2014

Word Reading Ability, Occupational Complexity, and Neuropsychological Functioning in a Clinical Older Adult Population

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A Dissertation
Submitted to the Faculty of Graduate Studies
through the Department of Psychology
in Partial Fulfillment of the Requirements for
the Degree of Doctor of Philosophy at
the University of Windsor

Windsor, Ontario, Canada

2013

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ABSTRACT

There is ample evidence that higher levels of mental stimulation, greater complexity of occupation, and higher word reading ability increase levels of cognitive reserve. The purpose of the current study was to investigate the unique contribution of these two proxy measures of cognitive reserve on measures of fluid and crystallized intelligence and episodic and semantic memory. This contribution was hypothesized to exist over and above the influence of age, formal education, ethnicity, gender, and overall cognitive status. The sample consisted of 218 African American and European American older adults seen in an urban outpatient clinic for suspected memory problems and other problems in thinking. The select neuropsychological measures administered included the WASI Vocabulary (Vocab) and Matrix Reasoning (MR) subtests, the Boston Naming Test (BNT), and the Logical Memory (LM) I subtest from the WMS-R. A missing value analysis determined that the pattern of missing data on the WASI Vocab and MR subtests and the LM I subtest was not at random, and not ignorable. A series of hierarchical regressions were run, with the Heckman two-step model included to correct for the missing data. Complexity of occupation was a significant predictor of performance on measures of fluid and crystallized intelligence and a measure of episodic memory. Similarly, oral word reading ability was a significant predictor of performance on measures of fluid and crystallized intelligence and semantic memory. The contribution of these predictors was found to exist beyond the expected impact of key background variables. These findings indicate that proxy measures of cognitive reserve, including complexity of occupation and oral word reading ability, are important factors to consider when examining neuropsychological test performance in clinical settings. The importance

of adequately assessing and addressing the problem of missing data is also highlighted by this study.

ACKNOWLEDGEMENTS

There are many individuals who provided much needed support in the journey to complete this degree.

Thank you to my advisor, Dr. Anne Baird, who provided invaluable insight and encouragement throughout this process. I always appreciated your gentle guidance and support.

Members of my committee, Dr. Chris Abeare, Dr. Julie Hakim-Larson, and Dr. Lorna de Witt were essential in helping shape the direction of this project. Dr. Peter Lichtenberg served as External Examiner. Thank you to the committee, and to Dr. Lichtenberg, for providing thoughtful and invaluable feedback.

Many thanks to Dr. Scott Millis, Dr. Joanna Kraft, Dr. Dennis Jackson, and Dan Edelstein for helping me solve many statistical challenges.

Thank you to my parents and sister for many years of unconditional love and support.

Thank you to John Monastero, for continuously providing much welcomed love and comic relief when new challenges arose.

Thank you to Kapil Mandraker, for always expressing interest in the project.

Thank you to Dr. Elizabeth Mundorf, Cristina Androtis, Drs. Joanna and.Adam Kayfitz, Dr. Ashley Paterson, Dr. Tara McHugh, Dr. Joanna Kraft, Jordan and Ruth Urlacher, Amanda Robinson-Howard, and Betty Rodriguez-Rubio for providing me with a family in Windsor.

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CHAPTER I

INTRODUCTION

Study Content and Purpose of the Current Study

Cognitive reserve is a theoretical concept that helps to explain why some individuals cope with brain pathology better than others, particularly later in life (Stern, 2009). According to Stern (2007), the brain uses compensatory approaches to help cope with neurodegeneration or neurological trauma; these processes are what constitute reserve. There are a variety of factors that are thought to positively affect cognitive reserve and cognitive status in older adults, including lifetime participation in cognitively stimulating activities (Hall et al., 2009; Reed et al., 2011; Wilson et al., 2003; Wilson, Scherr, Schneider, & Tang, et al., 2007), high levels of social engagement (Gallucci et al., 2009; Krueger et al., 2009), formal education (Dijk et al., 2008; Ngandu et al., 2007), and bilingualism (Bialystok, Craik, & Freedman, 2007). High complexity of lifetime occupation has also been shown to provide this benefit (Andel et al., 2007; Mortel, Meyer, Herod & Thornby, 1995). The majority of individuals spend a significant part of their adult lives at work (Andel et al., 2005). A person's work may provide sustained intellectual stimulation, but the cognitive demands placed on an individual (e.g., seeking or processing information) can vary widely (Wilson, Barnes, & Bennett, 2007). There also appears to be an association between a higher literacy level and higher cognitive functioning in older adults (Barnes et al., 2004; Manly et al., 2003) and it has been proposed that engaging in reading and writing tasks could enrich neural networks, which would therefore increase cognitive reserve levels (Barnes et al.). While cognitive reserve is a hypothetical construct, it is used to help clarify why there are individual differences between degree of neuronal pathology and performance on cognitive tasks (Jones et al., 2011).

The overall purpose of this study is to advance our understanding of the effect of complexity of lifetime occupation and word reading ability on neuropsychological performance later in life among African American and European American older adults seen in an outpatient clinic for suspected memory problems or other problems in thinking. As a foundation for this study, I will first review the literature on the impact of cognitive reserve and cognitive stimulation on cognitive performance and function in older adults seen in clinical settings. Occupational complexity and oral word reading ability will be the main focus of the review of cognitive reserve indicators. As well, I will focus on four areas of cognitive performance: fluid and crystallized intelligence and episodic and semantic memory.

Although there is some dispute in the literature about what abilities fall into these four areas, it is important to offer clear definitions for the purpose of this study. Fluid intelligence includes novel problem solving and abstract reasoning. Crystallized intelligence is the ability to recall factual information and is much more dependent on culture than is fluid intelligence. (Baron, 2004; Sattler, 2001). Episodic memory is memory for specific details and/or context of situations or events that one has experienced before (Balota et al., 2000). Semantic memory is non-autobiographical knowledge about the world (Bauer, Grande, & Valenstein, 2003; Squire & Zola, 1991). The focus of this study is to investigate the unique contribution of word reading and occupational complexity, beyond age, formal education, ethnicity, gender, and current overall cognitive status, on these four cognitive domains.

There does not appear to be a direct relationship between the extent of neurological damage and the clinical manifestation of cognitive impairment. Numerous studies have shown that the clinical expression of dementia does not correlate well with the amount of neurodegeneration present in post-mortem examinations (Lee, 2007). In some cases, pathological changes sufficient for diagnosis of Alzheimer's disease (e.g., number of neurofibrillary tangles or beta amyloid plaques) were present in the brains of older adults who died before showing signs of dementia. In other adults with a similar degree of neuropathology, signs and symptoms of dementia were also present prior to death (Lee, 2007). These findings suggest that there are individual differences in how much age-related neuropathological change individuals can tolerate before signs of dementia begin to be manifested clinically (Wilson, Barnes, & Bennett, 2007).

In the following sections, I will describe two proposed models of protection from neuropathology, brain reserve capacity and cognitive reserve. There is significant conceptual overlap between these models, which differ primarily in emphasis on relatively enduring neural components as opposed to malleable functional pathways influenced by environmental factors and life experiences**.** I will then detail two mechanisms that have been hypothesized to underline cognitive reserve, neural reserve and neural compensation. Lastly, I will discuss some of the factors thought to influence levels of cognitive reserve in older adults. Social engagement, years of formal education, physical activity, and participation in cognitively stimulating leisure activities will be discussed briefly, whereas oral word reading and complexity of occupation will be discussed in greater detail.

With regard to the literature detailed below, I began to delve into this topic by reading Stern's (2007) text, *Cognitive Reserve: Theory and Applications*. There, I began to have a general understanding of the concept of cognitive reserve, and which lifetime factors, including social engagement, occupational complexity, physical activity, and participation in cognitively stimulating activities, among others, were thought to influence levels of cognitive reserve in older adults. Stern's text also detailed the evidence of relationships between cognitive reserve and older adults' performance on neuropsychological measures, between word reading and cognitive decline, and between cognitive reserve levels and dementia risk.

While Stern served as the editor of the book, authors who had made long careers out of their work with cognition and older adults wrote the chapters. After reading the review chapters, I began to read multiple studies that had been previously conducted by Marcus Ricards, Robert Wilson, Lisa Barnes, David Bennett, Nikolaos Scarmeas, Paul Satz, and Jennifer Manly. I found that studies from the Rush Memory and Aging Project (e.g., Bennett, Schneider, & Buchman et al., 2005; Wilson, Beckett, & Barnes, et al., 2002), the Bronx Aging Study (e.g., Hall et al., 2007) and the Washington Heights-Inwood Columbia Aging Project (Manly, Touradji, Tang, & Stern, 2003; Manly et al., 1999) were especially informative. From there, I began to search for and read a number of additional studies that were cited by these authors, and begin to outline my own literature review and project. The results are below.

Literature Review: Models of Protection from Brain Damage or Dysfunction

Two models, the brain reserve capacity model and the cognitive reserve model, have been proposed to help explain mediators between neurological damage and clinically significant cognitive impairment.

Brain Reserve Capacity Model. First proposed by Satz (1993), the brain reserve capacity model proposes that relatively enduring structural factors (e.g., size of the cortex and number of synapses) are directly involved in protecting against the effects of neuropathology (Satz, 1993; Richards & Deary, 2005). Multiple factors can determine an individual's level of brain reserve capacity, including developmental differences, age, prior traumatic brain injury, or years of formal education (Ngandu et al., 2007; Satz, 1993). Once brain reserve capacity is depleted beyond a certain threshold, individuals begin to display the clinical or functional deficits of neurological damage and/or disease (Stern, 2007). It has been hypothesized that increased brain reserve capacity could protect an individual from experiencing cognitive and behavioural consequences of neuropathology, while an individual with less brain reserve capacity would be more vulnerable to neurological damage or trauma (Stern, 2007). While Satz (1993) believed that brain reserve capacity ultimately could be operationally defined (e.g., size of the neocortex or number of dendritic branches), he presented brain reserve capacity as a *hypothetical* construct that is related to the behaviour of an individual, and his/her cognitive state. Satz proposed that psychosocial factors, specifically general intelligence and level of formal education, represented an "indirect, albeit imprecise measure" of brain reserve capacity (Satz, 1993, p. 275).

In his original article, Satz (1993) hypothesized that intelligence, as measured by IQ, could be considered a more "valid indirect measure" of brain reserve capacity compared to years of formal education (p. 290). The rationale provided was that intelligence better reflected a person's cognitive capacity, whereas additional factors (e.g., socioeconomic status [SES]) could also influence how many years of formal education an individual receives. This notion provided a basis for a study conducted by Schmand et al. (1997), who investigated the association between education, premorbid intelligence and the development of dementia in 5600 individuals aged 65 to 84 who were enrolled in the Amsterdam Study of the Elderly. The authors used the Dutch Adult Reading Test (the Dutch version of the National Adult Reading Test [NART]), which is comprised of fifty words with irregular spellings. The number of correct responses was then converted to an IQ score. Word reading ability is frequently used as a measure of premorbid intelligence (Barnes, Tager, Satariano, & Yaffe, 2004; Kareken, Gur, & Saykin, 1995; Strauss, Sherman & Spreen, 2006). The findings from Schmand et al. suggested that an individual's pre-morbid intelligence (as estimated by word reading ability) was a better determinant of dementia development than years of formal education. Their results were consistent with Satz's theory of brain reserve capacity: intelligence is a more direct indicator of brain reserve capacity than years of formal education (Satz et al., 1993; Schmand et al., 1997).

Some studies have used physical factors as a surrogate for brain reserve capacity, such as direct measurement of the brain, head circumference, or intracranial size, though the results have been mixed (e.g., Edland et al., 2002; Jones et al., 2011; Wolf et al., 2003; Wolf et al., 2004). As the brain develops early in life, the cranial vault increases in size (Wolf et al., 2004). When the brain begins to shrink in midlife, the size of the cranial vault remains the same, and thus serves as an index of the maximum brain size that a person developed in life.

Wolf et al. (2004) examined intracranial volume and global cognitive impairment in neurologically normal adults, and older adults who had a diagnosis of Alzheimer's disease, vascular dementia, or mild cognitive impairment. Mild cognitive impairment is a diagnosis that is given when individuals experience mild memory complaints that, generally, do not interfere with daily functioning, but are greater than expected given their age and level of formal education (Ropper & Brown, 2005). In the dementia groups, there was a significant positive correlation between intracranial volume and cognitive performance. According to the authors, the results in this cross-sectional study suggested that among those already manifesting dementia in terms of their cognitive performance, a smaller intracranial volume could indicate one of two aspects of the dementia these individuals were experiencing. One possibility is that those with smaller intracranial volumes had more rapidly progressive cognitive impairment. Alternatively, those with smaller intracranial volumes may have had a longer course of cognitive impairment at the time of study. Both alternatives were considered compatible with the brain reserve capacity model. Although the intracranial volume of the mild cognitive impairment group did not correlate with cognitive performance, those in the lowest quartile in terms of intracranial volume were more likely to have lower cognitive test scores.

Also congruous with the brain reserve capacity model, Wolf et al. (2003) found correlations between intracranial volume, parenchymal head volume, cognitive function later in life, and years of formal education. As part of the Leipzig Longitudinal Study of the Aged, this sample was comprised of approximately 100 individuals aged 75-85 who were non-demented, or fell into one of three dementia groups (Wolf et al., 2003).

In contrast, Edland et al. (2002) used magnetic resonance imaging (MRI) data from neurologically normal older women and women with Alzheimer's disease and determined that there was a non-significant association between total intracranial volume and severity of Alzheimer's disease. Wolf et al. offered several possible reasons for these non-significant findings, including the fact that Edland et al. (2002) sampled individuals in "potentially disadvantaged groups" (Wolf et al, 2004, p. 1003). Further, Wolf et al. (2004) noted that their own sample was larger and more representative of the population as a whole.

Cognitive Reserve Model. The cognitive reserve model proposes that the brain "actively attempts to compensate for the challenges represented by brain damage … by using preexisting cognitive processing approaches or by enlisting compensatory approaches" (Stern, 2007, p. 1). Cognitive reserve is a hypothetical construct that currently cannot be measured directly. It does, however, aim to explain why there is individual variation between neuronal pathology and performance on cognitive tasks (Jones et al., 2011). In the cognitive reserve model, relatively permanent inter-individual physiological differences play a smaller role than in the brain reserve capacity model. Rather, it is the "cognitive processing" or "compensatory approaches" used by the brain in coping with normal aging or neurological damage that constitute reserve (Stern, 2007, p. 1). This definition of cognitive reserve will be used in the current review. A wide array of life experiences, such as years of formal education, social engagement, bilingualism, or occupational complexity may increase cognitive reserve, which is displayed in a variety of skill sets or behaviours (Bialystok, Craik, & Freedman, 2007; Scarmeas & Stern, 2003). Valenzuela and Sachdev (2006) refer to cognitive reserve as "behavioural brain reserve" (p. 441). This term likely suggests that behaviours that require complex mental activity lead to higher levels of reserve (Bialystok, Craik & Freedman, 2007). However, in the current review, the term "cognitive reserve" will be used.

Findings from the adult developmental literature suggest that, while slower processing speed is a common behavioural component of normal aging, there is still no one typical pattern of cognitive decline in normal aging (Miller, Myers, Prinzi, & Mittenberg, 2009; Salthouse, 1996; Singh-Manoux, & Kivimäki, 2010; Wilson, Beckett, Barnes, & Schneider et al., 2002). In the Rush Memory and Aging Project, cognitive functioning in approximately 700 older members of the Catholic clergy was assessed yearly for upwards of six years; participants did not meet clinical criteria for a dementia diagnosis at baseline (Wilson et al.). There was no clear-cut universal rate of change for individuals on measures of perceptual speed, visuospatial ability, and episodic, semantic and working memory. Cognition declined sharply in some individuals, while others had a more gradual rate of decline. Additionally, other individuals showed no change over time, while others' cognitive status improved overall. Examining rates of change in performance on these neuropsychological measures led the authors to conclude that changes in cognitive function in older adults are "highly specific to the individual" (Wilson et al., p. 190). Cognitive changes in the aging brain impact multiple cognitive systems and the authors stress that a variety of genetic and environmental factors, such as years of formal education, likely contribute to levels of cognitive reserve and thus alter the association between normal aging and cognitive function.

It is theorized that cognitive reserve does not protect individuals from acquiring neurodegenerative disease; rather cognitive reserve delays disease onset or inhibits disease detection (Richards & Deary, 2005). Because individuals with higher levels of cognitive reserve are better able to tolerate the pathological changes that occur with the development of Alzheimer's disease, memory deficits occur later on in these individuals, as compared to individuals with lower levels of cognitive reserve (Stern, 2009). Additionally, it has been theorized that, at a certain point, the pathological changes associated with Alzheimer's disease become too severe, and the neuronal mechanisms that are critical for cognitive reserve and memory fail. Were this the case, it could be assumed that, in patients with higher levels of cognitive reserve, there will be a shorter period between the time when this threshold is passed and the manifestation of severe cognitive impairment and/or the death of an individual (Stern, 2009).

