MONITORING IN LABORATORY AND REAL-WORLD TASKS

By

Allen L. Nida

Amanda J. Clark
Assistant Professor of Psychology
Committee Chair

Jill Shelton
Assistant Professor of Psychology
Committee Member

Amye Warren
Professor of Psychology
Committee Member

MONITORING IN LABORATORY AND REAL-WORLD TASKS

By

Allen L. Nida

A Thesis Submitted to the Faculty of the University of
Tennessee at Chattanooga in Partial
Fulfillment of the Requirements of the Degree
for Master of Science: Psychology

The University of Tennessee at Chattanooga

Chattanooga, TN

May 2016

ABSTRACT

Remembering to complete a future task, known as prospective memory (PM), often requires expending attention toward monitoring for the opportunity to complete that task. Current research indicates a lack of evidence for an individual's ability or propensity to monitor during laboratory PM tasks having any real-world correlate. This study assessed the relationship between monitoring during two PM tasks and performance during the UTC Multiple Errands Test (UTC-MET), a naturalistic measure of executive function. A sample of 8 healthy older adults was compared to 9 older adults diagnosed with Parkinson's disease. While accuracy on an eye-tracking PM task was a significant predictor of UTC-MET task completions, no other significant relationships were observed between these tasks. This suggests that laboratory-based PM performance is predictive of task completions when multiple goals must be considered simultaneously but other relationships between PM and executive functions remain unclear.

DEDICATION

This thesis is in dedication to my wonderful sister. You have demonstrated to me the value of an education, and have given me the courage to persevere through life's trials. Without your example, I almost certainly wouldn't have made it this far.

This work is also in dedication to my best friend Jordan Stephens, for sparking sincere, unbiased curiosity in my pursuit for understanding. You have been a role model for the type of academic I would love to become. I hope that your influence in my life will continue for years to come.

ACKNOWLEDGEMENTS

I would like to acknowledge my mentor, advisor, and friend, Dr. Amanda Clark. You have guided me toward this moment for nearly half a decade. There are no words I can conjure to express the gratitude and admiration I have for you. All this time, you saw something in me I couldn’t. This pushed me to become the student and researcher you knew I could be. Your words of encouragement and patience have guided me towards success. I would also like to thank my thesis committee members for their time and guidance throughout the thesis process. I would also like to thank my lab mate, Chris Branson, for aiding me with data collection and imputation. Your help has been invaluable. I would like to thank Sarah Finley and Carrie LeMay for believing in me, and allowing me to annoy them while working in the lab. Finally, I would like to thank my classmates and colleagues within the psychology department. You have all been a delight to work with.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PM, Prospective memory

PAM, Preparatory Attention and Memory Model

MET, Multiple Errands Test

PD, Parkinson’s disease

BA10, Brodmann’s Area 10

ABI, Acquired brain injury

UTC-MET, University of Tennessee Chattanooga-Multiple Errands Test

CHAPTER 1

INTRODUCTION

Many of life's activities involve keeping track of our goal-directed behaviors and external events that occur while trying to achieve those goals. This "keeping track" is often called strategic monitoring (McDaniel & Einstein, 2007). Examples of strategic monitoring include keeping track of the time so as not to miss an important appointment or watching other motorists while driving to ensure your safety as well as the safety of others. Strategic monitoring (henceforth simply referred to as monitoring) may also be necessary during prospective memory (PM) tasks (McDaniel & Einstein, 2007). PM is the process of remembering to complete tasks that must be put off until a particular time or when a particular event occurs. Whether monitoring is necessary during laboratory-based PM tasks has been the source of much theoretical debate (see McDaniel & Einstein, 2010; Smith, 2003; 2010), which in turn has led to a better understanding of PM and monitoring during laboratory-based tasks. However, researchers' understanding of monitoring during PM tasks remains limited in that there are few studies that have attempted to relate monitoring to any naturalistic task; PM related or otherwise.

In essence, the study of PM is concerned with the cognitive and behavioral mechanisms surrounding intentionality (McDaniel & Einstein, 2007). An intention is a task that must be put off until a pre-specified time or event, otherwise known as a cue, has occurred. A PM cue is anything that informs an individual that they should now engage in the intended task. For example, an individual may make the intention that he or she will take a medication once a timer goes off. Taking the medication would be considered the intention, while the timer would be the cue to complete that intention.

McDaniel and Einstein (2007) further elaborated on the requirements for what can be considered a PM task. First, they state that the intention cannot be completed immediately. In other words, some amount of time must elapse between the formation of a PM intention and when that intention can actually be carried out. Second, the cue for the initiation of a PM task should occur simultaneous with another activity; this simultaneous activity is typically referred to as the ongoing task. Third, there should be a limited amount of time allotted for the PM task to be initiated and completed once the appropriate cue for its commencement has occurred. Finally, the PM task cannot be habitual or part of a routine.

Theories of Prospective Memory and Monitoring

Much research has been dedicated toward two competing theories that attempt to describe the cognitive mechanisms that support PM. The Multiprocess Framework (McDaniel & Einstein, 2007) suggests that our ability to remember to complete tasks in the future can function through two means: monitoring and spontaneous retrieval. The Multiprocess Framework posits that individuals are most likely to monitor for the opportunity to complete a PM task when the cue to respond does not naturally occur within the individual’s focus of attention. As such, these types of PM tasks are referred to as non-focal – the cue is not within the focus of ongoing task.

Conversely, focal PM tasks involve cues that do occur within the focus of an ongoing task. Focal tasks do not require the individual to switch attention between the ongoing task and the intended PM task. Therefore, the cognitive processing that occurs during the ongoing task allows for the identification of the cue such that the intention is retrieved in an automatic or spontaneous way. This focal PM task then, according to the Multiprocess Framework (McDaniel & Einstein, 2007), does not require monitoring.

To illustrate the difference between focal and non-focal tasks, imagine that an individual is driving home from work and must remember to get off at a different exit than usual to pick up clothes from the dry cleaner. Apart from the other cognitive demands related to driving (e.g., focusing on the road, other drivers, the radio, etc.), he or she must also remember to complete a PM task (picking up dry cleaning) that is not within the focus of the ongoing task (i.e., driving). Non-focal tasks such as this, according to the Multiprocess Framework (McDaniel & Einstein, 2007), would require monitoring of the driving environment for a cue to turn off of his or her regular route in order to successfully complete the task of picking up the dry cleaning. In an adaptation of this scenario though, the intention could be spontaneously retrieved if the dry cleaner happened to be located on the same road as the individual's residence. The mere location of the dry cleaner being within the typical driving environment would serve as a visual cue, so that rather than devoting cognitive resources toward monitoring, the cue (the dry cleaner) would spontaneously trigger the individual's memory of the intention that must be completed (McDaniel & Einstein, 2007). However, there is ongoing debate around whether monitoring is required for focal PM tasks (Smith, 2003).

Another theory regarding retrieval of PM intetnions is referred to as the Preparatory Attention and Memory model (PAM; Smith, 2003). Unlike the Multiprocess Framework, the PAM model asserts that if an individual is to be successful in completing a PM task, monitoring must always take place. The PAM model leaves no possibility for intentions to be spontaneously retrieved. Additionally, this theory suggests that PM retrieval is dependent upon attention-related resources to be consistently dedicated toward monitoring for the PM intention.

The debate over whether spontaneous retrieval of PM intentions is possible has sparked much research that has led to a very rich understanding of how humans monitor within laboratory settings (Einstein et al., 2005; Horn & Bayen, 2015; Marsh, Hicks, Cook, Hansen, & Pallos, 2003; McDaniel, LaMontagne, Beck, Scullin, & Braver, 2013). A series of three experiments by Bugg and Scullin (2013) demonstrated that cognitive control, as it relates to executive function, is a significant factor in remembering to complete intentions, as well as appropriately forgetting them. Bugg and Scullin (2013) found that PM tasks that went uncompleted during an active PM phase were more likely to be responded to later, possibly through spontaneous retrieval mechanisms, during a phase where the PM task was no longer relevant. Erroneous PM responses could be indicative of a number of executive-related issues including deficits of inhibition resulting from the Zeigarnik effect (1938). The Zeigarnik effect refers to the heightened activation of tasks in memory that have been left incomplete, comparative to completed tasks.

In most laboratory research, monitoring is assessed by ongoing task costs. Ongoing task costs are measured by comparing mean response times during a condition with a PM task and a condition without a PM task (e.g., Smith & Loft, 2014). Increased response times to stimuli within a condition with a PM task are interpreted to suggest that the individual must devote attention away from the ongoing task, and toward monitoring for the opportunity to complete the PM task. There are very few studies wherein monitoring has been assessed via other means (for such a study see West, Carlson, & Cohen, 2007).

Using ongoing task cost as a universal method of measuring monitoring could be argued as being problematic both in terms of assessing the necessity of attention-related cognitive resources in PM retrieval (Einstein & McDaniel, 2010) and in establishing construct validity and ecological validity. Common method bias is a type of measurement error that is associated with implementing only one or very few methods of measurement (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Using a prototypical type of measurement infringes upon researchers' abilities to make conclusions about the variables they are measuring outside of the context of the particular paradigm. Therefore, it could be of use to implement other measures of monitoring such as West et al.'s (2007) use of eye-tracking technology to measure monitoring through visual attention.

Similarly, there are few studies that have examined the relationship between an individual's ability, or propensity, to monitor within a naturalistic task. There have been studies that have examined the relationship between PM performance in the laboratory and PM performance in naturalistic tasks, however this relationship is not well understood. For example, studies with healthy older adults demonstrate that their PM performance in laboratory settings is worse than that of younger adults. Interestingly however, older adults actually outperform younger adults in naturalistic PM tasks. This phenomenon has been termed the age-related PM paradox (Ihle, Schnitzspahn, Rendell, Luong, & Kliegel, 2012), and is a significant exemplar of how laboratory performance might not actually translate to abilities in the "real world".

Prospective Memory, Monitoring and Executive Function

There are circumstances where laboratory tasks might be insufficient for understanding how individuals perform during naturalistic tasks. The study of executive function is one example of where laboratory assessments may not directly relate to actual participant ability in the real world (Crawford, 1998). Executive function involves a number of cognitive abilities such as monitoring, set-shifting, initiation, working memory, and attention (Elliott, 2003). All of these cognitive functions are involved in propelling an individual toward the completion of his or her goals. Since monitoring, an executive function, plays a role in the ability to complete goals, measuring monitoring as it relates to naturalistic tasks is integral to our understanding. Brewer, Knight, Marsh, and Unsworth (2010) demonstrated that individuals with high working memory ability have perform better on measures of non-focal PM, evidencing the link between executive function and non-focal PM tasks. Likewise, Rose, Rendell, McDaniel, Aberle, & Kliegel (2010) found that working memory was a significant predictor for remembering to complete irregular PM tasks in older adults during a naturalistic laboratory PM task called the Virtual Week (Rendell & Craik, 2000). However, Crawford (1998) suggests that laboratory-based measures of executive function may be too structured, and therefore may miss many of the problems that individuals with executive dysfunction face in their daily lives: where many tasks are open-ended and unstructured. That is to say, these measures lack the necessary ecological validity to properly characterize possible dysfunction (Burgess et al., 2006).

For example, McAlister and Schmitter-Edgecombe (2013) investigated how age-related differences in PM performance and executive function might translate into real-world performance using a naturalistic measure of executive function called the Day Out Task (Schmitter–Edgecombe, McAlister, & Weakley, 2012). Testing took place in an apartment setting where participants were asked to complete a number of tasks to prepare for a day out. PM was measured using the Activity-Based Multiple Memory Processes Paradigm: Prospective Memory Test (Schmitter-Edgecombe, Woo, & Greeley, 2009). This PM assessment involved eight neuropsychological tests. During the completion of those tests, participants were instructed to remember to ask an experimenter for a medication for a pretend friend whenever asked to rate how difficult each of the neuropsychological tests were. PM performance was measured by how many times the participant successfully remembered to complete the intention.

