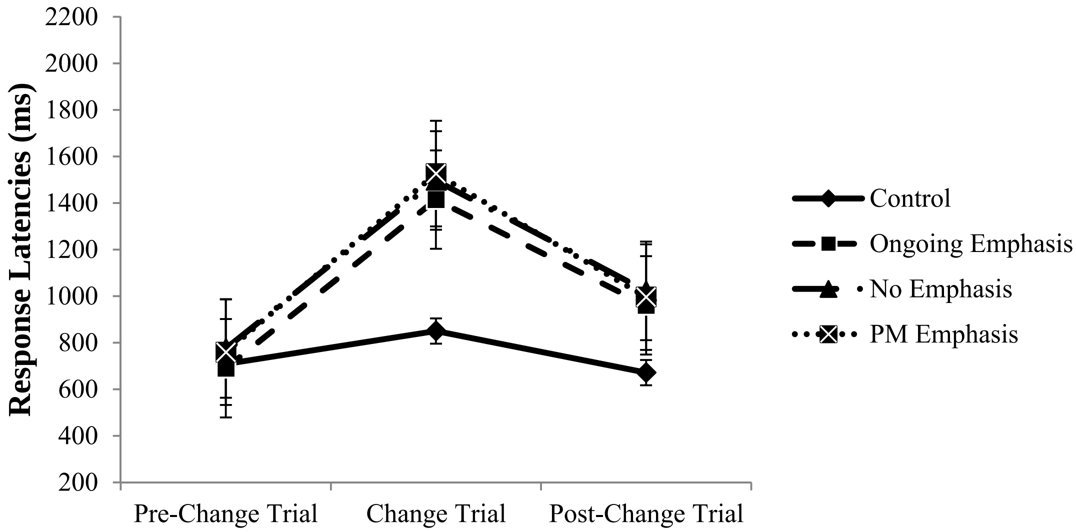

Figure 4
Behavioral Only Condition Performance Pre-change, Change and Post-change Latencies. Values are the average response latencies (ms) from the two pre-change, change, and post-change trials during the performance block from the behavioral only condition. Error bars represent one standard error of the mean.

It is clear from the data in Figure 4 that the interaction was driven by the fact that the control group did not slow down on the change trial to the degree that the PM groups slowed on this trial. This supports the idea that the PM cue was detected and participants likely engaged in retrieval processes related to the intention (e.g., what response to make, when to make it, etc.). This slowing occurred when participants made their lexical decisions prior to making the PM response. Thus, it shows the slowing was not simply a result of the PM groups making the PM response while the control group made lexical decisions. Although there still seems to be some small degree of carry-over from the change/PM trial for the PM groups, all of the groups are strikingly similar on the pre-change trial. This snap-shot analysis suggests that participants were not engaged in monitoring processes on the pre-change trial. However, this single trial analysis may have captured a point where monitoring has waned, if it previously occurred. Importantly, the pre-change, change and post-change latency results show evidence of spontaneous retrieval in that there doesn't seem to be an influence of the intention just before the cue appeared, but the cue captured the attention of the PM participants as soon as it did appear. Furthermore, the pre-change latencies do not seem to reflect a trade-off between accuracy, as it was similar across the groups.

6.2.2.2 Eye Tracking Condition

The same set of latency analyses were calculated for the eye tracking condition. Response latencies at the end of the baseline block were compared to the response latencies from the beginning of the performance block to determine whether the PM task had an effect on LDT performance. One participant from each group was dropped due to outlier performance. There were no differences from baseline to performance $F(1, 53) = 2.18$, $p = .15$, $\eta_p^2 = .04$, no group differences $F(3, 53) < 1.00$, $p > .05$, $\eta_p^2 = .03$, and the interaction was not significant $F(3, 53) = 1.75$, $p = .17$, $\eta_p^2 = .09$.

Table 4
Eye Tracking Condition LDT Response Latencies. Values are the average median response latencies (ms) to correct word trials during third baseline interval and the first performance interval. The performance interval 1 estimated adjusted means from the ANCOVA were evaluated at baseline interval 3 = 660 ms. Values in parentheses represent one standard error of the mean.

	Eye Tracking Condition LDT Response Latencies (ms)			
	Baseline Block Interval 3	*Performance Block Interval 1*	*Estimated Adjusted Means*	*Block Difference Scores*
Control (*n* = 15)	645 (23)	632 (26)	640 (16)	13 (18)
Ongoing Emphasis (*n* = 14)	687 (35)	661 (28)	646 (17)	27 (25)
No Emphasis (*n* = 14)	645 (20)	667 (21)	675 (17)	-22 (14)
PM Emphasis (*n* = 14)	662 (38)	616 (16)	615 (16)	46 (27)

The performance latencies from the first interval were also submitted to an ANCOVA with response latencies during the third baseline interval as the covariate as an attempt to reduce the error variance within each group. Baseline latencies were significantly related to performance latencies $F(1, 52) = 47.49$, $p < .01$, $\eta_p^2 = .48$, but the results of the ANCOVA still yielded null effects of group $F(3, 52) = 2.23$, $p = .10$, $\eta_p^2 = .11$. Thus, individuals who were slower at baseline tended to be slower at performance. Importantly, performance latencies were not affected by the control and PM instructions given at the end of the baseline block, even when the error variance was greatly reduced by accounting for the covariate. The ANCOVA results were replicated when comparing the difference between the third interval baseline and actual first interval performance results. Overall, the PM groups and control group showed similar performance. However, the no emphasis group slowed in the performance block where the other groups were all faster. Although the no emphasis group's results may indicate initial evidence of monitoring, the PM emphasis group showed no evidence. In fact, the PM emphasis group showed the greatest improvement. This is in contrast to the predictions made by both Preparatory Attention Theory, and the Multiprocess View that this group should show the greatest degree of monitoring or at least be most likely to employ such resources.

The "Next" response latencies from correct word trials during baseline interval 3 and performance interval 1 were submitted to a 2 (block) X 4 (group) mixed factorial ANOVA to determine whether monitoring was likely to occur at a point when participants were not directly engaged in the LDT. Unlike the behavioral only condition, the performance block was significantly faster than the baseline block $F(1, 50) = 12.92$, $p < .01$, $\eta_p^2 = .21$, and the effect of group was significant, $F(3, 50) = 3.23$, $p = .03$, $\eta_p^2 = 16$. The main effect of group was a result of slower responding by the no emphasis group compared to the ongoing emphasis group ($p = .05$). Notably, the interaction was not significant, $F(3, 50) = 2.16$, $p = .11$, $\eta_p^2 = .11$.

The performance block results were submitted to an ANCOVA with baseline "Next" latencies as the covariate. The ANCOVA results showed that baseline latencies were significantly related to performance latencies $F(1, 49) = 26.71$, $p < .01$, $\eta_p^2 = .35$ and the effect of group went away $F(3, 49) < 1.00$, $p > .05$, $\eta_p^2 = .05$. The results suggest the main effect of group that resulted from the ANOVA was driven by slower latencies in the no emphasis condition during both blocks of the task, and that these differences were not meaningful. Furthermore, if the differences were indicative of monitoring processes, they should have arisen between the control group and the PM groups, and not necessarily between the PM groups themselves. The "Next" response latencies were slower overall in the eye tracking condition (about 500 ms in both blocks) compared to the behavioral only condition (about 200 ms in both blocks); however, the results did not suggest that these responses were affected by monitoring processes.