Empirical support for this theory has been found (e.g., Hall et al. 2007; Hall et al., 2009; Sakurai et al., 2011). As part of the Bronx Aging Study, Hall et al. (2007) conducted yearly neuropsychological assessments and investigated rate of decline in 177 individuals (age 75-85) who ultimately developed dementia. An individual's change point, the point at which an individual began to experience an accelerated rate of cognitive decline, was estimated based on these yearly assessments. It was found that individuals with a greater number of years of formal education experienced a more rapid rate of decline in comparison to those with fewer years (Hall et al., 2007). In a slightly smaller sample from the same population, Hall el al. (2009) found that, once the change point was reached, those who had significantly more participation in cognitively stimulating leisure activities had a faster rate of decline in performance on a word list memory task than those who had less-frequent participation in cognitively stimulating leisure activities. As well, Sakurai et al. (2011) investigated the impact of sociodemographic and vascular risk factors in 150 Japanese individuals with Alzheimer's disease. They determined there were three variables associated with a faster disease progression of Alzheimer's disease: Younger age, greater years of formal education, and the presence of hypertension. That is, younger and more educated individuals, and/or individuals with hypertension had a faster rate of cognitive decline as measured by the Mini Mental State Exam (Folstein, Folstein, & McHugh, 1975), a brief screening measure of dementia, in comparison to their older, less educated counterparts. Overall, there is evidence to suggest that Stern's 2009 theory has empirical support. For those individuals who have the pathological changes associated with Alzheimer's disease, the individuals with higher levels of cognitive reserve have a shorter, steeper rate of cognitive decline in comparison to those with lower cognitive reserve levels.

Measurement of Cognitive Reserve. Traditionally, behaviours and/or environmental factors have been used as indirect, proxy measures of cognitive reserve. These include premorbid intellectual functioning (or premorbid IQ), years of formal education, occupational complexity, or lifetime participation in cognitively stimulating activities (Jones et al., 2011; Richards & Deary, 2005; Valenzuela & Sachdev, 2006). Overall, findings from these studies suggest that cognitive reserve is not set, but rather is influenced on an ongoing basis by a variety of behaviours in which an individual engages and environmental factors to which an individual is exposed over the course of his/her lifetime (Stern, 2009). The present review will focus on indirect, proxy measures of cognitive reserve and each will be discussed in detail below.

However, limitations exist in using these proxy measures to help estimate level of cognitive reserve and the progression of cognitive aging. As Jones et al. (2011) describe, a limitation of most cognitive reserve measures is that, “they may be linked to neuropsychological test performance *via* many alternative paths, not only *via* the hypothesized ‘reserve’ mechanisms. Distinguishing between these alternatives is crucial … to (understanding) the etiology of cognitive aging” (p. 3, emphasis in original). In their review of operational definitions of reserve in observational research, Jones et al. detail how factors can have a confounding effect on one another. For example, childhood IQ and childhood socioeconomic status may have a confounding influence on educational attainment, which can subsequently impact literacy level, occupational status, how one spends his/her leisure time, and socioeconomic status later in life. These factors can then directly affect physical health and the rate of age-related neurodegeneration. As a result, Jones et al. suggest that a multiple indicator model may be advantageous. This is because the latent variable approach combines several imperfect predictors of cognitive reserve into one latent variable, called ‘reserve’ (p. 4). The authors suggest that a more exact estimate of cognitive reserve is generated when multiple indicators are used, compared with a single proxy measure. Therefore, the relation between cognitive reserve and functioning can be summarized with only one coefficient (Jones et al.). As Stern (2011) summarizes, “the derived latent variable directly measures what cognitive reserve is supposed to do: account for the disparity between pathology and performance, and avoids the indirect route typically used to measure reserve based on proxy variables” (p. 641).

Reed et al. (2010) used a latent variable model and proposed a novel way of measuring cognitive reserve, termed the decomposition approach. In order to test this, they began with the premise that multiple factors, which could be measured, contributed to an individual's cognition. These factors included degree of neurodegeneration, a variety of demographic factors, and "a (residual) component that is independent of brain structure and demographic effects" (Reed et al., 2010, p. 2197). Even though one might expect that demographic factors related to education also might influence cognitive reserve, the authors reasoned that the residual component, in isolation, provides a conservative measure of reserve. For this initial study, the authors used performance on an episodic memory test in order to measure cognitive performance and magnetic resonance imaging (MRI) to measure neuropathology. The MRI measurements included brain matter and hippocampal volume and white matter hypertensities. An expectation of episodic memory performance based on years of formal education, gender, and ethnicity (Hispanic, African American, and European American) was calculated. The residual component, the difference between observed episodic memory performance and performance predicted by neuropathology on MRI and this set of demographics, served as an estimate of cognitive reserve. Reed et al. found that the residual component accounted for the largest proportion of performance on the episodic memory task. Their findings supported the decomposition approach method as a useful measurement of cognitive reserve (Reed et al., 2010), and subsequent studies validated their approach (Reed et al, 2011, described below). As well, Jones et al. (2011) argued that analyzing data using this decomposition approach is appropriate until a direct measure of cognitive reserve is found. There are a few disadvantages of the decomposition approach, however. As Stern (2011) argues, the approach is potentially limited by the current, available measures of pathology. As well, this approach takes "a snapshot of the current status of the individual" and his/her level of cognitive reserve and only provides information about how a disorder developed at a single point in time, rather than over the course of the disease (p. 641). Despite these limitations, Stern argues, the decomposition approach is the newest, and currently the most comprehensive approach to studying cognitive reserve, and can provide highly valuable information for researchers.

The findings from existing research studies elucidating precisely *how* functional and structural brain measures are directly related to measures of cognitive reserve in the same individual are both few and inconsistent (Solé-Padullés et al., 2009). However, neural reserve and neural compensation are two mechanisms that may underlie cognitive reserve; each will be discussed in turn.

Neural Reserve. Neural reserve refers to "inter-individual differences in cognitive processing that exist in the normal, healthy brain" (Stern, 2009, p. 2016); it is one mechanism proposed to help implement the cognitive reserve process (Stern, 2006). Neural reserve relates to inter-individual differences that are structural in nature, such as brain networks (Stern, 2006). Stern points out that several possible kinds of neural reserve that may exist. The first possibility is that individuals with greater neural reserve rely on the same synaptic connections to perform a task as those with less neural reserve. However, these networks are hypothesized to function with more accuracy or speed for the same degree of energy expenditure in individuals with greater neural reserve – in other words, they process information in a more efficient manner (Stern, 2009). According to Stern, a second possibility is that among normal individuals, greater neural reserve might be apparent in people who use a greater variety of networks in performing the same cognitive task. Having a greater variety of networks available results in networks that are less susceptible to disruption in comparison to a brain that has fewer networks available to perform a cognitive task (Stern, 2006). Stern (2009) noted that a third kind of neural reserve might be manifested by those who solve a cognitive problem using entirely different neuronal connections than other normal individuals with less neural reserve. It is important to stress that the concept of neural reserve relates to how individuals with normal, healthy brains process information, as opposed to individuals who have developed neuropathology. However, greater amounts of neural reserve help individuals better cope with brain pathology if and when it develops (Stern, 2011).

There is in fact experimental evidence from imaging studies in support of the first kind of neural reserve, the hypothesis that individuals with higher levels of cognitive reserve use the same neural networks more efficiently than those with lower levels to complete a given cognitive task (e.g., Solé-Padullés et al. [2009]). For example, Solé-Padullés et al. (2009) investigated the correlation between proxies for cognitive reserve (including education, occupation, and premorbid IQ), and brain activity and brain structure, both measured by functional MRI (fMRI). Their sample was comprised of 16 neurologically normal individuals, 12 amnesic patients diagnosed with mild cognitive impairment, and 16 patients diagnosed with mild Alzheimer's disease. All patients were recruited from a clinic in Barcelona, Spain. The three groups did not differ significantly in their recognition memory performance, but the neurological findings varied by group: in neurologically normal older adults, higher cognitive reserve was associated with higher amounts of brain volume, and reduced brain activity in multiple structures including the frontal lobe, the cerebellum bilaterally, the right temporal cortex, and left thalamus during a memory task (Solé-Padullés et al., 2009). In contrast, the opposite pattern was seen in the mild cognitive impairment and Alzheimer's disease groups. In these groups, lower cognitive reserve was associated with lower amounts of brain volume and a greater amount of brain activity in the anterior cingulate and lingual gyri during the memory task in comparison to the healthy controls. The authors interpret this finding to mean that the neurologically normal older adults used more efficient neural networks in both cortical and subcortical structures during the memory task compared to individuals in the cognitively impaired groups and therefore the normal group required less activation to execute the same task (Solé-Padullés et al., 2009).

Neural Compensation. According to Stern's (2009) definition, neural compensation occurs when individuals with brain pathology or with adverse changes associated with normal aging use a different set of networks to accomplish a task than they did before the pathology developed. In the presence of pathology, the standard processing networks may be disrupted, leading to impaired cognitive function. With neural compensation, it is thought that some individuals use compensatory mechanisms better than others. It is this development of neuropathology that is the primary difference between neural compensation and neural reserve (Stern, 2011). With effective neural compensation, the effects of neuropathology or normal aging are not manifested behaviourally or are manifested less than they would be otherwise (Stern, 2007). Stern (2009) describes multiple possible ways in which neural compensation might come into play when older adults attempt and succeed in cognitive tasks that in younger adults are reliant on neuronal pathways adversely affected by aging. Forms of possible neural compensation include using two separate neural networks, and recruiting and using areas of the brain not utilized by younger (cognitively intact) individuals. Alternatively, the older individuals could use networks identical to those used by younger people, but with a different organization of the networks between the two groups (Stern, 2009).

Neuroimaging also has emerged as one tool that has provided experimental evidence for neural compensation. It has been hypothesized, for example, that older adults use compensatory areas of the brain to complete cognitive tasks previously recruited with different or more limited regions. Reuter-Lorenz et al. (2000) investigated the performance of older and younger female adults on a verbal and a spatial working memory task. The authors also administered a control task similar to the verbal working memory but without a requirement of working memory; similarly, a control task for the spatial working memory task was given. While both groups were virtually 100% accurate on a control task for verbal working memory, the younger group was significantly faster than the older group on the verbal working memory task. Separate groups were enrolled for the spatial working memory task. Older responders who did not meet an accuracy criterion were screened out of the spatial working memory study. The younger and older adults who remained in the spatial working memory study did not differ on accuracy on the control and working memory tasks, but the older adults were slower on both. Additionally, PET imaging demonstrated that, in the younger group, in anterior areas there was greater left-hemisphere activation compared to right-hemisphere activation while they were completing the verbal working memory task and greater right-hemisphere activation compared to left-hemisphere activation when the younger group for that task was engaged in the spatial working memory task. In contrast, the older groups utilized both right and left frontal regions relatively equally, including Broca's area and the lateral supplementary motor area, while completing both memory tasks. The authors hypothesize that, because Broca's area is likely a component of the verbal working memory circuit that helps retain information for short periods of time, it is possible that "the bilateral activation of Broca's area in the older adult group reflects compensatory recruitment that maintains the functioning of the rehearsal circuit in the aging brain" (Reuter-Lorenz et al., 2000, p. 183).

An additional neuroimaging study by Cabeza et al. (2000) provides another example of neural compensation. They assessed performance on temporal-order memory and item retrieval tests in neurologically normal older and younger adults. Younger adults had significantly more right prefrontal cortex (PFC) activation during the temporal-order retrieval task compared with the item retrieval task. During the temporal-order retrieval task, a contrasting pattern was seen in the older group: there was an increase in left PFC activity, and a decrease in activity in the right PFC. The authors speculate that the pattern of activation seen in the older adult group during the temporal-order retrieval task may reflect ways of compensating with age-related deficits in episodic memory retrieval (Cabeza et al.).

While these neuroimaging studies suggest possible mechanisms for neural compensation and the study by Solé-Padullés et al. (2009) demonstrated one way in which neural reserve may protect individuals from behavioral impairment, a general comment made by Stern (2009) deserves mention. Specifically, Stern notes the possibility that generic networks that are not specific to any given task mediate cognitive reserve. These networks, in turn, may not be related to the neural networks that are activated during the neuroimaging studies cited in support of neural reserve and neural compensation.

Proxy Measures of Cognitive Reserve in Older Adults

The relationship between dementia risk and lifestyle factors has been explored (Andel et al., 2005). The following sections will review factors thought to be proxy measures of cognitive reserve (Jones et al., 2011). The literature covered will include both the adult developmental literature (neurologically normal individuals) and clinical cases. Participants in a small number of the reviewed studies are members of religious orders (e.g., Bickel & Kurz, 2009). The benefit of using religious orders in longitudinal studies that assess dementia risk and lifestyle factors is that, while individuals have had a wide range of educational or occupational experiences, lifestyle and environmental factors (e.g., living accommodations, nutrition, and access to medical care) remain relatively homogeneous across groups (Bickel & Kurz).

Social Engagement. There has been some examination of social relationships and social support, and their relationship to cognition later in life. Social interaction and high levels of social support have both been linked to protection from various physical and mental health disorders associated with cognitive decline, including heart disease, hypertension, and depressed mood (Seeman, Lusignolo, Albert, & Berkman, 2001). As well, it has been hypothesized that social interaction promotes continual cognitive engagement and therefore aids in the development of better cognitive functioning and cognitive reserve. As well, positive social interactions can lead to reduced feelings of stress. In a recent review, Fratiglioni, Paillard-Borg, and Winblad (2004) detail several studies that determined that higher levels of distress in older adults were associated with a higher risk of developing Alzheimer’s disease. Lastly, there is empirical evidence that positive social support and positive social interactions have both been associated with reduced neuroendocrine and cardiovascular reactivity, which are thought to have protective effects against cognitive decline (Seeman et al.)

Overall, the literature supports the idea that higher levels of social engagement and emotional support have a beneficial effect on cognition later in life (Fratiglioni et al., 2004; James et al., 2011; Kreuger et al., 2009; Seeman et al., 2001). However, the precise neural mechanisms involved with this beneficial effect are yet to be elucidated (James et al; Kreuger et al.,). Several hypotheses have been proposed. Fratiglioni et al. suggest that those older adults who are more socially engaged use neural networks more efficiently, and/or have a greater ability to use alternative brain networks after pathological damage occurs in other regions of the brain in comparison to their less-social counterparts. This idea is not unique to the social engagement domain and has been proposed by Barnes et al. (2004) to explain the association between high levels of cognitively stimulating leisure activities and better cognitive functioning in older adults. There are several limitations of the literature detailed here. First, several of the studies included high-functioning older adults (Seeman et al., Kreuger et al.) and therefore the reliability of generalizing the findings to other populations is called into question. It would be beneficial, for example, to investigate the association between cognition and social engagement in individuals who are not high functioning at baseline and have begun to experience some degree of cognitive decline. Optimally, this measurement would occur longitudinally, rather than from one time point (Fratiglioni et al.). Second, there was a general lack of consensus within the research reviewed here regarding how “social activities” and “social networks” are defined and measured. Should researchers come to agreement over these factors, it would be of great benefit to this area of study.

Years of Formal Education. Formal education is frequently used as an indirect, proxy measure of cognitive reserve (Dijk et al., 2008; Manly et al., 2003; Wilson, Barnes, & Bennett, 2003) as it is a marker of "resistance and compensation ability" of the brain when neurodegenerative changes occur (Bickel & Kurz, 2009, p. 554); the brain could then compensate for neuropathology by using alternative neural networks or by using existing networks more efficiently (Manly et al.). Both innate factors (e.g., talent) and environmental factors (e.g., access to formal education and SES) are known to influence how many years of formal education an individual receives (Dijk et al., 2008). Individuals with higher years of formal education may also ultimately lead healthier lives, and/or obtain higher occupational achievements, which could in turn reduce vascular and lifestyle-related factors associated with developing dementia later in life (Jones et al., 2011; Ngandu et al., 2007).

Overall, the literature suggests that years of formal education is not always a reliable predictor of when an individual will begin to experience dementia later in life; other factors, including the development of neuropathology beyond that associated with normal aging, determine whether or not an older will experience dementia at some point in his/her life. Multiple studies have demonstrated that other confounding factors, such as social engagement and late life participation in cognitively stimulating activities, may be better at predicting the starting point of dementia (e.g., Reed et al., 2011; Wilson, Bennett, et al., 2002). As well, some studies that determined that years of formal education increased levels of cognitive reserve did not take those later life cognitive factors (e.g., social engagement, cognitively stimulating activities) into consideration (e.g., Ngandu et al., 2007). As such, Stern (2009) notes that researchers must be mindful of possible confounds, such as these, which may impact study findings.

However, there is evidence that the point at which an individual begins to experience cognitive decline is delayed in those who have higher levels of education; once this decline begins, they also experience a faster, steeper rate of decline (Stern et al., 1999; Hall et al., 2007). This is an important factor for clinicians to consider, as those with more education are likely to have a better quality of life for a longer period of time in comparison to their less-educated counterparts. Additional confounds, such as familiarity with testing, may also impact performance on neuropsychological tests (Stern, 2009). It has been argued by Stern that a large component of an Alzheimer's disease diagnosis is an individual's performance on cognitive tests. Individuals with more years of formal education and/or higher IQ frequently outperform individuals with few years of formal education and/or a lower IQ (Stern).

There are also additional factors to consider when examining the relation between educational attainment and cognition in older adults who are from a minority culture and/or ethnic group. The educational attainment of an individual may not reflect the native ability of minority or immigrant older adults, who may have had limited access to education as a result of institutionalized racism and poverty (Manly et al., 2003). As a result, "Minorities with strong intellectual abilities may not achieve academic or occupational success because their opportunities are limited by societal forces beyond their native intellect or drive to succeed" (Manly et al., 2003, p. 681). Thus, for immigrant or minority older adults in particular, there is likely an underestimation of the relationship between educational attainment and the rate and/or degree of cognitive decline in older adults (Manly et al., 2003).

