THE UTILITY OF THE SPATIAL SPAN FROM THE WECHSLER MEMORY SCALES IN A GERIATRIC POPULATION WITH COGNITIVE IMPAIRMENTS

April Wiechmann, B.A.

Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

August 2010

APPROVED:

James R. Hall, Major Professor
Kim Kelly, Committee Member
Ed Watkins, Committee Member
Vicki Campbell, Chair of the Department of Psychology
James D. Meernik, Acting Dean of the Robert B. Toulouse School of Graduate Studies

Wiechmann, April. The utility of the spatial span form the Wechsler Memory Scales in a geriatric population with cognitive impairments. Doctor of Philosophy (Psychology), August 2010, 39 pp., 4 tables, 1 figure, references, 48 titles.

Performance on the Spatial Span subtest of the Wechsler Memory Scale has been viewed as an indicator of working memory and visuospatial processing. A number of factors including age and gender have been posited to effect performance on Spatial Span by older adults. The current study examined the impact of various forms of cognitive impairment and severity of impairment on Spatial Span performance. Five hundred thirty eight individuals between the ages of 65 and 89 were evaluated in a university memory disorders clinic using a battery of neuropsychological tests that included Spatial Span. Participants were grouped by consensus diagnosis into type of cognitive impairment (Alzheimer's disease, vascular disease, Amnestic mild cognitive impairment or Non-Amnestic mild cognitive impairment) or cognitively normal. As expected, an increase in severity of impairment results in a decrease in Spatial Span Total Score. Other findings included a weak relationship between age and Spatial Span Total Score. Gender, as well as age, did not fully account for the decline in Spatial Span Total Score. Spatial Span Forward score was not as good a predictor of severity in that reduction in score for Spatial Span Forward remains relatively stable regardless of level of impairment. Spatial Span Backward performance was found to be more sensitive to severity. No significant differences were found between performance of Alzheimer's disease and vascular disease suggesting they share similar deficit patterns with regard to the cognitive abilities measured by the Spatial Span subtest. A comparison between those diagnosed with mild cognitive impairment and normals showed no significant difference suggesting that visuospatial processes are not affected early in the dementing process.

TABLE OF CONTENTS

Chapter Page

I. INTRODUCTION ……1

Ageing
Neuropsychological Testing
Dementia
Cognitive Domains/Visuospatial Impairment

II. FACTORS INVOLVING MEMORY…..……...…8

Working Memory
Visuospatial Memory
Gender Differences
Digit and Spatial Span
Purpose
Hypotheses 1
Hypotheses 2
Hypotheses 3
Hypotheses 4

III. METHODS…….…….……..…..16

Participants
Procedure
Administration of the Spatial Span

IV. RESULTS…….…….….19

Statistical Analysis
Hypothesis 1
Hypothesis 2
Hypothesis 3
Hypothesis 4

V. DISCUSSION……..…..…….....……23

Summary
Hypothesis 1
Hypothesis 2
Hypothesis 3
Hypothesis 4
Conclusion

BIBLIOGRAPHY……..…….…..…….....34

CHAPTER I

INTRODUCTION

Ageing

In normal ageing a person can expect to have social, biological, and psychological changes and often these changes can occur with a great deal of overlap. Normal ageing is hard to define, but researchers understand that certain changes in higher cognitive functioning are evident. Most individuals realize that memory can change as a result of ageing, but language, personality, social adaptation, and processing speed can also be affected. However, some very important aspects of cognitive functioning remain intact. For instance, older individuals can learn just as much as younger adults, but more time is often needed in order to achieve the same level of learning (Fisk, Rogers, Cooper, & Gilbert, 1997). In addition, and contrary to conventional belief, immediate memory remains relatively intact (Williams, 1970). According to Lezak (1983) there are four primary areas of intellect that are affected by ageing: older individuals use less effective learning procedures, there is a diminished ability for abstract and complex problem solving and reasoning, mental inflexibility or an inability to change mental set, and behavioral slowing. All of these can affect cognitive, perceptual, psychomotor activity, and memory functions (Benton, 1977; Kramer & Jarvik, 1979).

Human ageing and cognitive decline has been well established by multiple empirically based studies. It is not the aim of this particular study to review the literature exclusively on cognitive ageing. Rather, it is important to take a closer look at the different aspects of memory, or more specifically, visuospatial working memory and the role of executive functioning in clinical, geriatric populations.

Neuropsychological Testing

When a patient comes in for testing there are three different potential sources of information available to the clinician. The first is the self-report, which can often be inaccurate because of a lack of insight by the patient and/or the denial of the patient. In addition, the self report also becomes less helpful the more severe the dementia (Tomaszewski, Mungas, Reed, Cahn-Weiner, Jagust, Baynes, et al. 2008). A second means of information gathering is the informant's report, which is often provided by a family member who has begun to notice changes in overall behavior and/or cognitive function. The third, and frequently the most reliable means of gathering information regarding the patient are the performance-based measures, which include neuropsychological testing (Tomaszewski et al., 2008). Neuropsychological testing can assess multiple areas of higher cognitive functioning. Neuropsychological testing can be used to screen individuals or determine if further testing is needed. It may also be used to monitor any changes that may occur in an individual in the future. Testing provides a clinician with feedback as to how an individual is doing in comparison to populations of similar age, gender, and education. Neuropsychological testing is used in a variety of settings, but in geriatric populations it is often used to screen for cognitive decline or dementia.

Dementia

Dementia is a common condition, especially among the elderly, and multiple forms of dementia exist. The *Diagnostic and Statistical Manual of Mental Disorders* (4th ed. [*DSM-IV*]) currently recognizes dementia to include multiple cognitive deficits along with the impairment of memory as a key feature. Other diagnostic features include aphasia, agnosia, apraxia, or an interruption in executive functioning (APA, 1994; McKahnn, Drachman, Folstein, Katzman, Price, & Stadlan, 1984). Other deficits can be found in expressive and receptive language

abilities, executive functioning, judgment, visuospatial skills, abstract thinking, and personality changes (McKahnn et al., 1984; Thompson, 2006). Identification of specific cognitive deficits in patients evaluated for dementia is a key component to determine a differential diagnosis. Most forms of progressive neurodegenerative dementia typically have a slow onset with a continual decline in higher cognitive functioning (Adelan & Daly, 2005). Although the *DSM-IV* lists over 12 types of dementia, two of the most common dementia syndromes diagnosed are Alzheimer's disease (AD) and vascular dementia (VaD) (Freedman, Leach, Kaplan, Winocur, Kenneth, & Delis, 1994; Kim, Lyons, Shin, & Yoon, 2003). The frequency of an AD diagnosis is between 50 and 60%. VaD has a diagnosis frequency rate between 15 and 20 percent and mixed dementia (AD and VaD) is diagnosed approximately 10 to 15 percent of the time. All other forms of dementia, including mild cognitive impairment (MCI), are diagnosed less than 10% of the time (Adelman & Daly, 2005; Elfgren, Brun, Gustafson, Johanson, Minthon, Passant, et al. 1994).