In this study, the authors found that PM performance was uniquely predictive of inefficient task completions and poor task sequencing. McAlister and Schmitter-Edgecombe (2013) suggest that older adults' reduced PM performance within laboratory settings could correlate with real world tasks that require the creation, maintenance, and implementation of strategies in order for efficient completion. In other words, when executive control is required for the completion of multiple goals, laboratory PM task performance that also relies on one's executive ability might predict completion of naturalistic goals. Therefore, individuals who have acquired executive-related deficits may have difficulty completing naturalistic goals in comparison to healthy controls.

A study conducted by Draper and Ponsford (2008) suggests that damage or disruption in the frontal lobes is related to a number of long-term cognitive and executive function-related deficits as assessed by standardized laboratory neuropsychological measures. Likewise, Morrison et al. (2013) implemented a revised version of a naturalistic shopping task called the Multiple Errands Test (MET) to assess executive function in participants six months following a stroke. Though they found that laboratory measures of executive function, that were administered at the time of hospital discharge, demonstrated no evidence of impairment, the revised Multiple Errands Test showed that the participants who had incurred a stroke had significant impairment compared to controls. While Draper and Ponsford (2008) and Morrison et al. (2013) have demonstrated that acquired brain injury relates to at least certain executive abilities in everyday life, the relationship between acquired brain injury and PM as examined in laboratory and naturalistic settings is an area of study that is still in its infancy. However, a growing amount of research seems to suggest that individuals with brain injury and/or degeneration such as Parkinson's disease (PD) that affects the prefrontal cortex or it's connected structures have difficulty with PM (Kliegel, Eschen, & Thöne-Otto, 2004; Mathias & Mansfield, 2005).

Burgess, Gilbert, Okuda, and Simons (2006) suggest that Brodman's Area 10 (BA10), the largest and most anterior structure within the prefrontal cortex, allows for the fluid transition of attention between multiple goals, ongoing tasks, and the strategies one must implement to see those goals to fruition. They have also suggested that when disruption to this area occurs it is accompanied with a number of executive function related deficits such as a reduction in monitoring, PM performance, and strategic goal performance. Consistent with their assertions, McDaniel and colleagues (2013) used functional magnetic resonance imaging (fMRI) to better understand which brain structures and neural pathways might be related to focal and non-focal PM task performance. They found that the left anterior prefrontal cortex, an area commonly associated with attention related monitoring during PM tasks (Burgess, Gonen-Yaacovi, & Volle, 2011), showed consistent activation during a non-focal PM task. This pattern of activation was not found during the focal PM task.

BA10 is not involved in maintaining the content of goals and strategies in memory. Rather, it is believed to be uniquely involved in switching attention between internal thoughts and task-relevant stimuli that involve one's ongoing goals (Burgess et al. 2006). Non-focal PM performance is also reliant on switching attention from an ongoing task toward a mental representation of an intention and its associated cue (Kliegel, Phillips, Lemke, & Kopp, 2005). Therefore, as BA10 is involved in the coordination of thinking about individual activities or strategies involved in completing a future goal and directing attention toward cues related to currently ongoing tasks (e.g. monitoring; Burgess, et al., 2006), it may also be involved in both monitoring during non-focal PM tasks and successfully applying strategies to be efficient in other, non-PM tasks

Executive Dysfunction in Those with Neurological Damage

The relationship between the frontal lobes, monitoring, PM performance, planning, strategy use, and other executive abilities has been studied under a variety of conditions. Many PM researchers agree that non-focal PM tasks require an individual to use executive functioning to facilitate PM intentions as the PM task requires self-initiated monitoring (McDaniel & Einstein, 2007; McDaniel et al. 2013; Smith, 2003). Much of what is known about how executive function relates to PM has been attained through research with healthy older adults and studies involving individuals with an acquired brain injury (ABI) or degeneration.

In their seminal study, Shallice and Burgess (1991) conducted a series of three case studies wherein the original MET was used to assess how executive dysfuntion manifests in a naturalistic shopping experience. During the MET, participants are asked to complete a number of tasks while simultaneously following a set of rules that govern how the tasks should be completed. Some rules are based on how one would typically go about completing tasks efficiently. For example, participants are instructed that they should never go into the same store twice while completing their list of tasks, as this would be inefficient. Upon observing the participants, Shallice and Burgess suggested that they were disorganized, broke many rules, and left many tasks incomplete. Building on those case studies, Burgess et al. (2008) suggest that many of the inefficient behaviors committed during the MET by individuals who have sustained frontal lobe damage could be conceptualized as PM failures. Buying only one item at a store when the participant could have purchased two is an example of a possible PM failure. However, there is still little research examining how PM performance, and more specifically, monitoring behavior in laboratory settings, might relate to inefficient behavior while completing multiple tasks.

Prospective memory, executive function, and monitoring deficits are not limited to healthy older adults and individuals who have acquired a brain injury. Individuals diagnosed with neurodegenerative disorders, such as PD have also demonstrated difficulties during PM tasks. Though PD symptomology is predominately related to dysfunction of the basal ganglia, research also suggests that the disease can result in frontal lobe blood flow circulatory disruption (Töster & Fields, 1995) and that the prefrontal structures and the basal ganglia may complement each other in their functional role in guiding goal-oriented behaviors (Dubois & Pillion, 1996). Foster, Rose, McDaniel, and Rendell (2013) used the Virtual Week (Rendell & Craik, 2000) to assess PM performance differences between groups of participants diagnosed with PD and controls. They were also interested in within-subjects differences in PM performance relative to PM task type (focal vs. nonfocal). Foster, et al. (2013) found that PD participants performed equitably with control participants on focal PM tasks. However, participants diagnosed with PD performed significantly worse on non-focal PM tasks, as well as PM tasks that were irregular. Because PD participants performed worse on irregular PM tasks (tasks that weren't repeated), it could suggest that individuals diagnosed with PD have a retrospective memory deficit that accounts for PM deficits associated with PD. Furthermore, this deficit can be overcome when the need for self-driven monitoring is reduced for successful PM.

Using a complex PM task, Kliegel, Phillips, Lemke, and Kopp (2005) compared PM performance between participants diagnosed with PD with healthy controls. Their measure allowed for the discrimination of performance for four phases of PM: intention formation, intention retention, intention initiation, and intention fidelity. They found that individuals diagnosed with PD were worse in the intention formation and the initiation phase. The intention formation phase involved formulating a specific and detailed plan about the tasks to be done and how much time to spend on them, while the initiation phase required the participant to remember to initiate the task at the appropriate time. Kliegel and colleagues interpreted this to indicate that PD participants might have more difficulty creating a plan for complex tasks that require the coordination of multiple goals and strategies. Interestingly, working memory performance explained much of the variance observed in initiation phase. Group differences in intention initiation were interpreted as being a possible result of poor intention formation, though the initiation phase also requires the implementation of strategic monitoring for the PM cue (Kliegel, Altgassen, Hering, & Rose, 2011).

Costa, Peppe, Caltagirone, and Carlesimo, (2008) used a time-based and event based PM task along with a battery of executive function measures to better understand the role frontal lobe systems play in PM deficits that individuals with PD may experience. Time-based PM tasks involve remembering to complete an intention at a pre-specified time. These types of PM tasks are generally categorized as non-focal (Foster et al., 2013) because most ongoing tasks do not involve directing attention toward the time. Rather, in order to complete time-based PM tasks, an individual must take focus away from an ongoing task to monitor for the correct time at which to execute the PM task. Event-based tasks involve remembering to complete the intention once a particular event has occurred. Event-based PM tasks can be categorized as either focal or non-focal depending on whether the cue can be detected without shifting attention away from the ongoing task. In this particular study, Costa at al. (2008) instructed participants diagnosed with PD and a control group to complete a total of three event and time based PM tasks over the course of three blocks of neuropsychological assessments including a modified card sorting task that assessed an individual's ability to alter their responses based on changing of rules and recurring feedback (i.e. set-shifting), a working memory task, and a verbal fluency task. For both the time based and event based PM task, the participant was to remember to carry out the PM intention after a 20-minute interval from the start of the study. The major difference between the time based and event based PM tasks was that the event based PM task was cued by a timer; while the time-based PM task required that the participant monitor a clock for the correct time for them to complete the PM task. Costa et al. (2008) found that time-based PM performance (a task that requires monitoring) was significantly correlated with performance on the modified card-sorting task. Importantly, card-sorting performance was unrelated to performance on the event based PM task: a task that did not require a participant to monitor. This suggests that monitoring ability may be related a PD patient's ability to switch between sets of rules while engaged in an ongoing activity (i.e., sorting and matching cards).

The results from the Costa et al. (2008) study suggest that PM ability on tasks that require effortful strategic monitoring might be related to shifting of attention between multiple tasks in individuals with PD. Indeed, there are other studies that suggest that declines in attention-shifting, or more specifically, set-shifting, are related to declines in non-focal PM tasks (Costa et al., 2014; Kliegel et al., 2011, Monchi, 2004). Set-shifting is a type of executive function that allows for switching attention between two ongoing tasks (Monchi et al., 2004). This ability sounds similar to what Burgess et al. (2010) explain as the primary function of BA10, however only some measures of set-shifting, such as the Wisconsin Card Sorting Task (Grant & Berg, 1985), that requires participants to contend with persistent rule changes, assess an individual's ability to switch attention between mental representations of tasks, strategies, or rules and ongoing tasks (Monchi et al., 2004).

Costa et al. (2014) conducted a study attempting to assess the relationship between set-shifting and PM performance during non-focal and focal PM tasks in participants diagnosed with PD. In addition, Costa et al. (2014) sought to understand if training in set-shifting could improve PM within this sample. They found that participants diagnosed with PD performed significantly worse on non-focal PM tasks that required the allocation of executive resources. Likewise, set-shifting was a significant predictor of PM performance in PD participants, and training in set-shifting improved PM performance compared to a placebo group. Monchi et al. (2004) suggest that set-shifting deficits that occur as a result of PD actually bare resemblance to similar executive dysfunction issues acquired from frontal lobe lesions. Using the Wisconsin Card Sorting Task, a measure of information updating and set-shifting, Monchi et al. (2004) found that individuals with PD have difficulties updating and switching to appropriate rules, resulting in greater errors of perseveration when compared to controls. Additionally, participants with PD also committed more errors even when the current rule was still appropriate, suggesting a deficit in an ability to switch attention between mental representations of task relevant rules and ongoing tasks.

Likewise, Kliegel and colleagues (2011) conducted a review of PM deficits in individuals diagnosed with PD. It was proposed that these deficits predominately occur within the formation and initiation phase, and that these deficits relate to impairment to executive function processes such as monitoring and set-shifting. As such, individuals diagnosed with PD appear to have intact PM when tasks are focal. Like for individuals who have ABI, it is only when the PM task requires strategic monitoring those individuals diagnosed with PD demonstrate significant PM deficits.

Purpose of Current Study

The purpose of the current study is to examine the relationship between monitoring during laboratory-based non-focal PM tasks and performance on a University of Tennessee at Chattanooga version of the MET (UTC-MET) in a sample of participants who have been diagnosed with PD and healthy, age- and education-matched older adults. Though previous research (e.g. McAlister & Schmitter-Edgecombe, 2013) could be interpreted to suggest a probabilistic correlation between monitoring and real-world strategy application and efficiency through the use of non-focal PM task performance (Burgess et al., 2008), there is no research that has correlated monitoring ability on a PM task with any naturalistic measure of executive function. As such, the aim of this study is to examine whether monitoring ability in PM tasks is related to executive functioning as measured by the UTC-MET.