Limitations exist within several of the studies mentioned here. First, there were several examples where the low educational attainment of study participants (e.g., Ngandu et al., 2007; Stern et al., 1999) or predominantly European American sample (Hall et al., 2007; Hall et al, 2009) limited the generalizability of the findings. Second, years of formal education was often self-reported (Hall et al., 2007; Hall et al., 2009), or recorded in an imprecise way (Bickel & Kurz, 2009). Third, there is ample evidence that quality of formal education can differ, often considerably, between geographic areas and/or ethnic groups (Manly et al., 2002; Manly et al., 2003). In many such cases oral word-reading level has been shown to be a better index of education quality than years of formal education (Baird et al., 2007; Manly et al., 2002; Manly, Schupf, Tang, & Stern, 2005).

Physical Activity. The literature has been mixed regarding whether or not physical activity alone is associated with a reduced risk of cognitive decline in older adults, and, if so, whether this reduced risk comes about as a result of increased cognitive reserve (Etgen et al., 2010; Sturman et al., 2005). The majority of studies mentioned here used self-report in order to assess physical activity (Etgen et al., 2010; Gallucci et al., 2009; Wilson et al., 2002). However, there are several studies that have moved away from self-report, a potentially flawed method of data collection because age-related cognitive decline may affect what individuals recall (Buchman, Wilson & Bennett, 2008). Several studies (e.g. Wilson, Bennett, Bienias, Aggarwal & Mendes de Leon et al., 2002 & Wilson, Scherr, Schneider, Tang, & Bennett, 2007) did not find an association between how many hours per week older adults engaged in physical activity and their risk of developing Alzheimer's disease.

Potentially impacting study findings is methodology, however. Some studies (e.g., Etgen et al., 2010; Gallucci et al., 2009; Wilson et al., 2002) used self-report to measure physical activity, whereas others had participants engage in a home-based physical activity program (e.g., Lautenschlager et al., 2008). Furthermore, other studies (e.g., Buchman, Wilson, & Bennett, 2008) used objective measures of physical activity (i.e., actigraphy). When physical activity was more objectively measured, it was determined that activity intensity was related to several cognitive domains and abilities, but the authors did not see an association when participant's self-report was used (Buchman, Wilson & Bennett). This finding, as well as findings from the randomized control trial conduced by Lautenschlager et al. (2008) suggests that physical activity later in life has a beneficial effect on level of cognitive reserve. With 20 minutes of physical activity per day, gains in cognition were seen for upwards of 12 months, and improvements in mood, quality of life, cardiovascular functioning and overall level of disability were also observed for upwards of a year and a half. Future studies are advised to use objective measures of physical activity. As well, the introduction of a physical activity intervention program could have multiple benefits for older adults.

Participation in Cognitively Stimulating Leisure Activities. Cognitive stimulation is a conceptual method based on the idea that both individual accomplishments and psychosocial factors contribute to cognitive abilities in older adults (Wenisch et al., 2007). Findings from the Rush Memory and Aging Project suggest that cognitive reserve is related to both the *types* of activities individuals participate in across the lifespan, and the *frequency* in which individuals engage in those cognitively stimulating leisure activities. (Wilson, Barnes & Bennett, 2003; Wilson, Barnes & Bennett, 2007). Wilson et al. (2007) define participation in cognitively stimulating leisure activities as “cognitive activities … in which seeking or processing information is central to participation in the activity” (p. 160). Such activities may include reading, writing letters or in a journal, visiting a library, or going to a concert (Reed et al., 2011). When individuals engage in cognitively stimulating leisure activities, neural systems become increasingly efficient and flexible (Wilson et al., 2007). The presence of neuropathy is therefore less likely to disrupt neural mechanisms and lowers the likelihood that individuals will display functional impairment (Wilson et al., 2003; Wilson et al., 2007). Wilson et al. (2007) view cognitively stimulating activities as, “indirect indicators of neural reserve capacity” (p. 161). Higher levels of cognitive reserve have also been associated with being in a stimulating environment and engaging in activities that require information processing (Dijk et al., 2008). Some studies have examined the impact of participating in cognitively stimulating leisure activities and performance on neuropsychological tests. For example, in a literature review Wilson et al. (2003) state that higher cognitively stimulating leisure activity participation over the lifetime is related with higher performance on measures of semantic memory, perceptual speed, and visuospatial ability.

Overall, there is strong evidence to support the idea that higher levels of cognitively stimulating leisure activity participation increase levels of cognitive reserve in older adults. This is supported when lifetime participation is measured (Hall et al., 2009; Reed et al., 2011; Wilson et al., 2003; Wilson, Scherr, Schneider, & Tang, et al.,

2007) or when a cognitive stimulation intervention program was introduced in older adults experiencing mild cognitive impairment (Wenisch et al, 2007). There are limitations to note. Several studies (Hall et al.; Reed et al.; Wilson et al., 2003; Wilson et al., 2007) used self-report to assess activity participation. Because individuals are asked to report their participation retrospectively, there is a possibility that recall bias will skew their results. The authors state that recall bias is unlikely in cases where participants were not experiencing dementia at baseline, however (e.g., Reed et al., Wilson et al., 2003; Wilson et al., 2007). Another limitation, as detailed by Hall et al, is that some cognitively stimulating leisure activities may have a larger effect on cognitive reserve than others. A prospective, 21-year longitudinal study determined that a variety of activities, including reading, playing board games and musical instruments, and dancing were associated with a lowered risk in developing dementia. Dancing, in particular was thought to reduce dementia risk because it provides a cardiovascular benefit, requires spatial memory, and it is a social activity. All factors were hypothesized to increase levels of cognitive reserve (Verghese et al, 2003). However, the majority of literature does not investigate the specific activities in such detail. Similar to Verghese et al., future studies would benefit in examining what specific activities were associated with a reduced risk of intervention, as this could help health care workers develop targeted interventions for older adults.

Word Reading Ability. According to the National Assessment of Adult Literacy (NAAL), literacy is “the ability to use printed and written information to function in society, to achieve one's goals, and to develop one's knowledge and potential” (White & McCloskey, p. 1). Single word reading ability is a vital component of literacy (White & McCloskey). Oral word reading measures use correct pronunciation of words on a printed list as an index of whether those words are within the examinee's reading vocabulary, which in turn is usually highly associated with crystallized intelligence and educational quality, as well as with literacy (Barnes et al., 2004; Fyffe et al., 2011 Manly et al., 2005).

Oral word reading tests are frequently used to estimate an older adult's premorbid level of intellectual functioning when the individual is experiencing dementia or milder cognitive decline (Barnes et al, 2004; Kareken et al., 1995; Schmand, Geerlings, Jonker, & Lindeboom, 1998; Strauss et al., 2006).] Additionally, oral word reading ability remains relatively intact when an individual has mild dementia (Baird, Podell, Lovell, & McGinty, 2001). Barnes, Tager, Sarariano, and Yaffe (2004) noted that literacy (as assessed through oral word reading) may provide an indirect index of a person's crystallized intelligence, because it reflects, "in part, the effects of formal and informal educational experiences during a person's lifetime" and the frequency and level in which a person engages in cognitively stimulating activities (Barnes et al., 2004, p. 393). It is possible that learning how to read and using literacy skills increases the brain's synaptic density and/or enriches neural networks. Thus, being a better or more frequent reader could increase levels of cognitive reserve, provide greater protection against cognitive decline, and lead to more efficient information processing (Barnes et al., 2004; Manly et al, 2003).

Word reading has been proposed as a better indicator of cognitive reserve than years of formal education because word reading ability better reflects an individual's quality of education (Barnes et al., 2004; Fyffe et al., 2011; Manly, Schupf, Tang, & Stern, 2005). There is literature to support this idea. Lichtenberg et al. (1998) used the

Wide Range Achievement Test-3 (WRAT-3) reading subtest, a measure of single-word reading ability, to assess oral word reading level in a study of 74 cognitively intact, ethnically diverse older adults from an urban area. Lichtenberg et al. determined that the grade level corresponding to the examinee's WRAT-3 score was approximately three years below the self-reported educational level. The authors concluded that the participant's self report "may not adequately capture the quality of the educational experience, and thus may not capture relevant cultural factors" (Lichtenberg et al., 1998, p. 152). In a more recent study of community dwelling, African American older adults from the same urban area, Schneider and Lichtenberg (2011) found that oral word reading ability (again assessed by the WRAT-3) explained a significant proportion of variance on neuropsychological measures of executive function, attention, working memory, and verbal fluency after the authors accounted for several demographic factors, including age, gender, and years of formal education.

Barnes Tager, Sarariano, and Yaffe (2004) used another oral word reading test, the North American Adult Reading Test (NAART), to investigate the association between literacy and cognition in 644 community-dwelling, primarily well educated, European-American older adults. The NAART is comprised of 61 irregularly spelled words (Blair & Spreen, 1989). Barnes et al. found that a higher literacy level (as measured by a higher NAART score) was associated with better performance in all cognitive domains, including executive functioning and attention, verbal memory, verbal fluency, and global cognitive function. Higher literacy level and better cognitive performance on the aforementioned measures was also found after the authors accounted for several demographic factors, including age, sex, native language, and health-related factors (e.g., alcohol consumption, smoking, or depression) (Barnes et al). For each domain, performance on the measures improved as level of literacy improved. Barnes et al. offer several explanations for their findings: Literacy level could reflect innate level of cognitive functioning or degree of education early in an individual's life. With regard to cognitive reserve, the authors state that reading and writing "could lead directly to enrichment of neural networks," thus resulting in higher levels of cognitive reserve (Barnes et al., p. 393).

Manly, Touradji, Tang, and Stern (2003) set out to explore the relation between performance on an oral word reading test (the WRAT-3) and ability on a verbal word list-learning task. Individuals were part of the Washington Heights-Inwood Columbia Aging Project sample; all were community dwelling, aged 65 and older, and dementia free at baseline. The authors used participants' initial oral word reading scores to stratify them, into "high" and "low" literacy groups (p. 684). They were followed for three years on average and assessed annually. It was found that both the "high" and "low" literacy group members experienced memory decline, but the decline was swifter in the "low" literacy group. Manly et al. suggest that this finding indicates that "high literacy skills do not provide a complete preservation of memory skills but rather a slowing of age related decline" (p. 685). Because oral word reading ability better predicted change in memory performance over time, the authors concluded that oral word reading ability could act as a more sensitive indicator of cognitive reserve compared to years of formal education (Manly et al.).

Manly et al. (1999) investigated whether performance on select neuropsychological measures was affected (or not affected) by level of literacy in a sample of individuals who had received three or fewer years of formal education. Individuals were part of the Washington Heights-Inwood Columbia Aging Project (WHICAP) sample and fell into one of three broad ethnic categories: Hispanic, African American, and European American. All participants were community dwelling, aged 65 and older, dementia-free, and reported having between zero and three years of formal education. In total, 187 individuals were included in the sample; 123 were classified as literate and 64 were classified as illiterate. Degree of literacy was determined, by asking participants, “Did you ever learn to read and write?” (p. 194). The examination was conducted in either Spanish or English, depending on the individual’s preference and degree of language proficiency.

After accounting for the effect of literacy on neuropsychological test scores and matching individuals on age, functional status, and gender, Manly et al. (1999) determined that the participants who were illiterate scored significantly lower on several neuropsychological measures. The first was a measure of visual matching and recognition; the authors hypothesize that the literate individuals had developed better “skills in organization and analysis of certain types of visualspatial information …(or) successfully (used) linguistic skills to mediate verbal tasks” as compared to their illiterate counterparts (p. 198). Individuals who were literate also scored higher on a measures of visual naming, a sentence comprehension subtest, and on a subtest that required individuals to state how two concrete objects or abstract ideas were similar to one another. With regard to verbal fluency, many illiterate individuals were not able to generate words for the letter fluency task, a task in which individuals are required to name as many words beginning with a single letter as they can in a one minute period, leading to a significant difference in performance between the two groups. Surprisingly, however, there was no significant difference in the number of words generated for the category fluency task, in which individuals were asked to quickly name animals, food, and clothing. Impaired letter fluency and intact category fluency is a pattern of performance seen in those individuals with Alzheimer's disease, and the authors state that their finding is beneficial because it may aid in the accurate diagnosis of Alzheimer's disease in individuals who are illiterate (Manly et al.).

There are several gaps in the literature reviewed here that the current study attempts to fill. For example, while the study completed by Barnes et al. (2004) is highly relevant to the current study, it should be noted that their sample was comprised of mainly European American, highly educated individuals (e.g., 92% of individuals had 12 years of formal education or higher) who were of a relatively high socioeconomic status (SES). The authors did not state whether or not the study participants were screened for suspected cognitive impairment, only noting that they were community-dwelling older adults who were participants in a community-based study of health and function. Their sample differs from the sample of the current study in multiple ways: this study will consist of a more ethnically-diverse sample, comprised of European and African American individuals seen for neuropsychological assessment due to suspected cognitive impairment. While an individual's SES was not recorded in the current study, it is expected that the range of SES is wider for the current study than that for Barnes et al.

With regards to assessment and cognitive domains of interest, the current study will differ from those reviewed in several ways. Lichtenberg et al. (1998) used the Boston Naming Test, a measure of visual naming, crystallized intellectual abilities, and semantic memory, and the Logical Memory I score, a measure of short-term, episodic memory, from the Wechsler Memory Scale-Revised (WMS-R), but their study did not investigate how word reading score and a person's lifetime occupational complexity contributed to performance on these tests. Examining these contributions is one of the aims of the current study. Barnes et al. (2004) examined performance in four cognitive domains, including global cognitive functioning, executive functioning and attention, verbal memory, and verbal fluency; multiple assessment measures were used, including the Mini Mental State Exam (Folstein et al., 1975), a brief screening measure for dementia, the Trail Making Test Part B, a measure of cognitive flexibility, scanning, and divided attention, the California Verbal Learning Test (CVLT), a verbal list learning task, and the Controlled Oral Word Association Test (COWAT), a task of verbal fluency that requires an individual to name words that begin with a specific letter (e.g., "F") for one minute (Lezak et al., 2004; Reynolds & Fletcher-Janzen, 2008). Manly et al. (2003) used a verbal list learning task, and Manly et al. (1999) looked at performance in multiple cognitive domains, including learning and memory, orientation, language ability, and visuospatial skills. The relations of interest in the current study are those between oral word reading and fluid and crystallized intelligence and episodic and semantic memory. These associations were not investigated in any of the studies reviewed here.

Overall, it appears that there is evidence of an association between better performance on a word-reading task and higher cognitive functioning in older adults (Barnes et al., 2004; Manly et al., 2003). Engaging in reading and writing tasks could also lead to the enrichment of neural networks, thereby increasing levels of cognitive reserve in older adults (Barnes et al.). As such, both reading practice and higher levels of oral word reading ability may be associated with higher levels of cognitive reserve and greater protection against neurodegeneration in older adults.

Occupational Complexity. Examining the relationship between intellectual stimulation at work and cognitive functioning in older adulthood is especially worthwhile. Most individuals spend large portions of their adult lives at work, and the amount of information seeking or processing that is required of individuals at work can vary widely (Andel et al., 2005; Wilson, Barnes, & Bennett, 2007). Occupational complexity has been described in multiple ways in the literature. Occupations have been broken down into six factors (substantive complexity, motor skills, physical demands, management, interpersonal skills, and undesirable working conditions [Stern et al., 1995]). Occupations have also been rated on the complexity of occupation in dealing with people, data, and things (Andel et al., 2005; Andel et al., 2007; Kröger, Andel, Lindsay, Benounissa, Verreault, & Laurin, 2008; Potter et al., 2006; Schooler Mulatu & Oates, 1999). An individual's highest level of vocational training has also been used as a marker for occupational complexity (Bickel & Kurz, 2009). Occupations have been rated according to psychosocial factors (e.g., social climate or social demands at work [Seidler et al., 2004]). Dividing occupations into "high" and "low" occupational complexity has also been used (e.g., Stern, Albert, Tang, & Tsai, 1999), as has rating occupation by units of prestige (Wilson, Bennett, Bienias, Aggarwal, & Mendes de Leon, et al., 2002). The following sections will summarize the association between occupational complexity and cognitive impairment in older adults. One of the many difficulties in examining the association between occupational characteristics and cognitive functioning later in life is that there are a host of other factors (e.g., I.Q., intellectual attainment and performance, SES, and a wide array of exposure to other environmental factors) that impact cognitive functioning and the complexity of the occupation in which the individual works (Potter et al., 2006). Because of the potential influence of genetic factors on cognitive functioning, studies using twin pairs have been conducted (e.g., Andel et al., 2005; Potter et al., 2006); these studies will be detailed first.

Potter et al. (2006) examined how particular occupational characteristics (e.g., general intellectual demands, human interaction and communication, physical exertion, and visual attention) impacted cognitive status change in 1940 twin pairs who were part of the National Academy of Sciences – National Research Counsel (NAS-NRC). All participants were veteran male twins born between 1917-1927; both monozygotic and dizygotic twins were included. All twin pairs underwent a cognitive status exam, the Modified Telephone Interview for Cognitive Status, via phone every 3-4 years, beginning in 1990. Information regarding their occupational history was also collected and classified according to the Dictionary of Occupational Titles (4^{th} ed.). All individuals were free from dementia at baseline and were screened on 3 separate occasions (every 3-4 years) at minimum. Members of the twin pairs did not differ significantly for age, years of formal education, years of employment, or medical conditions assessed, with the exception of hypertension status. The results demonstrated that those individuals who had occupations with higher intellectual demands had, overall, a "modest improvement" in cognitive functioning over a 7-year period (Potter et al., 2006, p.1380). Jobs that included higher physical demands or visual attention had a "modest decline" in cognitive status over the same span of time (p. 1381). These effects were found in the dizygotic, but not the monozygotic twins, suggesting that the "genetic influences within identical pairs explain much of the association between occupational characteristics and cognitive changes later in life" (p. 1381). Potter et al. (2006) hypothesize that the similarities between job characteristics and late life cognitive functioning in the monozygotic twins were due to cognitive reserve that is attributed to occupational status, and factors closely associated with genetics, such as underlying intelligence. As such, the authors conclude that both genes and environment affect an individual throughout his/her lifetime (Potter et al., 2006).