Direct pathological evidence for AD is difficult, so in most cases AD is diagnosed when all other etiological explanations have been ruled out (Foy, Bamford, Francis, Johnston, Lecouturier, Eccles, et al. 2007). For a diagnosis of VaD evidence of cerebrovascular disease must exist and believed to be related to the etiology of the dementia. Evidence of cerebrovascular disease can include laboratory findings, computed tomography or magnetic resonance imageing findings, or focal neurological signs (i.e., gait disturbances, lateralization, or weakness in an extremity (APA, 1994; Elfgren et al., 1994; Roman, Tatemichi, Erkinjuntti, Cummings, Masdeu, Garcia, et al. 1993).

Dementia can interfere with the ability to learn and retain new information, problem-solving, completing complex tasks, spatial awareness, receptive and expressive language, as well

as behavior changes (i.e., irritable, suspicious, etc.; Adelman & Daly, 2005; Elfgren et al., 1994). However, it is important to note that patients with dementia or patients showing the preclinical stages of dementia may present with different patterns of impairment.

Individuals with AD will vary somewhat in the way that they present clinically, but typically most clinicians will agree that in the first phase, the "forgetfulness phase", a person with AD will begin to show difficulty recalling recent events as well as misplace objects (i.e., lose their keys). Poor short-term memory may be evident as well as difficulty recalling the names of familiar people and places. Poor concentration, abstract thinking, and emotional changes also become evident (Thompson, 2006).

In the second phase, the "confusional phase", there is a decrease in attention span and overall intellectual performance. Memory tends to deteriorate, disorientation occurs, and word-finding problems are present. In addition, the ability to complete complex tasks deteriorates and the ability to live independently is in question (Thompson, 2006).

Finally, in the third phase, the "dementia phase", a person requires constant supervision because remaining intellect and self-care abilities are severely impaired and jeopardize the safety of the individual. Language is severely affected and often the person's behavior can become bizarre (Thompson, 2006).

Cognitive Domains/Visuospatial Impairments

With specific regard to visuospatial domains and AD, there is a lack of extensive research, but studies have shown that significant visuospatial impairment exists (Morris, 1994; Thompson, 2006). For example, Robbins, James, Owen, Sahakian, and Lawrence (1988) and Money, Kirk, and McNaughton (1992) found that early/mild AD patients show more rapid forgetting than the normal control group with visuospatial spans (e.g., as measured by Spatial

Span subtest). Baddeley (1996) explained this impairment as a "dysexecutive syndrome" and a dysfunction of the frontal lobe by linking the central executive function to visuospatial abilities (as measured on the Spatial Span subtest).

Unfortunately, VaD profiles are less clear than AD profiles because they are highly variable and dependent on the distribution of the cerebrovascular disease (Braaten, Parsons, Cue, Sellers, & Burns, 2005; Cummings & Benson, 1992). VaD can have different patterns depending upon whether or not the VaD is primarily cortical, subcortical, a mixture of the two, or the result of discrete hemmoraghic events or cumulative effects of ischemic changes. In addition, the infarct or lesion location can lead to highly specific deficits (Braaten et al., 2005).

With regard to visuospatial impairments in VaD, there are several components that can affect the outcome of visuospatial deficits. However, Bor, Duncan, Lee, Parr, and Owen (2006) used sensitive measures of spatial working memory spans and found that the prefrontal cortex is activated even in simple spatial span tasks. They also found that patients with frontal lesions were more impaired on spatial span tasks. Moreover, they found that patients with right dorsolateral prefrontal cortex lesions showed considerably more impairment. Thus, if the above mentioned areas of the brain are affected by cerebrovascular disease or infarct, the likelihood of visuospatial deficits increases.

A study by Paul, Moser, Cohen, Browndyke, Zawacki, and Gordon (2001) looked at the pattern of cognitive performance in patients with mild and severe VaD. Deficits were evident in all cognitive domains (i.e., executive function, psychomotor speed, verbal and visual learning, language, and visuospatial function) for both mild and severe VaD patients. Typically, the patients with severe VaD performed more poorly on the tests measuring the different cognitive domains with the exception of the executive function tests (letter fluency and Trail-Making Test

B). In sum, severity is related to increased impairments in all of the cognitive domains, but executive functioning was not significantly more impaired for severe VaD.

Currently, there is a considerable amount of research on AD and VaD, but the amount of research on mild cognitive impairment (MCI) is continuing to grow. MCI is an important diagnostic consideration because it describes changes in cognitions that may potentially lead to the preclinical phase of dementia (Celsis, 2000; Crowell, Luis, Vanderploeg, Schinka, & Mullan, 2002). Typically, MCI research focuses on memory functioning as a diagnostic criterion. However, clinicians understand that patients with MCI may also demonstrate relative weakness in other cognitive domains. Language, visuospatial abilities, and executive functioning may also be affected. MCI can be broken down into two categories--amnestic and non-amnestic. Amnestic MCI significantly affects memory, while non-amnestic MCI does not. Furthermore, amnestic MCI has been linked to Alzheimer's disease, while non-amnestic MCI has been shown to progress to other types of syndromes (i.e., frontotemporal dementia, primary progressive aphasia or dementia with Lewy bodies). On the other hand, some people with MCI fail to ever develop any type of dementia. Some patients remain stable, while a small percentage of others revert to normal (Celsis, 2000; Crowell, Luis, Vanderploeg, Schinka, & Mullan, 2002).

A study by Crowell et al. (2002) showed that testing for relative weaknesses other than memory functioning may provide useful in the diagnosis of MCI. The authors found that the MCI and AD groups did not significantly differ in their patterns of memory functioning. In addition, they found that executive functioning was the only non-memory cognitive domain in which the MCI group differed from the normal control group. This is an important consideration with regard to visuospatial abilities because the executive function is arguably responsible for

some mental manipulations in visual spatial manipulation (Curtiss, Vanderploeg, Spencer, & Salazar, 2001; Dobbs, Dobbs, & Kiss, 2001).

CHAPTER II

FACTORS INVOLVING MEMORY

Working Memory

There are four basic stages to memory: registration, encoding, storage, and retrieval. In order for something to be stored in memory it must be registered. In other words, an individual must attend to the information. Then, this information is encoded, either phonetically, semantically, or visually. Storage is the process in which the information is retained in memory and retrieval is the process in which the information becomes available from memory (Thompson, 2006; Salthouse,1994).

Memory functioning can be further broken down into long-term vs. short-term, semantic vs. episodic, and declarative vs. procedural. Short-term memory or working memory typically lasts for about 30 seconds whereas long term memory lasts for days, months, and even years. Semantic memories are typically context-free facts that are independent of time and place whereas episodic memories represent particular events or personal experiences. Finally, declarative memory is an individual's ability to store facts and procedural memory is reserved for skills or procedures for how to do something.