The hypotheses for the proposed study are: (1) PD participants will monitor less during a measure of non-focal PM as well as a novel eye-tracking PM task (Shelton, Christopher, In Press) with a non-focal PM component compared to a non-Parkinson's group. There is much research to suggest that declines in non-focal PM performance accompany executive dysfunction. (2) Participants diagnosed with PD will perform worse than age and education matched participants on a variety of UTC-MET performance indicators. Since there are a number of executive function related declines associated with PD, it is hypothesized that they will perform worse during unstructured tasks where rules must be considered simultaneously with a number of ongoing tasks. (3)

Non-focal PM performance will be significantly related to performance on the UTC-MET, and this relationship will be fully mediated by monitoring ability.

CHAPTER II

METHOD

Participants

Participants in this study were recruited from a variety of local institutions including PD support groups and senior centers. All participants were between the ages of 50-90 years old, were fluent in English, had normal or corrected-to-normal vision, and were safely mobile with minimal-to-no experimenter intervention. Participants within the control group had no history of serious head injury and participants in the PD group were all at least 1-year post diagnosis. Nine participants (three female) diagnosed with PD and 11 (nine female) non-Parkinson's older adults took part in the study.

Materials

The measures that were used in this study were part of a larger battery of neuropsychological and experimental assessments for another ongoing study that focuses more broadly on the everyday life impact of frontal lobe injury and degeneration. The full study took place over two days, but all of the tasks that were used in regard to the hypotheses were conducted on the second day of testing. For a complete list and description of all of the tests that participants completed see Appendix C. Only the measures with relevance to the hypotheses of this current study will be discussed within this section.

UTC Multiple Errands Test (UTC-MET)

The UTC-MET is a naturalistic assessment of executive function that is modified from the original version designed by Shallice and Burgess (1991). The UTC-MET involves completing a series of shopping tasks (e.g. buy a birthday card) while also following a set of rules (e.g. spend as little money as possible) within the University Center at the University of Tennessee at Chattanooga (UTC). These tasks and rules are printed on two sheets of paper and kept in a binder that the participant keeps with him or her while completing the task. Since some of the tasks involve making purchases and gathering information, the participant was also given a pen, a shopping bag, and $5.00. In addition, one of the tasks required that the participant meet the experimenter at a certain location at a certain time. Therefore, he or she was given a watch. A full list of the tasks each participant was asked to complete and the rules they were to follow, see Appendix B (Image 1).

UTC-MET performance is based on six dependent variables called performance indicators. UTC-MET performance indicators are as follows: task omissions, partial task failures, rule breaks, strategy use, inefficiencies, and a total errors composite score computed by summing the scores for omissions, partial task failures, and rule breaks. A task is considered complete if the participant is able to carry out the task as listed on the task sheet in a reasonably effective manner. If a task is not attempted at all, the participant receives a task omission. However, if for some reason the participant leaves part of the task incomplete he or she receives a partial task failure. For example, one task involved mailing something to an individual. If a participant gave the letter to the person who handles the mail, but did not write down to whom the letter should be sent, the participant would receive a partial task failure. In addition, during the UTC-MET, the participant was charged with following certain rules, such as not leaving the main floor of the University Center. If the participant broke a rule, it was marked as a rule break. The use of strategies to help complete tasks is also a variable of interest in the UTC-MET. If the participant went about completing tasks in a strategic manor, such as asking for help to find an item or utilizing self-talk to keep themselves on track, he or she was marked for each strategy used. The participant was also scored on how many task un-related inefficiencies they committed. An example of inefficiency is taking an unwarranted amount of time (> 2 minutes) to shop for a birthday card. Finally, a composite UTC-MET error score was calculated from summing the number of task omissions, partial task failures, and rule breaks.

Eye-Tracking Prospective Memory Task

The eye-tracking PM task is an experimental two-block measure of an individual's ability to complete an intention in the future. To complete this task participants were situated 55-65 cm in front of a laptop computer and a Sensori-Motoric RED-m eye tracker was used to track eye movements and fixation patterns. The "active-PM" block had a PM target that the participant had to remember to respond to, while the control block involved the participant simply completing the ongoing task. Blocks were randomly counterbalanced across participants. Each block consisted of 43 trials composed of collages of images of both living and nonliving objects. The active PM block images were accrued from the original experiment conducted by Shelton and Christopher (In Press). In the original document by Shelton and Christopher (In press), there were images imbedded within the ongoing task that were expected to result in spontaneous retrieval of the intention. It was found that these images resulted in cue-driven monitoring. There were a total of 10 images imbedded throughout the task that were believed to result in cue-driven monitoring. Images for the control block were selected using Google® image searches by a panel of research assistants. The panel decided on a number of search terms that we deemed affectively neutral. After images were gathered, they were numbered and randomly selected for trial number presentation. None of the images were repeated. There was an average of 15 images per collage. See Appendix B (Image 2) for a sample trial image. Each trial was presented for 12 seconds, and trials were separated by a fixation cross displayed for 500ms. The purpose of the fixation cross was to redirect gaze to the center of the screen as that helps to ensure that participants begin viewing the image at the same location. Participants were instructed to count the number of images that depict a living object (ongoing task). Each trial was further subdivided into 4 sub-trials. This was marked by a change in a smaller image that appeared either in the top right or bottom left (depending on the condition) of the collage. This area is called the target area. The smaller picture that appeared in the target area changed every three seconds (each change representing a subtrial). The PM cue (an apple) only appeared four times in the target area throughout the experiment. The PM target appeared on the 9^{th}, 17^{th}, 27^{th}, and 40^{th} trial, and appeared on different subtrials for each of the trials. The participant was instructed to click the left mouse button whenever he or she saw an apple appear in the target area. The decision to counterbalance the location of the PM-target area across participants (top right or bottom left) was made simply to ensure that the location of the target area on the screen did not affect monitoring for the PM cue.

The dependent variables measured by the eye-tracking PM task included PM performance and monitoring. PM performance reflects the amount of correctly executed PM tasks (clicking the left mouse button) when presented with the PM target (an apple in the target area). Responses made three sub-trials subsequent to the presentation of the PM target were considered correct. Monitoring was measured by computing the difference in number of fixations in the target area between the active PM phase and the control phase. A fixation was qualified as any time when the eye rested on an area of 200 pixels for longer than .075 seconds.

D-KEFS Verbal Fluency

The verbal fluency subtest of the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kramer, Kaplan, & Holdnack, 2004) is a measure of initiation, attention, and fluency that involves the participant saying as many words that he or she can think of that begin with a letter of the alphabet that the experimenter provides. The participant is allotted 60 seconds for each of three letter trials. The purpose of this task was to serve as a delay interval to ensure the PM task does not become a vigilance task: a task where successful completion relies upon sustained attention for an extended period of time (McDaniel & Einstein, 2007). The goal of most PM tasks, in general, is to assess an individual’s ability to remember to complete a task in the future, not their ability to hold on to an intention in working memory over extended periods of time. The delay period aids in redirecting attention away from the PM task after the PM task has been given and before beginning the ongoing task in which it is embedded.

Non-focal Prospective Memory Task

The non-focal PM task is a computer-based measure of one's ability to remember to complete an intention once a pre-specified event occurs. It is an adapted version from the task used by Lee, Shelton, Scullin, and McDaniel (2015) E-Prime, a stimulus presentation software suite, was used to present the stimuli and record responses. The non-focal PM task involved participants making semantic categorization decisions about words (ongoing task) while also trying to remember to carry out the PM task. During the ongoing task the participant decided whether a word that appeared in lower-case font on the left hand side of a computer screen was a member of a category word that was simultaneously presented in upper-case font on the right side of the computer screen. For each set of words the participant was instructed to respond yes or no, by pressing either the "1" or "2" keys (respectively) on a keypad, to indicate if the word on the left was a member of the category on the right. The PM task was to press the "Q" key on a keyboard whenever they saw a word beginning with either an "O" or an "L" (PM task). Whether the participant responded to an "O" or "L" word depended on the condition that he or she was assigned to. Some examples of target words are linen, lawyer, orange, and olive. The decision to utilize different PM targets for different conditions was made to ensure that PM performance would only reflect participant ability, rather than an influence from possible (however unlikely) idiosyncratic stimuli. Multiple lists of words and categories were used in the task, and participants were randomly assigned to a specific list. Multiple word-lists were implemented to ensure that PM performance, monitoring, or ongoing task performance were not related to the particular words that were used during the task, but rather were only related to the participant's own ability.

This task had two counterbalanced phases: an active PM phase where the participant had a PM intention that he or she should remember to complete, and a control phase where the participant only completes the ongoing task. These phases were counterbalanced to control for practice effects. Each phase contained 200 trials, and PM targets appeared after every 30 trials. Controlling for practice effects is important because as a participant engages in the same task over an extended period of time he or she could become faster at completing trials due to increased familiarity with the task. Since the main measure of monitoring in the non-focal PM task is that of ongoing task costs, it is important to control for this increased speed due to practice as it could influence the measure of monitoring (Smith, 2007).

There were a total of 6 PM targets throughout the task. PM performance reflects the amount of correct responses (pressing the "Q" key) to appropriate PM targets (words beginning with "L" or "O"). Responses made within three trials of a target presentation were also counted as correct. Monitoring was measured through ongoing task cost. : the difference in mean response times to ongoing task trials during the active PM phase and control phase. A retrospective memory questionnaire was also included in the non-focal PM task. This questionnaire was used to control for retrospective forgetting. Since the task is meant to measure PM performance, controlling for retrospective memory failures is important for an accurate representation of PM ability rather than possible retrospective forgetting of the intention.

D-KEFS Trail Making Task

Participants also completed conditions three and four of D-KEFS trail making task (TMT; Pearson Clinical Assessments, 2001) as the delay interval task for the non-focal PM task. TMT is a measure of processing speed and task switching ability. Condition three involves using a pencil to connect letters scattered amongst numbers in ascending order. Condition four involves switching between connecting letters and numbers in ascending order.

Montreal Cognitive Assessment

The Montreal Cognitive Assessment (MoCA; Nasreddine, et al., 2005) is a measure of mild cognitive impairment in older adults. It consists of 30 items that measure a variety of cognitive abilities such as memory, language, and spatial reasoning. A score below 26/30 is considered below normal. This measure served only to characterize the participants.

Reading Span

Reading Span (Oswald, McAbee, Redick, & Hambrick, 2015) is a computer-based measure of working memory. It was run on *E*-Prime experimental suite. Reading Span is a complex working memory task that instructs participants to judge to whether sentences are sensible or not. Simultaneoulsy, they are asked to recall numbers that appear in between each sentence presentation. Sentences were 10-15 words in length. Number sets ranged from 3-7 items per set, and each set appeared 3 times (for a total of 15 trials). Participants were scored on the correct number of numbers recalled in the correct order. This index constitutes the participant's reading span ability. This measure was included only to aid in characterizing participants.

Procedure

This study received ethics approval from the UTC Institutional Review Board (Appendix C). Upon obtaining informed consent, participants completed a neuropsychological assessment that was primarily used to characterize the sample of participants and to achieve the goals of the larger study. Afterward, the participant was administered the UTC-MET. For a complete list and description of all of the tests that participants underwent, see Appendix C.

UTC Multiple Errands Test (UTC-MET)

The first task that each participant completed was the UTC-MET. The UTC-MET began in the laboratory, where participants were asked a series of questions regarding his or her perceived ability to shop and find information. Additionally, he or she was asked about how familiar he or she was with the University Center at UTC. Next, the participant was informed about the general nature of the task, and was given the list of tasks and the list of rules. Participants were then asked to read each task and rule aloud. Afterward, the participant was given one minute to study the rule sheet. Because the goal of the UTC-MET is not to test memory, the participant was not required to memorize the rule or task lists. Participants had the task and rule lists with them at all times. However, each participant was asked to try to recall as many of the rules as possible so that the experimenter could be more confident that the participant knew and understood what he or she should do during the task. Therefore, if the participant was not able to remember a rule, the experimenter prompted him or her, and was eventually shown the rule on the rule list if required. The number of prompts required was recorded.