The link between complexity of lifetime occupation and the development of dementia later in life in 10,168 individuals over age 65 and part of the Swedish Twin Registry has been investigated (Andel et al., 2005). Occupations were coded and categorized according to the 1980 Swedish Population and Housing Census and the 1970 US Census. Occupational complexity scores were then derived from the US Dictionary of Occupational Titles and each occupation was rated on complexity of work with data, people, and things. Results demonstrated that higher complexity of work was associated with a reduced risk of Alzheimer's disease and all types of dementia later in life after controlling for age, gender, and level of education. Because the influence of higher occupational complexity also was evident within twin pairs, the authors concluded that their findings could not be confounded by genetic or familial factors (e.g., socioeconomic status). Specifically, on average an individual who had a higher complexity of work with data compared to his/her co-twin were was at a reduced risk for Alzheimer's disease relative to the twin, and the same was found for those who had a higher complexity of work with people. Presumably twins with higher occupational attainment enjoyed efficiencies in brain function or supplementary neuronal circuits (both factors that contributed to higher levels of cognitive reserve than his/her co-twin) that lowered the probability that they would manifest the behavioural signs of dementia before death (Andel et al, 2005).

The linkage between occupational complexity and performance on a shortened version of the Mini Mental State Exam (Folstein et al., 1975), a brief screening measure for dementia, has also been examined in a sample of adults in Sweden who were over aged 77 (Andel et al., 2007). Performance was examined in 386 individuals who were part of the Swedish Panel Study of Living Conditions of the Oldest Old (SWEOLD). Occupational complexity scores for each participant's longest lifetime occupation were generated using the same criteria described above (Andel et al., 2005). In advanced old age, individuals who had greater complexity of work with data and people had higher Mini Mental State Exam scores overall and were less likely to be deemed cognitively impaired. The effect of occupational complexity on mental status exam scores was still present after statistically controlling for age, gender, years of formal education, and childhood SES. The authors hypothesize that the intellectual stimulation provided by complex work results in greater cognitive reserve, which in turn leads to relatively lower levels of cognitive impairment compared to others of very advanced age (Andel et al., 2007).

The relationship between psychosocial factors in the workplace and the risk of dementia in older adults living in Germany has been explored (Seidler et al., 2004). Comprehensive occupational histories were taken as part of a standardized clinical interview. The majority of neurologically normal control subjects completed the interview and a next-of-kin (e.g., a child or partner) completed the interview on behalf of the participants with dementia. Occupations were classified according to the Occupational Classification of Finnish Censuses and each occupation was rated on the following psychosocial scales: social climate at work, control possibilities at work, work load, perceived risks for error at work, social demands at work, and supervisor support. The authors statistically controlled for age, region in Germany, gender, dementia in parents, category of formal education, smoking, and psychosocial network at age 30. Results suggested that those individuals who experienced high social demands and had high levels of occupational control during their working years were significantly less likely to have a diagnosis of dementia. The authors hypothesize that these occupational factors could have delayed the clinical onset of dementia symptoms by building cognitive reserve (Seidler et al., 2004).

The association between work-related physical activity, complexity of work with data, people, and things and onset of dementia was explored in approximately 3,600 community- and institution-dwelling individuals over the age of 65 as part of the Canadian Study of Health and Aging (Kröger, Andel, Lindsay, Benounissa, Verreault, & Laurin, 2008). Individuals were clinically examined for the presence of dementia, Alzheimer's disease, and vascular dementia. Longest lifetime occupation was coded according to the 1980 Canadian Standard Occupational Classification. Initial results were similar to those of Andel et al. (2007) in that those individuals who engaged in high and intermediate levels of complexity of work with data and people were significantly less likely to display clinical signs of dementia in comparison to those at the same age with low levels. Those individuals who had high complexity of work with people or things were also at decreased risk for Alzheimer's disease and vascular dementia, even after statistical adjustment for workplace physical activity, sex, and years of formal education (Kröger et al.). This finding is consistent with Seidler et al., 2004, mentioned above, which found that high social demands at work were associated with a decreased risk of dementia.

Stern, Albert, Tang, and Tsai (1999) also investigated rate of decline in Alzheimer's disease patients and occupational status in 177 African American and Hispanic American individuals who were part of the WHICAP sample. These individuals all met the National Institute of Neurological and Communicative Disorders and Stroke and Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) criteria for Alzheimer's disease at baseline. Participants were stratified into two occupational levels: low (including unskilled, skilled trade or craft, and clerical/office workers) and high (manager business/government and professional/technical). Their findings mirrored the educational attainment finding as detailed by additional studies (e.g., Andel et al., 2005; Andel et al., 2007): Those individuals in the high occupational attainment group had a significantly faster progression of Alzheimer's disease in comparison to those in the low occupational attainment group. These findings remained after statistical control for age, gender, race, ethnicity, presence of extra pyramidal signs, stroke and the presence of at least one ApoE4 allele (Stern et al., 1999). The results of this study are interpreted as compatible with the hypothesis that higher occupational achievement resulted in greater cognitive reserve for this group compared to people with lower occupational attainment.

There is some literature examining the relationship between brain reserve capacity, occupational complexity, and dementia development. Satz (1993) proposed that individuals who have greater amounts of brain reserve capacity are more intelligent, and that premorbid intelligence is a better measure of brain reserve capacity than other factors, such as years of formal education. Schmand et al. (1997) examined dementia development in a sample of 5600 individuals enrolled in the Amsterdam Study for the Elderly. They determined that pre-morbid intelligence, as measured by a word-reading test, was a significant predictor of dementia development. Complexity of occupation and years of formal education did not predict dementia development and the presence of cognitive decline. The authors state that their findings offer support for the brain reserve capacity theory (Schmand et al.) However, this study also provides support for the cognitive reserve theory: Schmand et al. found that working in a managerial position helped to protect individuals from developing dementia. They concluded that when an individual engages in continued mental stimulation during adulthood (as working in a managerial position would provide), an "independent protective effect" occurs with regards to dementia development (Schmand et al., 1997, p. 1341).

In a study using data from a 30-year longitudinal study, Schooler, Mulatu, and Oates (1999) examined how a complex work environment related to intellectual functioning in a group of older adults. Participants were American men who were first interviewed in 1964, and re-interviewed in 1974. In the 1974 sample, the wives of the married men in the original 1964 sample were also interviewed. Findings from the 2nd interview session suggested that when an individual's job provided challenges and afforded individuals the opportunity to engage in self-directed, relatively complex work, there was an increase in his/her mental flexibility. In contrast, jobs that did not afford these opportunities were associated with a decrease in an individual's mental flexibility.

Schooler, Mulatu and Oates (1999) conducted follow-up interviews with 160 men from the original 1964 and 1974 sample, and 73 women from the 1974 sample. It was found that both men and women who engaged in substantially complex work, defined as "work that in its very substance requires thought and independent judgment … (and) requires making many decisions involving ill-defined or apparently contradictory contingencies" had higher intellectual functioning (Schooler et al., p. 485). In addition, the cognitive benefits of engaging in intellectually challenging work appeared to be greater for the adults when they were older, as opposed to their younger selves. This implies that the benefits of participating in cognitively stimulating activities, including those related to a person's occupation, extend well into older adulthood, and this type of activity participation is highly encouraged in order to maximize intellectual functioning in older adults (Schooler et al.). The authors admit that the precise psychological mechanisms behind their findings are not clear, but hypothesize that when an occupation has complex environmental demands, workers are motivated to expend mental energy, which in turn leads to increased cognitive capacity and cognitive reserve. The cognitive capacity is then generalized to other situations (Schooler et al.).

In addition to occupational complexity, the amount of vocational training received by an individual has also been associated with lower incidence of dementia in some, but not in all examined cases. In a sample of 442 sisters who were members of the Congregation of the School Sisters of Notre Dame in Bavaria, Germany, the sisters were ranked with regard to educational level occupational training, and whether or not she had held a position of leadership while in the order (Bickel & Kurz, 2009). It was determined that for those sisters with the lowest level of education, there was a significant association between these factors: Sisters who had not obtained a leadership position, or received little or no vocational training were more likely to have developed dementia in comparison to those who had leadership positions, and/or greater amounts of occupational training. However, this association was not present for those sisters who had achieved either intermediate or high levels of education (Bickel & Kurz, 2009).

Richards and Sacker (2003) used path analysis, a statistical technique that allows the researcher to create a model of the relationships among variables (Tabachnick & Fidell, 2007) in order to determine the degree to which several factors, including paternal occupation, childhood intellectual functioning, years of formal education, and lifetime occupation contributed level of cognitive reserve in a selection of men from a socially stratified birth cohort, all born in the UK in 1946. These individuals were all part of the Medical Research Council National Survey of Health and Development. Level of cognitive reserve was measured by performance on an oral word reading test; this assessment took place when the men were around middle age, at 53 years old. The results showed that, with all factors considered, the path from childhood cognition was the strongest and the path from the adult's occupation was the weakest (Richards & Sacker).

The Chicago Health and Aging Project also examined the impact of perceived prestige of lifetime occupational status on the development of Alzheimer's disease (Wilson, Bennett, Bienias, Aggarwal, & Mendes de Leon, et al., 2002). Approximately 6,150 European and African American individuals were interviewed about several factors, including their participation in cognitive stimulating activities and their lifetime occupation. Approximately 800 individuals who did not display symptoms of Alzheimer's disease were interviewed again, four years later. It was determined that, when cognitive activity was not included in the model, there was a 1% decrease in Alzheimer's disease risk per unit of occupational prestige (Wilson et al.). However, once the model included how often individuals participated in cognitively stimulating leisure activities, the effect for lifetime occupation was no longer significantly related to the risk of developing Alzheimer's disease. The authors concluded that participation in cognitively stimulating activities mediated the association between risk of developing Alzheimer's disease and occupational prestige. Individuals who had less prestigious jobs were less likely to involve themselves with cognitively stimulating leisure activities than those with more prestigious jobs (Wilson et al.).

Overall, there is evidence that those individuals who engaged in more complex work have higher levels of cognitive functioning later in life (Potter et al., 2006); a reduced risk of developing Alzheimer's disease (Andel et al., 2005; Andel et al., 2007), and a faster rate of decline once a diagnosis of Alzheimer's disease is reached (Stern et al., 1999). The findings are mixed, however. For example, the effect for complexity of occupation on lifetime risk of developing Alzheimer's disease was no longer significant once another variable, participation in cognitively stimulating leisure activities, was introduced into the equation (Wilson et al., 2002). As well, Schmand et al. (1997) did not find occupational complexity to be a significant predictor of dementia and Richards and Sacker demonstrated that there was a very weak path between adult occupation and level of cognitive reserve at age 53. Particular components of occupation, however, have been shown to have protective effects against dementia. For example, Andel et al. (2005) determined that when an individual's occupation was associated with high complexity of work with people, there was a reduced rate of dementia; this finding was not found for individuals who had high complexity of work with data or things. The same reduced risk of dementia was also found in jobs that involved work with data, academic skills, and high amounts of vocational training (Potter et al., 2007), high social demands (Seidler et al., 2004) and high complexity of work with people and things (Kröger et al., 2008).

However, there are limitations noted in the aforementioned studies. First, it is impossible to control for all of the environmental factors that have the potential to impact cognitive function and cognitive reserve. For example, findings from Schooler, Mulatu, and Oates, (1999) suggest that having a cognitively demanding job can lead to increased mental flexibility as an individual gets older. As well, it was determined that both intellectual flexibility and substantive work complexity declined as individuals aged. Those individuals who had higher intellectual capacity at baseline were more likely to have a job that was more cognitively stimulating and complex throughout their lifetimes. Schooler et al. also note that the benefit of intellectually challenging work was greater for older workers than the younger workers. Second, the majority of studies reviewed above examined cognition and activity engagement, rather than disease pathology. Stern (2009) notes that, in many of the studies, "it is simply inferred that that reduced incidence of dementia is evidence of the effect of cognitive reserve on the clinical expression of the pathology" (p. 2017). Further investigations, ideally using the decomposition approach detailed (Reed et al., 2010; Reed et al., 2011) could help quantify the level of cognitive reserve that can be specifically attributed to occupational complexity, independent of other proxy measures of cognitive reserve.

The final limitation of the studies reviewed here is that the majority of studies that examine occupational complexity and cognition in older adults use a brief screening measure such as the Mini-Mental State Exam, the Telephone Interview for Cognitive Status, or the Geriatric Mental State Exam (Andel et al., 2005, Andel et al., 2007, Bickel & Kurz, 2009; Potter et al., 2006; Schmand et al., 1997) & Ybarra et al., 2008). Several studies noted that they administered neuropsychological tests, but did not name them specifically (Kröger et al., 2008), or gave an "in person, clinical diagnosis evaluation for dementia" but did not state what this examination specifically entailed (Andel et al, 2005, p. P252). Richards and Sacker (2003) looked at performance on list-learning and visual-search tasks. Wilson et al. (2002) used the most comprehensive test battery of all studies reviewed here. Their test battery included seven episodic memory tests, four semantic memory tasks, four working memory tests, two measures of perceptual speed, and two measures of visuospatial ability. They did not include, however, measures of fluid and crystallized intelligence, which the current study does. Because of these limitations in the literature, it would therefore be quite beneficial to use more comprehensive neuropsychological measures and examine specific cognitive domains (e.g., simple and complex attention, expressive vocabulary, nonverbal reasoning, verbal fluency, and visuospatial ability). Thus, the aim of the current study was to investigate the unique contribution of occupational complexity to four areas of cognitive functioning: fluid and crystallized intelligence and episodic and semantic memory.

Overall Summary of Proxy Measures of Cognitive Reserve in Older Adults. In summary, there is ample evidence that higher levels of mental stimulation increase levels of cognitive reserve (Bialystok et al., 2007). There is also evidence that cognitive reserve is influenced by a wide array of behavioural and environmental factors that occur throughout the lifetime, especially those which occur later in life (Stern, 2009). For example, overall, the literature supports the idea that higher levels of social engagement and emotional support have a positive effect on later-life cognitive functioning (Fratiglioni et al., 2004; James et al., 2011; Kreuger et al., 2009; Seeman et al., 2001), although the specific neural mechanisms that underlie this phenomenon have not yet been determined (James et al; Kreuger et al.). Because the majority of the literature described here has included data from high-functioning older adults (Seeman et al., Kreuger et al.), it would be beneficial to investigate the association between social support and cognitive function in individuals who are not high functioning at baseline and have begun to experience some degree of cognitive decline (Fratiglioni et al.).

With regard to education, the literature reviewed here demonstrates that years of formal education are not the best estimate of neuroprotection in individuals who have underlying neuropathology that puts them at risk for developing dementia. Those studies that found that higher educational attainment increased levels of cognitive reserve did not take other factors shown to enhance cognitive reserve (e.g., frequent social engagement or cognitively stimulating leisure activity participation) into account (Ngandu et al., 2007). It has also been shown that confounding factors, such as social engagement and late life participation in cognitively stimulating leisure activities, may better protect an individual from the effects of neuropathology than other factors, such as years of formal schooling (e.g., Reed et al., 2011; Wilson et al., 2002). However, multiple studies suggest that greater years of formal education is associated with a delayed start of cognitive decline in those who ultimately develop dementia, and that once this decline begins, older adults also experience a faster, steeper rate of decline in comparison to their less-educated counterparts (Stern et al., 1999; Hall et al., 2007).

There are also conflicting findings regarding participation in physical activity and its influence on cognitive reserve later in life, but measurement of physical activity likely impacts study findings. When physical activity was objectively measured, activity intensity was related to several cognitive domains and abilities later in life. When the patient's self-report was used, the association between physical activity and cognitive decline was not found (Buchman, Wilson & Bennett). The literature in this area also suggests that older adults experience many benefits after the introduction of a physical activity intervention program.

The current review of the literature suggests that there is an association between a higher literacy level and higher cognitive functioning in older adults (Barnes et al., 2004; Manly et al., 2003). Should older adults engage in more reading and writing tasks, it is possible that neural networks would become more enriched, thus leading to increased levels of cognitive reserve (Barnes et al, 2004). As a result, both reading ability and reading practice may result in higher levels of cognitive reserve in older adults. Lastly, level of literacy may reflect a person's level of crystallized intelligence, as it may be indicative of a person's lifetime experiences, such as years of formal education and cognitively stimulating leisure activity participation (Barnes et al., 2004).

There is also strong evidence to support the idea that higher levels of cognitively stimulating leisure activity participation increase levels of cognitive reserve in older adults (Hall et al., 2009; Reed et al., 2011; Wilson et al., 2003; Wilson, Scherr, Schneider, & Tang, et al., 2007; Wenisch et al, 2007). However, most of the literature cited here does not investigate what specific activities are associated with this protective mechanism. As such, it would be quite helpful for future research studies to investigate what specific activities were associated with a reduced risk of cognitive decline, as this would allow for health care workers to develop targeted interventions for older adults.