It is a common believe that older adults often perform more poorly on tests that measure working memory when compared to younger adults (Myerson, Emery, White, & Hale, 2003). However, which specific aspects of working memory are affected by the ageing process is less clear. Typically, most researchers use a two component model of working memory which includes a storage component and an executive functioning component. The storage component can be further broken down into phonological or visual components as well. The storage components are responsible for retaining verbal or visual information while the executive

function component processes, manipulates, filters, and coordinates information (Myerson et al., 2003). It is important to realize that ageing may not affect both components, but rather one more than the other. For example, older adults tend to show a greater discrepancy between their scores on Digit Span Forward and Digit Span Backward (Wechsler, 1997). Perhaps this discrepancy is due to a decline in function in one of the components. If Digit Span Forward score is better than Digit Span Backward score, then it is feasible to think that the storage component of working memory stays intact longer than the executive functioning component. In terms of dementia, it would appear to fit the pattern in that the highest cognitive functions are lost first. However, a cross-sectional analysis by Myerson et al. showed no significant differences between the slopes for forward and backward Digit Span performance. There was also no significant difference between the slopes for forward and backward Spatial Span performance. However, the regression of memory span indicated that the Spatial Span performance had a significantly more negative slope than Digit Span performance. In addition, Myerson et al. found a curvilinear trend when looking at the Letter-Number Sequencing scores with the rationale being attributed to a decline in executive functioning as a result of ageing.

According to Caine and Hodges (2001) there is a need to look more closely at the perceptual and visuospatial disturbances that occur in patients with Alzheimer's disease (AD). They recognize that an overwhelming amount of attention has been given to the semantic impairments that tend to occur first. For example, it has been demonstrated that one of the first recognizable signs of AD is impairment with immediate and delayed verbal memory (Thompson, 2006). However, a previous study by Martin, Brouwers, Lalonde, Cox, Teleska, and Fedio (1986) identified subgroups of patients with AD by breaking them down to those with semantic impairments and those with visuospatial and constructional impairments. Most notably, the two

distinct groups were approximately equal in size. Thus, it appears rather important to identify the nature of affected cognitive processes and the sequence in which they are affected.

Visuospatial Memory

Recently, there has been an interest in the investigation of visuospatial ability and its role in working memory with the understanding that working memory capacity is a key component to understanding reduced cognitive efficiency (Cornoldi, 2003). Visuospatial working memory has often been described as the most neglected component of working memory (Pearson, 2001).

Working memory can decrease with age (Robbins et al. 1998; Van der Linden, 1998), but there has also been a link to age related decline in executive functioning (Brennan, Welsch, & Fisher, 1997). More importantly, the central executive component of working memory has been shown to be at particular risk to the effects of ageing (Fisk & War, 1996).

There are few common approaches to investigating working memory, mental imagery, executive functioning, and spatial and visual processes. Currently, visual imagery can be defined as a mental process with an internal visuospatial representation that maintains and processes visual information within a temporary working memory storage (Cornoldi, 2003). This operational definition gives way for the idea that planning and control of movements as well as high-level perceptual processes all require mental imagery. Thus, visuospatial and mental imagery are parts of working memory functions (Cornoldi, 2003).

Logie (1995) came up with a modified model of working memory that expands on the simpler two component model of the working memory system. The two component model includes the articulatory loop that deals with verbal material, a visuospatial sketch pad (both of which make up the storage component), and a central executive component that is responsible for more complex tasks as well as the supervision of other functions. In Logie's model (see

Figure 1) he suggests that visuospatial working memory can be divided into different subcomponents, which is similar to and runs fairly analogous to the expansive research findings for the articulatory loop.

Gender Differences

Gender differences have been found when performance on different cognitive functions is compared. Men typically outperform women on mathematical problem solving, visual memory, and visuospatial ability. On the other hand, women tend to perform better on verbal fluency, perceptual speed tasks, fine motor skills, verbal memory, and verbal learning (Trenerry, Jack, Clifford, Cascino, Gregory, Sharbrough, et al. (1996); Weiss, Deisenhammer, Fleischhacker, & Delazer, 2002). With specific regard to visuospatial abilities, a meta-analysis by Linn and Petersen (1985) looked at over 50 years of research and concluded that there is a gender difference. However, the male advantage is confined to mental rotation and manipulation. Furthermore, Prinzel III and Freeman (1995) agree that men perform better on visuospatial tasks, and especially those that require mental rotation.

Unfortunately, no literature was found to date that discussed the performance differences between genders on the Spatial Span subtest of the Wechsler Memory Scales-Third edition (WMS-III).

Digit and Spatial Span

The WMS-III includes the Digit Span and Spatial Span subtests as simple measures of working memory. Baddeley (2000) argues that the Digit Span Forward is a good measure of the phonological loop and that Spatial Span Forward is a parallel measure for what Logie (1995) would call the visual inner scribe. Digit Span Backward and Spatial Span Backward have been argued to be good measures of executive function because they both require manipulation of the

information as well as temporary storage. However, according to Serova (2007) Spatial Span is a good measure of executive functioning, but Digit Span Forward and Backward are better measures of attentional capacity. Moreover, Curtiss et al. (2001) and Dobbs et al. (2001) have argued that impaired Spatial Span Backward is an indication of impaired central executive functioning in both clinical and non-clinical population samples. The overall purpose of the Wechsler subtest is to measure an individual's ability to hold a visual-spatial sequence in working memory and then to physically reproduce it. According to Wechsler (1997), the Spatial Span loads on the primary index of Working Memory as well as the Letter-Number Sequencing subtest on the WMS-III. Both of these subtests aim to measure an individual's ability to remember and manipulate verbal and visual information (Wechsler, 1997).

Groeger, Field, and Hammond (1999) report that Digit Span and Spatial Span are closely related, but are independent memory span measures. They believe that reverse Digit Span and Spatial Span can be regarded as executive functions. Numerous studies have shown a discrepancy in performance of verbal and Spatial Span memory tests. For example, a patient may score in the impaired range on Digit Span, but score in the normal range for Spatial Span or vice versa. The discrepancy in performance suggests that there is a separation between verbal and spatial spans.

Wilde and Strauss (2002) examined the performance of Wechsler's Digit Span and Spatial Span subtests in a mixed clinical sample and found differential performance patterns for Digit Span and Spatial Span tasks. Interestingly, they found that Digit Span Forward scores were not significantly higher than Digit Span Backward. In addition, they did not find any significant differences between Spatial Span Forward and Backward at the mean level, but approximately one-third of the sample showed better performances on Spatial Span Backward when compared

to Spatial Span Forward. Thus, the authors suggest that clinicians interpret Spatial Span Backward as a measure of working memory with caution.

