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The Effects of Cerebrovascular Accidents on Prospective Memory

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THE EFFECTS OF CEREBROVASCULAR ACCIDENTS ON PROSPECTIVE MEMORY

PROFESSIONAL DISSERTATION

SUBMITTED TO THE FACULTY

OF

THE SCHOOL OF PROFESSIONAL PSYCHOLOGY
WRIGHT STATE UNIVERSITY

BY

Scott A. Magnuson, M.A.

IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE
OF
DOCTOR OF PSYCHOLOGY

Dayton, Ohio   September, 2014

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WRIGHT STATE UNIVERSITY

SCHOOL OF PROFESSIONAL PSYCHOLOGY

June 25, 2013

I HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER MY SUPERVISION BY **SCOTT A. MAGNUSON** ENTITLED **THE EFFECT OF CEREBROVASCULAR DISEASE ON PROSPECTIVE MEMORY** BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PSYCHOLOGY.

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Dissertation Director

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La Pearl Logan Winfrey, Ph.D.
Associate Dean

Abstract

Prospective memory is the ability to remember to do something in the future, also known as meta-remembering. Prospective memory is required to complete certain tasks, such as remembering to take medications, pay bills, and perform various activities of daily living. The Memory for Intentions Screening Test (MIST) is a standardized objective assessment of prospective memory that has been utilized to document impairment in prospective memory in various clinical populations such as Alzheimer's Disease, mild cognitive impairment, mild traumatic brain injury, Human Immunodeficiency Virus (HIV), schizophrenia, and Parkinson's Disease (Raskin, 2009). The current research project utilized the MIST to identify the effect of CVA on prospective memory. Data were obtained from patient files diagnosed with CVA and compared to individuals who have not had a CVA, but have been diagnosed with cerebrovascular risk factors, such as diabetes, hypertension, hyperlipidemia, substance abuse, and tobacco use. Results of the study suggest that individuals who have had a CVA evidence greater impairment in prospective memory, as measured by the MIST, than individuals with cerebrovascular risk factors, particularly in regards to 15-minute delay trials.

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Chapter I

Literature Review

Memory can be considered to take two distinct forms, remembering what we have done, and remembering what we will do. Remembering past experiences has been labeled retrospective memory; and remembering what we will do in the future is referred to as prospective memory. Prospective memory has been defined as remembering to do something at a particularly moment, or time, in the future (Einstein & McDaniel, 1990). Prospective memory is a distinct form of memory that encompasses the formation, retention, and future retrieval of intended actions that are encoded for future purposes. It has been implicated as necessary for carrying out such actions to include, but not limited to, performing activities of daily living (ADL's), adhering to medication regimens, performing daily errands and chores, executing financial responsibilities, and the overall ability to live a functioning and independent life (Burgess, 2000; Costa, Perri, Serra, Barban, Gatto, Zabberoni, Caltagirone, & Carlesimo, 2010). Furthermore, it has been suggested that prospective memory plays a more integral role in these activities than other higher-level cognitive functions, such as retrospective episodic memory (Woods, Moran, Dawson, Carey, Grant et al., 2008).

Due to the complex nature of prospective memory, as well as the research findings suggesting that the frontal lobes are involved in executing prospective memory tasks (Cockburn, 1995; Shapiro, Shapiro, Russell, & Alper, 1998), it is likely that prospective memory is affected by cerebrovascular accidents, or strokes (McFarland &

Glisky, 2009). However, there is limited research available examining prospective memory deficits following stroke, despite its high prevalence in the adult population (Hachinsky, 2007) and the impact of stroke on executive functioning (Caplan, 2009). Furthermore, the studies that are available frequently utilized data gathering methodologies that have been cited for poor validity (Uttl & Kibreab, 2011).

Therefore, the goal of this research was to design an empirical study employing data collecting methodologies that had never been used in research of the effect of cerebrovascular accidents on prospective memory. Data were collected, using a repeated measures methodology, in order to investigate the impact of cerebrovascular accidents on prospective memory. The overall objective was to develop a more sophisticated understanding of how prospective memory is affected by ischemic cerebrovascular accidents. This information will allow clinicians to more accurately predict stroke patients' functional outcomes in terms of their need for living assistance and their ability to adhere to medication regimens and other treatment regimens to address individual patient needs.

In the following sections, specific limitations to the current research are initially addressed along with a review of the current literature on prospective memory as it pertains to current cognitive models, neuropsychological findings, and neuropsychological assessment tools. Next, a brief review of the limited stroke literature as it applies to prospective memory is presented.

Current Limitations in the Literature

Although there have been a growing number of publications over the past 10 years on prospective memory, the literature is still limited in regards to the tools for

assessing prospective memory, the diverse applications of prospective memory, the impact of pathology, and the precise neuroanatomical and physiological mechanisms that contribute to prospective memory. Furthermore, there is still disagreement over whether prospective memory is a subsystem of memory in and of itself, or comprised of distinct cognitive processes. Due to this discrepancy, Ellis (1996) asserted that in order to more accurately capture the nature of prospective memory, the term should be replaced by *realizing delayed intentions.* Therefore, some researchers prefer to use this term in place of prospective memory. Kvavilashvili (1987) attempted to differentiate prospective memory from other kinds of memory, such as short-term memory and long-term memory; however, Bisiacchi (1996) argued that the problem is not to demonstrate that prospective memory is different from other forms of memory, but instead to define which processes are involved in different task requirements. Overall, there are diverse opinions regarding what prospective memory is and how it should be studied.

Another limitation within the research is the variability and inconsistency in findings. McDaniel and Einstein (2007) hypothesized that some of the variability in the research findings can be due to some subjects' tendency to monitor more often than others. Prospective memory retrieval occurs through the attentional process of monitoring the environment for the target events. Once a target event is identified, subjects' attention shifts from the ongoing activity and initiates the processes necessary for performing the intended action. It is believed that these underlying processes are a significant confound within the research, which to date, has not been addressed (Einstein, McDaniel, Thomas, Mayfield, Shank, Morrisette, & Breneiser, 2005).

An additional challenge of researching prospective memory is the confound of interpreting poor performance on a prospective memory task as due to impaired prospective memory of retrospective memory. Retrospective memory plays an important role in prospective memory and therefore, in order to execute an intended action in the future, one has to be able to recall the intention first. For example, if an individual intends to stop by the grocery store on the way home from work, but forgets, it could be because the intention was not encoded properly (retrospective memory) or because the person failed to recognize the cue and associate it with the intention (the cue being driving home from work), which would be a prospective memory failure. Therefore, it should be noted that prospective memory involves a number of cognitive processes, any of which could confound study results. In order to address this problem, it is important for researchers to assess the components involved in prospective memory, such as retrospective memory, attention, verbal memory, and nonverbal memory (McDaniel & Einstein, 2007). Many of the available studies have failed to do this, which adds confounding variables to the data.

An additional limitation within the research is the discrepancy of findings regarding the relationship between age and performance of prospective memory. Laboratory findings have repeatedly shown that young adults outperform older adults on tasks of prospective memory; however, research in naturalistic settings shows no such effect. This inconsistency in findings has been coined the *age prospective memory paradox* (Rendell & Craik, 2000). The current hypothesis is that older adults acquire compensatory abilities that allow them to perform as well as young adults on these tasks, and therefore the laboratory findings lack ecological validity (Phillips, Henry, & Martin,

2008). It is important to note this possibility, particularly when working with older adults and attempting to generalize findings across persons with differing ages.

No research has examined the recovery of prospective memory by utilizing a repeated measures methodology. Collecting data within 1 month post-stoke, and again 3 to 6 months later will allow clinicians to develop a more sophisticated understanding of the recovery of stroke patients' prospective memory. Obtaining such data will enable health care providers to better predict functional outcome and ability to live independently.

The last gap in the literature that is noteworthy is the limited measures of prospective memory that are currently available. Many researchers have developed tasks for participants to perform in order to measure prospective memory (Cheng, Tian, Hu, Wang, & Wang, 2010; Kim, Craik, Luo, & Ween, 2009); other studies have utilized computer software and virtual reality tools to measure prospective memory (Brooks, Rose, Potter, Jayawardena, & Morling, 2004; McFarland & Glisky, 2009). These methods have several limitations; they are not standardized, which introduces numerous confounds; they lack ecological validity, which make results difficult to generalize from a laboratory setting to the real world; and finally they do not always take into account the different task requirements of prospective memory (time-based cues vs. event-based cues).