Finally, with regard to occupational complexity, while there is evidence that individuals with a more complex work history have higher levels of cognitive functioning later in life (Potter et al., 2006) and a reduced risk of developing Alzheimer's disease (Andel et al., 2005; Andel et al., 2007), there is evidence that there may be better proxy measures of cognitive reserve, such as cognitively stimulating leisure activity participation, may be a better predictor of cognitive decline later in life (Wilson et al., 2002). As such, future studies, potentially using the decomposition approach (Reed et al., 2010; Reed et al., 2011) could help quantify the level of cognitive reserve that can be specifically attributed to occupational complexity, independent of other proxy measures of cognitive reserve.

Neuropsychological Domains of Interest

Fluid and Crystallized Intelligence. Horn and Cattell (1967) proposed that two types of intelligence exist: fluid and crystallized. Briefly speaking, fluid intelligence involves novel problem solving and abstract reasoning, and crystallized intelligence involves recalling factual information that is highly dependent on one's culture (Baron, 2004). These are the definitions given earlier and used in the current review.

According to Horn and Cattell's (1967) theory, fluid intelligence involves "adaptive and new learning capabilities and is related to mental operations and processes" (Sattler, 2001, p. 140). Fluid intelligence tasks are relatively free from cultural influences and may be nonverbal in nature (Sattler). Often, these are unfamiliar tasks that require reasoning and problem solving (Lezak, Howieson, & Loring, 2004). Examples of tasks that measure fluid intelligence include figure classifications, figural analysis, number and letter series, matrices, and paired associates (Sattler). Fluid intelligence appears more sensitive to the effects of neuropathology and brain injury in comparison to crystallized intelligence (Miller et al., 2009; Sattler, 2001). Also, prior research supports the observation that abilities that require fluid intelligence show a fairly linear decline during adulthood and decline at a more rapid pace once an individual reaches old age (Baltes, Staudinger, & Lindenberger, 1999; Lezak et al.; Rabbit, Chetwynd, & McInnes, 2003; Wood et al., 2005).

However, Tranter and Koutstaal (2008) have found that it is possible for healthy older adults (aged 60-75) to increase their performance on a series of fluid intelligence tasks. In a randomized control trial, Tranter and Koutstall instructed the experimental group to engage in a variety of mentally stimulating activities both at home (two times per week), and during three in-lab sessions. Activities included identifying mystery photos, word-logic puzzles, creative modeling activities, exposure to and critiquing unfamiliar Tuvan throat music, origami, and constructing a newspaper tower. The control group was seen for assessment at baseline, and again after 10-12 weeks. Tranter and Koustaal conclude that engaging in novel, challenging activities can “lead to much more flexible and adaptive thinking than might be expected based on the standard view of cognitive aging” (p. 200). The results of this study could help assist in the creation of intervention programs for older adults.

While Tranter and Koutstall (2008) did not mention cognitive reserve in their paper specifically, one could hypothesize that because engaging in novel, mentally stimulating activities resulted in improvements in fluid thinking and intelligence, it is possible that these activities led to an increase in cognitive reserve as well, possibly providing protection against exhibiting the behavioral manifestation of neurodegeneration.

Baltes, Kühl, and Sowarka (1992) devised a study to test the hypothesis that those older adults who were not at risk of dementia would benefit from a program designed to provide fluid intelligence training, and that those at risk for dementia would not. Participants were 56 healthy and 25 at risk individuals living independently in senior apartment buildings in Germany; all individuals were randomly assigned to a fluid intelligence training group, or a control group. The experimental group received five one-hour sessions that focused on teaching different types of figural relations problems and allowed individuals to practice their new skills and receive corrective feedback. The study results demonstrated that those older adults found to be at risk for dementia did not benefit from the training, whereas those not at risk for dementia did benefit. The at risk group, the authors concluded, showed "insufficient reserve capacity to benefit from training (Baltes et al., 1992, p. P166). Although the authors stressed the need for replication of the findings with a larger group of older adults, Baltes concluded that their training of healthy older adults carried "a promising note" for possibly increasing cognitive reserve levels and improving fluid intelligence (Baltes et al., p. P167).

In contrast, crystallized intelligence refers to "acquired skills and knowledge that are developmentally dependent on exposure to culture… (involving) over learned, well-established cognitive functions … related to mental products and achievements" (Sattler, p. 140). Tasks requiring crystallized intelligence are typically familiar to the individual and reflect both formal and informal educational experiences (Cunningham, Clayton, &

Overton, 1975; Lezak et al., 1999). Examples of tasks that require and/or are used to measure crystallized intelligence include vocabulary, general information, abstract word analogies, reading, arithmetic, and mechanics of language (Martínez & Colom, 2009; Sattler). Prior research has shown that performance on tasks that use crystallized intelligence is relatively stable, or shows gains, into the sixth decade of life (Baltes et al., 1999; Cunningham et al., 1975; Lezak et al.; Miller et al., 2009; Rabbit et al, 2003; Wood et al., 2005). Decline in crystallized intelligence typically occurs only in very old age (Baltes et al.). There is a need to investigate these cognitive domains, which is the purpose of the current study. As noted above, the majority of the studies detailed did not investigate patterns of performance on tasks that measured fluid or crystallized intelligence specifically, and the unique contribution of complexity of occupation or word reading ability was not examined either.

Episodic and Semantic Memory. First proposed by Tulving (1972), declarative (or explicit) memory is the conscious, purposeful, recollection of past episodes and experiences. Declarative memory is supported by forebrain neural structures and requires intact medial temporal lobes and midline diencephalic structures (McNamera & Albert, 2003; Squire & Zola, 1991). Declarative memory can be divided into two forms: episodic and semantic memory (Kolb & Whishaw, 2003). Each will be described in turn.

Episodic memory "refers to the capacity for recollecting happenings from the past, for remembering events that occurred in particular spatial and temporal contexts" (Squire & Zola, 1991, p. 280). In doing so, stimuli that we are exposed to are changed into distinct representations of memory (Balota, Dolan, & Duchek, 2000). Episodic memory allows human beings to recall past individual experiences, and requires three elements. According to Tulving (as cited in Kolb & Whishaw, 2003), there are three components of episodic memory. The first is a sense of subjective time. The second is autoneotic awareness, or the ability to have knowledge regarding subjective time (e.g., the ability to project ones' self into the future;) de Oliveria et al., 2008). The third component of episodic memory is a 'self' that has the capability to travel in subjective time (e.g., a past, present, and future); Kolb & Whishaw). The frontal lobes are utilized in episodic memory processing and allow an individual to know where and when a specific event occurred in his/her life (Squire & Zola).

Episodic memory refers to one's memory for specific details or the context of prior situations or events. Previous studies have demonstrated that older adults have more difficulty recalling specific details of what they had studied (e.g., fictitious facts or the details from a story) in comparison to younger adults, and that, generally, a decline in episodic memory performance occurs as individuals age (Balota et al., 2000). More marked deficits in episodic memory have been documented in several clinical samples, particularly Alzheimer's disease. For example, Butters et al. (1987) determined that older adults who were diagnosed with dementia of the Alzheimer's type recalled significantly fewer accurate facts and made significantly more intrusion errors when recalling short stories in comparison to older adults with Huntington's disease, Korsakoff's dementia, and "young" (aged 57 or younger) and "old" (aged 58 or older) neurologically normal older adults (Butters et al., p. 481). The stories were similar in style and length to the Logical Memory Passages of the Wechsler Memory Scale, and were considered to be a measure of episodic memory. Butters et al. concluded that the ubiquity of these intrusions "exemplifies the Alzheimer patients' increased sensitivity to proactive interference and confirms other reports that intrusion errors are an important characteristic of these patients' episodic memory disorder" (p. 493).

Semantic memory, in contrast, is non-autobiographical and is the storage of all other types of knowledge about the world (e.g., general word knowledge, linguistic skills, vocabulary, historical events, and the ability to recognize familiar individuals [Bauer, Grande, & Valenstein, 2003; Kolb & Whishaw; Squire & Zola, 1991]). Semantic memory allows us to answer questions like, "Who wrote 'The Adventures of Huckleberry Finn?'", "Do fish have legs?" or "Is 'smergal' an English word?" In contrast to episodic memory, semantic memory as assessed by priming tasks remains generally stable in cognitively-healthy older adults (Balota et al., 2000). However, semantic memory as assessed by more effortful tasks that require rapid conscious retrieval of specific information, such as low-frequency names of objects, shows a greater decline in normal aging (Balota et al.). Indeed individuals with several clinical conditions, including Alzheimer's disease, demonstrate impairment in confrontation naming over and beyond that expected on the basis of aging alone.

There has been some investigation of semantic and episodic memory performance and several proxy measures of cognitive reserve and cognitive functioning in older adults. For example, Wilson, Beckett, & Barnes (2002) determined that there was no specific pattern of change in performance when older adults were given episodic and semantic memory tasks, and that cognitive change over time was non-uniform, and specific to the individual. Lichtenberg et al. (1998) used a measure of episodic memory and an oral word reading test to investigate the utility of a dementia screening battery in a group of African American and European American older adults from an urban area.

However, as previously stated, the majority of the studies detailed did not look at the unique contribution of complexity of occupation and/or word reading ability. Because of these gaps in the literature, one of the goals of the present study was to look at these contributions.

Study Purpose and Hypotheses

The purpose of the current study was to investigate the unique association of word reading and occupational complexity, beyond age, formal education, ethnicity, gender, and overall cognitive status, with performance on tasks from four cognitive domains: fluid and crystallized intelligence and episodic and semantic memory. It is important to note that each of the tasks described below is not a pure measure of each cognitive domain; there is some overlap between the tasks, which will be described below (see *Measures* section). The four research questions regarding the unique contribution of word reading and occupational complexity follow.

Research Question 1

Research Question 1a: *What is the unique contribution of complexity of occupation to the Wechsler Abbreviated Scale of Intelligence Vocabulary (WASI Vocab) subtest raw score?* **Research Question 1b***: What is the unique contribution of complexity of occupation to the Wechsler Abbreviated Scale of Intelligence Matrix Reasoning (MR) subtest raw score?* The first research question concerns how measures that tap into crystallized verbal abilities and measures that stress fluid intelligence are associated with complexity of past occupation in older individuals seen for neuropsychological assessment due to suspected cognitive impairment. In a review of the topic of lifespan psychology, Baltes et al. (1999) state that skills that require the use of fluid intelligence show a relatively linear decline during adulthood and decline more quickly as an individual reaches old age. In contrast, tasks that require more crystallized abilities do not show this linear decline, and may actually show signs of improvement into the seventh decade of life. A decline in crystallized abilities is not seen, typically, until an adult reaches very old age (Baltes et al., 1999). Richards and Sacker (2003) used path analysis to determine how much several factors, including paternal occupation, childhood intellectual functioning, years of formal education, and lifetime occupation contributed to level of cognitive reserve in men born in the UK in 1946. When all factors were considered, the path from the adult's occupation was the weakest in determining level of cognitive reserve later in life (Richards & Sacker). The work of Baltes et al. (1999) and Richards and Sacker (2003) suggests that crystallized intelligence is more affected than fluid intelligence by early life experiences, such as childhood education, and less affected by activities later in life, such as occupational pursuits.

Thus, it is hypothesized that complexity of past occupation will *not* uniquely account for a significant increase in explained variance in a measure of general word knowledge that taps into crystallized verbal abilities beyond age, formal education, ethnicity, gender, and current overall cognitive status. In contrast, I hypothesize that complexity of past occupation will uniquely account for a significant increase in the explained variance in a measure of fluid reasoning that taps into effortful information-processing, fluid intelligence and/or new information and skills beyond age, formal education, ethnicity, gender, and current overall cognitive status.

Research Question 2a: *What is the unique contribution of complexity of occupation to the Wechsler Memory Scale-Revised (WMS-R) Logical Memory I (LM-1) subtest raw score?* **Research Question 2b***: What is the unique contribution of complexity of occupation to the total score on the Boston Naming Test (BNT)?* Research Question 2a concerns whether a measure of episodic memory is associated with complexity of past occupation in this sample; research Question 2b concerns whether a measure of confrontation naming, which requires semantic memory retrieval, is associated with complexity of past occupation in this clinical sample.

The research in this area is too sparse to make a directional hypothesis. **Thus, the specific goal is to assess whether complexity of past occupation will account for a significant amount of variance in a measure of episodic memory (scores from the WMS-R LM I raw scores) and in confrontation naming (BNT total score) beyond age, formal education, ethnicity, gender, and current overall cognitive status.**

In a review of changes in memory in older adults, Balota et al. (2000) note that there is generally a decrease in episodic memory task performance as individuals age, whereas performance on semantic memory tasks remains relatively stable. Several studies have investigated the relationship between semantic and episodic memory performance and several proxy measures of cognitive reserve and cognitive functioning in older adults (e.g., Wilson, Beckett, & Barnes, et al., 2002; Wilson et al., 2002; Lichtenberg et al., 1998). However, the majority of the studies detailed did not look at the unique contribution of complexity of occupation. Thus, studies to date have been too sparse to make directional hypotheses as to whether or not occupational complexity will make a unique contribution to prediction of episodic memory and confrontation naming in this sample beyond demographic variables and current overall cognitive status.

Research Questions 3a: *What is the unique contribution of WRAT-3 Reading raw score to the WASI Vocab subtest raw score?* **Research Question 3b***: What is the unique contribution of WRAT-3 Reading raw score to the WASI MR subtest raw score?* Research Question 3a concerns whether a measure of crystallized intelligence is associated with oral word reading ability as measured by the WRAT-3 Reading subtest, an index of literacy, in this clinical sample; Research Question 3b concerns whether a measure of fluid intelligence is associated with oral word reading ability in the same clinical sample. Manly et al. (1999) found that, when comparing the cognitive task performance of older adults who had learned to read with those who had not, the illiterate individuals scored lower on measures of visual matching and recognition, and verbal ability. Barnes et al. (2004) found that a higher level of literacy (as measured by an oral word reading task) was associated with better performance on all measures of cognitive functioning, including global cognition, executive functioning, attention, and memory for verbal information. Both of these findings also add support to the theory that if one is a better or more frequent reader, then levels of cognitive reserve are increased, there is more protection against cognitive decline, and one is better able to efficiently process information. Lastly, oral word reading ability is thought to be a good estimate of premorbid intelligence, and relatively resistant to the effects of neurological damage (Strauss, Sherman & Spreen, 2006).

Thus, based on Manly et al. (1999) and Barnes et al., (2004), the following hypotheses are made: **Oral word reading ability will uniquely account for a**

significant increase in explained variance in a measure that taps into crystallized verbal abilities (WASI Vocab raw score) beyond age, formal education, ethnicity, gender, and current overall cognitive status. I also hypothesize that oral word reading ability will also uniquely account for a significant increase in the explained variance in a measure that taps into fluid intelligence, effortful information processing, and/or ability to learn new information and skills (WASI MR raw score) beyond age, formal education, ethnicity, gender, and current overall cognitive status.

Research Questions 4a*: What is the unique contribution of WRAT-3 Reading raw score to WMS-R LM I raw score performance?* **Research Question 4b**: *What is the unique contribution of WRAT-3 Reading raw score to BNT total score performance?* Research Question 4a concerns how a measure of episodic memory is associated with oral word reading ability, an index of literacy, in this clinical sample; Research Question 4b concerns how a measure of confrontation naming, which requires semantic memory retrieval, is associated with oral word reading ability in the same clinical sample. Manly et al. (1999) found that, when comparing the cognitive task performance of older adults who had learned to read with those who had not, the illiterate individuals scored lower on a measure of visual naming. Barnes et al. (2004) found that higher levels of literacy (as measured by an oral word reading task) was associated with better performance on all measures of cognitive functioning, including global cognition, executive functioning, attention, and memory for verbal information. Both of these findings also add evidence backing the theory that if one is a better or more frequent reader, then levels of cognitive reserve are increased, there is more protection against cognitive decline, and one is better able to efficiently process information. Although earlier studies in this area have been sparse, **the available literature leads to the hypothesis that oral word reading ability will uniquely account for a significant increase in explained variance in a measure of episodic memory (raw scores from the WMS-R LM I subtest) and a measure of confrontation naming (the BNT total raw score), beyond age, formal education, ethnicity, gender, and current overall cognitive status.**

CHAPTER II

METHOD

Participants

Archival data were collected from European American (62 men, 53 women) and African American (48 men, 55 women) individuals who were seen for neuropsychological assessment at Henry Ford Health System due to suspected memory problems or other problems in thinking. In total, the sample included 218 older adults ages 65 and above. The mean age of participants was 75.5 (*SD* = 5.9), the mean educational level was 12.1 years (*SD* = 3.3), and the mean Dementia Rating Scale (DRS) score was 120.6 (*SD* = 13.5), a score that is suggestive of mild dementia given the mean age and educational level of this sample (Mattis, 1988). With regard to occupational complexity, there were 77 individuals in the "high" complexity group, and 141 individuals in the "low" complexity group.

The Research Ethics Board (REB) at the University of Windsor (Windsor ON, Canada) and the Henry Ford Health System Institutional Review Board (IRB; Detroit, MI, USA) provided ethical clearance for data collection and analysis for the current study The following research protocols were submitted and approved: the IRB Research Protocol: The Validity and Reliability of the Henry Ford Health System Dementia Battery, (IRB no. D2384); REB Research Protocol: The Impact of Occupational Complexity: An Examination of Neuropsychological Test Performance in an Urban, Older Adult Population (REB# 09-126), approved August, 2010, and REB Research Protocol: The Interplay between Financial Capacity, Confrontation Naming, and Occupation in Older Adults (REB# 09-127), approved January 2012).