Once the task list and rule list were reviewed, two experimenters accompanied the participant while he or she navigated through the University Center. All participants began the UTC-MET at the same location (the east entrance near the bookstore). At this location the experimenter and the participant sat on a chair or bench and the participant was asked, “Now, in your own words, tell me what you must do.” The participant’s response was recorded and the participant was given the opportunity to ask questions. Once all of the participant’s questions were answered, the task began when the participant initiated movement. One experimenter took notes on the participant’s behaviors while the other recorded the entire session on a video camera. The video was used to score the participant’s performance.

During the UTC-MET the participant walked through the University Center, attempting to complete each of the tasks laid out on the task sheet. The participant was not allowed to ask for help from the experimenter to complete any of the tasks as doing so constituted a rule break. However, he or she was allowed to complete the tasks in any order, and by any means necessary as long as the method did not involve breaking a rule. Once the participant indicated to the experimenter that the task was concluded the participant was escorted back to the laboratory for a structured interview and debriefing. The structured interview involved probing the participant about his or her performance on the UTC-MET. They were also asked what they could have done differently to improve their performance. After completing this debriefing, participants completed the eye-tracking prospective memory task.

Eye-Tracking Prospective Memory Task

Before this task began, the eye tracker was calibrated to measure participants' eye movements. The calibration process involved the experimenter instructing the participant to watch a moving dot on the screen. This allows the eye-tracker to calibrate eye fixation locations with a program-generated stimulus, thus allowing for accurate readings. Once the eye tracker successfully calibrated eye fixation locations, participants were given instructions for how to complete the ongoing task, which involved counting the number of living images that appeared within a black and white collage in the center of the computer screen. This group of images changed every 12 seconds. A separate image, located either in the upper-right corner or bottom left corner of the greater group of images (depending on the counterbalanced condition the participant is assigned to), changed at four times the rate of the larger group. The participant was instructed to not include the smaller image in reported counts, but that it would change at four-times the speed of the larger collage. The target area is where the PM target (cue) appeared. Furthermore, participants were instructed to keep their hands on the table and not on the mouse or keyboard. Following the instructions, participants were presented with the PM task. Whenever an apple appeared in the top right or bottom left (depending on the condition) target area, the participant was instructed to remember to respond with a left-mouse button press. Subsequently, participants were immediately asked to recall the PM task that they were to remember to complete. Following a successful recall, participants completed two practice trials of the task. Afterward, D-KEFS verbal fluency (Delis, Kramer, Kaplan, & Holdnack, 2004) was administered as the delay interval. After completing verbal fluency, the eye-tracking prospective memory task trials began, and were not reminded of the PM task. PM responses (i.e. mouse clicks) were recorded using Eyeworks® experimental suite. Once participants completed the active PM phase, they were administered a retrospective memory questionnaire regardless of whether the control phase occurred before or after the PM phase. If the participant was given the active PM phase first, they were told that they should no longer attempt to respond to the PM task during the control phase. Following the eye-tracking PM task participants completed the non-focal PM task.

Non-focal Prospective Memory Task

At the beginning of the non-focal PM task the participant was given instructions on how to complete the ongoing semantic categorization task. These included how to complete the ongoing task, which involved keeping the index and middle fingers of the participant's dominante hand on the "1" and "2" key on the key pad on the keyboard. The participant was then allowed to practice completing the ongoing task. The active PM and control phases were randomly counterbalanced across participants so as to control for practice effects. After practicing the ongoing task, the participant was be given the PM task, which was to press the "Q" key on the keyboard whenever a word on the left begins with a pre-specified letter. Depending on the condition to which the participant was randomly assigned, the target letter was either "O" or "L". Following the administration of the PM task instructions, participants were asked to recall the intention. If they were unable to correctly recall either the PM target or action he or she will re-read the instructions. In order to continue with the experiment, participants were required to correctly recall the PM intention.

Following a participant's successful PM task recall, he or she was administered conditions three and four of D-KEFS TMT (Pearson Clinical Assessments, 2001). After the brief delay interval the participant proceeded into the actual non-focal PM task ongoing task and were not reminded of the PM task in any way. After completing all of the trials, the participant received the retrospective memory questionnaire to control for retrospective forgetting of the PM task.

Characterization Measures

The MoCA was administered either on the first day or second day of testing. During the task, participants were asked to complete a range of cognitive-ability tasks. Reading Span was the final task of the second day of testing. Participants were first given instructions for how to complete each separate task (i.e. reading task and number recall task), and allowed to practice them separately. They were then given instructions for how to complete the tasks simultaneously, and were subsequently allowed to practice them. During the sentence decision task practice, each participant's average response time was calculated. If the participant took longer than their average response time, it would count that part in error. Each participant was instructed to keep his or her sentence category decision score above 85% while trying his or her best to remember as many numbers in order as possible.

CHAPTER III

RESULTS

Due to hardware failure and participant attrition it was not possible to analyze all of the data. The hard drive crashed in the laptop that housed the data for the eye-tracking PM task resulting in a loss of PM data for four participants (i.e. three PD participants, one control participant). In addition, three control participants did not stay for the entire second day of testing, and therefore did not complete the non-focal task. This resulted in a loss of 17.6% of data from the non-focal PM task and 24% of the eye-tracking PM task data. Finally, one control participant scored well below the MoCA cutoff (<26), suggesting possible MCI, and was therefore removed from all analyses. There was only one retrospective memory failure during the eye-tracking PM task in the PD group, however, the participant correctly responded to all PM targets. Therefore, the participant was included in all analyses. There were no retrospective memory failures during the non-focal PM task. Each lost data point was coded as missing and was not included in any analysis regarding the respective task.

The final sample included *N*=15 participants (7 female). Mean age across both groups was *M*=69.19 (range = 29) and participants had completed *M*=15 (range = 8) years of education. Participants in the PD group had been diagnosed for an average of *M* = 8.81 years (*SD* = 9.41, range = 24.5). Of the remaining participants, those in the PD group and the control group were demographically similar. There were no differences in age (M_{PDgroup} = 71.33, *SD* = 9.41, $M_{\text{Control group}}$ = 66.43, *SD* = 6.05), $t(14) = -1.20$, p = .252. Likewise, participants in both groups were similar in years of education (M_{PDgroup} = 14.67, *SD* = 1.22, $M_{\text{Control group}}$ = 15.42, *SD* = 3.11), $t(7.37) = .596$, $p = .521$. However, there was a marginally significant difference in sex between groups $X^2 = 3.874$, p=.07, with the PD group comprised of 77.8% males.

To better characterize the sample, participant errors on D-KEFS verbal fluency and DKEF-S TMT were compared between groups. For D-KEFS verbal fluency, participant errors were classified as repetition errors wherein the same word was given more than once in the 60-second trial. A chi-square analysis demonstrated PD participants made more repetition errors than controls, $X^2 = 7.24$, $p<.02$. However, no significant differences in DKEF-S TMT errors were observed, $X^2 = .004$, p=.671. There was a significant difference in scores on the MoCA between groups (M_{PDgroup} = 22.22, *SD* = 2.91, $M_{\text{Control group}}$ = 26.29, *SD* = 2.91), $t(14) = 2.523$, $p<.03$. However, there were no significant differences in working memory span as measured by Reading Span, (M_{PDgroup} = 10.71, *SD* = 5.38, $M_{\text{Control group}}$ = 14.33, *SD* = 9.40), $t(11) = .870$, $p = .403$.

In order to examine the first hypothesis, that there would be differences in monitoring between the group of individuals diagnosed with PD and healthy controls, two repeated-measures ANOVAs were conducted with group serving as the between-subjects factor and response times for the active PM and control phase serving as the repeated, within-subjects factor. First, raw response time data for each participant was trimmed. Response times for PM trials as well as for incorrect ongoing task responses were removed. Likewise, response times that were 2.5 standard deviations above or below an individual's mean ongoing task response times were removed. As can be seen in Figure 1, there was not a within-subjects difference in response times between the active PM phase ($M = 1896.79$, $SD = 537.79$) and the control phase ($M = 1739.19$, $SD = 432.26$), $F(1,11) = 2.89$, $p = .117$, partial $\eta^2 = .208$, $MS = 90663.49$. Likewise, there was not a between-subjects difference between PD participants ($M = 1954.78$, $SE = 146.34$) and non-PD participants ($M = 1510.22$, $SE = 219.51$) in response times $F(1,11) = 2.84$, $p = .12$, partial $\eta^2 = .205$, $MS = 1094603.26$, nor was there an interaction between group and phase response time differences $F(1,11) = 1.049$, $p = .328$, partial $\eta^2 = .087$, $MS = 32929.05$.

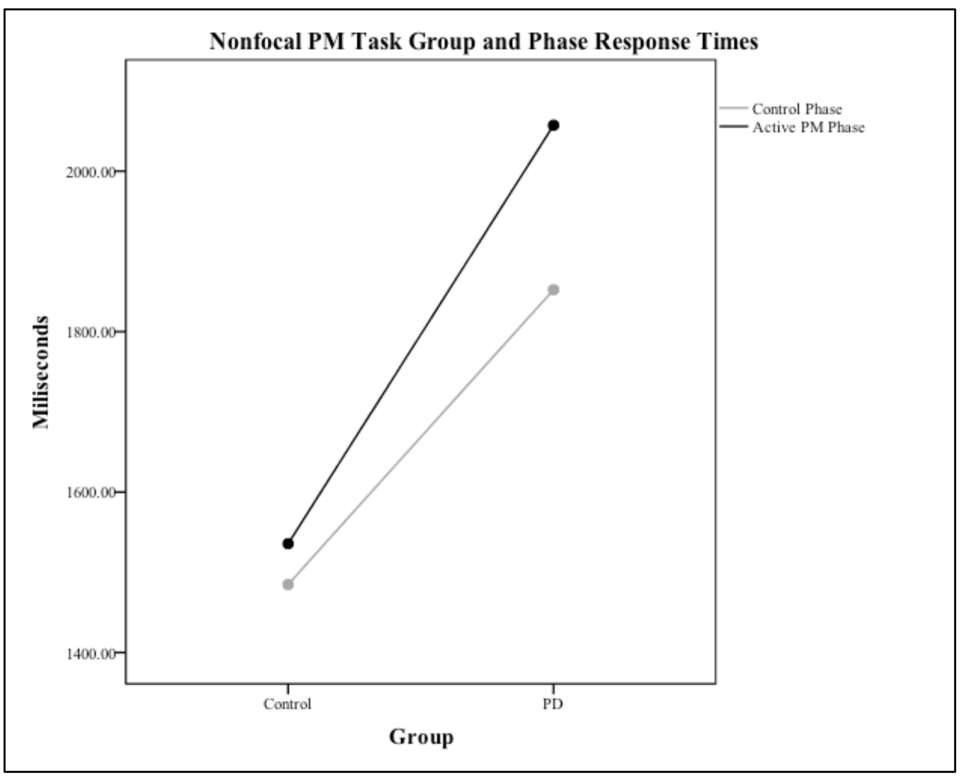


Figure 1 Monitoring differences between groups and phases on the non-focal PM task

Figure 2 demonstrates that in the second repeated measures ANOVA, regarding fixation counts within the target area for the eye-tracking PM task, there was a significant within-subjects main effect of task phase. Participants fixated in the target more during the active PM phase ($M = 40.38$, $SD = 46.61$) compared to the control phase ($M = 6.92$, $SD = 6.58$). $F(1,11) = 6.29$, $p < .03$, partial $\eta^2 = .364$, $MS = 6955.62$. There was not a main effect of group between PD participants ($M = 22$, $SE = 10.26$) and non-PD participants ($M = 25.07$, $SE = 9.5$) in mean fixations in the target area $F(1,11) = .048$, $p = .83$, partial $\eta^2 = .004$, $MS = 60.96$, nor was there an interaction between group and phase target area fixation differences $F(1,11) = .42$, $p = .53$, partial $\eta^2 = .037$, $MS = 464.23$.