Wilde and Strauss (2002) also found that Spatial Span Forward is modestly correlated with the perceptual organization and processing speed indexes of the WAIS-III. Spatial Span Backward, on the other hand, is significantly correlated with the visual perceptual and processing speed indexes as well auditory immediate and delayed memory. Furthermore, neither Spatial Span Forward nor Backward is significantly correlated with visual memory indexes or the WAIS-III Working Memory Index. Finally, Wilde and Strauss (2002) observed that no relationship exists between Spatial Span and Letter-Number Sequencing.

According to Wilde, Strauss, and Tulsky (2004) backward spans (i.e., Digit Span and Spatial Span) are not sensitive measures of working memory. Furthermore, the backward memory spans for both Digit Span and Spatial Span were not more affected by age or pathology than forward memory spans. In addition, the authors looked at the discrepancies in scores between Digit Span Forward and Digit Span Backward as well as Spatial Span Forward and Spatial Span Backward and found that large discrepancies were "reasonably rare" and occurred only 15% of the time for Digit Span performance and approximately 10% of the time for Spatial Span performance. However, Wilde and his colleagues found the largest discrepancies for Spatial Span performance occurred most frequently in AD patients with 39% of them showing an unusually large discrepancy. The authors noted that in their study those with AD were the only group to show a substantial frequency of occurrence for a large discrepancy. They did not, however, include vascular disease (VaD) in their analysis of discrepancy.

Purpose

The research discussed above suggests a number of unanswered questions regarding the relationship between performance on Spatial Span and type and level of cognitive impairment. The Spatial Span subtest of the Wechsler Memory scale has been described as a measure that "taps an examinee's ability to hold a visual spatial sequence of locations in working memory and then reproduce the sequence". The proposed study will examine the specific nature of this relationship and those factors that may have an impact on Spatial Span performance.

The rational for the hypothesis listed below were developed because there are very few studies that have investigated the relationship between visuospatial working memory in regard to diagnosis and diagnosis severity, there were no studies found that have directly compared gender differences on the WMS-III Spatial Span within different diagnosis groups or normals, and working memory has proved to be a very powerful predictor of a wide range of cognitive activities. It is also important to know what limits working memory span and to understand which diagnoses (i.e., AD, VaD, or mild cognitive impairment (MCI)) most affect working memory, particularly visuospatial working memory. Although most of the hypothesis are straight forward, hypothesis I may require some clarification. To recap, Hypothesis I was established because prior research suggested that MCI amnestic patients and those diagnosed with AD shared similar patterns and profiles with regard to cognitive decline. More specifically, research shows that amnestic MCI has been linked to AD. In addition, Non-amnestic MCI and VaD patients were predicted to perform significantly worse on Spatial Span Backwards and Total Score because 1) non-amnestic MCI has been shown to progress to other types of dementia syndromes, some of which have a severely affected executive function component, like frontotemporal dementia, dementia with Lewy bodies, or primary progressive aphasia, and 2)

Wild and Strauss (2002) found that Spatial Span Backward and Spatial Span Total Score are correlated with processing speed.

Hypothesis 1:

Non-amnestic MCI patients and patients with VaD will perform significantly worse on Spatial Span Total Score and Spatial Span Backward than patients with AD, amnestic MCI, and normals.

Hypothesis 2:

Spatial Span Total Score performance will deteriorate as the severity of dementia worsens.

Hypothesis 3:

Spatial Span Backward is a better predictor of severity than Spatial Span Forward.

Hypothesis 4:

Males will perform better on Spatial Span Backward than females regardless of diagnosis type.

CHAPTER III

METHODS

Participants

The sample consisted of a retrospective examination of records from patients evaluated at a geriatric outpatient clinic for possible cognitive dysfunction between February 2002 and October 2007. Five hundred thirty-eight evaluations were examined to determine appropriateness for inclusion in this study. Inclusion criteria include: 1. Ages between 65 and 89. 2. A diagnosis of one of the following: A consensus diagnosis of Alzheimer's disease (AD) using the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA; McKhann et al., 1984) criteria; a consensus diagnosis of vascular dementia (VaD) applying the NINCDS and Stroke and Association Internationale pour la Recherché et l'Enseignement en Neurosciences (NINCDS-AIREN) standard; a consensus diagnosis of mild cognitive impairment (MCI) according to the European Consensus DESCRIPA (development of screening guidelines and diagnostic criteria for pre-dementia Alzheimer's disease) criteria. The Global Deterioration Scale (GDS) is used to determine diagnosis severity. The GDS provides seven stages of cognitive function. Stages 1-3 are considered pre-dementia and 4-7 are dementia stages (Reisberg, Ferris, de Leon, & Crook, 1982). Finally, the sample included those considered cognitively normal (e.g. patient's who do not meet any of the diagnostic criteria for any form of dementia or cognitive impairment). Consistent with previous research, individuals diagnosed with mixed dementia were excluded from analyses. 3. A Mini Mental Status Examination score above 10.

There were no exclusions for gender or race. The sample consisted of approximately 90% Caucasian. The sample also consisted of approximately 65% female (see Table 1). As is

frequently found AD and VaD patients were significantly older than the non-demented groups and had a significantly lower level of education.

Procedure

Each participant was administered a standard battery of neuropsychological tests that included the Spatial Span (Forward and Backward) from the Wechsler Memory Scales-III (WMS-III) as part of a full neuropsychological battery. Spatial Span uses a three-dimensional board with 10 blocks on it to create a series of spatial patterns. Spatial Span Forward requires an examiner to point to a series of blocks at the rate of about one second per block in a specific, predetermined pattern. Then the examinee immediately attempts to duplicate the same pattern from memory.

Spatial Span Backward requires an examiner to point to a series of blocks at the rate of one second per block in a specific, predetermined pattern. However, this time the examinee is required to immediately attempt to duplicate the same pattern in reverse.

Both tests begin with a series of just 2 blocks and the examinee is allowed two attempts at each series length. The maximum number of block in a series is 8. Once the examinee misses both attempts per series, the subtest is discontinued. The examinee is awarded 1 point per correct series and the total possible points for the Spatial Span subtest is 32 (16 points possible for Spatial Span Forward and 16 points possible for Spatial Span Backward).

Administration of the Digit Span from the WMS-III requires an examiner to present a string of numbers of increasing length auditorily and then the examinee is asked to repeat them back verbatim. Digit Span Backward requires the examiner to present a new string of numbers auditorily and then the examinee is asked to repeat the numbers backwards. The examinee is awarded 1 point per trial. After the examinee scores 0 on both trials of an item, the subtest is then

discontinued. A total of 16 points are possible Digit Span Forward and 14 for Digit Span Backward. Scale Scores based on the WMS-III age related norms were also used in the analyses.

CHAPTER IV

RESULTS

Statistical Analysis

Hypothesis 1: Non-amnestic mild cognitive impairment (MCI) patients and patients with vascular dementia (VaD) will perform significantly worse on Spatial Span Total Score and Spatial Span Backward than patients with Alzheimer's disease (AD), amnestic MCI, and normals.