Several questionnaires have been developed to assess prospective memory, including the Memory Questionnaire (MemQ), Time Cued Prospective Memory Questionnaire (TCPMQ), Comprehensive Assessment of Prospective Memory (CAPM), Prospective Memory Questionnaire (PMQ), and the Prospective and Retrospective

Memory Questionnaire (PRMQ). Uttl and Kibreab (2011) recently compared the results of these prospective memory questionnaires with prospective memory performances in laboratory and naturalistic settings. They found that correlations between questionnaires of prospective memory and objective measures were generally very weak at best, indicating no relationship between the questionnaires and performance and a lack of convergent validity with criterion measures.

The standardized assessments of prospective memory that are available include the Rivermead Behavioural Memory Test-II (RBMT-II), Cambridge Prospective Memory Test (CAMPROMPT), and the Memory for Intentions Screening Test (MIST). The RBMT-II (Wilson, Cockburn, & Baddeley, 1985) was developed to detect impairment of everyday memory functioning and monitor change over time. The test is comprised of 11 subtests; however, only 3 of the subtests measure prospective memory (the Belonging, Appointment, and Messages subtests). Although the RBMT-II has been found to have good ecological validity (Strauss, Sherman, & Spreen, 2006), the limited measures of prospective memory make it an insufficient assessment of prospective memory ability. A comprehensive prospective memory assessment should include a number of measures of the different types of prospective memory.

The CAMPROMPT (Wilson, Emslie, Foley, Shiel, Watson, Hawkins, et al., 2005) is a modified version of the Cambridge Behavioral Prospective Memory Test. The CAMPROMPT requires participants to remember to carry out 4 time-based and 4event-based tasks at different times, while performing distracter activities, using both verbal and written instructions. The 4 time-based tasks include (a) reminding the examiner after 15 minutes not to forget his or her keys, (b) requesting a newspaper after 20 minutes, (c)

working on one task for 20 minutes and then switching to a second ambiguous task after an additional 5 minutes, and (d) after the instructions are given the examinee is to open or close a booklet after 3 minutes. The four event-based tasks are (a) reminding the examiner about five hidden objects after the examiner says the testing has concluded, (b) putting a briefcase under the desk after an alarm rings, (c) switching pens after completing seven distracter assignments, and (d) giving an envelope to the examiner when told there are 10 minutes left. Participants are permitted to take notes and use strategies to help them remember. The CAMPROMPT produces scores on time-based and event-based subscales. Research on the CAMPROMPT scores have revealed significant group differences according to age, use of note-taking strategies, and estimated IQ in healthy controls. Limited research does support a modest correlation with the RBMT; however, clinical utility is dependent upon future research in order to establish its psychometric properties and construct validity in healthy and clinical populations (Fish, Wilson, Manly, 2009; Woods, Carey, Moran, Dawson, Letendre, & Grant, 2007).

Similarly, the MIST (Raskin, 2004) is a recently developed neuropsychological measurement of prospective memory that to date has only slightly more psychometric data to support its validity than the previously reviewed measurements. The MIST was designed to assess the different characteristics of prospective memory, including the type of cue (time-based or event-based), type of response (action or verbal), and length of delay period (long or short). Additionally, this measurement was developed to be a comprehensive, yet efficient measurement of prospective memory. In order to achieve this goal, the developers constructed the test to be administered in approximately 30
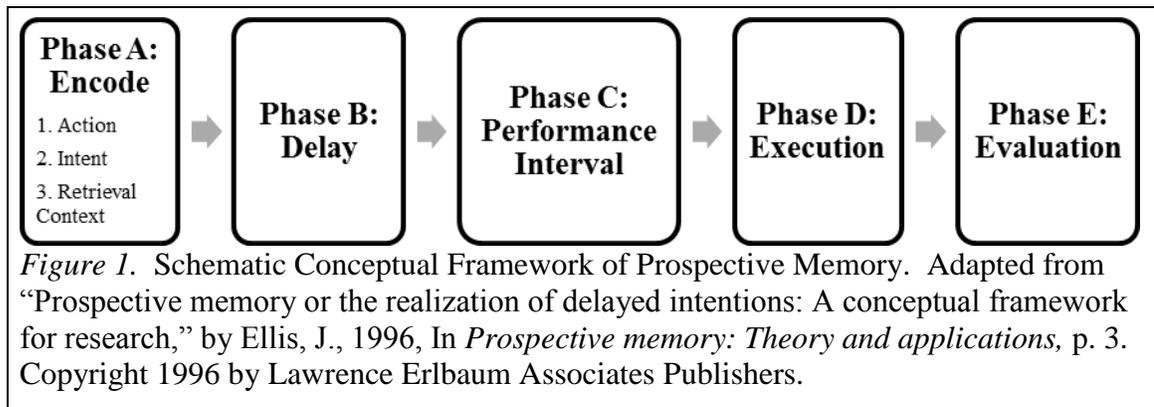
minutes. Research has provided evidence that the MIST has acceptable validity, reliability and specificity (Raskin, 2004; Woods, Moran, Dawson, Carey, Grant et al., 2008). Overall, the MIST has the most data to support its validity and appears to be the most comprehensive measurement of prospective memory. This test will be discussed in more detail later.

In summary, the current literature regarding prospective memory remains uncertain about the conceptualization of prospective memory and the cognitive domains that contribute to individuals' ability to execute future intentions. Furthermore, there is a need for additional research in order to develop a better understanding of the effects of neuropathology, specifically stroke, on prospective memory. Addressing this need will allow clinicians to make more educated predictions about patients' overall prospective memory recovery, ability to adhere to medication regimens, and capacity to function independently. To achieve this objective, it is necessary to collect additional data to further validate the MIST.

Cognitive Processes Involved in Prospective Memory

Prospective memory, according to Ellis (1996), is conceptualized as a variety of cognitive processes that collectively work as an interface between memory, attention, and action processes that are intimately associated with the control and coordination of future actions and activities. It is for this reason that Ellis prefers to refer to prospective memory as *realizing delayed intentions,* in order to more accurately encompass all of the cognitive processes that are involved in prospective memory. In order to more easily conceptualize the stages, or phases of prospective memory discussed previously, Ellis

(1996) developed a schematic framework (Figure 1), but has added an additional phase that was not addressed in the earlier model.

Figure 1. Schematic Conceptual Framework of Prospective Memory. Adapted from "Prospective memory or the realization of delayed intentions: A conceptual framework for research," by Ellis, J., 1996, In *Prospective memory: Theory and applications,* p. 3. Copyright 1996 by Lawrence Erlbaum Associates Publishers.

Phase A (Encoding) of Ellis' model is primarily concerned with the formation of retaining an action, developing an intent to perform the action, and constructing a retrieval context that describes the condition for the action to be recalled. More precisely, it is a declaration of *what, when, and why* one intends to perform a future action. The following sentence exemplifies these three factors: "I will (intent) stop by the grocery story (action) on my way home from work (context)." Planning and motivational operations occurring during this phase highly influence the encoding and ultimate performance of the delayed intention.

Phase B of the model represents the delay between encoding and the initiation of the potential performance. The duration of this delay is an indefinite amount of time, lasting anywhere from seconds to days. Phase C refers to the period of time when the intended action should be retrieved, otherwise known as the performance interval. It is important to distinguish between the retention interval (Phase A) and the performance interval (Phase C), as they apply to the example previously used. If individuals were to find that they were out of milk as they were making breakfast before work, they might say, "I will pick up milk on my way home from work this evening." The intention to

pick up milk is encoded in the morning before work, and the action will take place approximately 9 hours later on their way home from work. Therefore, the retention interval lasts for approximately 9 hours; in contrast, the performance interval is the duration of time it takes to perform the action (driving to the store and buying milk). It is important to note that the performance and retention intervals may vary in duration, and the delayed intention may be remembered a number of times during either interval. However, in order to execute the delayed intention successfully, it must be recognized during the appropriate context (while driving home from work) and associated with the intention to perform the action (I will go to the grocery to pick up milk).

Phases D and E depict the initiation and implementation of the intended action, as well as the evaluation of the consequential outcome. Phase E is necessary for two reasons: in order to circumvent performing an unnecessary action that has already been executed, and to evaluate the success or failure of the delayed intention.