The data of patients seen for the first time in the Henry Ford Health System Neuropsychology Clinic from April 2001 to June 2007 were included in the database. In the current study, archival data from 2004 to 2005 were used; the data were collected from a metropolitan healthcare system in Detroit, Michigan (USA). Only a selection of all individuals seen from 2004 to 2005 were coded and included in data analysis. Data were collected from this database twice, once for my M.A. thesis (Krasean, Unpublished M.A. Thesis, 2008), and once for my Minor paper (Krasean, Unpublished Minor Paper, 2011); these data were combined for the current study.

For each data collection, I aimed to have, at minimum, 25 individuals in each group (e.g., 25 European American women, 25 African American women, 25 European American men, and 25 African American men). No more than 35 individuals per group were coded. In coding patient data, it became apparent that there were many more European American than African American individuals seen for neuropsychological assessment at Henry Ford Health System who met the study inclusion criteria. However, it was important to have a sufficient number of African American individuals included in the final coded sample. In particular, there were more files for European American men that met the study inclusion criteria: There were 42 European American men that were excluded from the final coded sample once I reached the quota of 35 individuals per group. In summary, there were more European American men than European American women and African American men and women that met study criteria. This discrepancy appeared to be representative of the sample seen at Henry Ford Health System from 2004 to 2005, but this imbalance may not exist at another point in time (A. Baird, Personal Communication, 2012).

As well, this imbalance was not representative of the population as a whole. Typically, in an older adult population, both African American and European American women outlive European and African American men (Fried, Kronmal, Newman, & Bild et al., 1998). There are several possible reasons why more European American men were seen for neuropsychological assessment more frequently than the other three demographic groups: Men may have been more likely than the women to be working, and/or have had more responsibilities that made suspected cognitive impairment more apparent to those around them, resulting in testing referrals. When men are widowed, it is possible that cognitive impairment was more obvious if the men were living on their own. As well, it is possible that there is some sort of bias in favour of men over women (e.g., men are viewed by some as more important in Western society and control a greater percentage of the wealth [Hogan & Perrucci, 2007]), and thus, men are more likely to be referred for neuropsychological assessment.

This research protocol was approved under the expedited review process at HFHS as an archival study involving an existing database specifically for the purpose of the analyses used in the current study and in two previous studies which formed the basis of my master's thesis and minor paper. The database contains information normally collected in the routine work with the individual, information that would have been collected whether or not the research project was conducted. Multiple steps were taken in order to ensure the confidentiality of the data. Test scores and demographics (age, sex, education, race, handedness, occupation) were entered into a computerized database in which participants were assigned a number. The computer file linking the identifying information to the database is on a password-protected server within the

Neuropsychology Division at Henry Ford Health System. Identifying information (name, date of birth, medical record number) was not included in the database. The database, and computers on which the database was stored, were password protected. The original files were kept in locked cabinet within the Neuropsychology Division at Henry Ford Health System

Some data from individuals in the current study were included in prior analyses (Krasean, Unpublished MA Thesis, 2008; Krasean, Unpublished Minor Paper, 2011). For example, the performance of European American and African American men and women on the Benton Visual Form Discrimination task, a task that requires visual scanning and the detection of non-linguistic target shapes (Benton, 1983) and the Money Management and Health and Safety subtests of the Independent Living Scales, direct performance measures of personal health and safety and money management (Loeb, 1996) were examined. However, performance on the neuropsychological measures which serve as the dependent variables in the current study (e.g., the WASI Vocabulary subtest, a measure of general word knowledge, WASI Matrix Reasoning subtest, a measure of fluid reasoning, the BNT, a measure of confrontation naming, and the WMS-R LM I subtest, a measure of episodic memory) was not examined in relation to the unique contribution of oral word reading ability and occupational complexity in any prior studies.

For all studies mentioned here, A. Baird served as the primary investigator for the database at Henry Ford Health System and the Faculty Supervisor at the University of Windsor, and I served as the Student Investigator at the University of Windsor. The data used in those studies, and the current study, are the property of Henry Ford Health System; I, in conjunction with A. Baird, was given permission from HFHS to code and analyze the data in order to complete several academic projects, including my M.A. thesis, Minor Paper, and Dissertation. None of the 218 individuals used in the current study were included in any other past research conducted at this facility (e.g., Baird, 2006; Baird, Ford, & Podell, 2007; Baird et al., 2001).

Inclusion/Exclusion Criteria. The current study included individuals who were over the age of 65 at the time of their assessment. Ethnic status of the individual (i.e., African American, European American, or of other ethnic status or origin) was recorded by the examiner, who gathered this information using either physical characteristics or by asking the patient directly. Patients who were not of African American or European American ethnic status, or whose primary language was not English, were excluded. Other exclusion criteria were hospital inpatient status and/or a diagnostic impression of significant, ongoing major depression or psychosis was detailed in the neuropsychological report.

Participants were not included in the final coded sample if the neuropsychologist who supervised the case and/or authored the report suspected that ongoing substance abuse had an impact on the participant's neuropsychological or functional test performance. Patients who experienced non-neurodegenerative disorders (i.e., a acute or sub-acute traumatic brain injury or acute or sub-acute focal stroke) within 6 months of the assessment were also excluded from the final coded sample. Each patient included in the coded sample had 4 or more years of education, based on the UNESCO standard that, at minimum, four years of schooling is necessary to obtain a level of functional literacy (Rogers & Herzog, 1966).

The total number of excluded cases due to the above criteria can be found in Table 1.

In terms of inclusion criteria, data was coded and analyzed only from participants who had completed the Dementia Rating Scale, a measure of both premorbid cognitive functioning and cognitive impairment, the Wide Range Achievement Test-3 (WRAT-3), an oral-word reading test, and the Boston Naming Test, a measure of naming and semantic memory, and only from those whose neuropsychological report contained information pertaining to their occupational status. These measures are a fundamental part of even a brief cognitive assessment for older adults.

Participants' occupations were coded according to the Bureau of Labor Statistics Standard Occupational Classification (SOC) system. The primary occupation as listed in the individual's neuropsychological report was placed into one of 23 major groups provided by the SOC. Based on a system generated by Stern, Albert, Tang, and Tsai (1999), the occupational classification groups were then divided into low (e.g., healthcare support occupations, protective service occupations, food preparations and service related occupations, production occupations, and construction and extraction operations) and high (e.g., management occupations; business and financial operations occupations; life, physical, and social science occupations; legal occupations; and community and social service occupations) occupational status.

Table 1

Patients Excluded from the Final Coded Sample

Exclusion Criteria	n
Excluded Participants (N = 267)	
Incomplete data file	119
Re-evaluation	50
European American Men Post Study Quota	42
TBI	15
Primary language not English	13
Active major depression/schizophrenia	6
Ethnic status not stated and/or conflicting	7
Stroke ≤ 6 months	3
Epilepsy	3
Hydrocephalus	2
Recent Neurosurgery/ Intraventricular shunt	2
< 3 years formal education	1
Possible Toxic Exposure	1
Post-operative encephalitis	1
Aneurysm	1
Hospice care	1

Note: TBI: Traumatic Brain Injury

levels (See Appendix A.) Based on the inclusion/exclusion criteria detailed in Stern et al., individuals who listed homemaker as their primary occupation were excluded from analysis.

Measures

Wechsler Abbreviated Scale of Intelligence. The WASI was designed to "meet the demands for a short and reliable measure of intelligence in clinical, psychoeducational, and research settings" (Wechsler, 1999, p.1). The four subtests in the WASI were chosen because they load highly onto *g*, a general intellectual ability factor (Hart et al., 2010; Strauss et al.). Two of these subtests—Vocabulary and Matrix Reasoning—are used in the current study (Wechsler). The standardization data for the WASI were collected from a national sample that was representative of the US population (Wechsler). The reliability coefficients for the Vocabulary and Matrix Reasoning subtests range from .90-.98 for Vocabulary and from .88-.96 for Matrix Reasoning; these reliability coefficients are very similar to those from the WAIS-III. The WASI has a high test-retest reliability and good content validity, and steps were taken to ensure the content validity of the WASI. Lastly, the construct validity of the WASI was determined by factor analysis (Wechsler).

The Wechsler Abbreviated Scale of Intelligence Vocabulary subtest. The WASI Vocab subtest is similar in format to the WAIS-III Vocab subtest (Strauss, Sherman, & Spreen, 2006). The WASI Vocab subtest is a 42-item task and requires individuals to give the oral definition of words that are presented both orally and visually to the examinee; possible raw scores range from 0-80 (Wechsler, 1999). The Vocab subtest is a measure of general and crystallized intelligence, which requires the retrieval and application of general knowledge (Lezak et al., 2004; Sattler, 2011; Strauss et al.; Wechsler). In the current study, it was used as a measure of crystallized intelligence. The Vocab subtest taps into the following domains: memory, learning ability, and concept and language development (Wechsler).

The Wechsler Abbreviated Scale of Intelligence Matrix Reasoning subtest. The WASI MR subtest is also quite similar in format to the WAIS-III Matrix Reasoning subtest (Strauss, Sherman & Spreen, 2006). The MR subtest is comprised of 35 items; possible raw scores range from 0-35. The examinee is shown a gridded pattern with one missing item and told to find the picture that best completes the pattern by selecting from five possible choices (Wechsler, 1999). The MR subtest of the WASI is a measure of fluid intelligence and general intellectual ability (Wechsler). In the current study, it was chosen as an index of fluid intelligence. Successful task completion requires problem solving, perceptual reasoning skills and attention to visual detail (Lezak et al., 2004; Sattler, 2011). The MR subtest is an untimed task; it is possible that these scores are more resistant to cognitive impairment than measures of fluid intelligence that have a time limit. For example, Wood et al. (2005) found that, in a group of older adults, cognitive speed was strongly associated with performance on several functional measures that had a time component (e.g., the Timed Instrumental Activities of Daily Living measure, or the Road Sign Test). As well, Salthouse (1996) has determined that processing speed is a mediating factor between age and multiple cognitive domains.

The standardization data for the WASI were collected from a national sample that was representative of the US population (Wechsler, 1999). The reliability coefficients for the Vocab and MR subtests range from .90-.98 for Vocabulary and from .88-.96 for

Matrix Reasoning; these reliability coefficients are very similar to those from the WAIS-III.

The Boston Naming Test. The BNT (Kaplan, Goodglass, & Weintraub, 1983) is a confrontation naming task that requires individuals to name black and white drawings of common, everyday items; this task has 60 items and taps into semantic memory and crystallized verbal intelligence (Mitrushina et al., 2005; Strauss et al., 2006). Scores on the BNT range from 0-60. In the current study, the BNT was selected to tap semantic memory. At the beginning of the test, items are typically more common and familiar, such as “tree” and “pencil,” compared to items at the end, such as “sphinx” and “trellis” (Lezak et al., 2004). Successful completion of the BNT requires that the visual recognition system and language processing system are intact (Reis et al., 2001). Confrontation naming performance in community dwelling and cognitively impaired individuals has been associated with several factors, including age, ethnicity, years of formal education, reading vocabulary, verbal intellectual ability and literacy (Hawkins et al., 1993; Henderson et al., 1998; Inouye et al., 1993; Lichtenberg et al., 1998; Lucas et al., 2005; Manly et al., 1998; Randolph et al., 1999; Reis et al., 2001; Strauss et al.).

The range of the internal reliability coefficient for the BNT total score ranges between .78-.96; test-retest reliability is also high (Strauss, Sherman & Spreen, 2006). With regard to normative data, very few older adults over the age of 75 were included in normative data collected prior to 1990 (Kaplan, Goodglass, & Weintraub, 2001; Ross et al., 1995). However, several attempts have been made to collect BNT norms from more ethnically diverse samples, specifically investigating the performance of African American older adults (e.g., Ross, Lichtenberg & Christensen, 1995; Lichtenberg et al.

1998; Lichtenberg, Ross, & Christensen, 1994; Ross & Lichtenberg, 1998; Lucas et al., 2005). Ross et al. (1995), Lichtenberg et al. (1998) and Ross and Lichtenberg (1998) all collected normative data from an urban area. These normative sample had a larger number of African American individuals than the original normative sample did, which was collected by Kaplan, Goodglass, and Weintraub (1983) and described by Kaplan, Goodglass and Weintraub (2001). Kaplan et al. (1983) did not provide any information about the ethnicity or geographic region of the sample, but these were individuals of above-average education - about 14 years. As well, most normative samples for standard neuropsychological measures were collected from groups that were primarily European American and had an insufficient number of individuals from other cultural groups (Teng and Manly, 2005). The sample from the current study is more similar to the one collected by Ross et al., Lichtenberg et al. and Ross and Lichgenburg than the original normative sample, as participants in the current study were from an urban area (Detroit, MI, USA), had fewer years of formal education, and were from generally lower SES than the original normative sample (Kaplan et al., 1978; Kaplan et al., 2001). The current sample differs from Lucas et al. in that our sample was collected from Detroit, Michigan, and their sample was collected primarily in Florida and Arizona.

It is quite important to have ethnically diverse normative samples for a number of reasons. Studies have shown that ethnic groups differ on BNT performance, even when equivalent on years of formal education and reading level. Baird, Ford, and Podell (2007) examined BNT performance in a group of African American and European American older adults seen for neuropsychological assessment in an urban area. European American individuals scored higher than African American individuals on the BNT, even after controlling for reading level, age, and years of formal education (Baird et al.). Krasean (Unpublished MA Thesis, 2008) found that European American men seen for neuropsychological assessment in the same urban area performed significantly higher on the BNT than African American men and women, and European American women, after controlling for age, years of formal education, level of cognitive impairment, and word reading ability, replicating the findings of Baird et al.

Boone, Victor, Wen, et al. (2007) looked at BNT performance in an ethnically diverse group of 161 individuals seen for neuropsychological assessment in an outpatient clinic. They found that, after adjusting for age and years of formal education, European American individuals scored 9-10 points higher on the BNT than African American and Hispanic individuals. In postulating reasons for this significant score discrepancy, Boone et al. suggested that, “the test stimuli themselves may be systematically biased against those groups” (Boone et al., 2007, p. 361). Thus, Manly (2005) has argued that diagnostic accuracy can be greatly improved when normative data is collected from individuals who are demographically similar to the clinical population.

The Wechsler Memory Scale-Revised Logical Memory I Subtest. The WMS-R (Wechsler, 1987) is an “individually administered, clinical instrument for appraising major dimensions of memory functions in adolescents and adults” that is to be used as part of a neuropsychological examination or other clinical investigation of memory functions (Wechsler, 1987, p. 1). The Logical Memory (LM) subtest of the WMS-R has stories that are very similar to the original WMS stories. During this task, two brief stories are read to the examinee. At the conclusion of each story, the examinee is asked to retell the story from memory. The LM I subtest score is comprised of the number of ideas that were recalled for both stories immediately after hearing each (Lezak, Howieson & Loring, 2004; Wechsler, 1987); possible scores range from 0-50. Stories very similar in nature to the WMS have been used as a measure of episodic memory in a number of studies (e.g., Butters et al., 1987). In the current study, the LM I subtest is used as a measure of episodic memory, as individuals are required to recall details from a specific short story (Strauss et al., 2006). The reliability coefficients for LM I range from .67-.80 and the interscorer reliability coefficients for the LM I and II subtests was .99 (Wechsler, 1987).

The Wide Range Achievement Test-3 Reading Subtest. The WRAT-3 Reading subtest is a test of oral word reading; participants are asked to read single words orally; scores can range from 0 to 57 (Wilkinson, 1993). The WRAT-3 Reading subtest includes some words for which the orthography follows the rules of representing phonetics in English (i.e., are phonetically regular) and some of which do not (i.e., are phonetically irregular; Wilkinson, 1993). The WRAT-3 Reading subtest has been used as an estimate of premorbid intelligence and performance on this measure is thought to be resistant to neurological damage (Strauss, Sherman & Spreen, 2006). The total number of correctly read words was totaled for the WRAT-3 Reading raw score. The WRAT-3 Reading subtest has good internal consistency (with reliability coefficients above .90 for almost all ages), test-retest reliability, and content validity (Strauss, Sherman, & Spreen).

The Dementia Rating Scale. The DRS is an index of cognitive function (Mattis, 1988) and provides information regarding attention, initiation/perseveration, construction, conceptualization, and memory in older adults with known or suspected dementia; the DRS total score can range from 0-144 (Strauss, Sherman, & Spreen, 2006). The test-retest reliability for the DRS total score is high (above 0.95), and the DRS total score correlates highly with other measures of mental status that are frequently used in a clinical setting (Strauss, Sherman & Spreen). It should be noted that the DRS total score reflects age and education as well as the effects of cognitive impairment on the areas assessed by the test. Further, the mean level of performance differs for African American and European American samples of older adults (Strauss, Sherman & Spreen).

Overall, it is important to acknowledge that there are no 'pure' measures of fluid or crystallized intelligence or episodic or semantic memory. Each of the neuropsychological measures in this study taps into multiple cognitive domains. For example, the WASI Vocab, BNT, DRS, and WRAT-3 Reading test all require the use of crystallized abilities in some way (Strauss, Sherman, & Spreen, 2006). The WASI MR and LM I are both untimed subtests, and require fluid intelligence in order to complete successfully (Strauss et al.). However, as noted earlier, for the current study, the WASI Vocab subtest, the WAIS MR subtest, the BNT total score, and the LM I subtest were chosen as indices of crystallized intelligence, fluid intelligence, semantic memory, and episodic memory, respectively.