Finally, response latency comparisons were conducted for the pre-change, change, and post-change trials. As with the behavioral only condition, only participants who made correct LDT responses on all trial types were included in the following analyses. This requirement excluded participants who made their PM response early. The number of participants included in the baseline block comparisons were control $n = 16$, ongoing emphasis $n = 15$, no emphasis $n = 14$, and PM emphasis $n = 14$. The number of participants included in the performance block comparisons were control $n = 15$, ongoing emphasis $n = 14$, no emphasis $n = 14$, and PM emphasis $n = 12$.

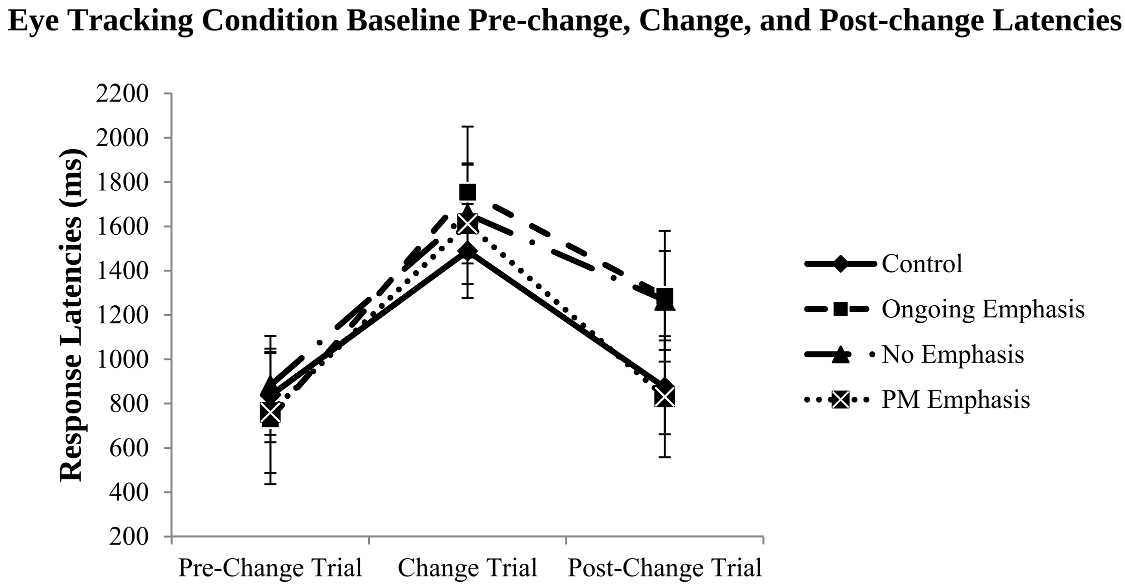

Figure 5
Eye Tracking Condition Baseline Pre-change, Change, and Post-change Latencies. Values are the average response latencies (ms) from the two pre-change, change, and post-change trials during the baseline block from the eye tracking condition. Error bars represent one standard error of the mean.

Baseline data are displayed in Figure 5. The pattern of results replicated those of the behavioral only condition. Pre-change latencies were very similar for all of the groups, everyone slowed when the change occurred, and participants tended to speed back up following the change, although some slowing still occurred. These results were confirmed by a 3 (trial type) X 4 (group) mixed factorial ANOVA. There was a significant effect of trial type $F(2, 110) = 36.34$, $p < .00$, $\eta_p^2 = .40$, no effect of group $F(3, 55) = 1.18$, $p > .05$, $\eta_p^2 = .06$, and the interaction failed to reach significance $F(6, 110) = 1.00$, $p > .05$, $\eta_p^2 = .05$. Follow-up post-hoc tests were conducted using a Bonferroni correction. The results showed that the change trial was significantly slower than the pre-change and post-change trials (both significant at $p < .01$), and the pre-change trial was significantly faster than the post-change trial ($p = .01$). The results demonstrate that the groups performed similarly at baseline. Comparable to the behavioral only condition, everyone slowed significantly on the change trials, suggesting it captured attention.

Eye Tracking Condition Performance Pre-change, Change, and Post-change Latencies

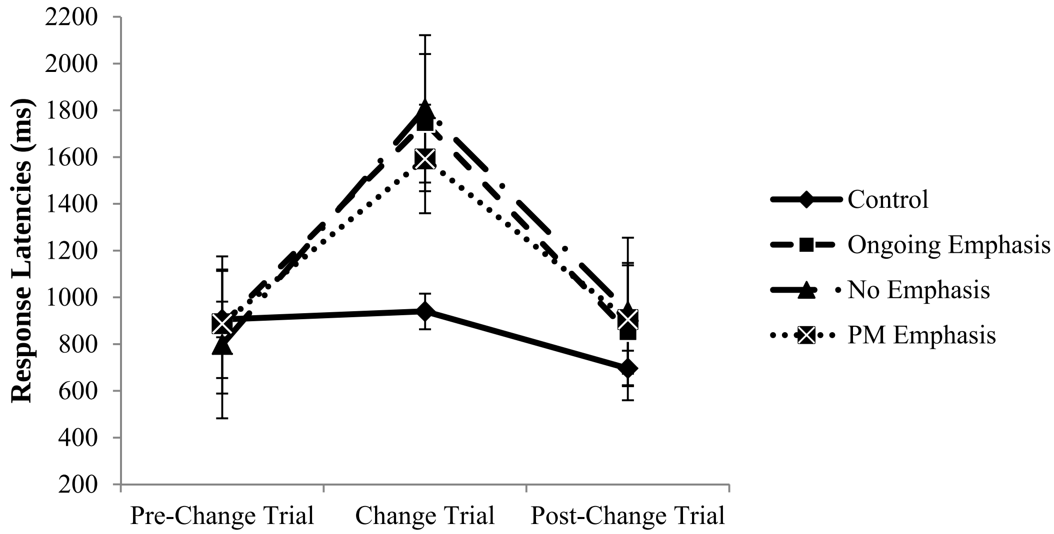

Figure 6
Eye Tracking Condition Performance Pre-change, Change, and Post-change Latencies. Values are the average response latencies (ms) from the two pre-change, change, and post-change trials during the performance block from the eye tracking condition. Error bars represent one standard error of the mean.

The pre-change, change/PM, and post-change latency data from the performance block are displayed in Figure 6 and replicate those produced by the behavioral only group. There was a main effect of trial type $F(2, 102) = 41.25$, $p < .01$, $\eta_p^2 = .45$, a main effect of group $F(3, 51) = 3.53$, $p = .02$, $\eta_p^2 = .17$, and the results were qualified by a significant interaction $F(6, 102) = 3.73$, $p < .01$, $\eta_p^2 = .18$. The change/PM trial was significantly slower than the pre-change and post-change trials, but the pre-change trial did not differ from the post-change trial (all comparisons evaluated at $\alpha = .05$). Unlike the behavioral only condition, there were not any carryover effects in the performance block. Importantly, only participants in the PM groups slowed when the change occurred, even though this was not the exact moment when they were to make the PM response. Notably, the results replicate the behavioral only condition showing additional support for spontaneous retrieval in the current paradigm because the PM groups responded just as quickly as the control group on the pre-change trial and slowed significantly when the cue appeared. LDT latencies on the pre-change trial do not reflect a speed-accuracy trade-off as all of the groups showed similar levels of accuracy on all three trial types. Altogether the pre-change, change, and post-change results do not suggest that the PM task negatively influenced LDT performance.