Likewise, Figures 3 and 4 show there were no group differences in PM performance on the non-focal PM task, $t(11) = .697$, $p = .5$, $d = .41$, or the eye-tracking PM task, $t(11) = .36$, $p = .729$, $d = .20$. Mean performance on the non-focal PM task was, $M_{\text{PDgroup}} = .37$, $SD = .41$ and $M_{\text{Control group}} = .54$, $SD = .42$, and mean performance on the eye-tracking PM task was, $M_{\text{PDgroup}} = .420$, $SD = .492$ and $M_{\text{Control group}} = .50$, $SD = .354$. It should also be noted that on the non-focal PM task 25% and 67% of PM responses from the PD and non-PD groups, respectively, were considered late (a PM response that occurred 1-3 subtrials after the target presentation). Like with on the eye-tracking PM task 66% and 40% of PM responses within the PD and control groups, respectively, were considered late. There were no differences between groups in responding late to PM targets for either the non-focal PM task, $X^2 = 1.367$, $p = .279$, nor for the eye-tracking PM task, $X^2 = .533$, $p = .5$.

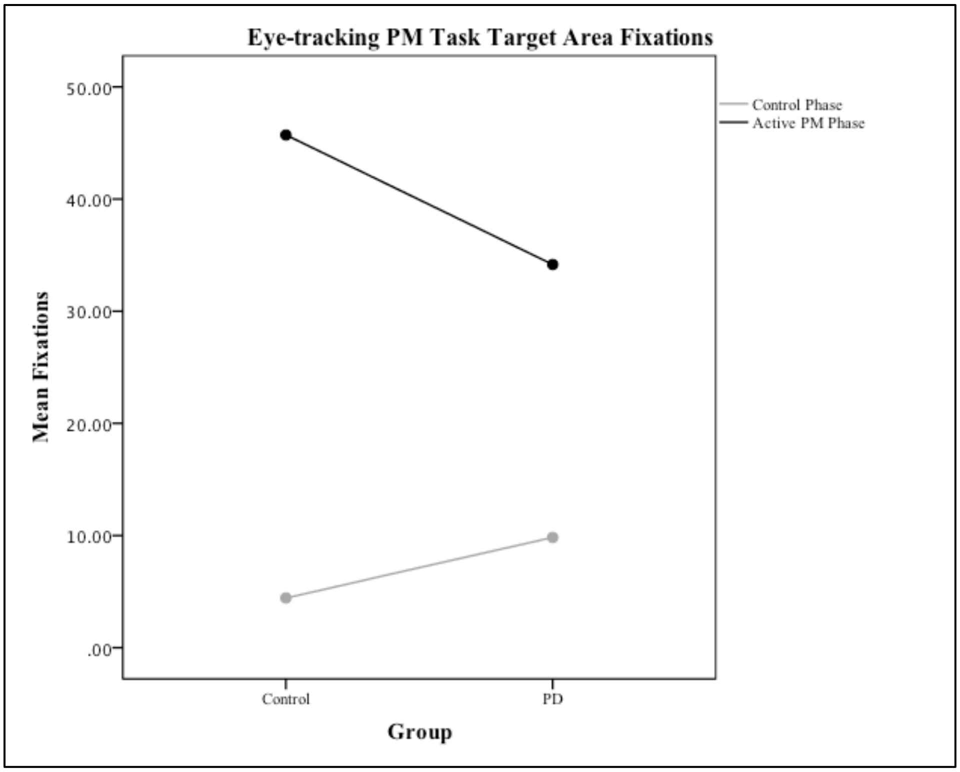


Figure 2 Monitoring differences between groups on the eye-tracking PM task

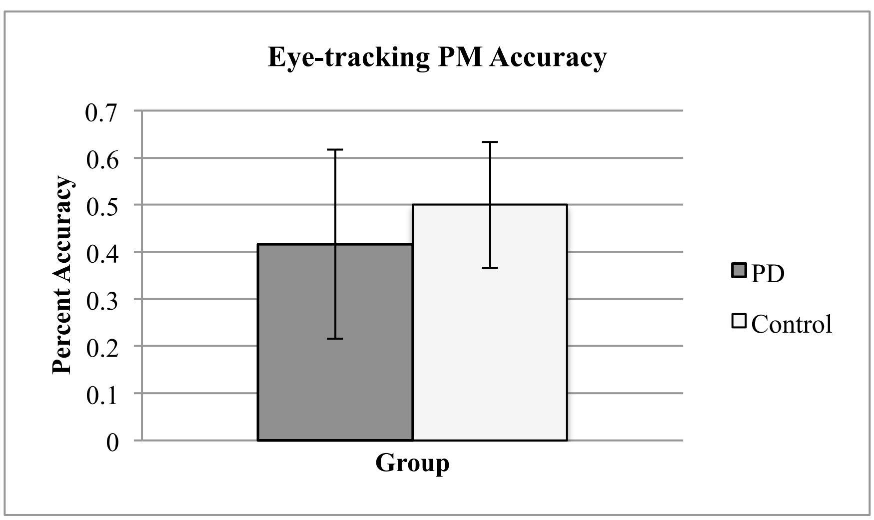


Figure 3 PM accuracy between groups for the Eye-tracking PM task

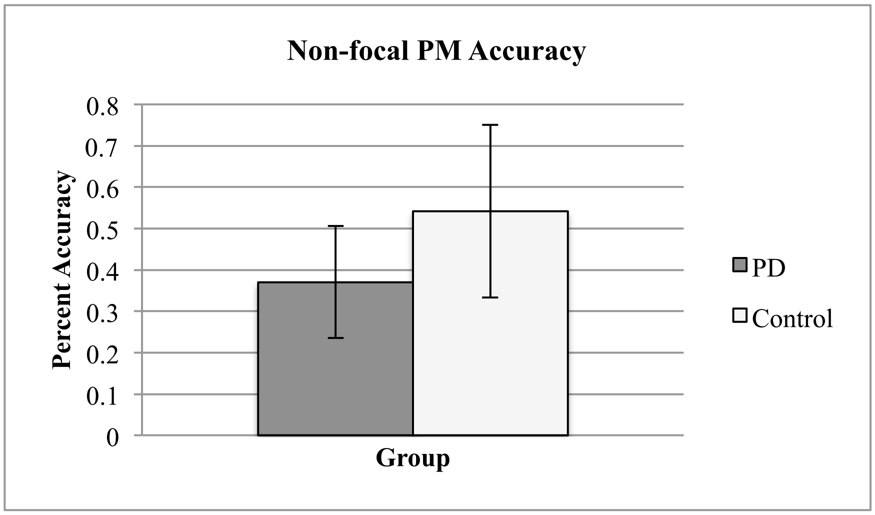


Figure 4 PM accuracy between groups for the non-focal PM task

The second hypothesis associated with this study was that individuals diagnosed with PD would perform worse on the UTC-MET than the healthy control individuals. To assess whether there were differences, an independent samples *t*-test was conducted using the UTC-MET total errors composite score. Though not statistically significant, a trend toward a group difference was observed, $t(15) = 1.54$, $p = .145$, $d = .750$. Participants diagnosed with PD made more errors than the control group ($M_{\text{PDgroup}} = 7.56$, $SD = 2.60$, $M_{\text{Control group}} = 5.63$, $SD = 2.56$).

In order to obtain a better understanding of each groups' performance, an additional series of five independent samples *t*-tests were conducted on each of the other five UTC-MET performance indicators. Table 1 contains mean performance scores for each of the UTC-MET indicators. There were no differences observed on any of these measures.

Table 1 Comparison of UTC-MET Performance Indicators between PD participants and controls

Performance Indicator	PD Mean (SD)	Control Mean (SD)	*t* statistic	Cohen's *d* effect size	95% Confidence Interval	
					Upper Bound	Lower Bound
Total Errors	7.56 (2.60)	6.14 (2.27)	-1.137	0.55	-0.49	1.52
Strategies	25.89 (13.75)	30.86 (21.08)	0.571	0.30	-1.28	0.71
Inefficiencies	4.00 (3.12)	2.00 (1.41)	-1.565	0.72	-0.33	1.70
Rule Breaks	2.22 (2.44)	1.43 (1.40)	-0.765	0.39	-0.63	1.36
Omitted Tasks	2.33 (2.82)	2.85 (2.47)	0.387	0.20	-1.17	0.81
Partial Task Failures	3.00 (2.74)	1.85 (1.57)	-.981	0.50	-0.53	1.48

The third hypothesis was that monitoring on PM tasks would mediate the relationship between PM performance and UTC-MET performance. To this end, raw response times and target area fixations were converted into Z-scores (within task phases) to normalize measurements of monitoring across the non-focal and eye-tracking PM tasks, respectively. For the purposes of these analyses, the term monitoring will refer to the Z-scores for the response times for the non-focal PM task (or target area fixations for the eye-tracking PM task) during the active PM phase of each respective task, while holding the Z-scores for response times (or target area fixations) during the control phase constant.

These mediation analyses, consisting of a series of regression analyses, were conducted with both the non-focal and the eye-tracking PM tasks. The mediation analysis procedure was the same for both tasks. UTC-MET performance was first regressed onto PM performance. Second, monitoring was regressed onto PM performance. Finally, UTC-MET performance was regressed onto monitoring, while holding PM performance constant.

There was a significant correlation between both measures of PM performance, $r = .629$, $p = .05$, indicating good construct validity. Across both tasks, mean PM performance was generally acceptable, that is, ceiling and floor effects were avoided ($M_{non\text{-}focal} = .423$, SD = .400; $M_{eye\text{-}tracking} = .462$, SD = .406. Interestingly though, there was not a significant relationship between monitoring as measured by the two measures of PM, $R^2 = .320$, $\beta=.201$, $p = .772$.

The mediation for the non-focal PM task occurred first. There was no significant relationship between non-focal PM performance and the UTC-MET composite errors score, $R^2 =.05$, $\beta=.233$, $p = .444$. However, as expected, monitoring was a significant predictor of PM performance, $R^2 =.421$, $\beta = 1.35$, $p < .03$. Contrary to prediction, there was also a positive trend observed where monitoring was a predictor of UTC-MET errors, $R^2 = .28$, $\beta = 1.145$, $p=.079$, indicating that as participants monitored more for the PM target, they also made more errors on the UTC-MET. In the final analysis, PM performance was held constant across participants to assess whether monitoring was a significant mediator. When PM performance was held constant, monitoring was not a statistically significant predictor of UTC-MET errors, $R^2 = 29$,$\beta = 1.331$, $p = .126$.

Next, the same mediation methodology was used with the eye-tracking PM task and the UTC-MET total errors composite score. PM performance was not a significant predictor of UTC-MET errors $R^2 = .0002$, $\beta = -.016$, $p = .960$. However, monitoring, as measured by number of fixations, was a significant predictor of PM performance, $\beta = .637$, $p < .02$. Next, the UTC-MET total errors composite score was regressed onto monitoring during the eye-tracking PM task. Monitoring was not a significant predictor of UTC-MET total errors alone, $R^2 = .197$, $\beta = -.321$, $p = .29$, nor when PM performance was held constant to test for the mediation, $R^2 = .25$, $\beta = -.515$, $p = .21$.