Procedures

As described in the *Participants* section, patients were seen for neuropsychological assessment for a variety of reasons, but the primary reason was memory complaints. These patients were referred from multiple sources, including neurologists and general practitioners. Upon coming into the clinic, the patients completed the consent procedure, in which they gave permission for their results to be sent to their referral source and to be included in the Henry Ford Health System record.

Typically, their insurance was billed for the services provided by the Neuropsychology Division. Patients did not complete a specific consent for the current study, but as described in the Participants section, their data were part of a specific database maintained by Henry Ford Health System.

Typically, patients came into the clinic for a half-day assessment. Each patient was assigned to a staff neuropsychologist. This neuropsychologist interviewed the patient; frequently, with the patient's permission, a caregiver and/or family member was interviewed too. The neuropsychologist decided what tests were to be administered, and in what order. These tests were then administered, by a psychometrician, psychology intern, postdoctoral fellow, or by the neuropsychologist him/herself. All individuals had been trained to administer the tests in a systematic way. Before administering tests to patients, the psychometricians, psychology interns, and postdoctoral fellows are trained for one month or more by a veteran neuropsychologist and M.A. level psychologists, who are experts in test administration. These experts then assess the readiness of the psychometrician, psychology intern, or postdoctoral fellow to test independently after a month or more of training.

Within the Neuropsychology Division at Henry Ford Health System, there is a suggested set of tests for older adults with suspected memory problems, but the neuropsychologist in charge of the assessment is not required to adhere to that protocol. Reasons for deviating from the protocol were often unique to the patient, and included factors such as fatigue, level of cognitive impairment, or limitations related to a specific medical condition.

Generally, the DRS and WRAT-3 Reading subtest were the first tests administered, as these measures provided the neuropsychologist with a general sense of both the patient's current cognitive functioning and premorbid cognitive functioning. When these patients underwent testing, the WMS-R was frequently given early on in the assessment as well, since memory impairment was a common referral question. The WMS-R gives more detail on memory impairment than the DRS. Confrontation naming ability, as measured by the BNT, was also often administered, since this cognitive domain is typically impaired early on in the course of dementia (Sherman, Spreen & Strauss, 2006). Measures of premorbid intellectual functioning (e.g., the Vocabulary and Matrix Reasoning subtests from the WASI) were frequently excluded from the test battery because they are not as core to the assessment of dementia as the aforementioned measures. These tests were often, but not always, included with other measures, including the Independent Living Scales Money Management and Health and Safety subtests (Loeb, 1996), the Trail-Making Test (Trails A & B), the Controlled Oral Word Association Test, the Benton Visual Form Discrimination Test (Benton, 1983), and the Wisconsin Card Sorting Test. These additional measures were not included in the current study since the literature did not permit a basis for advancing hypotheses for these variables and the effects of cognitive reserve.

After testing, the data were scored in a systematic way and included on a data summary sheet. The neuropsychologist, and/or a psychology intern, or postdoctoral fellow wrote all neuropsychological reports. When an intern or postdoctoral fellow wrote the reports, it was under the supervision of the neuropsychologist. All raw test data, the data summary sheet, and the neuropsychological report were included in the test file. As mentioned before, only individuals who completed the DRS, WRAT-3 Reading subtest, and the BNT, and had information relating to their occupational complexity included in the report, were included in the final coded sample. If participants had also completed the WASI Vocab, WASI MR, and/or WMS-LM I subtests, those scores were coded and included in data analysis as well. Occupational complexity was the only variable of interest generated from the report. All other variables were recorded from the data summary sheet.

CHAPTER III

RESULTS

Data Cleaning and Diagnostics

A missing value analysis was conducted using SPSS 19 in order to investigate if ‘missingness’ (the pattern of missing data) was associated with any other variables used in data analysis. The missing value analysis included all categorical and interval variables. It was determined that data were not missing at random, and were not ignorable for all dependent variables except the BNT score (Tabachnick & Fidell, 2007). Having data that is not missing at random and is not ignorable indicates that the missingness is related to the dependent variable in some way, and cannot be removed or ignored (Tabachnick & Fidell, 2007). Because of this missingness, a number of statistical techniques, such as standard non-parametric statistics, and multiple imputation were not appropriate to use (Kraft, Personal Communication, March 29, 2012; Tabachnick & Fidell, 2007).

Missing data accounted for 25.7% of WASI Vocab scores, 26.1% of WASI MR scores, and 6.9% of WMS-R LM I scores. Out of 218 cases, the non-missing case totals are as follows: WASI Vocab, 162; WASI MR, 159; WMS-R Logical Memory, 203. All 218 scores were present for the BNT. From the 218 cases, 157 had complete cases, and 61 were missing one or more tests. In total, 7 individuals (3.2% of the final coded sample) were missing just one test, 41 individuals (18.8% of the final coded sample) were missing two tests, and 13 individuals (5.9% of the final coded sample) were missing all three. The majority of individuals with missing data were missing two tests, and an examination of the raw data revealed that the WASI MR and WASI Vocab tests were the most common missing measures.

The missing value analysis determined that those individuals with missing WASI Vocab raw scores had lower BNT raw scores (*M* present = 44.3, *M* missing = 38.6; $t(91.8) = 2.7$, $p < 0.01$), were older (*M* present = 75.0, *M* missing = 77.2; $t(95.4) = -2.4$, $p < 0.05$), had lower DRS total raw scores (*M* present = 123.4, *M* missing = 113.7; $t(83,2) = 4.5$, $p < 0.001$) and WRAT-3 reading raw scores (*M* present = 41.6, *M* missing = 38.9; $t(76.3) = 2.1$, $p < 0.05$), and had a lower level of occupational complexity (*M* present = 1.40, *M* missing = 1.23; $t(109.1) = 2.4$, $p < 0.05$).

It was also found that those individuals with missing WASI MR raw scores had lower BNT raw scores (*M* present = 44.5, *M* missing = 38.1; $t(95.5) = 2.7$, $p < 0.1$), lower WMS-R LM I raw scores (*M* present = 24.6 , *M* missing = 20.0; $t(70.0)= 2.2$, $p < 0.05$), were older (*M* present = 75.0, *M* missing = 77.2; $t(97.2) = -2.4$, $p < 0.05$), had fewer years of formal education (*M* present = 12.4, *M* missing = 11.4; $t(120.7) = 2.2$, $p < 0.05$), had lower DRS total raw (*M* present = 123.3, *M* missing = 114.0; $t(87.8) = 4.5$, $p < 0.001$) and WRAT-3 reading raw scores (*M* present = 41.7, *M* missing = 38.8; $t(78.9) = 2.3$, $p < 0.05$), and had a lower level of occupational complexity (*M* present = 1.40, *M* missing = 1.21; $t(116.7) = 2.9$, $p < 0.01$).

Lastly, those individuals with missing LM I raw scores had lower BNT raw scores (*M* present = 43.4, *M* missing = 35.0; $t(15.8) = 2.2$, $p < 0.05$), fewer years of formal education(*M* present = 12.3, *M* missing = 10.1; $t(16.8) = 2.8$, $p < 0.05$), had lower DRS total raw (*M* present = 122.1, *M* missing = 103.9; $t(15.1) = 4.2$, $p = 0.01$), and WRAT-3 reading raw scores (*M* present = 41.3, *M* missing = 35.9; $t(15.4) = 2.3$, $p < 0.05$, and had a lower level of occupational complexity (*M* present = 1.37, *M* missing = 1.13; $t(18.2) = 2.4$, $p < 0.05$.

In summary, individuals with missing data had lower scores on the BNT, DRS, and WRAT-3 reading subtest, were older, had fewer years of formal education, and had lower levels of occupational complexity. However, the missing value analysis revealed that individuals with missing data were no more likely to be male than female, nor were they more likely to be European American or African American.

Preliminary Data

Descriptive statistics (range, means, medians, standard deviations, and number of non-missing scores) for all continuous variables can be found in Table 2. The possible values and number of non-missing scores for all dummy coded (categorical) independent variables are presented in Table 3.

The mean performance of the combined sample on the WASI Vocab, WASI MR, WMS-R LM I, BNT, DRS, and WRAT-3 Reading subtest also was described in terms of the available normative data for individuals of the same age, or for someone of the same age as the mean age of the combined sample (*M* = 75.6, *SD* = 5.9), and, in some cases, ethnicity. In the current study, mean performance on the WASI Vocab subtest yielded a T-score that fell in the Average range (34th percentile) and the mean performance on the WASI MR subtest yielded a T-score that fell into the Average range (37th percentile) (Wechsler, 1999). Average performance on the WRAT-3 Reading subtest yielded a standard score that fell into the Average range (32nd percentile; Wilkinson, 1993). Mean raw score performance on the WMS-R LM I subtest would be considered to be in the Average range (60-71st percentile) for European American individuals (Ivnik et al., 1992)

Table 2

Descriptive Statistics for all Continuous Independent and Dependent Variables

	Observed Range	*N*	*Median*	*M*	*SD*
WASI Vocab raw score	17-74	162	52	50.5	11.4
WASI MR raw score	2-52	159	10	12.7	7.9
BNT total raw score	13-60	218	48	42.8	13.3
WMS-R LM I raw score	0-60	203	22	23.6	12.6
DRS Total raw score	74-143	218	123	120.9	13.4
WRAT-3 raw score	6-57	218	41	40.9	7.3
Age	65-89	218	75	75.6	5.9
Education	5-22	218	12	12.1	3.3

Note: M: mean; *SD:* Standard Deviation; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest; MR: Matrix Reasoning subtest; BNT: Boston Naming Test; WMS-R LM I: Wechsler Memory Scale, Revised, Logical Memory I subtest; DRS: Dementia Rating Scale; Education: Years of formal education.

Table 3

Descriptive Statistics for Categorical Independent Variables (N = 218)

	n
Ethnicity	
European American	115
African American	103
Sex	
Men	114
Women	104
Complexity of occupation	
Low	141
High	77

Note: The following variables were dummy coded: gender (men = 1, women = 0), ethnicity (EA = 1, AA = 0), and complexity of occupation (high = 1, low = 0).

and in the High Average range for African American individuals (72-81st percentile; Lucas et al., 2005a). The mean raw score performance on the BNT would be considered to be in the Mildly Impaired range (6-10th percentile) for European Americans (Ivnik et al., 1996) and in the Average range (41-59th percentile) for African Americans (Lucas et al., 2005b). Mean raw score performance on the DRS would be considered to be in the Moderately Impaired range (2nd percentile) for European American individuals (Lucas et al., 1998), and in the Mildly Impaired to Low Average range (11-18 percentile) for African American individuals (Rilling et al., 2005).

All assumptions of multiple regression analysis were tested prior to analysis. With regards to sample size, Field (2009) suggests that a sample size ratio of 10 observations per predictor is typical. The current study meets this assumption both with the variable with the smallest number of non-missing observations (*N* = 161) and the one with the largest (*N* = 218). In other words, with six predictors, an *N* of 60 is acceptable, and the number of available observations in this study consistently exceeds this number.

Concerning outliers, one univariate outlier was found (cutoff of z = +/-3.00; Stevens, 2002). Tabachnick and Fidell (2007) suggest a cut-off of an absolute value of 2.5 standard deviations for standardized residuals. Using this cut-off for standardized residuals, one outlier on Y was found. Additionally, one outlier on X was identified with the use of the $p < .001$ criterion for Mahalanobis Distance, a test of multivariate outliers. No influential observations were found. Analyses were run with and without outliers removed; no significant differences existed. Further, influential observations are a larger concern than outliers on either X or Y (Stevens, 2003). Thus, due to the low number of outliers and their limited influence on the results, the two cases with outliers were kept within the analysis.

Another assumption of multiple regression is the absence of multicollinearity and singularity. Correlations between all pairs of variables were at or less than .90 and tolerance and variance inflation factor (VIF) scores were in the desired range. Thus, no multicollinearity was detected (Field, 2009). Bivariate correlations between all independent and dependent variables are presented in Table 4. With regard to normality, scatter plots demonstrated a normal curve. Shapiro-Wilk's test was significant for all

Table 4

Bivariate Correlations between all Independent and Dependent Variables

	1	2	3	4	5	6	7	8	9	10	11
1. Vocab	-	.56**	.71**	.53**	.67**	.70**	-.13	.56**	-.10	-.38**	.44**
2. MR		-	.42**	.28**	.54**	.47**	-.17*	.39**	-.07	-.19*	.25**
3. BNT			-	.55**	.68**	.57**	-.25**	.43**	-.19*	-.49**	.33**
4. LM I				-	.61**	.29**	-.31**	.38**	-.21**	-.15**	.30**
5. DRS					-	.47**	-.40**	.44**	-.06	-.24**	.22**
6. WRAT-3						-	.02	.56**	.06	.59**	.44**
7. Age							-	-.14*	.20**	-.02	.01
8. Edu								-	-.12	-.28**	.56**
9. Gender									-	.04	-.21**
10. Eth										-	-.32**
11. OC											-

Note: * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed); WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest raw score; MR: Matrix Reasoning subtest raw score; BNT: Boston Naming Test total raw score; WMS-R LM I: Wechsler Memory Scale, Revised, Logical Memory I subtest; DRS: Dementia Rating Scale; Education: Years of formal education; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), ethnicity (EA = 1, AA = 0), and complexity of occupation (high = 1, low = 0).

variables, but examination of the skewness and kurtosis scores were all within the normal range. Thus the assumption of normality was met. Evaluation of the residual scatter plot provides evidence for the assumption of linearity and homoscedasticity of errors. The assumption of independence of errors was not violated as the Durbin-Watson statistic for all analyses was in the desired range (1.5 to 2.5, Stevens, 2002). Table 4 includes the bivariate correlations between all variables.

Main Analyses

Data analysis was run with Stata Statistical Software 12.0. As noted earlier, a missing values analysis disclosed that data were missing not at random and not ignorable for all dependent variables except the BNT scores. To deal adequately with this situation, the Heckman two-step model was used (Heckman, 1979).

Before deciding to use the Heckman two-step model (1979), considerable research was conducted. First, I consulted with Joanna Kraft, the Psychology Department Statistics Consultant during the Winter 2012 term. I did several web-based searches to try and find possible solutions to the missing data problem. A website from the Sociology Department at The Ohio State University ("Missing Data," 2012) mentioned both the Heckman selection model and pattern mixtures as possible corrections when data was missing not at random. This webpage also noted that the selection models, including the Heckman two-step model, were developed by social science researchers, and were more frequently used in social science research in comparison to pattern mixture, another missing data technique ("Missing Data," 2012). Their reference list led me to several articles (e.g., Dunning & Freedman, 2007; Hogan & Perrucci, 2007). I did a literature search for articles that had used the Heckman correction; these were published in other disciplines, the majority being related to the field of economics. One article, published in a sociology journal, used the Heckman two-step model (Hogan & Perrucci). This article, described on the following pages, was helpful in my understanding of both the use of the Heckman correction, and as a way to present data in table form. After examining the Hogan and Perrucci article and discussions with J. Kraft, A. Baird, and D. Jackson, it was determined that using the Heckman two-step model was the best course of action to adequately address the missing data problem.

Subsequently, I also consulted with Scott Millis, Ph.D., MEd, CStat, a statistical expert who has extensive experience with complex regression problems, including use of the Heckman method. He suggested that I conduct a sensitivity analysis by using two alternative methods to analyze the data and seeing how the results of such analyses compared to the results using the Heckman correction. These methods were the full information maximum likelihood method (FIML), which is a general linear regression with a maximum likelihood model, and the likelihood-ratio test of the linear hypothesis (lrtest), which uses structural equation modeling (StataCorp, 2009; StataCorp, 2011). At the suggestion of the committee, a hierarchical regression analysis also was run without the Heckman correction. I have conducted these analyses, which yielded similar, but not identical results to the Heckman method, especially in terms of the variables of interest, occupational complexity and word reading ability. The similarity of the results suggests that, for the most part, the general conclusions drawn from the Heckman method are sound. The overall results for these analyses can be found in Appendix C, Appendix D, and Appendix E.

Heckman created his two-step model in order to help deal with the problem of selection bias in statistical samples (Allison, 2002; Dunning & Freedman, 2007). Using the Heckman correction, a model is created for the probability of missing data, and this model creates a regression equation that will predict missing data for a given variable for which data are missing in a non-random pattern and are not ignorable, as the data from the current study were (Heckman, 1979). Predictors in this model are those variables found to be associated with missingness in a missing value analysis. For example, in the case of the present study, for WASI Vocab, the predictor set for the Heckman variable included age, occupational complexity, and BNT, DRS, and WRAT-3 Reading raw scores, since the missing value analysis described earlier showed that these variables were associated with missingness. The regression equation provides a new variable that is informative as to whether or not data will be missing for a given participant on the dependent variable, based on this predictor set (D. Edelstein, personal communication, March 22, 2012; StataCorp, 2009). In the second stage of the model, this missingness-informative variable is transformed to create a variable, labeled the Heckman variable, which can be included as an additional explanatory variable at each step of a hierarchical regression (Allison, 2002; D. Edelstein, personal communication, March 22, 2012; Hogan & Perrucci, 2007; StataCorp, 2009). Due to the extent of the missing values for the WASI Vocab, WASI MR, and WMS-LM I raw scores, it was necessary to use the Heckman correction in analyses for which these variables were the dependent variable (J. Kraft, personal communication, March 29, 2012; StataCorp 2009).