6.2.3 Prospective Memory Performance

Prospective memory performance was calculated as the proportion of participants who responded at least once to the PM cues because PM performance within each condition was about equal across the PM groups on both PM trials (proportion correct values: behavioral only condition PM 1 = .65, PM 2 = .66; eye tracking condition PM 1 = .71, PM 2 = .78). PM performance results include participants who made their PM responses early (i.e., they made their PM response instead of their lexical decision on the change trial), and those who made late responses (made a PM response on the trial that immediately followed the change). In the behavioral only condition, there were two participants in each of the ongoing and PM emphasis groups that responded early on the first PM trial. There were also two ongoing emphasis participants who responded late on the first PM trial. On the second PM trial one participant in the PM emphasis group responded early and no one responded late. In the eye tracking condition there was one participant in the ongoing emphasis condition who responded early on both PM trials, a single participant in the no emphasis condition who responded early on the first PM trial, and two PM emphasis participants who responded early on both PM trials. There were not any participants in the eye tracking condition who made a late PM response. The PM performance data for both the behavioral only and eye tracking conditions are included in Table 5.

Table 5
Prospective Memory Performance. Values in parentheses represent one standard error of the mean.

	Prospective Memory Performance	
	Behavioral Only Condition	*Eye Tracking Condition*
Ongoing Emphasis	.68 (.08)	.80 (.13)
No Emphasis	.78 (.07)	.80 (.11)
PM Emphasis	.69 (.08)	.80 (.11)

One-way ANOVAs were conducted on PM performance for each experimental condition. The emphasis instructions did not influence prospective memory performance in either condition: behavioral only $F(2, 110) < 1.00$, $p > .05$, $\eta_p^2 = .01$, eye tracking $F(2, 42) < 1.00$, $p > .05$, $\eta_p^2 = .00$. One-tailed bivariate correlations were run to examine the relationship between speed of processing before and during the PM trial and PM performance. Any significant correlations were expected to be positive, showing that slower processing was related to an increase in PM performance. The reported latencies only include trials where correct lexical decisions were made. The correlations were nearly identical when incorrect responses were included, but the correlations from correct trials are reported to remain consistent with the previous analyses.

In the behavioral only condition, PM performance was not correlated with response latencies on the pre-change trial ($r = .14$, $p = .09$), nor was it correlated with the average response latencies before the first change ($r = .13$, $p = .09$). However, PM performance was correlated with speed of processing on the change trial. Participants who made slower lexical judgments on the PM trials were more likely to complete the intention ($r = .49$, $p < .01$). Likewise, participants who made slower responses on the “Next” slide of the PM trials (the moment when the PM response was to be made) were more likely to complete the intention ($r = .52$, $p < .01$).

In the eye tracking condition, PM performance was not correlated with response latencies on the pre-change trial ($r = -.18$, $p = .11$), nor was it correlated with the average response latencies before the appearance of the first PM cue ($r = -.06$, $p = .35$). In fact, both relationships were in the opposite direction of what was expected. Comparable to the behavioral only condition, PM performance was correlated with processing on the change trial. Those who made slower lexical decisions ($r = .31$, $p = .03$) and who made slower responses on the "Next" slide ($r = .38$, $p = .01$) were more likely to complete the intention.

Conclusions drawn from the bivariate correlations show that speed of processing before the PM cue appeared was not related to PM performance, but speed of processing on the PM trial was strongly related to PM performance. The correlation results also support the claim that when the PM cue captured attention participants in the PM groups slowed to engage retrieval processes related to the intention.

6.3 Eye Movement Results and Analyses

Similar to the response latency data, eye movement data from correct word LDT trials following the second color change at baseline and before the first color change during performance were analyzed because they were expected to be best suited for detecting monitoring processes. To determine if the PM instructions influenced participants' lexical decisions the average amount of time spent looking at the LDT stimulus was calculated as well as the number of fixations that were made on the LDT stimulus before making a decision. These measures can be considered to be more precise than the response latency measures because they exclude fixations away from the LDT stimulus and potentially thoughts not related to the task set. Two participants, one from the ongoing emphasis and one from the PM emphasis groups, were dropped from the duration analyses due to significantly longer fixation durations.

Likewise, one control participant was dropped from the analyses on the number of fixations. In addition, one participant in the control group and one participant in the no emphasis group were dropped from the eye movement analyses because their data were not recorded during the performance block. The duration data are reported in Table 6 and are slightly longer than the response latency data because there were instances where the last fixation on the fixation slide spilled over onto the LDT slide. However, the observed increase was similar for each group, both during the baseline and performance blocks.

Table 6
Fixation Durations on the LDT. Values are the average fixation durations (ms) on the LDT during the third baseline interval and the first performance interval. The performance interval 1 estimated adjusted means were evaluated at baseline interval 3 = 949 (ms). Values in parentheses represent one standard error of the mean.

	Eye Tracking Condition Average LDT Fixation Durations (ms)			
	Baseline Block Interval 3	*Performance Block Interval 1*	*Estimated Adjusted Means*	*Block Difference Scores*
Control (*n* = 15)	940 (49)	908 (50)	910 (39)	33 (40)
Ongoing Emphasis (*n* = 14)	1028 (49)	995 (47)	970 (42)	33 (73)
No Emphasis (*n* = 14)	955 (49)	991 (40)	990 (41)	-36 (45)
PM Emphasis (*n* = 14)	874 (52)	816 (31)	839 (41)	59 (47)

The duration results did not yield a significant effect of block $F(1, 53) < 1.00$, $p > .05$, $\eta_p^2 = .01$. There was a significant effect of group $F(3, 53) = 3.45$, $p = .02$, $\eta_p^2 = .16$, and the interaction was not significant $F(3, 53) < 1.00$, $p > .05$, $\eta_p^2 = .03$. The group main effect was driven by significant differences between the ongoing emphasis condition and the PM emphasis conditions ($p = .02$). The results of the ANCOVA revealed a significant relationship between baseline and performance fixation durations $F(1, 52) = 7.89$, $p = .01$, $\eta_p^2 = .13$, and no effect of group during the performance block $F(3, 52) = 2.62$, $p = .06$, $\eta_p^2 = .13$. The group trend was driven by differences between the ongoing and PM emphasis groups and none of the PM groups were statistically different from the control group. The amount of time spent looking at the LDT stimulus mimics the overall response latency results. These results are not surprising considering that close to 99% of the time of each trial was spent looking at the LDT stimulus as opposed to other screen locations, including the color box area.

Table *7*
Number of Fixations on the LDT. Values are the average number of fixations on the LDT during the third baseline interval and the first performance interval. The performance interval 1 estimated adjusted means were evaluated at baseline interval 3 = 2.3. Values in parentheses represent one standard error of the mean.