As can be seen in Figure 5, PM performance for the eye-tracking PM task was significantly related to UTC-MET accurate task completions, $r = .58$, $p < .04$. Therefore, a final exploratory mediation analysis was conducted using UTC-MET task completions as the dependent variable and PM performance and monitoring as the independent predictors. As the correlation would suggest, PM performance was a significant predictor of UTC-MET task completions, $R^2 = .34$, $\beta = .580$, $p < .04$. However, monitoring during the eye-tracking PM task was not a significant predictor of UTC-MET task completions, $R^2 = 1.54$, $\beta = .389$, $p = .208$. Likewise, when PM performance was held constant, monitoring was still not a significant predictor of UTC-MET performance, $R^2 = 339$, $\beta = .034$, $p = .926$.

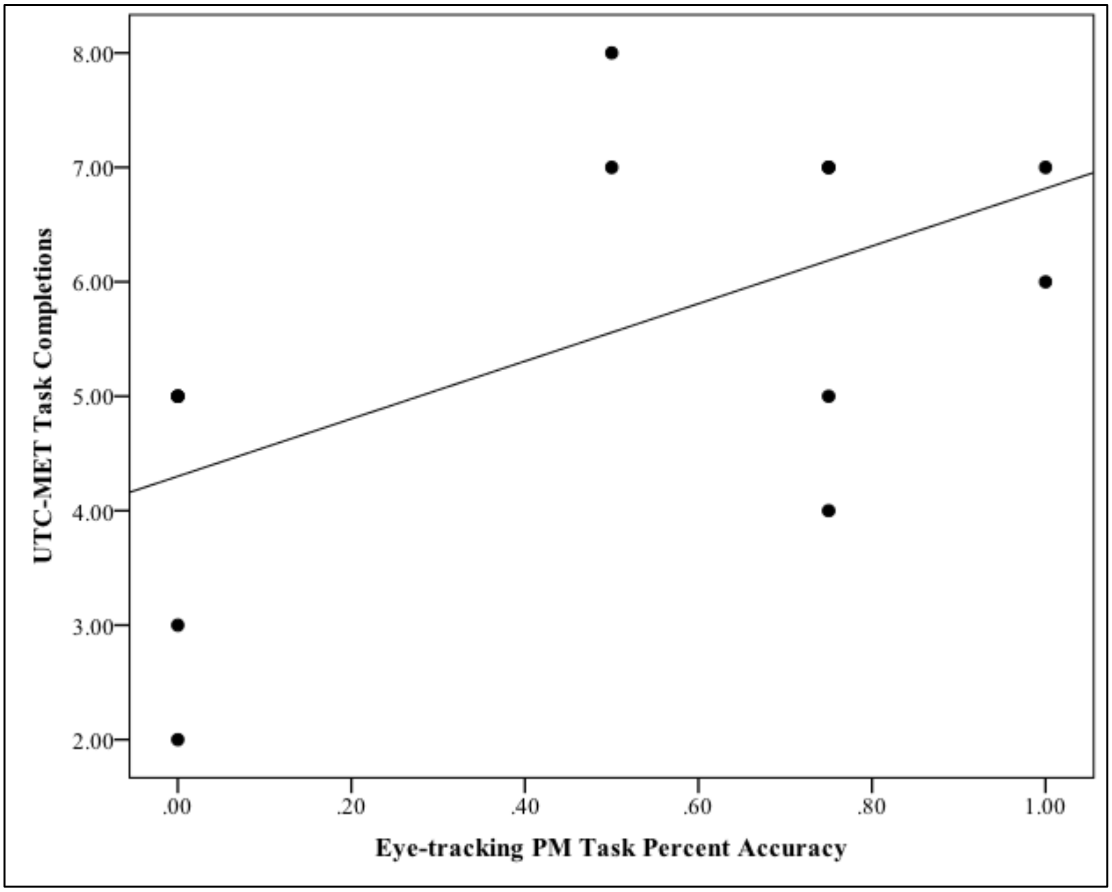


Figure 5 Relationship between PM performance on the Eye-tracking PM task and UTC-MET task completions

CHAPTER IV

DISCUSSION

The aim of the present study was to assess monitoring differences during PM tasks between a control group of healthy older adults and older adults diagnosed with PD. Additionally, I sought to understand whether there were group differences on a naturalistic shopping measure of executive function. The final goal of the experiment was to see if monitoring during a PM task mediates the relationship between PM performance and performance on the naturalistic shopping task. This was accomplished using three tasks: a laboratory non-focal PM task, an experimental eye-tracking PM task, and a site-specific adaptation of the Burgess and Shallice's (1991) MET named the UTC-MET.

Monitoring in Parkinson's disease.

The first hypothesis was that there would be significant group differences in monitoring during both the non-focal PM task and the eye-tracking PM task. This hypothesis was not supported by the data for either the non-focal PM task or the eye-tracking PM task. In the non-focal PM task monitoring was assessed by response time cost to the active PM phase of the ongoing categorization decision task in comparison to the control phase. In the eye-tracking PM task, monitoring was measured by comparing the number of fixations within the target area between an active and control phase of a visual search counting task. There were no significant differences in monitoring between groups for either of these tasks.

The lack of differences in monitoring could indicate that individuals diagnosed with PD do not differ from age and education matched controls in their ability to direct attention away from an ongoing task and monitor for the opportunity to complete a PM task. It should be noted, however, that while not statistically significant, the PD group responded slower than the non-PD group during the non-focal PM task. Since PD is associated with declines in executive domains such as set-shifting (Monchi, et al., 2004), it seems unlikely that PD participants were monitoring more during the task. Instead, it is more likely that some other factor was involved. One possibility is medication use in the PD group. Reaction times during decision making tasks can vary significantly with levels of dopaminerigic agonists, such as levadopa in PD participants (Pullman, Watts, Juncos, Chase, & Sanes, 1988). This could explain the slower overall response times. Timing and use of medication could also account for the surprising trend toward a positive relationship between monitoring during the non-focal PM task and UTC-MET total errors. Additionally, PD participants were more variable in responding on the non-focal PM task. Therefore, it is plausible that this high variability might be driving this trend. Another possible explanation could be that PD participants simply incurred greater costs when contending with two simultaneous tasks or while multi-tasking in general.

As previously stated, there were no group differences in the monitoring index provided by the eye-tracking PM task. This could suggest that individuals diagnosed with PD are as capable or as likely to visually monitor for a PM target as matched controls. Nevertheless, PD participants monitored only 59% as often as controls.

Therefore, the eye-tracking PM task may be a more appropriate estimate of monitoring than the non-focal PM task's estimate of monitoring. This supposition is further supported by the non-significant relationship between monitoring during the eye-tracking PM task and UTC-MET total errors. Nevertheless, further research is needed to clarify whether these relationships exist at all, and if so, assess the incremental validity of visual attention as a measure of monitoring over motor response times in PM tasks in PD participants and in general populations.

Naturalistic assessment of executive function in Parkinson's disease

The second hypothesis was that PD participants would perform worse than control participants on the UTC-MET, a naturalistic measure of executive function. The data from this study suggest that there were no differences between groups on any of the UTC-MET performance indicators. This could suggest that PD participants are as capable of performing an unstructured executive function task as matched control participants. Furthermore, this might suggest, however unlikely, that any executive dysfunction experienced by PD participants as measured in laboratory settings might not have any real-world performance correlate. An alternative explanation could be that the UTC-MET is not sensitive to the types of executive function related deficits that PD participants experience in real-world environments. There was, however, a large effect of inefficiencies on the UTC-MET between groups in the expected direction. However, this difference did not reach statistical significance. This could indicate that there wasn't sufficient power.

Monitoring and executive function in Parkinson's disease

The final hypothesis was that monitoring would mediate a relationship between PM performance and the UTC-MET total errors composite score. PM performance as measured by the non-focal PM task and the eye-tracking PM task was not statistically significantly related to the UTC-MET total errors. However, there was a trend toward monitoring on the non-focal PM task to predict UTC-MET total errors, however, in the unexpected direction. This could indicate that older adults in general may have difficulty contending with multiple task demands, and that increased cognitive load could be detrimental to real-world task completions. Though more research is needed to explain this surprising result.

An exploratory analysis demonstrated that PM performance on the eye-tracking PM task was a significant predictor of UTC-MET accurate task completions. This suggests that PM performance and monitoring as measured by laboratory PM tasks may be related to naturalistic measures of executive function, however, more research is needed. Moreover, monitoring during the eye-tracking PM task was a significant predictor of PM performance, however, this index of monitoring was not a significant mediator of the relationship between PM performance and UTC-MET task completions. This might suggest that PM performance on the eye-tracking PM task is in some way unique in its ability to predict accurate task completions on the UTC-MET.

Limitations

Though this study presents many interesting findings, these results should be interpreted skeptically. There were a number of limitations that should be considered when assessing the accuracy of these results. Due to hardware failure and participant attrition during the testing sessions, each analysis was effectively conducted with a slightly different sample, with varying characteristics. For example, regression analyses involving the non-focal PM task included a sample of nine participants in the PD group, and only five participants in the control group. Simultaneously, the regression analyses involving the eye-tracking PM task included 6 participants diagnosed with PD and seven control participants. Only four participants within the control group, and six participants within the PD group, were included in all analyses. This not only reduces the statistical power for each analysis, but also brings into question the interpretation of the performance measures across tasks. With varying inclusion factors for the tasks, the results reported herein could be biased toward or against the characteristics within each "sub-sample". Another possible limitation is that cue-driven monitoring effects within the eye-tracking PM task were not controlled for. Therefore, the index of monitoring reported here could have been influenced by cue-based spontaneous retrieval and subsequent monitoring, rather than totally on self-initiated monitoring processes.

Likewise, the total sample for the study was quite small in reference to other studies of PM in PD participants. For example, a study by Kliegel, et al. (2005) used a sample of 16 participants diagnosed with PD matched with another 16 participants in a control group, and found large effects in PM performance between groups. Likewise, Costa et al. (2014) also found a large effect size of PM performance when comparing PD participants with healthy controls PM, $d = .99$. Therefore, using a post hoc effect size estimate of $d = .99$, and statistical power of .80, 16 participants should have been included in each group to accurately replicate previous studies' findings of group differences in PM performance. Additionally, the non-significant findings reported in this study could be attributed to the low degree of severity of the participants' PD. Whittington, Podd, and Stewart-Williams (2006) found that PM deficits in non-demented PD participants were moderated by the severity of the disease. The PD participants in this study were at stages 1 and 2 of PD, and executive function and PM deficits might be more pronounced at later stages of the disease.

One final limitation to the present study is that medication use in either group was not controlled. Therefore, it is possible that medications typically prescribed for PD, such as levadopa could have affected performance. For example, individuals diagnosed with PD can often experience on/off moments when levadopa is ineffective and this can result in decreased mobility and decreased alertness (Lees, 1989). Considering the long periods of testing, it is possible that participants experienced an off moment or reduced drug effectiveness.

Future Directions

Apart from addressing these limitations, future studies should continue to better understand the relationship between PM performance and performance of naturalistic measures of executive function in healthy older adults and those diagnosed with PD. As was demonstrated in this study, utilizing the traditional ongoing task cost index of monitoring for PM cues may not be sufficient in understanding monitoring in participants diagnosed with PD, and possibly other clinical populations that suffer from motor impairments. One possible method for accomplishing this could be to control for general response times and processing speed using standardized response time measures.

In addition, future investigations should continue to examine the relationship between PM performance and UTC-MET performance indicators. It remains possible that the changing target area in the eye-tracking PM task served as a trigger/reminder for completing the PM task much like the task sheet may have served as a reminder for the tasks that had yet to be completed. To this end, future studies should assess how visual monitoring might relate to monitoring a task sheet for completeness.