Ellis' model expands on the work of Einstein and McDaniel (1990), who compared prospective memory and retrospective memory. The results of their work indicated there is a retrospective memory component that is necessary in order to execute a prospective memory task. These findings are consistent with Ellis' model in that Phase A (which is concerned with the retention and encoding of the intended action, as well as the context for which it is to be executed) is proposed to utilize a retrospective component of memory. Phases B through E depict the process of realizing and executing the delayed intention, which are proposed to be more pure components of prospective memory (Ellis, 1996).

Kvavilashvili and Ellis (1996) highlighted the fact that each of these phases can vary in the nature and complexity of demands. The task of remembering to execute a specific behavior in the future can vary on many different levels. This collaborative work divides prospective memory into four phases of information processing: encoding, retention, retrieval, and performance.

Encoding. During the encoding phase, the intentions to perform future actions can be based on simple or difficult decisions; self- or other-generated intentions; important or unimportant decisions; or pleasant, neutral, or unpleasant intentions. Simple vs. difficult decisions that precede the formation of an intention may influence the likelihood of the intention to occur. For example, a person may decide to stop by the grocery store on the way home from work, which is a relatively easy task. However, if the person has a time constraint that requires him or her to be somewhere else after work, this easy task has just become more difficult and the psychological intentions have now been transformed. Several factors suggest that one is more likely to forget a simple future intention than a difficult one because difficult tasks are usually more time consuming and therefore require more elaborate and distinctive planning processes (Kvavilashvili, 1992; Kvavilashvili, & Ellis, 1996).

Self- vs. other-generated intentions refer to the fact that some future intentions are a result of a personal need to do something, whereas other future intentions are the result of a request from someone else. The main difference between these two encoding processes is that self-generated intentions satisfy one's own needs, whereas other-generated intentions satisfy others' needs. It should be noted that experimental tasks have only focused on other-generated intentions, and therefore the precise difference

between these two modes of encoding are not fully understood (Kvavilashvili & Ellis, 1996).

Important and unimportant future intentions may be encoded very differently. This concept is almost intuitive; we are more likely to forget to perform trivial actions than we are very important actions. Empirical data support this notion. It is hypothesized that people tend to think about important future intentions more frequently than they do unimportant ones, and therefore the important ones are encoded more effectively than the unimportant ones (Ellis, 1988).

Pleasant, neutral, or unpleasant intentions refer to the emotional and cognitive meanings that we associate with a future intention. To date, experimental studies have investigated only the remembering of neutral intentions; however, questionnaire studies have addressed pleasant and unpleasant intentions. This research found that intentions that were unpleasant were just as likely to be remembered as pleasant intentions, but substantially less likely to be executed (Meacham & Kushner, 1980).

Retention. The retention of future intentions is distinguished in terms of the delay between the time at which the intention is encoded and the designated moment in which it will be retrieved. The delay can be conceptualized as occurring on a continuum from long-term to short-term, with no precise time specified as distinguishing between the two intervals. The vast majority of laboratory research has focused on studying short-term retention of prospective memory (Kvavilashvili, & Ellis, 1996). However, some of the more recently developed comprehensive assessments of prospective memory instruct the participant to call the researchers at a specified time (approximately 24 hours after the

testing session), which allows researchers to investigate long-term prospective memory (Raskin, 2004).

Retrieval. The retrieval phase occurs when the intention is retrieved from memory with the opportunity to be executed. The intention must be retrieved during a predetermined circumstance in order to be successfully executed. However, executing this delayed intention is dependent upon the type of intention. There are four distinct forms of intentions: event-, time-, or activity-based intentions; pure or combined intentions; episodic or habitual intentions; pulse, intermediate, or step intentions.

Kvavilashvili (1990) distinguished three different forms of intentions (event-, time-, or activity-based); however, the majority of other researchers only differentiate between time- and event-based intentions (Brandimonte, Einstein, & McDaniel, 1996; Kliegel, McDaniel, & Einstein, 2008). Event-based intentions are defined as an intention that is to be executed during a specific event, an activity-based intention is executed after the occurrence of a specific activity, and a time-based intention is to be executed at a certain time. Einstein and McDaniel (1990) studied the difference between event- and time-based retrieval in older adults. They found that older adults performed better with event-based tasks than time-based tasks. They hypothesize that this discrepancy exists because during event-based tasks, the event serves as the cue to execute the intention. However, time-based intentions do not have such external cues and require additional internal mediation of cognitive processes.

Pure intentions refer to an intention that is exclusively time-based or exclusively event-based. In contrast, combined intentions refer to intentions that are event- *and* time-based. Ellis (1996) argued that combined intentions occur more frequently in naturalistic

environments. An example of a combined intention would be to go to the store at 6:00pm (time-based) when work is over (event based). According to findings, combined intentions may be more easily retrieved because there are more cues to prompt retrieval (Kvavilashvili & Ellis, 1996; Loftus, 1971; West, 1988).

Episodic intentions are performed infrequently or irregularly, such as paying annual income taxes; and habitual intentions are executed regularly and in a routine manner, such as brushing one's teeth. Meacham and Singer (1977) attempted to investigate the differences between habitual and episodic intentions and found no significant differences. However, other researchers have criticized their methodology and hypothesized that significant differences do exist (Harris, 1984; Kvavilashvili, & Ellis, 1996; Meacham & Leiman, 1975).

The last distinction is the temporal specification in which the intention is to be retrieved. Pulse intentions refer to an intention that is to be retrieved at a specific moment (I have to leave the house at 8:00am), step intentions are to occur at a more flexible point in time (I have to leave the house sometime this morning). An intermediate retrieval is a combination between the two. The research regarding the differences between step and pulse intentions is limited and therefore no conclusions can be drawn at this point (Ellis, 1988; Kvavilashvili & Ellis, 1996).

Performance. This phase of prospective memory refers to the execution of the intention. Kvavilashvili and Ellis (1996) highlighted the fact that although performance of the intended action may not seem as pertinent for prospective remembering as the retrieval phase, it may have a significant impact on retrieval. It is therefore necessary to recognize that the performance of an intention can vary according to the length of time it

takes to execute the intention, as well as the number of times one has to remember an intention in order to complete it.

The first distinction of the performance phase is the length of time that it takes to complete the task. This can be categorized as momentary, short, or long tasks. Some tasks can be completed momentarily, such as conveying a message; others require an extensive amount of time, such as remembering to go to a meeting. Those tasks that require more than a couple minutes, but less than several hours, such as making a telephone call, are classified as short intentions. Although there are no precise classification criteria, it is apparent that more time consuming intentions require a more elaborate planning process during encoding. Therefore, it is likely that more time consuming intentions are more likely to be recalled than short or momentary intentions. To date, no research has addressed this theory.

The second distinction concerns the number of times an intention has to be recalled in order to be effectively executed. These tasks are divided into stages; for example, remembering to mail a letter after work is a one-stage task (driving to the mailbox on the way home from work). However, remembering to get the letter from an assistant *and* then mailing it after work requires two stages in order to be executed accurately. Applicable theories concerning this notion do not agree regarding the likelihood that single stage or multistage intentions are more likely to be executed accurately. According to Lewin (1926/1951), remembering the first stage of a multistage task may result in decreased tension associated with that intention, and thus may result in forgetting to execute the subsequent steps in order to fully complete the task. In contrast, Norman (1981) and Reason (1984) suggested that remembering the first part of the task

will enhance the activation of thoughts associated with that intention and will increase the likelihood of remembering the subsequent stages. Aside from the previously mentioned theories, currently no applicable empirical studies support these hypotheses (Kvavilashvili & Ellis, 1996).

The last cognitive model that is noteworthy in this context is based on the works by McDaniels and Einstein (2000), who proposed the Multiprocess Theory of Prospective Memory. The basis of this theory is grounded in three general assumptions. The first assumption is that multiple processes can support prospective memory. These processes range from strategic monitoring of the environment for the target event to spontaneous retrieval processes, which act as a reflex to the target event and/or cues associated with the intention. For example, one can constantly be monitoring the environment in a very calculating manner waiting for the cue to execute the intention; or, the retrieval process can occur in a much more spontaneous manner.