	Eye Tracking Condition Average Number of Fixations Per Trial			
	Baseline Block Interval 3	*Performance Block Interval 1*	*Estimated Adjusted Means*	*Block Difference Scores*
Control (*n* = 14)	2.0 (0.2)	1.9 (0.1)	2.0 (0.1)	0.1 (0.1)
Ongoing Emphasis (*n* = 14)	2.5 (0.2)	2.3 (0.1)	2.2 (0.1)	0.3 (0.2)
No Emphasis (*n* = 15)	2.2 (0.2)	2.3 (0.2)	2.3 (0.1)	-0.1 (0.2)
PM Emphasis (*n* = 15)	2.5 (0.3)	2.1 (0.1)	2.1 (0.1)	0.4 (0.1)

The results on the number of fixations made per trial were slightly different from the fixation duration results. The effect of block was not significant, $F(1, 54) = 3.24$, $p = .08$, $\eta_p^2 = .05$, the effect of group was not significant $F(3, 54) = 1.23$, $p > .05$, $\eta_p^2 = .06$, and the interaction also failed to reach significance $F(3, 54) < 1.00$, $p > .05$, $\eta_p^2 = .05$. The ANCOVA showed that the number of fixations made at baseline was related to the number of fixations made during the performance block $F(1, 53) = 22.15$, $p < .01$, $\eta_p^2 = .30$, but there was no effect of group at performance $F(3, 53) < 1.00$, $p > .05$, $\eta_p^2 = .05$. Together the results from the duration and number of fixations suggests that participants made slightly fewer fixations during the performance interval compared to baseline, but this did not affect the overall amount of time spent processing the LDT stimulus, nor did the PM instructions have an effect on these variables.

The same variables were calculated for the “Next” slide. There were no differences between the baseline and performance blocks in the duration $F(1, 50) < 1.00$, $p > .05$, $\eta_p^2 = .00$, nor in the number of fixations made $F(1, 51) < 1.00$, $p > .05$, $\eta_p^2 = .02$. There were also no group differences in the “Next” duration measure $F(3, 50) < 1.00$, $p > .05$, $\eta_p^2 = .05$, nor the number of fixations $F(3, 51) = 1.93$, $p > .05$, $\eta_p^2 = .10$. Both interactions also failed to reach significance: duration $F(3, 50) < 1.00$, $p > .05$, $\eta_p^2 = .01$, and number of fixations $F(3, 51) < 1.00$, $p > .05$, $\eta_p^2 = .04$. The duration ANCOVA results did reveal a significant relationship between baseline and performance looking times $F(1, 49) = 13.66$, $p < .01$, $\eta_p^2 = .22$, but accounting for baseline processing duration did not reveal significant differences between the groups at performance $F(3, 49) < 1.00$, $p > .05$, $\eta_p^2 = .05$. Interestingly, the results of the ANCOVA on the number of fixations made on the “Next” slide did not reveal a relationship between baseline and performance fixations $F(1, 50) = 2.11$, $p > .05$, $\eta_p^2 = .04$, and the null effects at performance persisted $F(3, 50) = 1.25$, $p > .05$, $\eta_p^2 = .07$. The eye movement results from the “Next” slide further suggest that monitoring did not occur at this point in the trial.

Monitoring processes in the form of checking for the cue were expected to be manifested in the number of fixations on the color change area on non-change trials and the proportion of time spent processing on this area. In other words, if participants thought about the intention and needed to check to see if they should make their PM response, they were expected to look at the color change area. Furthermore, if the color change area was fixated, participants in the PM groups were expected to spend more time looking at the area than the control group suggesting they were retrieving information about the intention. This did not turn out to be the case. The color box area was very rarely fixated upon on non-change trials both during baseline and performance. In fact, most participants never looked at the color change area and those that did usually made a single fixation. There were also no group differences in the proportion of time spent looking at the color change area during baseline and performance, nor were there any group differences. During baseline, participants were more likely to fixate upon the color box on the few trials following a change. During the performance block, this pattern carried on for the control group, but the PM participants who looked at the color change area were likely to look at random times throughout the block. The latter finding may indicate that a few of the PM participants did feel compelled to check for the cue, while the control participants looked because the change captured their attention. The proportion of participants in each group who fixated upon the color box is displayed in Figure 7.

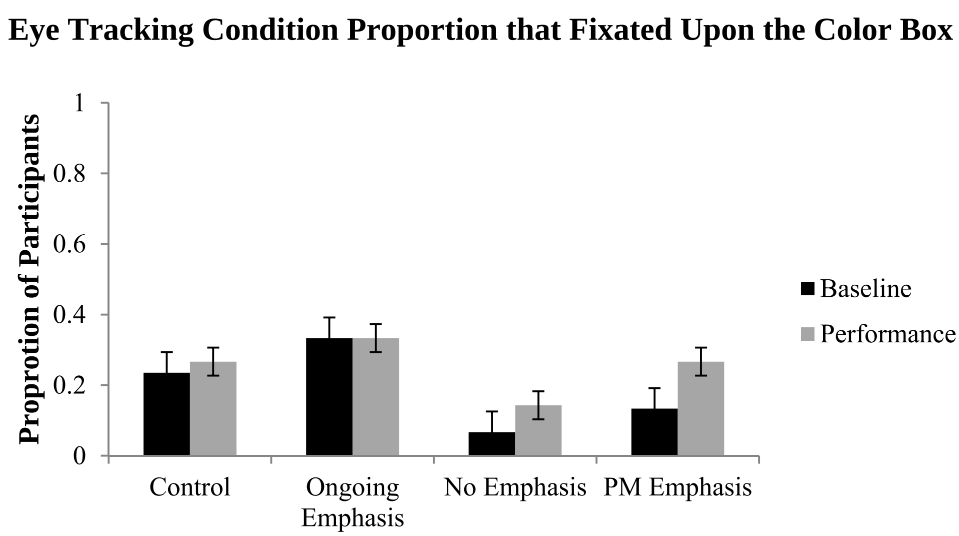

Figure 7
Eye Tracking Condition Proportion that Fixated Upon the Color Box. Bars represent the proportion of participants in each group who fixated upon the color box at least once during the baseline and performance blocks. Error bars represent one standard error of the mean.

Interestingly, few participants looked at the color change area on change trials although, all participants indicated in the post-experiment questionnaire that they noticed the change and several were able to correctly recall the colors that appeared. This finding supports the prediction that the change would be distinct and very noticeable.

6.4 Predictor Measures

Bivariate correlations were first conducted to determine the relationship between PM performance and the results from each predictor measure. If the predictor variable was related to PM performance, the relationship was further examined through a multiple regression model. The first predictor variable was working memory capacity assessed by Ospan performance. Ospan performance was calculated as a cumulative score based on the number of letters correctly remembered in serial order across all of the trials. Only participants who maintained their math accuracy at 85% or better were included in the Ospan analyses.

The second predictor measure was Stroop performance, designed to assess each individual's ability to inhibit irrelevant information. Two variables were created from this task: the number of response errors made to color word trials (e.g., reading the word "red" instead of stating the color it was presented) and the difference in response latency between color word trials and neutral word trials (words unrelated to colors presented in a color) when a correct response was given. As mentioned in the methods section, the Stroop task was designed such that the computer generated 90 trials and repeated the sequence. There were a few instances where the color or word that appeared on trials 90 and 91were related (e.g., "green" or "red" in green print). Cases where such a match occurred were removed from the dataset. The data were also trimmed to exclude trials faster than 200 ms because they often occurred due to microphone errors. Trials exceeding three standard deviations beyond the participant's mean response latencies were also excluded. This resulted in a loss of less than 3% of the data in both the behavioral only and eye tracking conditions. Participants who indicated that they were colorblind in their demographics questionnaire were excluded from the results (behavioral only $n = 2$; eye tracking $n = 1$).