A one-way between-groups analysis of variance was conducted to explore the differences in Spatial Span Total scaled score and Spatial Span Backward scaled score for the different diagnostic groups. Preliminary checks were conducted to ensure that the homogeneity of variances were not violated. There was a statistically significant difference between diagnostic groups for Spatial Span Total scaled score F (4, 301) = 10.41, $p < .001$ as well as Spatial Span Backward scaled score F (4, 301) = 10.25, $p < .001$.

Spatial Span Total Scaled Score post-hoc comparisons using the Tukey Honestly Significant Difference test indicated that the mean score for those with AD were significantly different from normals, and the non-amnestic MCI group, but not the VAD or amnestic MCI groups (see Table 2). Those with VAD shared a similar pattern in that they only showed a significant difference from normals and non-amnestic MCI. The amnestic MCI group was significantly different from the AD group while the non-amnestic MCI group was significantly different from AD and VAD groups. Lastly, the normal group showed significance differences between the AD and VAD groups, but neither of the MCI groups.

Spatial Span Backward scaled score post-hoc comparisons were also completed using the Tukey HSD test. See Table 3 for Spatial Span Total and Spatial Span Backward comparisons.

Hypothesis 2: Spatial Span Total Score performance will deteriorate as the severity of dementia worsens.

A one-way between-groups analysis of covariance was conducted to evaluate the relationship between level of impairment and Spatial Span Total Scaled Score. The dependent variable was Spatial Span Total Scaled Score and the independent variable was diagnosis severity. Age and Gender were used as covariates in this analysis. For all analysis, preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate. After adjusting for gender and age, a significant difference was found between groups, F (5, 291) = 7.05, p = <.0005, partial eta squared = .193. In addition, weak relationships for gender and age as indicated by a partial eta squared value of .002 for gender and .015 for age were found.

Hypothesis 3: Spatial Span Backward is a better predictor of severity than Spatial Span Forward

A one-way between-groups analysis of variance was conducted to evaluate the impact of level of cognitive impairment on Spatial Span Backward Scaled Score and Spatial Span Forward Scaled Score. The dependent variables were Spatial Span Backward and Forward Scaled Scores and the independent variable was diagnosis severity. Patients were divided into five levels according to their severity (Level 1: no severity level assigned; Level 2: Mild; Level 3: Mild-to-Moderate; Level 4: Moderate and Level; 5: Moderate-to-Severe/Severe). Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate.

Level of impairment significantly affected Spatial Span Forward and Backward Scores, F (4, 244) = 5.75, $p < .001$ and F (4, 244) = 12.87, $p < .001$. Post-hoc comparisons using the Tukey HSD test indicated significant differences between severity levels for Spatial Span Forward Scaled Scores and Backward Scaled Scores (see Table 4 for mean scores across levels of impairment). The effect size for differences in mean scores between the levels for Spatial Span Forward was moderate with an effect size of .09. The difference in mean scores between the levels for Spatial Span Backward was large with an effect size of .17.

Hypothesis 4: Males will perform better on Spatial Span Backward than females regardless of diagnosis type

A one-way between-groups multivariate analysis of variance was performed to investigate gender differences in Spatial Span performance. Two dependent variables were used, Spatial Span Forwards Scaled Score and Spatial Span Backward Scaled Score. The independent variable was gender. The covariate was diagnosis (AD, VaD, Normals, MCI amnestic, and MCI non-amnestic). Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity, with no violations noted. There was a statistically significant difference between males and females on the combined dependent variables, F (2, 303) = 4.06, p = .018; Wilks' Lambda = .98; partial eta squared = .009. When the results for the dependent variables were considered separately, both reached statistical significance, Spatial Span Forward Scaled Score, F (1, 257) = 3.89, p = .009, partial eta squared = .03, and Spatial Span Backward Scaled Score, F (1, 257) = , p = .050, partial eta squared = .02. The mean scores indicated that males (M = 9.09, SD = 2.62) obtained a higher score on Spatial Span Forwards than females (M = 7.96, SD = 3.08). On Spatial Span Backward, males (M = 8.96, SD = 3.02) also outperformed females (M

= 7.58, *SD* = 3.14). However, when the dependent variables were considered separately with the effects of the covariate (diagnosis) only Spatial Span Backward Scaled Score reached statistical significance, F (1, 257) = 11.56, p = .001, partial eta squared = .04.

CHAPTER V

DISCUSSION

Summary

The present study investigated a number of hypothesis related to the affects of type and level of cognitive impairment on performance on Spatial Span measures in a sample of elderly individuals.

Hypothesis 1: Non-amnestic mild cognitive impairment (MCI) patients and patients with vascular dementia (VaD) will perform significantly worse on Spatial Span Total Score and Spatial Span Backward than patients with Alzheimer's disease (AD), amnestic MCI, and normals.

Performance on Spatial Span tasks is not significantly affected by type of cognitive impairment. Essentially, if the criterion for dementia was met, there was a significant difference in scores when compared to non-demented individuals. Visuospatial memory and executive functioning skills required to complete the Spatial Span and Spatial Span Backward are without a doubt affected by dementia. The lack of significant difference between dementia groups (AD vs. VaD) suggests that they share similar deficit patterns with regard to the cognitive abilities measured by the Spatial Span.

The performance of individuals diagnosed with MCI (the potential preclinical phase of dementia), did not show any significant differences when compared to normals. This finding does not support the hypothesis. In turn, it suggests that visuospatial processes are not affected early in the dementing process. However, the fact that the performance of the amnestic MCI group only differed significantly from the AD group while the non-amnestic group differed significantly from the AD and VaD groups suggests that individuals with amnestic MCI and

individuals with vascular dementia may share a similar pattern of deficits. Performance on Spatial Span tasks may be an indicator of increased risk for conversion to dementia for amnestic MCI patients. Future studies may want to focus on the rates of decline, especially those with MCI and related amnestic features to observe these conversion rates.

Hypothesis 2: Spatial Span Total Score performance will decrease as the severity of dementia worsens.

The current findings provide evidence that Spatial Span Total Score is consistently impaired as severity increases. Previous researchers found this to be true with the Digit Span, but no previous research existed regarding the consistency of this finding with the Spatial Span. Previous findings also showed that working memory can decreases with age and age can impact executive functioning (Robbins et al. 1998; Van der Linden, 1998; Brennan, Welsch, & Fisher, 1997). Additionally, age was previously found to affect visuospatial processing more than verbal processing (Myerson et al. 2003; Hester, Kinsella, & Ong, 2004).

Age, however, was not a significant determinant of Spatial Span performance in the current research. Gender as well as age was weakly related to Spatial Span performance, but neither explained a great deal of the overall variance. Spatial Span appears to be more sensitive to cognitive impairment than normative changes related to ageing or gender. Visuospatial processes required to complete the Spatial Span are undoubtedly affected by cognitive impairment and severity of impairment significantly impacts overall performance. Thus, the current findings do not support previous research that indicates a decline in working memory as a result of an increase in age (Baeckman, Small, Wahlin, & Larsson, 2000; Salthouse, Fristoe, Lineweaver, & Coon, 1995). It also challenges the findings of Hester et al. (2004) who found that Spatial Span demonstrated greater age-related decline that Digit Span. Although the current

study found that age could not explain the overall variance for decreased performance on Spatial Span, it did not look at decreased performances on Digit Span. Therefore, limitations to study include that fact that Digit Span was not used in this particular study and therefore no span comparisons can be made.