The second assumption is that the process that individuals employ and the effectiveness of that process are dependent on the characteristics, nature, and demands of the task, as well as the characteristics of the individual executing the task. For example, when people perceive that the context in which the task is to be carried out will probably aid in the spontaneous retrieval, they will be less likely to engage in monitoring processes. Conversely, if the context is perceived to not encourage spontaneous retrieval, the individual is more likely to allocate additional attentional resources in order to monitor the environment and be more aware of subtle contextual cues. This assumption was supported by Marsh, Hicks, Cook, Hansen, and Pallos (2003). Participants were administered an ongoing lexical decision task and on the first condition were given the

prospective memory intention of pressing a key whenever they saw the word *dog*. For the other condition, whenever participants saw a word naming an animal, they were instructed to press a key. In the first condition, participants were given clear directions regarding the cue to which they were to react; thus, they believed that they would easily identify when it was time to retrieve and execute the intention. In the second condition, participants perceived that spontaneous retrieval would be more difficult and therefore they would need to be more vigilant in how they monitored for the cue. Results indicated significant differences in performances across the two conditions.

The third assumption of the Multiprocess Theory is that people tend to rely on spontaneous retrieval, as opposed to constant monitoring, because the demands of constant monitoring of one's environment tends to consume significantly greater attentional resources. Although the latter technique may enhance the likelihood of successful prospective memory retrieval in many situations, it may interfere with other demands. For example, if the intention is to relay a message to a coworker, it would be an inefficient use of attentional resources to sit at one's desk and scan the office until the coworker arrives at work. Instead, people can rely on the fact that they will be able to spontaneously retrieve the intention when they encounter the coworker, therefore allowing them to go about their business and accomplish other tasks.

To summarize the central claims of this theory, there are multiple approaches for solving a prospective memory problem, and the most useful method will likely depend on many variables, such as the relevance of the task, the nature of the cues, the relation of the cues to the intention, the nature of the task, and individuals' cognitive and personality characteristics (McDaniels & Einstein, 2000, 2007).

Neuropsychology and Prospective Memory

Although there have been an increasing number of publications studying

prospective memory, the overall literature is still quite limited. The vast majority of these

publications have concluded that prospective memory is mediated by the frontal lobes;

however, their precise role in prospective memory remains unclear. The majority of the

research on prospective memory has studied older adults and compared their

performances on these tasks to younger adults. Researchers also have analyzed the effect

of pathology on prospective memory utilizing clinical subjects, such as those diagnosed

with traumatic brain injury, Alzheimer's disease, Parkinson's disease, HIV, and

schizophrenia; however, the literature is extremely limited when it comes to examining

the effects of cerebrovascular accidents on prospective memory. Only three publications

have been found to date.

Kim, Craik, Luo, and Ween (2009) compared the performances of 12 stroke

patients (average length of time since stroke was 2.99 years) with 12 healthy individuals

on various neuropsychological and prospective memory tasks. Participants were

administered the Mini Mental Status Exam (MMSE), Trail Making Test (TMT), Verbal

Fluency (FAS and Animals), the Sustained Attention to Response Task (SART), Verbal

Paired Associates (from WMS-III), and the California Verbal Learning Test-II (CVLT-

II). Measures of prospective memory included the Virtual Week (VW), which is a board

game developed by Rendell and Craik (2000) to assess prospective memory. The game

is divided into single days of the week and participants move around the board with the

roll of a die. They are required to remember to execute specific activities either at

particular times (as they pass a specified square on the board), or in response to specific

events, which are instructed on event cards picked up during the course of the game. There are two types of prospective memory tasks: Regular (tasks that are to be repeated several times during the game) or Irregular (tasks are more varied). Participants were also administered the Remembering a Belonging subtest of the RBMT and the Prospective and Retrospective Memory Questionnaire (both previously described). The results of this study found that the control group made significantly more correct responses and significantly fewer incorrect responses than the stroke patients did on the Virtual Week board game, which is indicative of poor prospective memory. Additionally, the control group also outperformed the patient group on the time-based tasks, but not the event-based tasks. The Remembering a Belonging and the Prospective and Retrospective Memory Questionnaire indicated no significant differences. Group differences in the executive tasks also revealed mixed results as patients showed deficits in some executive functioning tasks, but not all. For example, stroke patients did not show deficits in perceptual speed (Trails A and B), and some aspects of sustained attention (SART: error of omission). However, tasks that involve inhibitory control (SART: error of commission) and unguided retrieval (verbal fluency) showed large stroke related deficits. Therefore, researchers concluded that lesions in certain areas of the brain can cause impairment in stroke patients' ability on certain tasks requiring "self-initiation" (Craik, 1983, 1986) and cognitive control, which reflect inefficiencies of frontal lobe functioning.

Another study by Cheng, Tian, Hu, Wang, and Wang (2010), compared event-based and time-based prospective memory performances of patients with thalamic stroke. Eighteen patients were recruited (8 with a lesion in right thalamus, 8 with a lesion in left,

and 2 with lesions of bilateral thalamus). Patients were administered the Wechsler Adult Intelligence Scale–Revised Chinese (WAIS-RC), Verbal Fluency Test, MMSE, a time-based and event based prospective memory task and subjected to magnetic resonance imaging (MRI) and computed tomography (CT) approximately 2 weeks to 2 months post-stroke. Results were compared to a demographically matched control group. Of the neuropsychological measures administered, the only significant difference found was on the Verbal Fluency Test, on which the control group significantly outperformed the patient group. This was also the case for several components of the time-based prospective memory tasks. However, within the patient group, there was no significant difference in performance between the left and right thalamic stroke groups on time-based and event-based prospective memory tasks. Based on the authors' findings, thalamic stroke patients were significantly impaired in the time-based prospective memory tasks, but not in the event-based prospective memory tasks. This provides evidence that the thalamus is associated with time-based prospective memory, which implies that time-based and event-based tasks may be mediated differently by the thalamus, and the thalamus may be particularly involved in time-based prospective memory.

The final study, by Brooks, Rose, Potter, Jayawardena, and Morling (2004), analyzed the effects of cerebrovascular accidents on prospective memory utilizing a virtual reality task. Forty-two stroke patients (ranging from 1 week to 2 months post-stroke) were administered the virtual reality task, which required them to help move various items from one house to another. Their performances were compared to a demographically matched control group. The results indicated that the performance of

the control group was higher than that of the patients in event-, time- and activity-based prospective memory tasks. However, there appears to be less difference between patients and controls in the time-based task than in the activity- and event-based tasks. The most unexpected result was that patients performed more similar to the control group on the time-based prospective memory tasks than on the event- or activity-based tasks. However, it should be noted that 17 of the 42 stroke patients, as well as 4 of the 29 control participants were unable to recall all three of the prospective memory task instructions immediately after they had finished the prospective memory tasks, despite the fact that they were able to recall them immediately prior to beginning the tasks. This study has several distinct limitations that are not addressed. First, the average age of the participants was 71.8 and it is highly likely that they are not familiar with virtual reality, as well as the intricacies involved with using such sophisticated technology. Therefore, it is likely that this confounded their results by causing additional problems for the participants and may account for the fact that so many of them could not recall the instructions at the end of the task. Furthermore, the researchers did not explicitly outline the inclusion and exclusion criteria, which mean that patients may not have been cognitively able to perform these tasks (Brooks, Rose, Potter, Jayawardena, & Morling, 2004).

Overall, the three studies that have explored the effect of cerebrovascular accidents on prospective memory have several limitations. First, none of the studies used a comprehensive assessment of prospective memory. The previously mentioned studies employed prospective memory tasks that have very few publications, if any, analyzing their psychometric properties. Secondly, these tasks likely have very little ecological

validity, and therefore it is not fully understood how these results can be generalized. Lastly, two of these studies used very small sample sizes in order to obtain their data. Again, this limits the authors' ability to generalize their results.

A 2009 study by McFarland and Glisky compared 32 participants' (aged 65 or older) performance on a prospective memory task after they were divided by frontal lobe functioning and medial temporal lobe funcitoning (high vs. low) based upon their performance on neuropsychological tests. Individuals were adminstered a series of tests known to measure frontal lobe and medial temporal lobe functioning. The frontal lobe measures included the Arithmatic subtest from the WAIS-R, the Mental Control and Backwards Digit Span subtests from the WMS-III, the total number of words generated from the Controlled Oral Word Association Test, and the number of categories sorted on the Wisconsin Card Sorting Test. The measures of medial temporal lobe functioning included the Verbal Paired Associates I, Faces I, and Logical Memory I subtests from the WMS-III, the Visual Paired Associates II from the WMS-R, and the Long Delay Cued Recall from the CVLT. Participants' scores for both factors represent average z-scores relative to the normative population of 227 older adults (Glisky& Kong, 2008). Variability attributed to age was removed and equal numbers of participants were placed into each of four possible categories created by the two factors (frontal lobe functioning as either high or low; medial temporal lobe functioning as either high or low). Results of these participants' scores were compared to a group of young adults' scores who had been administered identical tests. All participants were administered an ongoing background task that required them to take a multiple-choice test based on general knowledge. The prospective memory task of the experiment required them to press one

of two buttons in an alternating fashion at 5-minute intervals. Additionally, at the end of

this task, participants were administered a basic time awareness test in which they were

shown a green triangle for 27 seconds and asked to estimate how long they saw the

triangle. Another time awareness test showed them the green triangle and then asked

them to indicate when they had viewed the triangle for 10 seconds.