The final set of variables included in the bivariate correlations came from the demographics questionnaire and the post-experiment questionnaire. The eye movement data were also included (for the eye tracking group). Responses to each of the questions were included in the bivariate correlations to determine whether any were related to PM performance. Variables that were significantly correlated with PM performance or those that were expected to correlate with PM performance are presented Tables 8 and 10. Two-tailed Pearson's correlations were run because there was not always a theoretical prediction for the direction of each relationship.

As previously shown, PM performance was significantly correlated with processing speed when the PM cue appeared. Table 8 also shows that PM performance was negatively correlated with how difficult participants in the behavioral only PM groups rated the task set, indicating that those who rated the combination of the LDT and PM tasks as being easier were more likely to remember to carry out the intention. PM performance was also positively correlated with participants' use of strategies. The last question on the post-experiment questionnaire inquired about strategy use. Responses were scored from 0 to 3 and higher values indicated strategies that were less likely to reflect monitoring processes. If participants said they did not use a strategy, their response was marked as 0, if they said they searched for the cue and thought about the PM task throughout, their response was marked as a 1, if they said they the intention popped into mind, but sometimes thought about the cue, their response was marked as

2, and last, if they said they did not think about the PM cue until it appeared, i.e. it popped into mind, their response was marked as a 3. Most participants' responses were marked as either a 3 or 1, with very few 2's and no 0's. Thus, the correlation with strategy indicates that participants in the behavioral only condition who subjectively stated that they did not monitor for the PM cue were more successful at the PM task.

Table 8
Behavioral Only Condition Bivariate Correlations. Values significant at $\alpha = .05$ are marked with a single asterisk (*) and values significant at $\alpha = .01$ are marked with two (**). Variable 8 was the only demographic result related to PM performance and variables 9 to 11 were the only post-experiment outcomes related to PM performance.

Behavioral Only Condition Bivariate Correlations

		1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
1.	PM	1									
2.	PM Latency	.52**	1								
3.	Change Trial Latency	.49**	.42**	1							
4.	Performance Interval 1 Latency	.13	.25**	.35**	1						
5.	Ospan Score	.07	.01	-.03	.02	1					
6.	Stroop Word Errors	-.02	-.06	-.03	.00	-.13	1				
7.	Stroop Latency Difference	-.16	.01	.21*	.08	-.01	.02	1			
8.	Anxiety Medication	.21*	.11	.07	-.03	-.08	.01	-.13	1		
9.	Effort Toward LDT	-.12	-.25**	.00	-.23*	-.23*	.14	-.13	-.04	1	
10.	Difficulty to do Both	-.27**	-.26**	-.17	.05	.01	.01	.14	-.09	-.02	1
11.	Strategy	.32**	.33**	.25**	.16	.10	.08	.07	.00	-.16	-.15

Surprisingly, the only demographics question related to PM performance was whether participants were taking any anxiety medications (1 = yes; 2 = no). The positive correlation shows that participants who were not taking anxiety medications were more likely to complete the intention than those taking these medications. However, this outcome is to be interpreted with caution as there were only four participants who indicated that they were taking anxiety medications.

Interestingly, how much effort participants devoted to the LDT over the PM task did not correlate with PM performance, but it did correlate with their response latencies. The negative correlation between effort and PM latencies, and effort and performance block interval 1 latencies indicated that participants who devoted less effort to the LDT and more effort to the PM task were slower than those who placed more effort on the LDT. Notably, which task they devoted more effort toward did not directly influence PM performance. Effort also correlated with Ospan performance suggesting that those who scored higher in the Ospan task were more likely to place effort toward the PM task.

Also of interest were the Ospan and Stroop correlations which did not relate with PM performance. Ospan scores did not correlate with either measure of Stroop performance. These results do not replicate Kane and Engle (2003) who found that Ospan performance predicted slowing in the Stroop task when all or most of the Stroop trials were incongruent like the current Stroop task; However, the results are in line with findings obtained by Miyake, et al. (2000). In their work, Miyake et al. (2000) found evidence through structural equation modeling that Ospan and Stroop performance measured separate executive functions. Specifically, Ospan performance was related to the ability to update information in memory and Stroop performance was related to the ability to inhibit irrelevant information. From their conclusions, it is not surprising that a relationship between Ospan and Stroop performance was not found in the current results because updating and inhibition were thought to be distinguishable functions. The implications of these results are considered in the discussions section. Lastly, the difference in response latencies between correct color word trials and correct neutral word trials in the Stroop task was correlated with processing speed when making an LDT judgment on the change trial.

Table 9
Behavioral Only Condition Regression Model. Values significant at $\alpha = .05$ are marked with a single asterisk (*) and values significant at $\alpha = .01$ are marked with two (**).

Behavioral Only Condition Regression Model

Variable	β	Semipartial *r*	*t*-value	R^2
PM Latency	.38	.34	4.28**	.42**
Change Trial Latency	.35	.33	4.35**	
Difficulty to do Both	-.10	-.10	-0.98	
Strategy	.05	.05	0.41	

Note – $R^2 = .42$, $F(4, 97) = 17.66$, $p < .01$.

To determine which variables most strongly predicted PM performance, the variables that correlated with PM were entered simultaneously into a multiple regression analysis. Although the use of anxiety medications was correlated with PM performance, this variable was not included in the regression model because there were so few participants who indicated that they were taking such medications. The outcome of regression model for the behavioral only condition is in Table 9. The table includes beta values (β), semipartial correlations, the significance test (t (97)) for each predictor variable, and the multiple R^2 value for the entire model. The multiple regression model was able to account for 42% of the variance in PM performance. Moreover, the only two significant predictors were response latencies when participants were supposed to make their PM responses and response latencies when participants made LDT decisions in the face of the PM cues. Although the other variables were related to PM performance, they cannot be used to predict PM performance in the current paradigm. These results again suggest that the distinctiveness of the PM cue overrode perceptions of the difficulty of the task set, strategy, and the use of medications that may otherwise interfere with performance.

Bivariate correlations were also conducted for the eye tracking condition. These data can be found in Table 10. The response latency results were very similar to the fixation duration results. As such the former were excluded from the table to prevent duplication. The results were similar to the behavioral only correlations showing that PM performance was significantly correlated with processing speed when the PM cue appeared, and with the use of a waiting or pop-up strategy. The use of a pop-up strategy was also related to greater slowing when participants were to make their PM response. However, none of the demographic variables correlated with PM performance, nor did the post-experiment variables intended to assess participants' perceptions of task difficulty.

Also of interest were the Ospan and Stroop correlations which did not relate with PM performance. Ospan score did correlate with the response latencies when participants were supposed to make their PM response. These results suggest that participants who scored lower in working memory capacity slowed more at this juncture than those who scored higher. In contrast to the behavioral only condition, Ospan score did correlate with Stroop performance. The results replicate Kane and Engle (2003) showing that participants who scored lower in the Ospan task experienced greater slowing on color word trials than neutral word trials compared to those who scored higher in the Ospan task.

Table 10
Eye Tracking Condition Bivariate Correlations. Values significant at α = .05 are marked with a single asterisk (*) and values significant at α = .01 are marked with two (**). Variable 9 was the only post-experiment outcome related to PM performance.