Finally, it was observed that some participants were quite anxious while completing the UTC-MET. For example, after making an error one participant repeatedly announced that she was "bombing this test". Likewise, another participant told the experimenter how anxious she was to complete the UTC-MET because it was in a place she had never been. This anxiety could have affected performance on the UTC-MET. As such, future studies may want to control for state anxiety before and after administering such tests.

Conclusion

In conclusion, this study sought to understand how PD affects monitoring during PM tasks and naturalistic measures of executive function, and how monitoring might be related to real-world task performance. This study indicated negligible differences between individuals diagnosed with PD and an age and education matched control group in PM performance and monitoring in two PM tasks. Likewise, this study suggests that participants diagnosed with PD perform just as well as controls on the UTC-MET, a naturalistic measure of executive function. However, PM performance during an eye-tracking PM task is significantly related to task completions during the UTC-MET.

REFERENCES

Brewer, G. A., Knight, J. B., Marsh, R. L., & Unsworth, N. (2010). Individual differences in event-based prospective memory: Evidence for multiple processes supporting cue detection. *Memory & Cognition*, *38*(3), 304-311. doi:10.3758/MC.38.3.304

Burgess, P. W., Dumontheil, I., Gilbert, S. J., Okuda, J., Schölvinck, M. L., & Simons, J. S. (2008). On the role of rostral prefrontal cortex (area 10) in prospective memory. In M. Kliegel, M. A. McDaniel, G. O. Einstein, M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.) , *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives* (pp. 235-260). New York, NY: Taylor & Francis Group/Lawrence Erlbaum Associates.

Burgess, P. W., Gonen-Yaacovi, G., & Volle, E. (2011). Functional neuroimaging studies of prospective memory: What have we learnt so far? *Neuropsychologia*, *49*(8), 2246-2257. doi:10.1016/j.neuropsychologia.2011.02.014

Burgess, P. W., Gilbert, S. J., Okuda, J., & Simons, J. S. (2006). Rostral prefrontal brain regions (area 10): A gateway between inner thought and the external world? In N. Sebanz, W. Prinz, N. Sebanz, & W. Prinz (Eds.), *Disorders of volition* (pp. 373-395). Cambridge, MA, US: MIT Press.

Burgess, P. W., Alderman, N., Forbes, C., Costello, A., Coates, L. M. A., Dawson, D. R., … & Channon, S. (2006). The case for the development and use of ‘‘ecologically valid’’ measures of executive function in experimental and clinical neuropsychology. *Journal of the International Neuropsychological Society, 12,* 194–209.

Bugg, J. M., & Scullin, M. K. (2013). Controlling intentions: The surprising ease of stopping after going relative to stopping after never having gone. *Psychological Science*, *24*(12), 2463-2471. doi:10.1177/0956797613494850

Canty, A. L., Fleming, J., Patterson, F., Green, H. J., Man, D., & Shum, D. K. (2014). Evaluation of a virtual reality prospective memory task for use with individuals with severe traumatic brain injury. *Neuropsychological Rehabilitation*, *24*(2), 238-265. doi:10.1080/09602011.2014.881746

Costa, A., Peppe, A., Caltagirone, C., & Carlesimo, G. A. (2008). Prospective memory impairment in individuals with Parkinson's disease. *Neuropsychology*, *22*(3), 283-292. doi:10.1037/0894-4105.22.3

Costa, A., Peppe, A., Serafini, F., Zabberoni, S., Barban, F., Caltagirone, C., & Carlesimo, G. A. (2014). Prospective memory performance of patients with Parkinson's disease depends on shifting aptitude: evidence from cognitive rehabilitation. *Journal of the International Neuropsychological Society*, *20*(7), 717-726. doi:10.1017/S1355617714000563

Crawford, J.R. (1998). Introduction to the assessment of attention and executive functioning. *Neuropsychological Rehabilitation*, *8*, 209–211.

Delis, D. C. Kramer, J. H., Kaplan, E., & Holdnack, J. (2004). Reliability and validity of the Delis-Kaplan Executive Function System: An update. *Journal of the International Neuropsychological Society, 10*, 301-303. doi:10.1017/S1355617704102191.

Draper, K., & Ponsford, J. (2008). Cognitive functioning ten years following traumatic brain injury and rehabilitation. *Neuropsychology, 22*(5), 618-625. doi: 10.1037/0894-4105.22.5.618

Dubois, B., & Pillon, B. (1996). Cognitive deficits in Parkinson’s disease. *Journal of Neurology*, *244*(1), 2-8.

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

Einstein, G. O., & McDaniel, M. A. (2010). Prospective memory and what costs do not reveal about retrieval processes: A commentary on Smith, Hunt, McVay, and McConnell (2007). *Journal Of Experimental Psychology: Learning, Memory, And Cognition*, *36*(4), 1082-1088. doi:10.1037/a0019184

Grant, D. & Berg, E. (1985). The Wisconsin Card Sorting Task. *Test Critiques, 4,* 677-682.

Horn, S. S., & Bayen, U. J. (2015). Modeling criterion shifts and target checking in prospective memory monitoring. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41*(1), 95-117. doi: 10.1037/a0037676

Ihle, A., Schnitzspahn, K., Rendell, P. G., Luong, C., & Kliegel, M. (2012). Age benefits in everyday prospective memory: The influence of personal task importance, use of reminders and everyday stress. *Aging, Neuropsychology, and Cognition, 19*(1-2), 84-101. doi: 10.1080/13825585.2011.629288

Kliegel, M., Altgassen, M., Hering, A., & Rose, N. S. (2011). A process-model based approach to prospective memory impairment in Parkinson's disease. *Neuropsychologia*, *49*(8), 2166-2177. doi:10.1016/j.neuropsychologia.2011.01.024

Kliegel, M., Eschen, A., & Thöne-Otto, A. I. T. (2004). Planning and realization of complex intentions in traumatic brain injury and normal aging. *Brain and Cognition, 56*(1), 43-54. doi: 10.1016/j.bandc.2004.05.005

Kliegel, M., Phillips, L. H., Lemke, U., & Kopp, U. A. (2005). Planning and realisation of complex intentions in patients with Parkinson's disease. *Journal Of Neurology, Neurosurgery & Psychiatry*, *76*(11), 1501-1505. doi:10.1136/jnnp.2004.051268

Lee, J., Shelton, J., Scullin, M., & McDaniel, M. (2015). An implementation intention strategy can improve prospective memory in older adults with very mild Alzheimer's disease. *British Journal of Clinical Psychology*. doi: 10.1111/bjc.12084

Lees, A.J. (1989). The on-off phenomenon. *Journal of Neurology, Neurosurgery, and Psychiatry Special* (29-37), doi:10.1136/jnnp.52.Suppl.29

Levine, B., Stuss, D. T., Milberg, W. P., Alexander, M. P., Schwartz, M., & MacDonald, R. (1998). The effects of focal and diffuse brain damage on strategy application: Evidence from focal lesions, traumatic brain injury and normal aging. *Journal of the International Neuropsychological Society, 4*(3), 247-264.

Marsh, R. L., Hicks, J. L., Cook, G. I., Hansen, J. S., & Pallos, A. L. (2003). Interference to ongoing activities covaries with the characteristics of an event-based intention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*(5), 861-870. doi: 10.1037/0278-7393.29.5.861

Mathias, J. L., & Mansfield, K. M. (2005). Prospective and declarative memory problems following moderate and severe traumatic brain injury. *Brain Injury, 19*(4), 271-282.

McAlister, C. & Schmitter-Edgecombe, M., (2013) Naturalistic assessment of executive function and everyday multitasking in healthy older adults. *Aging, Neuropsychology, and Cognition*, *20*(6), 735-756. doi:10.1080/13825585.2013.781990

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

McDaniel, M. A., LaMontagne, P., Beck, S. M., Scullin, M. K., & Braver, T. S. (2013). Dissociable neural routes to successful prospective memory. *Psychological Science, 24*(9), 1791-1800.

Monchi, O., Petrides, M., Doyon, J., Postuma, R. B., Worsley, K., & Dagher, A. (2004). Neural bases of set-shifting deficits in Parkinson's disease. *The Journal of Neuroscience*, *24*(3), 702-710. doi:10.1523/JNEUROSCI.4860-03.2004

Morrison, M. T., Giles, G. M., Ryan, J. D., Baum, C. M., Dromerick, A. W., Polatajko, H. J., & Edwards, D. F. (2013). Multiple errands test-revised (MET-R): A performance-based measure of executive function in people with mild cerebrovascular accident. *American Journal of Occupational Therapy, 67*(4), 460-468.

Nasreddine, Z. S., Phillips, N. A., Bedirian, V., Charbonneau, S., Whitehead, V., Collin, I. et al. (2005). The Montreal Cognitive Assessment, MoCA: a brief screeningtool for mild cognitive impairment. *Journal of the American Geriatric Society*, *53*, 695-699.

Oswald, F. L., McAbee, S. T., Redick, T. S., & Hambrick, D. Z. (2015). The development of a short domain-general measure of working memory capacity. *Behavior Research Methods*, *47*(4), 1343-1355. doi:10.3758/s13428-014-0543-2

Pearson Clinical Assessments (2001). Delis – Kaplan Trail Making Test. Retrieved from:http://www.pearsonclinical.com/psychology/products/100000618/deliskaplan-executive-function-system-d-kefs.html

Podsakoff, P. M., MacKenzie, S. B., Lee, J., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879-903. doi:10.1037/0021-9010.88.5.879

Pullman, S.L., Watts, R.L., Juncos, J.L., Chase, T.N., & Sanes, J.N. (1988). Dopaminergic effects on dimple and choice reaction time performance in Parkinson's disease. *Neurology, 38*(2), 249-254.

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

Rose, N. S., Rendell, P. G., McDaniel, M. A., Aberle, I., & Kliegel, M. (2010). Age and individual differences in prospective memory during a 'Virtual Week': The roles of working memory, vigilance, task regularity, and cue focality. *Psychology And Aging*, *25*(3), 595-605. doi:10.1037/a0019771

Schmitter–Edgecombe, M., McAlister, C., & Weakley, A. (2012). Naturalistic assessment of everyday functioning in individuals with mild cognitive impairment: The day-out task. *Neuropsychology, 26*(5), 631-641. doi: 10.1037/a0029352

Shallice, T., & Burgess, P. W. (1991). Deficits in strategy application following frontal lobe damage in man. *Brain,* (Vol. 114), 727-741. doi: http://dx.doi.org/10.1093/brain/114.2.727

Shelton, J. & Christohper, E. (In Press). A Fresh Pair of Eyes on Prospective Memory Monitoring. *Memory and Cognition*

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

Smith, R. E. (2010). What costs do reveal and moving beyond the cost debate: Reply to Einstein and McDaniel (2010). *Journal Of Experimental Psychology: Learning, Memory, And Cognition*, *36*(4), 1089-1095. doi:10.1037/a0019183

Smith, R. E., & Loft, S. (2014). Investigating the cost to ongoing tasks not associated with prospective memory task requirements. *Consciousness and Cognition: An International Journal, 27*, 1-13. doi: 10.1016/j.concog.2014.04.002

West, R., Carlson, L., & Cohen, A.-L. (2007). Eye movements and prospective memory: What the eyes can tell us about prospective memory. *International Journal of Psychophysiology, 64*(3), 269-277. doi: 10.1016/j.ijpsycho.2006.09.006

Whittington, C. J., Podd, J., & Stewart-Williams, S. (2006). Memory Deficits in Parkinson's Disease. *Journal Of Clinical And Experimental Neuropsychology*, *28*(5), 738-754. doi:10.1080/13803390590954236

Wilson, B.A., Cockburn, J., & Baddeley, A.D. (1985). *The Rivermead Behavioural Memory Test.* London: Pearson Assessment.