Hypothesis 3: Spatial Span Backward is a better predictor of severity than Spatial Span Forward.

Not all aspects of Spatial Span are equally sensitive to cognitive impairment. Performance on Spatial Span Forward remains relatively stable regardless of level of impairment. Spatial Span Backward, on the other hand, is more sensitive to severity with notable decline especially evident when compared to normals. Thus, Spatial Span Backward is a better predictor of severity than Spatial Span Forward. These findings suggest that the Spatial Span Backward task is more difficult and requires more complex working memory skills such as manipulation than the Forward task. These results confirm the general expectation that Spatial Span Backward demands more executive functioning abilities than Spatial Span Forward. Future studies may want to closely examine the role of executive functioning in visual manipulation and how that relates to the different stages of dementia.

Previous studies have shown that working memory declines with age (Baeckman et al. 2000; Salthouse et al. 2004). Hester et al. found that age affected both forward and backward spans equally in that they found no evidence of a differential rate of decline between forward and backward spans. However, the current results demonstrate differential declines in Spatial Span Forward and Spatial Span Backward, but explained the difference in terms of severity of cognitive impairment. The fact that age was not used as a covariate for this hypothesis is a possible limitation. However, age was used as a covariate in the previous hypothesis that looked at Spatial Span Total Score and age did not explain the overall variance. Future studies may want

to confirm that age related decline in working memory does not explain a majority of the variance for Spatial Span Forward or Backward in geriatric populations with cognitive impairment.

Hypothesis 4: Males will perform better on Spatial Span Backward than females regardless of diagnosis type.

The present findings support the current literature that men perform better on visuospatial tasks. Performance differences between genders on the Spatial Span showed that men significantly outperformed women on Spatial Span Backward regardless of diagnosis type. Exploratory analysis showed that men also outperformed women on Spatial Span Forward as well. However, when diagnosis was used as a covariate, the only significant difference evident was with Spatial Span Backward, which, as the literature suggests, is primarily manipulation. Unlike previous literature, this finding indicates that visual spatial abilities for men, especially manipulation, are reserved regardless of severity of impairment. This is an important consideration between genders because a higher score may have different implications depending on the gender. Repercussions of these findings may trickle down to treatment recommendations made by providers. For example, driving recommendations may need to be taken into account because visual-spatial attention has been shown to be integral for the planning of object-related actions (Handy, Borg, Turk, Tipper, Grafton, & Gazzaniga 2005; Nagamatsu, Lui-Ambrose, Carolan, & Handy, 2009). Furthermore, Nagamatsu et al. (2009) found that visual spatial abilities are an important consideration with falls in the elderly. Future studies may want to integrate the literature on dementia, treatment planning, and visual spatial performance.

Conclusion

A number of questions remain unanswered regarding the nature and value of the Spatial Span tasks in the assessment of cognitive functioning. The role of executive functioning in Spatial Span performance remains unclear as does the relationship between measures of visuospatial processing and executive functions. The suggestion that Spatial Span may be an indicator of conversion from amnestic MCI requires prospective studies to assess the predictive value of Spatial Span. Although these questions remain unanswered, the present research provides support for the utility of the Spatial Span tasks in the assessment of cognitive impairment.

Finally, it is important to address the modifications made in the newly revised Wechsler Memory Scales-Fourth Edition (WMS-IV). Major revisions resulted in many dropped subtests including the Spatial Span, Digit and Letter Number Sequencing, Mental Control, Orientation and Information, Faces, Family Pictures, and Word List. According to Pearson Education, Inc (2008), the Spatial Span was replaced with a newly developed and improved measure of mental manipulation of visual information because there was a need to reduce processing speed and motor demands as well as a need to improve the ease of administration. “Spatial Addition” has now replaced the Spatial Span. Pearson Education, Inc reports Spatial Addition to be a measure of spatial working memory requiring both storage and manipulation of visual spatial information.

Countless new tests are developed each year and with no end in sight. The development of new tests comes from professional disagreement over the best strategies for measuring human characteristics as well as the pressure to develop accurate and unbiased tests. Additionally, publishers and authors stand to make a profit if successful. However, according to Kaplan and

Saccuzzo (2001), an examination of major reference books on tests shows that a majority of new tests are based off the same principles and theories used to develop previous tests.

As the use of the newly revised WMS-IV increases, more and more research will be published on the specific nature of the Spatial Addition. However, it is important to recognize and build from previous findings, like those in this study, so that research related to visual working memory and geriatric populations with cognitive impairments continues to build and move forward rather than regress and start afresh.