The overall results of this study found that the high functioning frontal lobe group

completed significantly more time-based prospective memory tasks than the low

functioning frontal lobe group, and the low functioning frontal lobe group committed

significantly more prospective memory errors than the high functioning frontal lobe

group. Furthermore, the low and high functioning medial temporal lobe group did not

significantly differ on the prospective memory task. When the results were compared

across age groups, the younger adults significantly outperformed the older adults. This

was found for all older adult subgroups except for the high frontal lobe/high medial

temporal lobe functioning older adult group, which did not differ from the younger

adults. Researchers concluded that there is a relationship between neuropsychological

functioning of the frontal lobes and the execution of time-based prospective memory

tasks, which is consistent with theoretical notions regarding the role of the frontal lobes

in the performance of time-based prospective memory tasks (McFarland & Glisky, 2009).

Cohen and o'Reilly (1996) characterized the function of the prefrontal cortex and

the hippocampus in terms of informational processesing mechanisms in which the

important function of the prefrontal cortex is the representation and maintenance of

contextual information, or information that must be held in mind in order to be used to

conjecture an appropriate behavioral response. In contrast, the role of the hippocampus is

to establish novel associations that can be used to guide behavoir. Therefore, prospective

memory can be conceptualized as the interaction between these two systems by allowing

specified behaviors to be associated with new conditions and providing a mechanism for

planning. If the prefrontal cortex does not allow one to hold contextual information, the

person will be unable to monitor the environment, such as noting the time when the

intended action is to be executed. Therefore, it is very likely that the prefrontal cortex,

and frontal lobes in general, play an important role in monotoring for contextual cues to

execute the delayed intention. This explains how poor frontal lobe functioning can

account for poor performance on time-based prospective memory tasks (Cohen &

O'Reilly, 1996; Einstein, & McDaniel, 1990).

In order to compare the differences between time-based and event-based

prospective memory tasks, Raskin, Woods, Poquette, McTaggart, Sethna, Williams, and

Trster (2011) compared the performances of patients with Parkinson's disease to healthy

adults using the MIST. As mentioned previously, the MIST is comprised of four time-

based and four event-based trials, which enables researchers to analyze potential deficits

in both types of tasks. Researchers administered the MIST to 88 participants, including

54 individuals with Parkinson's disease and 34 healthy adults. The results revealed a

significant interaction between the performance of individuals with Parkinson's disease

and prospective memory cue type, with the clinical group performing significantly worse

on time-based versus event-based tasks. This suggests that individuals with Parkinson's

disease experience particular difficulty executing future intentions when the cue to

execute the intention requires a higher level of cognitive control, which is typically the

case for time-based tasks. Given that patients with Parkinson's disease typically show a

high level of executive dysfunction, it is theorized that poorer performance on time-based tasks can be attributed to the Parkinson's disease related deficits of frontal systems and associated executive functions (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Raskin et al., 2011).

Research has clearly found deficits in prospective memory, particularly time-based tasks in not only clinical populations, but also healthy older adults. These deficits in prospective memory tasks have been documented in laboratory findings as well as natural settings. However, it has been found that individuals generally perform better in natural settings, as they have developed compensatory techniques that aid in executing future intentions (Masumoto, Nishimura, Tabuchi, & Fujita, 2011).

One of the more important prospective memory tasks that commonly occur in the natural setting is remembering to take one's medication. A 2009 study by Contardo, Black, Beauvais, Dieckhaus, and Rosen analyzed the relationship of prospective memory to patients' medication adherence. Ninety-seven patients who had previously tested positive for HIV were recruited and administered the MIST as well as other neuropsychological tests. Adherence to prescribed medications was measured by electronic monitoring caps placed on patients' pill bottles. Data revealed that three subscales of the MIST (action response, 15-minute delay, and event cue recall) significantly correlated with medication adherence, thus indicating that these subscales may be particularly accurate predictors of medication adherence.

Neuropsychology and Cerebrovascular Accidents

Cerebrovascular accidents, also more commonly known as strokes, are defined as the acute onset of loss of brain functions due to a disturbance in the blood supply to the

brain (Cohen& Gunstad, 2010). Strokes are classified is either ischemic (lack of blood supply) or hemorrhagic (leakage of blood). Ischemic strokes can be further subdivided into thrombosis, which is an obstruction of blood flow due to a localized occlusion, and embolism, which occurs when material formed elsewhere in the vascular system lodges in an artery and blocks blood flow (Caplan, 2009). In both ischemic and hemorrhagic strokes, the affected brain regions are damaged, which produces neurological symptoms such as aphasia, hemiparesis, hemiplegia, or visual neglect. In 2005, nearly 1.1 million stroke survivors reported difficulty performing basic activities of daily living, making strokes a significant cause of disability. Every year, approximately 795,000 people in the United States have a stroke, and approximately 137,000 Americans die of stroke every year, making it the third leading cause of death (Lloyd-Jones, Adams, Brown, et al., 2010).

Risk factors have been identified that increase one's chances of experiencing a stroke. These risk factors include advanced age, hypertension, previous stroke or transient ischemic attach (TIA), diabetes, high cholesterol, atrial fibrillation, smoking, and obesity. After the occurrence of a stroke, it is common for people to experience some sort of cognitive impairment, which can vary in severity, and the specific nature of cognitive impairment varies as a function of the location and size of the affected area. Most common impairments include memory, attention, executive functioning, language, and motor functions (Cohen & Gunstad, 2010).

The circulatory system that supplies blood flow to the brain is made up of vast networks of interconnected arteries, veins, and capillaries. The three main arteries include the anterior cerebral artery (ACA), the middle cerebral artery (MCA), and the

posterior cerebral artery (PCA). Smaller blood supply lines branch from these main

arteries to supply the cortex, underlying white matter, and subcortical structures of the

brain. Each hemisphere of the brain is supplied by one internal carotid artery (ICA;

Festa, Lazar, & Marshall, 2008). While the brain accounts for approximately 2% of the

overall adult's body weight, it requires an uninterrupted supply of oxygen and glucose,

and therefore uses approximately 20% of cardiac output when the body is at rest (Gusev

& Skvortsova, 2003). When the brain is deprived of nutrients, it can function for only

approximately 6 to 8 minutes. Therefore, in the occurrence of a cerebrovascular accident,

when blood supply to the brain in restricted, it is easy to understand how cell damage can

occur so rapidly. The degree of cell damage is dependent on many factors including the

ischemia duration, the location, history of prior strokes, and individual variability in

vascular organization (Festa, Lazar, & Marshall, 2008).

     Clinical syndromes that are commonly presented following a cerebrovascular

accident also vary for each individual and are dependent on many variables, such as

lesion location. Research on the cerebral localization has confirmed that some

neurological functions do have a distinct hemispheric localization. Speech and language

are most often associated with left hemisphere functions (Damasio, 1992); and

visuospatial processes are most often associated with the right hemisphere (Brown,

Spicer, Robertson, Baird, et al., 1989). Visual neglect is a syndrome in which a patient

can see all of the visual field but ignores objects on one side. This syndrome is most

often associated with right hemisphere lesions (Scott & Schoenberg, 2011). Lastly,

motoric and somatosensory impairment occurs contralateral to the hemisphere in which

the cerebrovascular accident occurred (Hom & Reitan, 1990).