Eye Tracking Condition Bivariate Correlations

		1.	2.	3.	4.	5.	6.	7.	8.
1.	PM	1							
2.	PM Latency	.38*	1						
3.	Change Trial Fixation Duration	.66**	.67**	1					
4.	Change Trial Fixation Count	.38*	.61**	.62**	1				
5.	Interval 1 Fixation Duration	-.08	.10	.06	.18	1			
6.	Ospan Score	.09	-.29*	-.22	-.21	-.04	1		
7.	Stroop Word Errors	-.05	.27*	.09	-.04	-.25	-.06	1	
8.	Stroop Latency Difference	.01	.10	.18	.06	.00	-.35**	.19	1
9.	Strategy	.40**	.35*	.19	-.15	.03	-.09	.03	.20

Variables that shared a significant correlation with PM were entered simultaneously into a multiple regression analysis to determine which might actually predict PM performance. The outcome of the regression model for the behavioral only condition is in Table 11. The table includes beta values (β), semipartial correlations, the significance test (*t* (34)) for each predictor variable, and the multiple R^2 value for the entire model. The multiple regression model was able to account for 50% of the variance in PM performance. To prevent issues with multicollinearity, the response latency results that correlated with PM performance were not included with the exception of response latencies when the PM response was supposed to be made. Unlike the behavioral only condition, the only two significant predictors were the amount of time spent processing the LDT when the change occurred and the type of strategy that was employed. The outcome of the regression analysis suggests that slowing in the presence of the cue benefits PM performance, and that the use of a pop-up strategy was advantageous in the current paradigm.

Table 11
Eye Tracking Condition Regression Model. Values significant at α = .05 are marked with a single asterisk (*) and values significant at α = .01 are marked with two (**).

Eye Tracking Condition Regression Model

Variable	β	Semipartial *r*	*t*-value	R^2
PM Latency	-0.12	-0.09	-0.71	.50**
Change Trial Fixation Duration	0.58	0.43	3.54**	
Change Trial Fixation Count	0.18	0.14	1.15	
Strategy	0.26	0.25	2.04*	

Note – $R^2 = .50$, $F(4, 34) = 8.56$, $p < .01$.

Chapter 7 General Discussion

The purpose of the present study was to improve our current understanding of the cognitive processes that are carried out in event-based PM tasks. Of major debate in the literature is the extent that resource demanding processes are required to complete these tasks. Where some have found that event-based PM intentions can be completed without consuming additional attentional resources beyond those required to complete the ongoing task (e.g., Einstein et al., 2005), others have found that adding an intention to the ongoing task taps a resource pool that must be shared between the two tasks, negatively influencing ongoing performance (e.g., Smith et al., 2007). A precedent has been set to examine the cognitive processes involved in PM tasks by measuring the response latencies during the ongoing task. However, it is possible that response latencies capture processes that are not directly related to the task set (e.g., Marsh et al., 2005). If this is the case, response latencies provide an equivocal estimate of the cognitive processes carried out in event-based PM tasks.

The two main goals established for this study were first, to examine whether the current design was sufficient to evoke spontaneous retrieval of the intention or whether monitoring processes would be required to support retrieval. The second goal was to determine if eye movement measures would provide a better measure of the cognitive processes carried out in an event-based PM task over response latencies alone. Of particular interest, was whether eye movements would be sensitive enough to detect monitoring processes that were not detected through the response latency results. The predictions and findings for each goal are further considered.

The Preparatory Attentional view and multiprocess view make contrasting predictions regarding the use of monitoring processes. According to the Preparatory Attentional view, there should have been evidence of monitoring in both the behavioral results and they eye movement results; however, the multiprocess view predicts that the current task conditions were likely to support spontaneous retrieval and eliminate monitoring processes. The behavioral results supported the multiprocess view, and did not suggest that monitoring occurred nor that it would have been beneficial to PM performance. Participants in the PM groups in both the behavioral only and eye tracking conditions displayed comparable performance to their control group in the ongoing LDT. The fixation duration and number of fixation results replicated the behavioral measures, even though these measures were expected to be more sensitive and more likely to detect evidence of monitoring.

Importantly, the results showed that the PM cue was distinct and noticeable and that these qualities led to spontaneous retrieval of the intention. In both the behavioral only and eye tracking conditions, when the color change appeared at baseline, everyone slowed significantly. In comparison, only the PM groups slowed when the color change appeared during the performance block. These results suggest that the PM cue captured attention at baseline, and at performance only those with a goal to respond to the change took notice. Evidence of spontaneous retrieval was further supported by the striking similarity in response latencies on the pre-change trial during the performance block for all of the groups in each condition followed by the exaggerated slowing that occurred in the PM conditions on the PM trial. It is essential to point out that this slowing occurred as soon as the change appeared and was not a result of the PM participants making the PM response while the control participants made a lexical decision. The eye movement results showed that this slowing occurred even though most participants did not look at the color change area. Many participants slowed, but maintained fixation on the LDT stimulus.

Further support for the multiprocess view arose in the PM accuracy results. Participants were highly successful at the PM task even though evidence of monitoring was not found, suggesting that these additional resources were not necessary. Although PM performance was very high, there still appears to be room for improvement. The PM results suggest that the distinctiveness of the color change did capture attention and for most participants enabled them to stop processes devoted to the LDT and retrieve information related to the PM tasks. This type of cue may not supersede focal ongoing and PM tasks. As previously noted, the multiprocess view predicts that PM performance benefits from an overlap in the cognitive processes required to complete the PM task and the ongoing task. Thus if the ongoing task also required perceptual processing, PM performance may improve. In addition, the assumption was made that general PM instructions would reduce the cognitive load associated with the PM task compared to specific instructions to respond to a predetermined color; however, this was not directly tested in the current study. Finally, Yantis and Jonides (1990) found that highly focused attention may prevent stimulus onsets from automatically capturing attention. It is possible that missed PM responses were a result of such highly focused attention. It would be worthwhile for future research to examine whether focal processing and/or specific PM instructions would improve PM performance in the current paradigm without finding evidence of monitoring.

In regard to the first goal, the behavioral and eye tracking results from the current study supported the multiprocess view and showed that the current conditions were sufficient to support PM performance without monitoring and also elicited spontaneous retrieval of the intention. In comparison, conclusive evidence showing that eye movements provided a better estimate of monitoring processes than response latencies was not obtained. This, however, should be interpreted with caution because null results were obtained in both measures regarding monitoring processes. Although evidence of monitoring was not obtained, the eye movement data did provide insight into the cognitive processes that were engaged during the change trial. Additionally, the eye movement results provided insight into potential individual differences in "checking" behaviors.

The eye movement data showed that while most participants were able to make their PM response without fixating on the color box on the PM trial, those that did fixate on the PM cue all remembered to complete the intention. None of the participants who missed the PM response ever fixated on the PM cue. This is in contrast to West et al. (2007) who found that on close to 50% of missed PM trials, participants actually fixated on the PM cue. The current results shed some light on how the PM cue captures attention and suggests that when the PM cue is strong enough to capture overt attention, PM success is highly likely. In contrast, when only covert attention is captured, PM success may still occur but the rate of success declines. In addition, participants who never looked at the color box on the change trial and forgot to carry out the intention may exemplify those proposed by Yantis and Jonides (1990) to be engaged in highly focused attention away from the onset, which prevented the onset from automatically capturing attention.