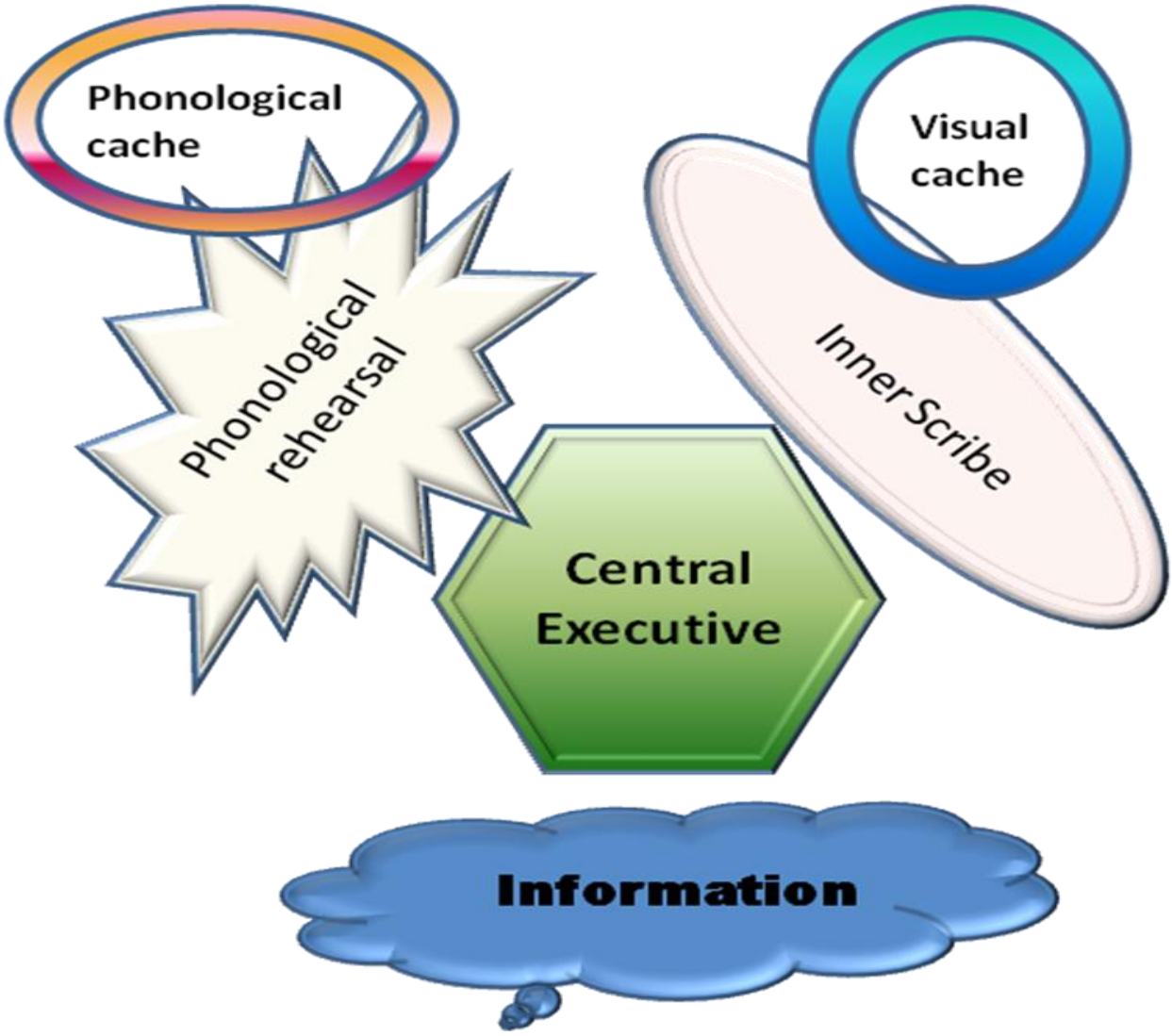

Figure 1. Logie's modified working memory model (1995).

Table 1

Demographic Characteristics of Sample

Diagnosis	*n*	Mean Age (*SD*)	Mean Education (*SD*)	Female (% of *n*)	Male	Mean MMSE Total Score (*SD*)
AD	261	80 (7.27)	12.96 (3.21)	183 (71%)	129	21.16 (4.43)
VaD	107	81 (6.32)	12.88 (3.02)	76 (71%)	54	24.98 (2.98)
MCI Amnestic	55	74 (8.01)	15.03 (2.62)	33 (65%)	22	28.39 (2.18)
MCI Nonamnestic	71	77 (5.48)	14.61 (2.30)	28 (60%)	17	26.94 (2.00)
Normal	44	77 (6.82)	14.73 (2.56)	29 (66%)	20	27.11 (1.78)

Table 2

Mean Scores and Standard Deviations by Diagnosis for Spatial Span Total Scaled Score and Spatial Span Backward Scaled Score

Diagnosis	Spatial Span Total Score Mean	(SD)	Spatial Span Backward Score Mean	(SD)
AD	7.16	(2.98)	7.33	(3.22)
VAD	7.44	(2.70)	7.51	(2.83)
None	10.27	(2.92)	10.19	(3.16)
Amnestic MCI	8.69	(2.41)	9.11	(1.93)
Non-Amnestic MCI	9.14	(2.45)	9.62	(2.81)

Table 3

Significant Differences by Diagnostic Groups for Spatial Span Total Score and Spatial Span Backward Score

		P value	
Diagnosis	Significant Difference	Spatial Span Total	Spatial Span Backward
AD	Normal	<.001	<.001
	Amnestic MCI	.029	.013
	Non-amnestic MCI	.001	<.001
VaD	Normal	<.001	.001
	Non-amnestic MCI	.014	.002
Amnestic MCI	AD	.029	.013
Non-amnestic MCI	VaD	.001	<.001
	AD	.014	.002
Normals	AD	<.001	<.001
	VaD	<.001	.001

Table 4

Mean Scores for Spatial Span Forward and Backward Across Level of Impairment

Level of impairment	Spatial Span Forward Mean Score (SD)	Spatial Span Backward Mean Score (SD)
None	8.26 (2.54)	9.14 (2.37)
Mild	8.96 (2.75)	8.46 (3.08)
Mild to Moderate	6.97 (2.67)	6.67 (3.17)
Moderate	7.75 (3.29)	6.29 (2.60)
Moderate to Severe/Severe	6.53 (2.83)	6.67 (2.97)

BIBLIOGRAPHY

Adelman, A. & Daly, M. (2005). Initial evaluation of the patient with suspected dementia. *American Family Physician, 71*(9), 1745-1750.

American Psychiatric Association, (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author

Baeckman, L., Small, B. J., Wahlin, A., & Larsson, M., (2000). Cognitive functioning in very old age. In F.I.M. Craik (Ed.), *Handbook of ageing and cognition* (2nd ed., pp. 499-558). Mahwah, NJ: Lawrence Erlbaum Associates.

Baddeley, A. (1996). Exploring the central executive. *Quarterly Journal of Experimental Psychology, 49,* 5-28.

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences, 4,* 417-423.

Benton, A. (1977). Interactive effects of old age and brain disease on reaction time. *Archives of Neurology, 34,* 369-370.

Braaten, A. J., Parsons, T.D., McCue, R., Sellers, A., Burns, W.J. (2005). Differential diagnosis of dementia. *Archives of Clinical Neuropsychology, 19,* 8.

Brennan, M., Welsh, M., & Fisher, D. (1997). Ageing and executive function skills: An examination of a community dwelling older adult populations. *Perceptual and Motor Skills, 84,* 1187-1197.

Bor, D., Duncan, J., Lee A., Parr, A., Owen, A. (2006). Frontal lobe involvement in spatial span: Converging studies of normal and impaired function. *Neuropsycholiga, 44,* 229-237.

Caine, D. & Hodges, J. (2001). Heterogeneity of semantic and visuospatial deficits in early Alzheimer's disease. *Neuropsychology, 15,* 155-164.

Celsis, P. (2000). Age-related cognitive decline, mild cognitive impairment or preclinical Alzheimer's disease? *Annals of Medicine, 32,* 6-14.

Cornoldi, C. & Vecchi, T. (2003). *Visuo-spatial working memory and individual differences.* New York, U.S.: Psychology Press.

Crowell, T. A., Luis, C. A., Vanderploeg, R. D., Schinka, J. A., & Mullan, M. (2002). Memory patterns and executive functioning in mild cognitive impairment and Alzheimer's disease. *Ageing, Neuropsychology, and Cognition, 9,* 288-297.

Cummings, J.L., & Benson, D.F. (1992). *Dementia: A clinical approach.* Stoneham, MA: Butterworth-Heineman.

Curtiss, G., Vanderploeg, R. D., Spencer, J., & Salazar, A. M. (2001). Patterns of verbal learning and memory in traumatic brain injury. *Journal of the International Neuropsychological Society, 7,* 574–585.