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

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

THE UNIVERSITY of TENNESSEE UT CHATTANOOGA

Institutional Review Board
Dept. 4915
615 McCallie Avenue
Chattanooga, TN 37403-2598
Phone: (423) 425-5867
Fax: (423) 425-4052
instrb@utc.edu
http://www.utc.edu/irb

MEMORANDUM

TO: Dr. Amanda Clark **IRB # 13-163**
Dr. Chris Young

FROM: Lindsay Pardue, Director of Research Integrity
Dr. Bart Weathington, IRB Committee Chair

DATE: 11/20/2015

SUBJECT: IRB #:13-163: Functional Impact of Executive Dysfunction

The Institutional Review Board has reviewed and approved the following changes for the IRB project listed below:

- Changes in recruitment strategies. Recruit at organizations and events that are take place within the Chattanooga community with the expressed consent of the organization to recruit. Examples of such established organizations are: the Chattanooga Stroke Camp (affiliated with Erlanger Hospital), the Eastgate Senior Center, Chattanooga YMCAs, Alexian Village, the Northgate Shopping center and other similar venues.

You must include the following approval statement on research materials seen by participants and used in research reports:

***The Institutional Review Board of the University of Tennessee at Chattanooga (FWA00004149) has approved this research project* # 13-163.**

Please remember that you must complete a Certification for Changes, Annual Review, or Project Termination/Completion Form when the project is completed or provide an annual report if the project takes over one year to complete. The IRB Committee will make every effort to remind you prior to your anniversary date; however, it is your responsibility to ensure that this additional step is satisfied.

Please remember to contact the IRB Committee immediately and submit a new project proposal for review if significant changes occur in your research design or in any instruments used in conducting the study. You should also contact the IRB Committee immediately if you encounter any adverse effects during your project that pose a risk to your subjects.

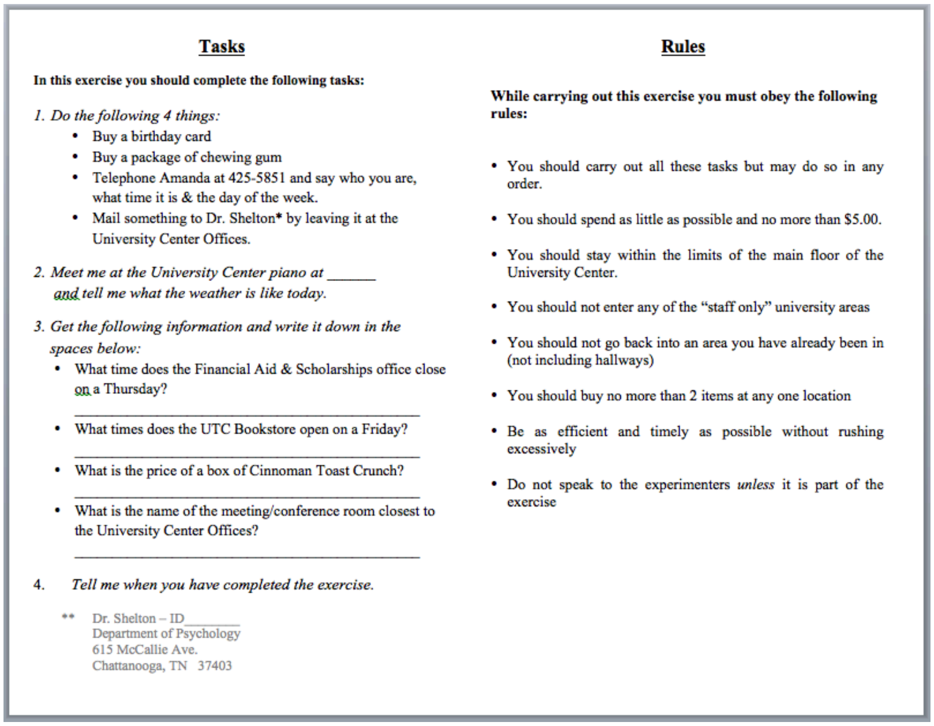
For any additional information, please consult our web page http://www.utc.edu/irb or email instrb@utc.edu

Best wishes for a successful research project.

Page **1** of **1**

APPENDIX B

TASK AND MEASURE IMAGES



Tasks

In this exercise you should complete the following tasks:

1. Do the following 4 things:

- Buy a birthday card
- Buy a package of chewing gum
- Telephone Amanda at 425-5851 and say who you are, what time it is & the day of the week.
- Mail something to Dr. Shelton* by leaving it at the University Center Offices.

2. Meet me at the University Center piano at ______ and tell me what the weather is like today.

3. Get the following information and write it down in the spaces below:

- What time does the Financial Aid & Scholarships office close on a Thursday?
  ____
- What times does the UTC Bookstore open on a Friday?
  ____
- What is the price of a box of Cinnoman Toast Crunch?
  ____
- What is the name of the meeting/conference room closest to the University Center Offices?
  ____

4. *Tell me when you have completed the exercise.*

** Dr. Shelton – ID________
Department of Psychology
615 McCallie Ave.
Chattanooga, TN 37403

Rules

While carrying out this exercise you must obey the following rules:

- You should carry out all these tasks but may do so in any order.
- You should spend as little as possible and no more than $5.00.
- You should stay within the limits of the main floor of the University Center.
- You should not enter any of the "staff only" university areas
- You should not go back into an area you have already been in (not including hallways)
- You should buy no more than 2 items at any one location
- Be as efficient and timely as possible without rushing excessively
- Do not speak to the experimenters *unless* it is part of the exercise

Image 1 UTC-MET task and rule sheets

Image 2 Sample eye-tracking trial stimulus

APPENDIX C

COMPLETE TESTING BATTERY

Day One Tests (In order of occurence	Description
1. Informed Consent	
2. Demographics Questionnaire	This is a brief questionnaire developed by the current investigators to collect information related to education and vocational history, current health conditions and medications, and history of medical illness/event that could produce neurological changes, including changes to cognition.
3. MoCA (Counterbalanced with MMSE)	This is a very brief screening assessment for mild cognitive dysfunction. We will be using this measure to identify any participant who may currently be experiencing mild cognitive impairment. The assessment addresses a participant's attention, memory, language, conceptual thinking and orientation to place and time.
4. Geriatric Depression Scale	This self-report scale was developed to identify depression, specifically in a geriatric population. The questionnaire features 30 questions to which participants respond with either yes or no.
5. BRIEF-A	This is a standardized measure that is designed to measure a participant's perceived self-regulation and executive function skill. In total, the self-report questionnaire includes 75 questions that ask the participant about how often he/she encountered certain events in his/her everyday environment.
6. Attention Related Cognitive Errors Scale	This is a brief 12-item self-report questionnaire that is designed to determine how often a participant experiences attention-related errors in everyday life.
7. Test of Premorbid Intelligence 8. Pearson Word Choice Test	This instrument is a 70-item reading test that calculates an IQ estimate based upon reading proficiency and several demographic variable (e.g., age, education, vocational history). This is a measure of effort. For this assessment, participants are shown and told a series of 50 words in succession. For each word, they are instructed to identify the words as either man-made or natural. The participant is later shown a card with 50 pairs of words, and is asked to name the word from each pair that was previously presented.
9. Wechsler Abbreviated Scale of Intelligence	The participant will complete the Matrix Reasoning and Similarities subtests from the WASI-2. Matrix Reasoning is a measure of visuospatial inductive reasoning in which individuals are asked to identify the missing part of a pattern. Similarities is a measure of verbal abstraction in which individuals are asked to identify how two words are alike. In addition to these tests providing information of verbal and nonverbal abstraction, an estimate of current intellectual functioning (IQ) is able to be calculated.
10. Texas Functional Living Scale	This measure was fairly recently developed as a means of providing a performance-based, naturalistic assessment of one's functional abilities in everyday life. This measure requires approximately 30 minutes to complete and assesses a participant's skills in four areas: one's ability to use clocks and calendars (time), one's ability to count money and write checks (calculation), one's ability to communicate, and one's ability to remember simple information.
11. Slip Induction Task	The SIT is a computer-administered task that attempts to mimic an everyday action routine within a controlled laboratory setting. Rarticipants learn a series of seven hand movements to target buttons as instructed by arrow cues that are presented on a computer screen. The arrow cues are spatially compatible with the target button that they point to. Later participants are asked to inhibit their routine response pattern in favor for a novel stimulus
12. Y Balance Test & Debriefing	Participants stand on one leg on the center of a "Y" shape which is taped out on the floor. While standing at the center of the Y participants reach with their other foot forward, back and to the left as well as back and to the right. As such, there are 6 trials:

Day Two Tests (In order of occurrence)	Description
1. Informed Consent	
2. MMSE (Counterbalanced with MOCA)	The MMSE is an 11-item questionnaire that measures general cognitive impairment. It is experimenter-administered.
3. Multiple Errands Test	The Multiple Errands Test (MET) is a real-world assessment of executive function that is completed by participants on the main floor of the University Center at UTC. Prior to beginning this assessment participants are given a list of tasks that they must complete as well as a list of rules that they must following during the completion of the test. Tasks include items like, find out what time the Bookstore closes on a Thursday, buy a can of Coca-Cola and meet the experimenters at the UTC piano at a specified time. Examples of rules include, never buying more than 2 items from one store and not discussing the task with the experimenter. Participants are given as much time as they need to complete the entire task and most participants complete the test in 20 to 40 minutes
4. Visual Prospective Memory Task 5. DKEFS Letter Fluency	This task is a measure of monitoring for a cue associated with an intention that needs to be carried out in the future. It is administered on a laptop computer utilizing eye-tracking hardware and software. Participants are presented with a number of images. Some of these images are living and nonliving (inanimate). Their first job is to count how many living and nonliving images appear on the screen. Their second job is to remember to respond by saying "hit" whenever an image of an apple appears at the top right-hand corner of the screen during the experiment. We anticipate this task to take approximately 15 minutes. In this assessment, the participant is asked to say as many words as he/she can think of that begin with a certain letter of the alphabet. The participant is given 60 seconds for each of 3 trials. In general, this measure requires participants to generate words fluently in an effortful format.
6. Non-Focal Prospective Memory Task 7. DKEFS Trail Making	This is a computer-based assessment that measures an individual's ability to remember to carry out an intention. Participants are asked to categorize words or nonwords as they appear on the screen. While doing this, they must also remember to respond via a key press whenever a word appears that begins with the letter "g". This will take approximately 10 minutes This visuomotor assessment requires participants to, basically, connect the dots. In one trial, he/she draws a line between numbers (1-16), in another trial he/she must draw a line between letters (A-P) and in another trial, he/she must alternate between numbers and letters (1-A, 2-B, 3-C etc…). This task measures cognitive flexibility and motor speed.
8. Reading Span Task	This is a working memory task. Participants are given two alternating tasks. During the first task, participants are asked to remember single letters in the order in which they appear. Between each letter presentation, participants are presented with a sentence. They are asked to judge whether the sentence makes sense or not. This cycle continues until the end of a trial where the participant is asked to recall each letter in order.
11. Debriefing	

VITA

Allen Nida was born in Detroit, Michigan on July 12, 1989, the year of our lord, to his parents, Stephen L. Nida and Gina D. Mills. He is the second of two children, a younger brother. He received his high school diploma at Soddy Daisy High School, in Soddy Daisy, TN. He studied at the University of Tennessee at Knoxville for two years before transferring to the University of Tennessee at Chattanooga to graduate Summa Cum Laude with a Bachelors of Science degree in Psychology. During this time, he became interested in cognitive neuroscience, and sought to continue his education at the Master's level under the advisement of Dr. Amanda Clark. He seeks to continue this pursuit at the doctoral level.