The eye movement results were also expected to provide insight about individual differences in monitoring, if they occurred. In general evidence of monitoring was not found, but there was initial evidence suggesting that some participants occasionally checked the box color. Some participants were more likely to look at the color change area, although very infrequently. In the current study, very few participants ever checked the box color on the non-change trials, but the pattern of results from the performance block may indicate monitoring behaviors. During the performance block control participants were likely to look at the box immediately following a change. In contrast, the PM participants who looked on non-change trials were more likely to do so at random points throughout the block. These results suggest that control participants looked at the box because the change caught their attention. However, the PM participants' random checking may point to instances where the participant consciously oriented overt attention toward the box or instances where overt attention was oriented outside of conscious awareness. In either case, they represent shifts in overt attention that may resemble monitoring processes, and that likely would not be detected by the response latency results. Response latencies on these trials were not much different from trials where participants did not check the box color. It is possible that the some of the discrepant findings in the literature were in part due to the degree that response latencies detect processes not associated with the task set and individual differences in checking behaviors. In other paradigms, where the cue may not be as distinct but monitoring was still not theoretically necessary, there may have been a larger number of participants who actually "checked" for the cue or a few who "checked" often who went unnoticed because checking was not directly assessed. Although broad evidence of monitoring was not found in the eye movement results, they did provide greater insight into the cognitive processes carried out during the ongoing task and when participants made or missed the opportunity to make the PM response.

Another potential concern was related to participants' perceptions of the task set, which may confound the results reported in the literature. This issue was dealt with in two ways: first, by instructing PM participants to place emphasis on one task over the other, and second, by directly assessing their perceptions at the end of the experiment session. The current results did not show meaningful differences between the PM groups, nor did perceptions of difficulty influence evidence of monitoring. These results suggest that the qualities of the task set, such as the very noticeable PM cue, likely served to mitigate the influence of the instructions and perceptions of the task set. Participants tended to rate the task set as not difficult, almost all of the participants said they placed more effort on the LDT over the PM task, and similarly said they thought the LDT was the most important component. Preference was given to the LDT in both effort and importance, regardless of the PM emphasis instructions. Thus, under the current conditions where the task set was universally perceived as easy, emphasis instructions and attention allocation policies did not influence the results. Attention allocation policies are thought to be set based on an individual's perceptions of the task set. If everyone's perception is the same, then there should not be variability in attention allocation policies.

The final outcome of the current study showed that slowing that occurs when the PM cue appears is the best predictor of PM performance. This was the case for both the behavioral results and the eye movement results. Additionally, the results did not show an influence of working memory ability or inhibitory abilities on PM performance. This outcome is in line with the multiprocess view that the current design did not require monitoring and therefore should not be related to attentional measures.

The current findings provide support for the multiprocess view, in additions to providing fruitful evidence from eye movement measures. However, there are a few limitations to the current study that need to be addressed. First, there were a few inconsistencies in the behavioral results between the behavioral only condition and the eye tracking condition. Some of these issues were likely caused by low power in the eye tracking condition. For instance, the behavioral only condition showed significantly faster response latencies in the performance block interval compared to the baseline block interval. The effect of block failed to reach significance in the eye tracking condition, but the effect size obtained from each analysis was similar (behavioral only condition, $\eta_p^2 = .06$; eye tracking condition $\eta_p^2 = .04$). These results suggest that the effect of block accounted for a similar amount of the variance, but there was not enough power in the eye tracking condition for the results to reach significance.

Similarly, the pattern of results obtained from the “Next” slide varied slightly. This can likely be attributed to the different response mechanisms in each condition. The “Next” response in the behavioral only condition was to press the spacebar on the keyboard. This was a very easy response and one that participants likely had ample experience with before entering the experiment. This would explain the very rapid “Next” response obtained by this condition as well as the similarity in responding. In comparison, the “Next” response in the eye tracking condition was to press a button on the top of a game controller. For participants without gaming experience, this may have proven to be a slightly more difficult response. In fact, participants were often observed pressing the button more than once before a response was registered. This may account for the improved latencies observed from baseline to performance. Importantly, neither group showed evidence of monitoring during the “Next” slide.

One major inconsistency that warrants a discussion is the difference in ANCOVA results on the performance block latencies with baseline as the covariate between the two experimental conditions. The behavioral only condition showed poorer performance in the ongoing and PM emphasis conditions compared to the control condition. At first glance, this outcome seems to resemble monitoring; however, it is not immediately clear why the ongoing emphasis group would show evidence of monitoring and the no emphasis condition would not show a similar pattern. One alternative explanation is that emphasizing either task, increases the amount of cognitive resources given to the task set. In turn, participants in the ongoing emphasis group may not have improved as much as expected because they were focused on improving accuracy in the LDT during the performance block resulting in a trade-off in latency improvement. In comparison, the PM emphasis group may have obtained a similar pattern of results because they did engage in monitoring processes to ensure that they remembered to complete the intention. This account can explain the intermediate results obtained in the no emphasis group. The no emphasis group did not have the same incentive to focus on one task over the other allowing them to improve compared to baseline, but they also had an intention to maintain, preventing them from improving as much as the no intention control improved. The latter account, that placing emphasis on either task increases the cognitive demand of the task set, seems to be more plausible. However, the pattern of results from the eye tracking condition raises an issue for both accounts. The PM emphasis group in the eye tracking condition showed the greatest improvement and the no emphasis group got slower during the performance block. The ANCOVA results did not yield a significant effect of group, but this was likely a result of low power. The simplest interpretation is that the small sample size of the eye tracking condition may be producing unreliable results. Thus, if more participants were included in this condition the results may take on the pattern obtained from the behavioral only condition. This inconsistent pattern of results presents a problem for the current study that limits the ability to generalize the findings.

Finally, the relationship between Ospan and Stroop performance varied across the two experimental conditions. First, no relationship was found between Ospan and Stroop performance in the behavioral only condition, but those with higher Ospan scores in the eye tracking condition were significantly less likely to slow on color word trials compared to neutral word trials (Stroop latency difference values). The former finding supports Miyake et al. (2000) while the latter replicates Kane and Engle (2003). Second, and markedly, the direction of the correlation between Ospan score and Stroop word errors was different in the behavioral only condition than the eye tracking condition. These conflicting outcomes may call into question the reliability of one or both tasks and the ability to generalize any relationships obtained between these variables, but are not thought to be a major limitation of the current study. The main reason for including the Ospan and Stroop tasks was to determine if Ospan and Stroop performance were capable of predicting PM performance and monitoring. As evidence of monitoring was not found, the relationship between Ospan score and monitoring and Stroop performance and monitoring is moot. Because monitoring did not affect PM accuracy, the same argument can be made for the relationship between PM performance and Ospan score and PM performance and Stroop performance. In other words, a relationship between Ospan score and variables affecting prospective memory and Stroop performance and variables affecting prospective memory were expected to occur only if the prospective task required attentional resources.

Despite these limitations the value of the current proposal rests on the novel findings obtained from the eye movement results. First, the results of the study have provided some insight into the discrepancies reported in the literature. Second, the current methodology allowed the cognitive processes associated with the ongoing task and those associated with the PM task to be teased apart. Third, the eye movement results have shown initial evidence that covert attention alone may not guarantee PM success, even though it may still occur. Importantly, the current results show the potential usefulness of eye movement measures to PM studies.