Memory for Intentions Screening Test

As briefly highlighted previously, the MIST (Raskin, 2004) is one of the few comprehensive assessments of prospective memory. This neuropsychological tool has received notable attention recently, as it addresses an area of assessment that plays a crucial role in daily functioning. As mentioned previously, prospective memory plays an important role and has been suggested as being an essential cognitive component in performing daily activities, even more so than other higher-level cognitive functions, such as retrospective episodic memory (Woods, Moran, Dawson, Carey, Grant et al., 2008). Despite all this, tests of prospective memory have yet to find their way into the arsenal of clinical neuropsychologists. In a recent survey of neuropsychological practitioners, no measures of prospective memory ranked among the most commonly used assessments (Rabin, Barr, & Burton, 2005); however, the RBMT was endorsed by 6.4% of neuropsychologists. As mentioned previously, the RBMT is not a comprehensive assessment of prospective memory, as only two of the subtests measure delayed intentions. It is likely that the lack of prospective memory assessments being utilized by professionals is indicative of the paucity of literature, as well as the unavailability of comprehensive measures of prospective memory (Woods, Moran, Dawson, Carey, Grant et al., 2008).

The MIST was designed specifically to address these problems. The test duration is approximately 30 minutes in which the examinee is required to perform 8 tasks that vary in terms of delay interval (2-minute or 15-minute delay), cue type (time-based or event-based), and response type (verbal or action response). For example, on the first task, the examinee is told, "In 15 minutes, tell me that it is time to take a break." This

would be a 15-minute delay, time-based, verbal response. On another task, the examinee

is told, "When I hand you a Request for Records Form, write your doctors name on it."

Although it is not stated, the examiner would hand the Request for Records Form two

minutes later. This is an example of a 2-minute delay, event-based, action response.

Table 1 displays the types of tasks for Trials 1 – 8.

Table 1

MIST Trials 1 – 8

Trial	Delay	Cue Type	Response Type
1	2-Minutes	Time	Verbal
2	2-Minutes	Event	Action
3	2-Minutes	Event	Verbal
4	15-Minutes	Time	Verbal
5	15-Minutes	Event	Action
6	15-Minutes	Event	Action
7	2-Minutes	Time	Verbal
8	15-Minutes	Time	Action

Participants are engaged in a word-search puzzle that serves as a distracting task,

during which time they are required to perform these varying prospective memory tasks.

Incorrect responses are recorded in a way that operationalizes common errors of omission

(loss of time) and commission (task substitution errors). Following this, participants are

administered a multiple choice recognition test. The final trial of the assessment is a 24-

hour delay in which the participants are asked to telephone the clinician the next day and report the number of hours they slept the previous night (Raskin, 2004).

The MIST has evidenced acceptable psychometric properties. It was administered to 200 healthy individuals and correlated with the two prospective memory subtests from the RBMS (r = .80). The MIST is available in two forms, which allow retesting to be performed. Interform reliability was demonstrated in a group of 20 individuals (Spearman-Brown coefficient = .70). Internal consistency of the six subscales also was also found to be within acceptable limits (Cronbach's alpha = 0.886; Woods, Moran, Carey, Dawson, Iudicello, Gibson, et al., 2008). The MIST has also been shown to distinguish between many clinical groups such as mild cognitive impairment (Karantzoulis, Troyer, & Rich, 2009), HIV (Carey, Woods, Rippeth, Heaton, Grant, et al., 2006; Woods, Moran, Carey, Dawson, Iudicello, Gibson, et al., 2008), and schizophrenia (Twamley, Woods, Zurhellen, Vertinski, Narvaez, Mausbach, Jeste, et al., 2008; Woods, Twamley, Dawson, Narvaez, & Jeste, 2007).

Repeatable Battery for Assessment of Neuropsychological Status (RBANS)

The RBANS (Randolph, 1998) was designed to measure attention, language, visuospatial abilities, and immediate and delayed memory for the purposes of detection and characterization of dementia in the elderly or as a neuropsychological screening battery. The authors developed this assessment to be used as an efficient screening tool for mild cognitive impairments as well as dementia. The RBANS can be administered in approximately 30 minutes. The overall assessment includes 12 subtests that are divided into five domains, which combine to yield a total scale score.

The RBANS has been found to have adequate psychometric properties, to include construct and predictive validity (Larson, Kirschner, Bode, Heinemann, & Goodman, 2005), and to be sensitive both in terms of detecting and characterizing cognitive impairment (Randolph, Tierney, Mohr, & Chase, 1998). In a 2006 study by Wilde, 210 acute ischemic stroke patients were administered the RBANS. A principal components analysis yielded a two-factor (Language/Verbal Memory and Visuospatial/Visual Memory) solution that accounted for 61% of the variance. Utilizing a subgroup of 111 left and right hemispheric stroke patients, a comparison of the obtained factors showed that the left hemisphere stroke patients' performances were more impaired on the Language and Verbal Memory factor in comparison to the right hemisphere stroke patients; conversely, the right hemisphere stroke patients' performances were more impaired on the Visuospatial and Visual Memory factor score. Based on the knowledge of hemispheric localization, the authors concluded that these factor indices are valid measures. In a follow up study, Wilde (2010) administered the RBANS to a group of 164 ischemic stroke patients and found that he was able to distinguish cortical stroke patients from subcortical stroke patients based on their performances on the Visuospatial/Constructional Index, as subcortical patients outperformed the cortical patients.

Although the RBANS does not include any prospective memory measures, it is able to account for retrospective memory, which is an essential component of prospective memory (Burgess & Shallice, 1997). The Delayed Memory Index of the RBANS is comprised of the List Recognition, Story Recall, and Figure Recall subtests, which are all valid measures of retrospective memory (Randolph, Tierney, Mohr, & Chase, 1998). The

inclusion of these tests, along with measures of prospective memory, enables clinicians to develop a better understanding regarding the potential errors of failing to execute a delayed intention. If one is unable to encode the information, as measured by the previous assessments, than the delayed intention will not be executed upon cue recognition. Therefore, it is essential to include assessments of retrospective memory when attempted to assess prospective memory.

Brixton Spatial Anticipation Test

The Brixton Spatial Anticipation Test, also known as the Brixton, was developed by Burgess and Shallice (1997) as part of the Hayling and Brixton tests as an assessment of executive functioning. Participants are presented with a 56-page stimulus booklet in which each page displays 10 circles arranged in two rows by five rows. Each circle is numbered from 1 to 10. On each page, one of the circles is shaded in and the position of the shaded circle changes from page to page in a specific pattern, which intermittingly changes as the test progresses. Participants are presented one page at a time and are asked to indicate where the shaded circle will be on the next page. Responses are considered correct if the participant accurately anticipates the location of the shaded dot on the next page. The total number of errors across 55 trials is used as the outcome measure and higher scores reflect more impaired performance.

A recent study compared the ability of the Brixton to distinguish between stroke patients and normal individuals and found that after age-, sex- and years of education-adjusted analysis patients with stroke performed significantly worse than the healthy control group. However, within the group of patients with stroke, there was no difference in Brixton error scores between the right- and left-hemisphere patients. However, this is

probably due to the heterogeneity of cognitive impairment in patients with strokes (Van Den Berg, Nys, Brands, Ruis, van Zandvoor, & Kessels, 2009). Overall, there is limited research regarding the psychometric properties of the Brixton. However, this assessment is part of the standard neuropsychological battery that is administered to patients, and therefore that was one of the few executive functioning measures that was available in the chart for the retrospective data collection.

Hypothesis

In summary, prospective memory plays an intricate and significant role in daily functioning that allows individuals to execute delayed intentions. Furthermore, the frontal lobes have been found to play an important role in prospective memory (Cockbrun, 1995). Considering the fact that cerebrovascular accidents affect executive functioning (Caplan, 2009), it is very likely that strokes have a significant effect on prospective memory. However, the literature addressing this issue is limited. Therefore, the purpose of this research is to analyze the effect of stroke on prospective memory. The hypothesis is that individuals in the stroke group will demonstrate significantly more impairment on the MIST.

Chapter II

Method

Participants

Data were collected from the archival records at Kettering Medical Center. To be considered for inclusion, individuals had to have been diagnosed with a cerebrovascular accident within 30 days of initial data collection, as verified by either MRI or CT scan. Individuals were excluded from the study if they had been diagnosed with a previous stroke, as indicated by their MRI or CT scan, or had a history of auxiliary neurological or psychiatric disorders prior to the occurrence of the stroke. Additionally, individuals were excluded if they had obtained a score less than 20 on the Montreal Cognitive Assessment (MoCA). The recommended cut off utilized for screening cognitive impairment is 26, and the mean score for patients with mild cognitive impairment is 22.1, with a standard deviation of 3.1 (Nasreddine, 2011). Since cognitive impairment is typically present after the occurrence of a stroke, it was decided to utilize a lower cut-off score for the MoCA in order to increase the number of potential participants while continuing to screen out individuals whose cognitive impairment might introduce too many confounding variables, such as impairment in attention that precluded them from completing the neuropsychological assessment. The study was approved by the Wright State University Institutional Review Board, as well as by the Kettering Medical Center Institutional Review Board.