Dobbs, B., Dobbs, A., Kiss, I. (2001). Working memory deficits associated with chronic fatigue syndrome. *Journal of the International Neuropsychological Society, 7,* 285-293.

Elfgren, C., Brun, A., Gustafson, L., Johanson, A., Minthon, L., Passant, U., et al. (1994). Neuropsychological tests as discriminators between dementia of Alzheimer's type and frontotemporal dementia. *International Journal of Geriatric Psychiatry, 9,* 635-642.

Fisk, A., Rogers, W., Cooper, B., & Gilbert, D. (1997). Automatic category search and its transfer: Ageing, type of search, and level of learning. *Journal of Gerontology, 52*(2), 91-102.

Foy, R., Bamford, C., Francis, J., Johnston, M., Lecouturier, J., Eccles, M., et al. (2007). Which factors explain variation in intention to disclose a diagnosis of dementia? A theory-based survey of mental health professionals. *Implement Science, 2,* 31.

Freedman, M., Leach, L., Kaplan, E., Winocur, G., Kenneth, I. S., & Delis, D. C. (1994). *Clock drawing: A neuropsychological analysis.* New York: Oxford University Press.

Handy, T. C., Borg, J. S., Turk, D. J., Tipper C. M., Grafton, S.T., & Gazzaniga, M. S. (2005). Placing a tool in the spotlight: Spatial attention modulates visuomotor responses in cortex. *NeuroImage, 26,* 266-276.

Hester, R., Kinsella, G. J., & Ong, B. (2004). Effect of age on forward and backward span tasks. *Journal of International Neuropsychological Society, 10,* 475-481.

Kaplan, R. & Saccuzzo, D. (2001). *Psychological Testing: Principles, Applications, and Issues* (5th ed.). Belmont: Wadsworth/Thomson Learning.

Kim, J-M., Lyons, D., Shin, I-S., & Yoon, J-S. (2003). Differences in the behavioral and psychological symptoms between Alzheimer's disease and vascular dementia: Are the different pharmacologic treatment strategies justifiable? *Human Psychopharmacology, 18,* 2215-220.

Kramer, N. & Jarvik, L. (1979). Assessment of intellectual changes in the elderly. In Raskin, A & Jarvik, L. (Eds.), *Psychiatric symptoms and cognitive loss in the elderly*. Washington, DC: Hemisphere.

Lezak, M. (1983). *Neuropsychological assessment* (2nd ed). New York: Oxford University Press.

Linn, M., & Petersen, A. (1985). Emergence and characterization of gender differences in spatial abilities: A meta-analysis. *Child Development, 56,* 1479-1498.

Logie, R. (1995). *Visuo-spatial working memory*. Hove, UK: Lawrence Erlbaum Associates Ltd.

Martin, A., Brouwers, P., Lalonde, F., Cox, C., Teleska, P., Fedio, P. (1986). Towards a behavioral typology of Alzheimer's patients. *Journal of Clinical & Experimental Neuropsychology, 8,* 594-610.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. (1984). Clinical diagnosis of Alzheimer's disease; Report of the NINCDS-ADRDA work group under the auspices of the Department of Health and Human Services Task Force on Alzheimer's disease. *Neurology, 34,* 939-944.

Money, E. A., Kirk, R. C., & McNaughton, N. (1992). Alzheimer's dementia produces a loss of discrimination but no increase in rate of memory decay in delayed matching to sample. *Neuropsychologia, 30,* 133-143.

Morris, R. (1994). Working memory in Alzheimer-type dementia. *Neuropsychology, 8,* 544-554.

Myerson, E., Emery, L., White, D., & Hale, S. (2003). Effects of age, domain, and processing demands on memory span: Evidence for differential decline. *Ageing Neuropsychology and Cognition, 10,* 20-27.

Paul, R., Moser, D., Cohen, R., Browndyke, J., Zawacki, T., & Gordon, N. (2001). Dementia severity and pattern of cognitive performance in vascular dementia. *Applied Neuropsychology, 8,* 211-217.

Pearson Education, Inc. (2008). *Wechsler Memory Scales fourth edition: Clinical features of the new edition.* Retrieved February 5, 2010, from http://www.pearsonassessments.com/NR/rdonlyres/77AB9FD3-5181-4265-9C89-E00CEA5D0561/0/WMSIV_2_06_08.pdf

Prinzel III, L., Freeman, F. (1995). Sex differences in visuospatial ability: Task difficulty, speed-accuracy tradeoff, and other performance factors. *Canadian Journal of Experimental Psychology, 49,* 530-539.

Robbins, T., James, M., Owen, A., Sahakian, B., Lawrence, A. (1988). A study of performance on tests form the CANTAB battery sensitive to frontal lobe dysfunction in a large sample

of normal volunteers: Implications for theories of executive functioning and cognitive ageing. *Journal of the International Neuropsychological Society, 4,* 474-490.

Roman G. C., Tatemichi, T., Erkinjuntti, T., Cummings, J. L., Masdeu, J. C., Garcia, J., et al. (1993). Vascular dementia: diagnostic criteria for research studies. Report of the NINDS-AIREN International Workshop. *Neurology, 43*(2), 250-260.

Salthouse, T. (1994). The ageing of working memory. *Neuropsychology, 8,* 535-543.

Salthouse, T., Fristoe, N., Lineweaver, T. T., & Coon, V. E. (1995). Ageing of attention: Does the ability to divide decline? *Memory and Cognition, 23,* 59-71.

Serova, S. (2007). *Factor structure of the neurocognitive battery in a geriatric sample with cognitive impairments.* Unpublished master's theses, University of North Texas, Texas.

Tomaszewski, F., Mungas, D., Reed, B., Cahn-Weiner, D., Jagust, W., Baynes, K., et al. (2008). The measurement of everyday cognition: Scale development and initial validation. *Neuropsychology, 22,* 531-544.

Thompson, S. (2006). *Dementia and memory: A handbook for students and professionals.* Great Britian: Antony Rowe Ltd.

Trenerry, M., Jack, Jr., Clifford, R., Cascino, Gregory, D. Sharbrough, et al. (1996). Sex differences in the relationship between visual memory and MRI hippocampal volumes. *Neuropsychology, 10,* 343-351.

Van der Linden, M. (1998) The relationships between working memory and long-term memory. *Comptes Rendus de l'Academie des Sciences - Serie III, 321,* 175-177.

Wechsler, D. (1997). *WMS-III administration and scoring manual*. San Antonio, TX: The Psychological Corporation, Harcourt Brace Jovanovich.

Weiss, E., Kemmler, G., Deisenhammer, E., Fleischhacker, W., & Delazer, M. (2002). Sex differences in cognitive functions. *Personality and Individual Differences, 35,* 863-875.

Williams, M. (1970). Geriatric patients. In Mittler, P. (Ed.), *The psychological assessment of mental and physical handicaps.* London: Methuen.