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Appendix A

Dependent Variables and Measures

Variable or Measure	Cognitive Process Assessed	Influence on PM performance
Correct LDT Response Latencies	Amount of time required to make correct lexical decisions – longer responses by the PM groups indicates influence of monitoring	Slower responding may increase the likelihood of completing the PM task
PM Performance		
Fixation Durations on the LDT (correct responses)	Amount of time required to make correct lexical decisions – longer responses by the PM groups indicates influence of monitoring	Longer durations may increase the likelihood of completing the PM task
Number of Fixations on the LDT (correct responses)	Estimate of the resources required to make correct lexical decisions – more fixations by the PM groups indicated influence of monitoring	More fixations may increase the likelihood of completing the PM task
Ospan	Working Memory Capacity	Higher capacity scores should be related to better PM performance
Stroop	Ability to inhibit irrelevant information – more errors and greater response latency difference scores suggest worse ability to inhibit	Fewer errors and lower difference scores should be related to better PM performance
Task Set Difficulty	Subjective index of difficulty	Viewing the task set as difficult may increase likelihood that participants will engage in monitoring
More Effort	Subjective index of cognitive	Devoting more effort away from the

Devoted to LDT	effort devoted to the ongoing task	PM task should decrease PM performance and evidence of monitoring
More Effort Devoted to PM task	Subjective index of cognitive effort devoted to the PM task	Devoting more effort toward the PM task should increase PM performance and evidence of monitoring
LDT Most Important	Subjective index of task importance	Should decrease PM performance and monitoring
PM Most Important	Subjective index of task importance	Should increase PM performance and monitoring

Appendix B

Demographics Questionnaire

1. Please indicate your grade level.
    a. Freshman
    b. Sophomore
    c. Junior, Senior
    d. 5th Year or More [Participants were instructed to answer this question based on the number of credit hours they had completed. The 5th Year or More option only applied to graduate students.]
2. Please indicate your gender.
3. What is your Ethnicity?
    a. White
    b. African American
    c. Asian American
    d. Hispanic/Latino
    e. Native American
    f. Other
4. Is English your first language?
5. How many exams do you have this week?
6. How much sleep have you had over the last 48 hours?
7. How many 12 oz cups of caffeine have you consumed today?
8. How many medications are you currently taking?
    a. What is the name of each medication?
    b. What is the purpose of each medication?
9. Do you have normal, corrected to normal, or uncorrected vision?
10. Are you red/green colorblind?
11. Please indicate the time of day at which you perform your best.
    a. 12am-4am
    b. 4am-8am
    c. 8am-12pm
    d. 12pm-4pm
    e. 4pm-8pm
    f. 8pm-12am

Appendix C[1]

Post-Experiment Questionnaire

Subject #: __________ Part 1 Exp Name: ____________________________________

1. Did you notice the box change colors during the last task?
2. If so, how many times did it change colors?
3. What colors did it change to?
4. Please rate the difficulty of noticing this box color change on a scale of 1 (very easy) to 10 (very difficult).
5. Please rate the difficulty of the word/nonword task on a scale of 1 (very easy) to 10 (very difficult).
6. Please indicate with an "X" on the line below, what proportion of your efforts were devoted to the color change task versus the word/nonword task. If you did not receive instructions for the color change task, please skip this question.

Effort more toward Color Change Task — Effort more toward Word/Nonword Task

7. Which task did you think was most important? If you did not receive instructions for the color change task, please skip this question.
8. How difficult was it to perform both tasks together? Please make your rating on a scale of 1 (very easy) to 10 (very difficult). If you did not receive instructions for the color change task in addition to the word/nonword task, please skip this question.
9. Did you remember to complete the color change task?
    a. What were you instructed to do when you noticed a color change?
10. If so, were you able to do so because you continuously searched for color changes or because it just popped into mind?

[1] Participants in the control group only answered questions 1-5. Question 1: "yes" responses were coded as 1 and "no" responses were coded as 2. Question 6: the visual scale was converted into a numerical scale that ranged from 1 to 9 with lower values indicating more effort toward the color change task, and higher values indicating more effort devoted to the word/nonword task. Question 7: 1 = word/nonword was indicated as most important, and 2 = PM task was most important. Question 9: 0 = "no", 1 = "once" (if this was indicated), and 2 = "yes". Question 10: 0 = none, 1 = "search", 2 = "both", and 3 = "pop-up".

Appendix D[2]

Performance Block Instructions

Control: In this experiment, we are also interested in your ability to perform different cognitive tasks. You will engage in another task and then return to a task similar to the one you just completed. When you return to the word judgment task, you may occasionally notice one of the boxes on the screen change colors. Do your best to ignore these changes and continue making your word/nonword judgments. You will have a few practice trials to familiarize yourself with this task. Do you have any questions? Press ENTER when you are ready to begin.

Ongoing Emphasis: In this experiment, we are also interested in your ability to perform different cognitive tasks. Specifically, we are interested in your memory for doing something in the future. If at any point while you are making your word/nonword judgments you notice a color change in the bottom [top] center box, please press the tilde "~" key [B button]. Please press the "~" key [B button] AFTER you have made your word/nonword judgment, but BEFORE you press the SPACE bar. You must press the "~" key [B button] anytime you encounter a color change. Pressing the "~" key [B button] will return the box to its original color. Although we are interested in your memory for this task, it is MOST important that you perform your word/nonword decisions as quickly and accurately as possible. Thus, please place emphasis on making word/nonword judgments. You will have a few practice trials to familiarize yourself with this task. Do you have any questions? Press ENTER when you are ready to begin.

No Emphasis: In this experiment, we are also interested in your ability to perform different cognitive tasks. Specifically, we are interested in your memory for doing something in the future. If at any point while you are making your word/nonword judgments you notice a color

[2] The instructions in brackets, e.g., [top] and [B button] refer to the counterbalancing condition instructions and the eye tracking condition PM response respectively.

change in the bottom [top] center box, please press the tilde "~" key [B button]. Please press the "~" key [B button] AFTER you have made your word/nonword judgment, but BEFORE you press the SPACE bar. You must press the "~" key [B button] anytime you encounter a color change. Pressing the "~" key [B button] will return the box to its original color. You will have a few practice trials to familiarize yourself with this task. Do you have any questions? Press ENTER when you are ready to begin.

PM Emphasis: In this experiment, we are also interested in your ability to perform different cognitive tasks. Specifically, we are interested in your memory for doing something in the future. If at any point while you are making your word/nonword judgments you notice a color change in the bottom [top] center box, please press the tilde "~" key [B button]. Please press the "~" key [B button] AFTER you have made your word/nonword judgment, but BEFORE you press the SPACE bar. You must press the "~" key [B button] anytime you encounter a color change. Pressing the "~" [B button] key will return the box to its original color. Although we are interested in your memory for this task and your ability to make word/nonword judgments, it is MOST important that you remember to press the "~" key [B button] when you encounter a color change. Thus, please place emphasis on noticing the color change and remembering to press the "~" key [B button]. You will have a few practice trials to familiarize yourself with this task. Do you have any questions? Press ENTER when you are ready to begin.

Vita

Noelle Brown is from Peachtree City, Georgia, and graduated from McIntosh High School in1998. She received a four-year athletic scholarship to attend the University of Central Florida where she received her Bachelor of Science degree in psychology in 2003. In 2005 she was accepted to Louisiana State University's doctoral program in the field of cognitive psychology, and awarded a Huel Perkins Fellowship. In 2007, Noelle received her Master of Arts in psychology from Louisiana State University. Noelle currently works with Dr. Jason L. Hicks where she studies prospective memory and recognition memory.