Data were collected from twenty one charts, 13 of which were in the CVA group

and 8 were in the control group. Additionally, of the individuals in the CVA group, 7 had

left hemisphere strokes and 6 had right hemisphere strokes, which were located within

the frontal or temporal regions of the brain. Those individuals in the control group had

all been diagnosed with cerebrovascular risk factors, as defined as 2 or more of any of the

following: type 2 diabetes (adult onset), hyperlipidemia, and hypertension. Individuals in

the control group had been admitted to the inpatient unit due to orthopedic complications,

such as a fall, and were participating in physical therapy and occupational therapy. These

individuals were screened to ensure that they were not experiencing significant pain that

could influence their performance during testing. They were also screened to ensure that

they were not currently taking any medications that could affect cognition, such as pain

medication. Patient data were used if they had been administered the MIST, they had

been diagnosed with 2 of the 3 previously mentioned cerebrovascular risk factors, and

they met all other inclusion and exclusion criteria.

This sample was relatively limited because the MIST was included in the standard

neuropsychological battery that was administered to individuals on the in-patient unit for

a short time period. Therefore, before individual patient data could be screened for

inclusion and exclusion criteria, it was necessary to ensure that the MIST had been

included in the neuropsychological battery.

Nineteen individuals identified as Caucasian and 2 identified as African

American. Eighteen were right hand dominant and 3 individuals were left hand

dominant. The two groups were not significantly different in regards to age, education,

or performance on the MoCA (Table 1).

Table 2

Descriptive Statistics by Group

	CVA *(SD)*	Control *(SD)*	*p*
MoCA (out of 30)	26.08 (0.76)	27.13 (2.1)	.211
Age	62.31 (11.0)	67.81 (9.98)	.250
Education	12.92 (1.61)	14.13 (3.23)	.352
Gender (% women)	61.5	62.5	
Handedness (% right)	84.6	87.5	
Ethnicity (% Caucasian)	92	87.5	

The mean number of days individuals were tested after the stroke was 16.54 days with a standard deviation of 8.57 days. The minimum and maximum number of days individuals were tested after stroke was 5 and 30, respectively.

Materials

Data were collected from the archives of the Kettering Medical Center. Participants were administered the following neuropsychological assessment battery: RBANS, Brixton Spatial Anticipation Test, Trail Making Test, Verbal Fluency (FAS), MoCA, and the MIST. This assessment battery is a standard clinical routine that is administered to individuals on the inpatient unit, and therefore, no additional tests were administered. The assessment battery was administered by the author of this dissertation, who later decided to use the data for research. Individuals' testing was completed on the inpatient unit during one testing session.

Procedures

Archival records were reviewed for participants meeting all inclusion and exclusion criteria. Data were securely stored separate from participants' identifying information, which remained in a secure place to insure confidentiality. Additionally, data were coded with identification numbers to ensure confidentiality. All patient records were reviewed to ensure that they were administered the entire standard assessment battery, as previously mentioned, as well as to ensure they met all inclusion and exclusion criteria.

Participants' demographic information, scores for all measures, and coded classification of lesion locations were input into the statistical software and analyzed using computerized statistical software. Group comparisons for specific MIST variables were analyzed using a multivariate analysis of variance (MANOVA). The MIST was designed to convert raw scores to age-corrected percentile ranks. Since the participants varied across age and education level, the percentile rank scores for the 2-Minute Time Delay, 15-Minute Time Delay, Time Cue, Event Cue, Verbal Response, Action Response, Prospective Memory Total, and Retrospective Recognition Total scores were included in the analysis. An overall significant effect was defined as $p < .05$. Individual ANOVA tests were used to evaluate the statistical significance of between-group effects.

Chapter III

Results

A between-groups multivariate analysis of variance was calculated. The independent variable had two levels, the CVA group and the Control group. The dependent variables were the calculated indices on the MIST. The results of the group comparisons are depicted in Table 2. The MANOVA results disclosed statistically significant overall effects between group performances on the MIST (Pillai's Trace = .85), $F(8, 12) = 8.513$, $p < .001$, partial eta squared = .85. Pillai's Trace was used because it tends to be less sensitive to small sample sizes and uneven cell sizes. Power to detect the effect was .998. Thus, the null hypothesis was rejected and it was concluded that there was an overall difference between groups' performances on the MIST.

Given the significance of the overall test, the univariate main effects were examined. Significant main effects were found for 7 of the 8 variables included in the analysis. The 2-minute time delay questions did not yield a significant between groups difference. Results are displayed in Table 3.

In order to further analyze the differences between group performances, a between-groups multivariate analysis of variance was performed comparing the raw scores of the two groups' performances on the eight individual tasks on the MIST. The independent variable was Group (CVA or Control) and the dependent variables were the individuals' raw scores (ranging from 0 to 2) on Trials $1 - 8$ on the MIST. The

Table 3

Mean Percentile Rank of Participants by Group

MIST Indices	Group	Mean	SD	N
Prospective Memory Total	Control	64.25	24.563	8
	CVA	18.38	13.457	13
2-Minute Time Delay	Control	55.75	36.931	8
	CVA	28.62	28.109	13
15-Minute Time Delay	Control	72.50	23.755	8
	CVA	25.54	13.112	13
Time Cue	Control	59.38	34.029	8
	CVA	13.92	13.156	13
Event Cue	Control	84.38	21.267	8
	CVA	48.69	33.730	13
Verbal Response	Control	65.75	37.743	8
	CVA	22.62	16.899	13
Action Response	Control	65.25	14.440	8
	CVA	31.23	23.246	13
Retrospective Recognition Total	Control	81.50	32.933	8
	CVA	43.92	27.378	13

MANOVA results indicated statistically significant effects between group performances on the eight tasks (Pillai's Trace = .773), $F(8, 12) = 5.110$, $p = .006$, partial eta squared = .773. Power to detect the effect was .949. Table 4 displays the groups' mean scores and standard deviation on Trials $1 - 8$ of the MIST.

Table 4

Tests of Between-Subject Effects for Groups Performances on the MIST

Dependent Variable	F	Sig.	Partial Eta Squared	Observed Power
Prospective Memory Total	30.945	.000	.620	1.000
2-Minute Time Delay	3.641	.072	.161	.441
15-Minute Time Delay	34.510	.000	.645	1.000
Time Cue	19.090	.000	.501	.985
Event Cue	7.123	.015	.273	.716
Verbal Response	13.067	.002	.407	.929
Action Response	13.708	.002	.419	.939
Retrospective Rec. Total	8.010	.011	.297	.766

Given the significance of the overall test, the univariate main effects were examined and significant main effects were found for Trial 4 (15-minute time delay, time cue, verbal response) $F(1, 19) = 6.81$, $p = .017$, partial eta square $= .264$, power $= .697$; and Trial 5 (15-minute time delay, event cue, action response) $F(1, 19) = 12.27$, $p = .002$, partial eta square $= .392$, power $= .913$. The results of the univariate analysis for Trials 1 – 8 are depicted in Table 5. On Trial 4, 3 of the 8 individuals in the control group responded incorrectly, whereas 12 of the 13 individuals in the CVA group responded incorrectly. On Trial 5, 1 of the 8 control group members made an error in comparison to 8 of the 12 individuals in the CVA group.

Table 5

Trials 1-8 Mean Raw Score Between Groups

	Group	Mean	Std. Deviation	N
Trial 1 Raw	Control	1.25	.886	8
	CVA	.54	.776	13
Trial 2 Raw	Control	1.75	.707	8
	CVA	1.23	1.013	13
Trial 3 Raw	Control	1.75	.707	8
	CVA	2.00	.000	13
Trial 4 Raw	Control	1.25	1.035	8
	CVA	.31	.630	13
Trial 5 Raw	Control	1.75	.707	8
	CVA	.46	.877	13
Trial 6 Raw	Control	1.75	.707	8
	CVA	1.54	.877	13
Trial 7 Raw	Control	1.75	.707	8
	CVA	1.08	.954	13
Trial 8 Raw	Control	.50	.535	8
	CVA	.15	.376	13

In order to understand why these groups performed differently, additional analyses were performed in order to examine several cognitive domains known to affect prospective memory. For example, McDaniel and Einstein (2007) suggest that researchers assess the components involved in prospective memory, such as retrospective memory, attention, verbal memory, and executive functioning. In order to do this, several additional assessments were explored. The first analysis was performed on several known measures of attention. A multivariate analysis of variance was calculated in which the independent variable was group, and the dependent variables were

individuals' scores on the Trail Making Test-A (T-score), the RBANS Digit Span (z-score), and the RBANS Coding (z-score) tests. The results indicated statistically significant effects between group performances F (3, 13) = 3.43, p = .049, partial eta square = .442, power = .631. Statistically significant univariate main effects were found for Trail Making Test-A F (1, 13) = 4.66, p = .047, partial eta square = .237, power = .524, and Coding F (1, 13) = 5.35, p = .035, partial eta square = .263, power = .581.

Table 6

Results of the Univariate Analysis for Trials 1 – 8

Dependent Variable	F	Sig.	Partial Eta Squared	Observed Power
Trial 1 Raw Score	3.742	.068	.165	.451
Trial 2 Raw Score	1.605	.221	.078	.225
Trial 3 Raw Score	1.680	.210	.081	.234
Trial 4 Raw Score	6.810	.017	.264	.697
Trial 5 Raw Score	12.270	.002	.392	.913
Trial 6 Raw Score	.331	.572	.017	.085
Trial 7 Raw Score	2.956	.102	.135	.372
Trial 8 Raw Score	3.054	.097	.138	.382

An additional analysis was performed in order to examine verbal memory. These tests include the following subtests from the RBANS: List Learning, List Learning Recall, List Learning Recognition, Story Memory, and Story Recall. The overall results yielded a statically significant MANOVA F (5, 12) = 6.63, p = .004, partial eta square =

.734, power = .962. Significant between subjects effects were identified for the List

Learning F (1, 12) = 8.74, p = .009, partial eta square = .353, power = .793 and List

Recall F (1, 12) = 7.76, p = .013, partial eta square = .327, power = .744 subtests.

In order to examine if the groups' differed in executive functioning skills, scores

from the Brixton Spatial Anticipation Test (scaled score), the Phonemic Fluency (T-

score), and Trail Making Test-B (T-score) were examined. The results of the

multivariate analysis of variance indicated on overall significant main effect F (3, 15) =

5.58, p = .019, partial eta square = .650, power = .794. Univariate main effects were

found for the Trail Making Test-B F (1, 15) = 13.56, p = .004, partial eta square = .552,

power = .917 and Phonemic Fluency F (1, 15) = 7.23, p = .021, partial eta square = .397,

power = .688.

Chapter IV

Discussion

In the present study, the performances of patients diagnosed with ischemic CVA were compared to individuals with cerebrovascular risk factors who have not had a CVA on the MIST. Deficits in prospective memory have been documented in a number of neurological and psychiatric disorders (Raskin, 2009). Drawing from McDaniel and Einstein's (2000) Multiprocess Theory, this study hypothesized that individuals who had been diagnosed with a CVA would evidence significant impairments as measured by the MIST in comparison to individuals who had not had a CVA, but who have been diagnosed with cerebrovascular risk factors. The overall findings confirm the hypothesis and suggest that individuals who have had a CVA display significant prospective memory impairment, as measured by the MIST, in comparison to individuals who have not had a CVA but have been diagnosed with cerebrovascular risk factors, such as hyperlipidemia, hypertension, and adult onset type 2 diabetes.

The MIST is comprised of eight distinct trials that vary on three different types of tasks (Time Delay, Cue Type, and Response Type), and each task is comprised of two distinct dimensions. All eight tasks vary in time delay and are eight 2-minute or 15-minute delays. Significant group differences were evidenced for the 15-minute delay tasks. Cue Types vary by either Time Cues or Event Cues, both of which evidenced significant between group effects. The Response Types are comprised of Verbal or Action responses and both types of responses were significantly different between

groups. The one dimension that did not significantly distinguish patients whom had a CVA from the control group was the 2-minute delay tasks. Both groups performed in the average range, with the mean performance of the CVA group at the 28.62 percentile and the mean performance of the control group at the 55.75 percentile.

Additionally, when the groups' performances on the eight individual trials were analyzed, the groups significantly varied on Trial 4 and Trial 5. Trial 4 is a 15-minute time delay, time cue, verbal response in which participants are instructed, "In 15 minutes, tell me that it is time to take a break." Trial 5 is a 15-minute time delay, event cue, action response. For Trial 5, individuals are told, "When I hand you a red pen, sign your name on your paper." While both of these Trials are 15-minute delays, the results from the other two 15-minute delayed Trials did not evidence significant between group differences. In order to consider why these differences occurred, it is noteworthy that Trials 4 and 5 are the first two trials of the MIST. Therefore, participants are given the overall instructions of the MIST, including instructions that they will be simultaneously completing a word search, which serves as a distractor task. Once participants begin the word search, they are immediately given instructions for completing Trial 4, "In 15 minutes, tell me that it is time to take a break"; and then one minute later, they are given instructions for Trial 5, "When I hand you a red pen, sign your name on your paper." People have limited attentional resources, particularly after the occurrence of a CVA. Therefore, since participants are required to ingest and process more information during the initial portion of the test, it is possible that this might prevent them from adequately encoding the information in order to be recalled at a later time.

In considering McDaniel and Einstein's (2000) Multiprocess Theory, in which they assert that individuals' have limited attentional resources, and tend to rely on spontaneous retrieval, as opposed to constant monitoring, as the demands of constant monitoring of one's environment tends to consume significantly greater attentional resources. Additionally, this theory also assumes that the process and its effectiveness that individuals use in order to perform a prospective memory task are dependent on the characteristics, nature, and demands of the task. Therefore, due to the timing and requirements of Trials 4 and 5, it is possible that greater attentional demands are required in order to accurately process and encode the information in order to recall it at a later time.

Additionally, it was also found that the CVA group evidenced significant impairment on measures of attention, executive functioning, and verbal memory when compared to the control group. These cognitive domains are theorized to be particularly important in order for prospective remembering to occur. In order to learn and encode the necessary information, memory is required. In order to attend and monitor one's environment, attention, and other components of executive functioning are important mediators.

While the overall study yielded practical and useful clinical results, it is important to consider the implications. Prospective memory is a very complex memory system that is mediated by many different cognitive processes. After a CVA, it is very likely that one of these cognitive processes that mediate prospective memory can be negatively affected, which can impair individuals' overall ability to perform prospective memory tasks. It is also important to consider the fact that impaired prospective memory likely affects

individuals' level of independence, such as forgetting to take their medications and problems managing their finances. Therefore, it may be beneficial to measure prospective memory functioning in order to predict level of independence and more accurately plan for hospital discharges.

I think there are several limitations to this study that should be noted. First, due to time constraints, there was a limited sample size of data collected from 21 participants. Although statistically powerful results were obtained, it would have been beneficial to have a larger sample. It was not possible to increase the sample size for this particular study due to time constraints. Additionally, the sample data were predominantly collected from Caucasian participants. It would be beneficial to obtain additional data from a more diverse sample in order to increase external validity. This sample was collected at a medical center that is not located in a very diverse area, and therefore does not see many minority patients. Therefore, we were unable to recruit more minority patients for our sample.

Another limitation with this study is the fact that the control group and CVA group were not a homogenous sample, which is why there was significant variability in their performances. For example, the control group is comprised of individuals who have been diagnosed with cerebrovascular risk factors, such as adult onset type 2 diabetes, hyperlipidemia, and hypertension. However, there are some very important variables that were not accounted for, such as were these risk factors medically controlled? If so, for how long? How long had these risk factors been untreated? In regards to the CVA group, we limited patients to those with frontal or temporal strokes. However, there is

significant variability between these two types of strokes, which negative affect individuals in very different ways.

Future research should address the overall performance pattern of individuals diagnosed with CVA on measures of prospective memory. It may be helpful to address within group differences by comparing performances on the MIST of individuals with right hemisphere and left hemisphere CVA, as well as anterior and posterior lesions.

In summary, the present study compared the performance of individuals diagnosed with CVA to individuals with cerebrovascular risk factors on a measure of prospective memory. The overall results indicate the individuals diagnosed with CVA evidence increased impairment on measures of prospective memory, particularly on tasks with longer time delays between encoding and recall.

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