The theory behind the Heckman two-step model is rather complex, so having a concrete example for guidance was quite helpful in interpreting this analysis. Hogan and

Perrucci used data from the Health and Retirement Survey to examine how gender and racial income inequality presents itself as people move from working to retirement. They examined data from European American men and women and African American men and women who were working in 1992, but had retired by 2000. Their sample was heavily skewed, with more European American individuals (735 men and 503 women) having retired in 2000 as compared to African American individuals (103 men and 155 women).

Hogan and Perrucci used multiple regression in order to determine what factors would best predict employment in 1991 and retirement status in 2000. Factors that were entered into the regression equation to predict retirement status in 2000 included Social Security old age pension, private pension (including annuities), income earned from assets, and spousal Social Security income (when applicable). In their regression equation, the Heckman variable was entered into each stage of the regression equation in order to correct for the effects of sampling bias in the decision to retire. Using the Heckman model, they determined that individuals were more likely to be retired if they were older than 65, had health insurance in 1992, received a Social Security pension in 2000, and had assets that totaled over $200,000, were retired in 1992, and had a spouse who was retired by 2000. They then used the Heckman model to determine if there were ethnic and gender group differences in retirement status by the year 2000. Their findings, among others, determined that both European American and African American women were less likely to be retired than male members of their cohort, even after controlling for work history, age, insurance, assets, and spousal work/retirement status.

Hogan and Perrucci (2007) presented their data in table form. Reported in their table were the coefficients, standard errors, and F-value from the Heckman model, as well as the Adjusted R^2 value, and whether or not the overall model was significant. The text of the results section, while sparse, suggested that it was necessary to detail how including certain variables improved the explanatory power of the model at each step. It was for these reasons that I found the Hogan and Perrucci helpful, but the way that they presented their results did not map on exactly to the way that I wanted to present the results of the current study. For example, I also calculated the F-change statistic, in order to determine if the change in the R^2 value was significant after predictors were added at each step of the model (Field, 2009).

I also examined the adjusted R^2 value in order to determine how much of the variability in raw score performance was predicted by the variables that had been entered into the model at a given step of the regression equation. In doing so, I was also able to calculate the extent of the prediction added by each variable set of interest.

As explained above, the missing value analysis indicated that neither ignoring the missing values for these dependent variables nor imputing those values was acceptable. For example, had I simply removed the cases with missing values, the most cognitively impaired individuals would have been removed from the sample, giving us biased results that did not reflect the true nature of the sample. Both dichotomous and continuous variables can be included in the Heckman correction (Dunning & Freedman, 2007). Hierarchical regression without the Heckman correction was run when examining the BNT total score, as all cases were present for all variables in analyses in which the BNT raw score was the dependent variable.

Using the Heckman two-step and hierarchical regression methods, the predictors were entered into the model before the variable of interest (Field, 2009). Traditionally, demographic variables are entered into the model first (D. Jackson, personal communication, September 18, 2011). In the current study, the categorical demographic variables (gender and ethnicity) were added to the first block, and age and years of formal education were added to the second block. The categorical variables (gender, ethnicity) were dummy coded. The DRS total score was added to the third block. In the fourth and final block, the variable of interest (occupational complexity, for Research Questions 1 and 2, and WRAT-3 Reading raw score for Research Questions 3 and 4) was added. As a categorical variable, occupational complexity was also dummy coded.

Research Question 1a: *What is the unique contribution of complexity of occupation to the WASI Vocab subtest raw score?* A Heckman two-step correction model was used to investigate this research question. It was hypothesized that complexity of past occupation would not uniquely account for a significant increase in explained variance in WASI Vocab raw score performance beyond age, formal education, ethnicity, gender, and current overall cognitive status. This hypothesis was not supported. As shown in Table 5, when entered into the first block of the equation, ethnicity, and the Heckman variable (labelled "lambda" on all statistical output) contributed a significant amount of variance to the WASI Vocab raw score performance. The variables in the model in the second block accounted for a significant amount of variance in the WASI Vocab raw score, as shown by the significant *F* value in Table 5. Examination of significance of coefficients showed that ethnicity, years of formal education, and the Heckman variable each contributed a significant amount of variance to the WASI Vocab raw score performance, with the addition of age and education resulting in a significant R^2 change. The adjusted R^2 value of .54 indicates that over half of the variability in WASI Vocab raw score is predicted by gender, ethnicity, age, years of formal education, and the Heckman variable. In the third block of the equation, ethnicity, years of formal education, and the DRS total score contributed a significant amount of variance to the WASI Vocab raw score performance, with the addition of the DRS resulting in a significant R^2 change. The adjusted R^2 value of .59 indicates that 59% of the variability in WASI Vocab raw score is predicted by the DRS total score, plus the other five variables in the model.

Lastly, in the fourth block, ethnicity, years of formal education, DRS total score, the Heckman variable, and the variable of interest, occupational complexity, contributed a significant amount of variance to the WASI Vocab raw score performance, with the addition of occupational complexity resulting in a significant R^2 change. The adjusted R^2 value of .63 suggests that almost 63% of the variability in WASI Vocab raw score performance is predicted by occupational complexity and the six other variables in the model at this step (as shown in Table 5).

Research Question 1b: *What is the unique contribution of complexity of occupation to the WASI MR subtest raw score?* A Heckman two-step correction model was used to investigate this research question. It was hypothesized that complexity of past occupation would uniquely account for a significant increase in the explained variance in WASI MR raw score beyond age, formal education, ethnicity, gender, and current overall cognitive status. This hypothesis was supported. As shown in Table 6, when entered into the first block of the equation, only the Heckman variable contributed a significant amount of variance to the WASI MR raw score performance. The variables in the model in the second block accounted for a significant amount of variance in the WASI MR raw score, as shown by the significant F value in Table 6. Examination of the significance of coefficients showed that years of formal education, and the Heckman variable each contributed a significant amount of variance to the WASI MR raw score performance, with the addition of age and education resulting in a significant R^2 change. The adjusted R^2 value of .23 indicates that less than a quarter of the variability in WASI MR raw score is predicted by gender, ethnicity, age, years of formal education, and the Heckman variable. In the third block of the equation, years of formal education, and the DRS total score contributed a significant amount of variance to the WASI MR raw score performance, with the addition of the DRS total score resulting in a significant R^2 change.

The adjusted R^2 value of .31 indicates that 31% of the variability in WASI MR raw score is predicted by the DRS total score, plus the other five variables in the model.

Lastly, in the fourth block, the DRS total score, and the variable of interest, occupational complexity, contributed a significant amount of variance to the WASI MR raw score performance, with the addition of occupational complexity resulting in a significant R^2 change. The adjusted R^2 value of .32 suggests that 32% of the variability in WASI MR raw score performance is predicted by occupational complexity and the six other variables in the model at this step (as shown in Table 6).

Table 5

Research Question 1a: Hierarchical Multiple Regression Analysis using the Heckman Model Predicting WASI Vocabulary (n = 162) raw score with Gender, Ethnicity, Age, Years of Formal Education, DRS Total Score, Occupational Complexity, and the Heckman Variable

Step/Predictor	Coefficient	(SE)	*p* value	CI	*F*	R^2	Adj R^2	$R^2 \Delta$
Step 1								
Gender	- 0.48	1.29	.709	(- 3.0, 2.3)				
Ethnicity	- 5.61	1.32	<.001	(- 8.2, -3.0)				
Heckman	-36.01	3.38	<.001	(-42.8, -29.4)				
					54.31**	.51	.50	--
Step 2								
Gender	- 0.38	1.23	.761	(- 2.8, 2.1)				
Ethnicity	- 4.54	1.29	.001	(- 7.1, -2.0)				
Age	0.22	0.12	.072	(- 0.1, 0.5)				
Edu	0.71	0.21	.001	(- 0.3, 1.1)				
Heckman	-33.38	4.16	<.001	(-41.6, -25.2)				
					39.18**	.56	.54	0.05**
Step 3								
Gender	- 0.74	1.17	.530	(-3.1, 1.6)				
Ethnicity	- 4.43	1.22	<.001	(-6.8, -2.0)				
Age	0.14	0.11	.221	(- 0.1, 0.4)				
Edu	0.89	0.21	<.001	(- 0.5, 1.3)				
DRS total	0.51	0.12	<.001	(0.3, 0.75)				
Heckman	- 1.43	8.45	.865	(-18.1, 15.3)				
					62.89**	.60	.59	0.05**
Step 4								

Gender	0.42	1.15	.715	(-1.9, 2.7)				
Ethnicity	- 2.93	1.21	.017	(-5.3, - 0.5)				
Age	- 0.10	0.12	.409	(- 0.4, 0.1)				
Edu	0.58	0.21	.006	(- 0.2, 1.0)				
DRS total	0.96	0.16	<.001	(0.7, 1.3)				
Occupation	8.65	2.06	<.001	(- 4.6, 12.7)				
Heckman	32.80	11.45	.005	(10.2, 55.4)				
					39.82**	.64	.63	0.04**

Note: * Value is significant at the 0.05 level (2-tailed); ** Value is significant at the 0.01 level (2-tailed); SE: Standard Error; CI: Confidence Interval; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest; DRS: Dementia Rating Scale; Heckman: Heckman missingness variable; Education: Years of formal education; Occupation: Complexity of occupation; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), ethnicity (EA = 1, AA = 0), and complexity of occupation (high = 1, low = 0).

Table 6

Research Question 1b: Hierarchical Multiple Regression Analysis using the Heckman Model Predicting WASI Matrix Reasoning (n = 159) raw score with Gender, Ethnicity, Age, Years of Formal Education, DRS Total Score, Occupational Complexity, and the Heckman Variable

Step/Predictor	Coefficient	(SE)	*p* value	CI	*F*	R^2	Adj R^2	$R^2\,\Delta$
Step 1								
Gender	0.77	1.19	.515	(- 1.6, 3.1)				
Ethnicity	- 1.36	1.22	.269	(- 3.8, 1.1)				
Heckman	-22.85	4.44	<.001	(-31.6, -14.1)				
					11.15**	.18	.16	--
Step 2								
Gender	1.12	1.14	.329	(- 1.1, 3.4)				
Ethnicity	- 0.44	1.20	.714	(- 2.8, 1.9)				
Age	0.03	0.11	.776	(- 0.2, 0.2)				
Edu	0.70	0.17	<.001	(0.3, 1.0)				
Heckman	-19.57	4.91	<.001	(-29.3, -9.9)				
					10.56**	.26	.23	0.08**
Step 3								
Gender	0.40	1.11	.715	(- 1.8, 2.6)				
Ethnicity	- 0.55	1.15	.632	(- 2.8, 1.7)				
Age	0.06	0.10	.555	(- 0.1, 0.3)				
Edu	0.49	0.17	.005	(0.2, 0.8)				
DRS total	0.27	0.07	<.001	(0.1, 0.4)				
Heckman	- 3.65	6.07	.549	(-15.6, 8.3)				
					12.53**	.33	.31	0.07**
Step 4								

Gender	0.49	1.09	.654	(- 1.7, 2.6)				
Ethnicity	- 0.24	1.14	.832	(- 2.5, 2.0)				
Age	- 0.22	0.17	.207	(- 0.5, 0.1)				
Edu	- 0.21	0.38	.583	(- 1.0, 0.5)				
DRS total	0.56	0.16	<.001	(0.2, 0.9)				
Occupation	9.14	4.51	.044	(0.3, 18.1)				
Heckman	34.75	19.88	.082	(-4.5, -22.7)				
					11.55**	.35	.32	0.02*

Note: * Value is significant at the 0.05 level (2-tailed); ** Value is significant at the 0.01 level (2-tailed); *SE:* Standard Error; *CI:* Confidence Interval; WASI: Wechsler Abbreviated Scale of Intelligence; MR: Matrix Reasoning subtest; Heckman: Heckman missingness variable DRS: Dementia Rating Scale; Education: Years of formal education; Occupation: Complexity of occupation; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), ethnicity (EA = 1, AA = 0), and complexity of occupation (high = 1, low = 0).

Research Question 2a: *What is the unique contribution of complexity of occupation to the WMS-R LM-1 subtest raw score?* The hypothesis was non-directional, but the results suggested that occupational complexity contributed a significant amount of variance to LM I score performance. A Heckman two-step correction model was used to assess this research question. As shown in Table 7, when entered into the first block of the equation, both gender and the Heckman variable contributed a significant amount of variance to the LM I raw score performance. The variables in the model in the second block accounted for a significant amount of variance in the LM I raw score, as shown by the significant *F* value in Table 7. Examination of significance of coefficients showed that gender, age, years of formal education, and the Heckman variable each contributed a significant amount of variance to the LM I raw score performance, with the addition of age and education resulting in a significant R^2 change. The adjusted R^2 value of .29 indicates that less than a third of the variability in LM I raw score performance is predicted by gender, ethnicity, age, years of formal education, and the Heckman variable. In the third block of the equation, gender, years of formal education, DRS total score, and the Heckman variable contributed a significant amount of variance to the LM I raw score performance, with the addition of the DRS total score resulting in a significant R^2 change. The adjusted R^2 value of .44 indicates that 44% of the variability in LM I raw score is predicted by the DRS total score, plus the other five variables in the model.

Lastly, in the fourth block, DRS total score, the Heckman variable, and the variable of interest, occupational complexity, contributed a significant amount of variance to the LM I raw score performance, with the addition of occupational complexity resulting in a significant R^2 change. The adjusted R^2 value of .46 suggests that 46% of the variability in LM I raw score performance is predicted by occupational complexity and the six other variables in the model at this step (as shown in Table 7).

Research Question 2b*:* *What is the unique contribution of complexity of occupation to the total score on the BNT?* The hypothesis was non-directional, but the results suggested that occupational complexity did not contribute a significant amount of variance to BNT score performance. A standard hierarchical regression without the Heckman correction was used to test this hypothesis, as there were no missing data. As shown in Table 8, when entered into the first block of the equation, both gender and ethnicity contributed a significant amount of variance to BNT total score performance. The variables in the model in the second block accounted for a significant amount of variance in BNT total score, as shown by the significant *F* value in Table 8. Examination of significance of coefficients showed that ethnicity, age, and years of formal education each contributed a significant amount of variance to BNT total score performance, with the addition of age and education resulting in a significant R^2 change. The adjusted R^2 value of .38 indicates that 38% of the variability in BNT total score performance is predicted by gender, ethnicity, age, and years of formal education. In the third block of the equation, gender, ethnicity, and the DRS total score contributed a significant amount of variance to BNT total score performance, with the addition of the DRS total score resulting in a significant R^2 change. The adjusted R^2 value of .59 indicates that 59% of the variability in BNT total score is predicted by the DRS total score, plus the other five variables in the model.

Lastly, in the fourth block, the addition of occupational complexity did not produce a significant change in R^2. In other words, occupational complexity was not a significant predictor of BNT total score beyond age, years of formal education, ethnicity, and the DRS total score (as shown in Table 8).

Table 7

Research Question 2a: Hierarchical Multiple Regression Analysis using the Heckman Model Predicting WMS-R Logical Memory I (n = 203) raw scores with Gender, Ethnicity, Age, Years of Formal Education, DRS Total Score, Occupational Complexity, and the Heckman Variable

Step/Predictor	Coefficient	(SE)	*p* value	CI	*F*	R^2	Adj R^2	$R^2\,\Delta$
Step 1								
Gender	- 4.55	1.57	.004	(-7.6, -1.6)				
Ethnicity	- 2.44	1.58	.123	(-5.6, 0.7)				
Heckman	-38.03	5.75	<.001	(-49.4, -26.7)				
					19.71**	.23	.22	--
Step 2								
Gender	- 3.14	1.52	.040	(-6.1, -0.1)				
Ethnicity	- 1.47	1.55	.343	(-4.5, 1.6)				
Age	- 0.44	0.13	<.001	(-0.7, -0.2)				
Edu	0.87	0.26	<.001	(0.4, 1.4)				
Heckman	-26.62	6.01	<.001	(-38.5, -14.8)				
					17.59**	.31	.29	0.08**
Step 3								
Gender	-2.99	1.35	.028	(-5.7, 0.3)				
Ethnicity	0.74	1.41	.602	(-2.0, 3.5)				
Age	-0.12	0.13	.322	(-0.4, 0.1)				
Edu	0.70	0.23	<.001	(0.3, 1.1)				
DRS total	0.74	0.10	<.001	(0.5, 0.9)				
Heckman	22.43	8.60	.010	(-5.5, 39.4)				
					27.36**	.46	.44	0.13**
Step 4								
Gender	- 2.12	1.36	.119	(-4.8, 0.6)				
Ethnicity	2.01	1.44	.164	(-0.8, 4.9)				

Age	- 0.15	0.12	.236	(-0.4, 0.1)				
Edu	0.35	0.25	.171	(-0.2, 0.8)				
DRS total	0.82	0.10	<.001	(0.6, 1.0)				
Occupation	5.84	1.78	.002	(2.0, 9.0)				
Heckman	31.24	8.89	.001	(13.7, 48.8)				
					25.82**	.48	.46	0.03**

Note: * Value is significant at the 0.05 level (2-tailed); ** Value is significant at the 0.01 level (2-tailed); *SE:* Standard Error; *CI:* Confidence Interval; WASI: Wechsler Abbreviated Scale of Intelligence; WMS-R LM I: Wechsler Memory Scale-Revised Logical Memory I subtest; Heckman: Heckman missingness variable DRS: Dementia Rating Scale; Education: Years of formal education; Occupation: Complexity of occupation; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), ethnicity (EA = 1, AA = 0), and complexity of occupation (high = 1, low = 0).

Table 8

Research Question 2b: Hierarchical Multiple Regression Analysis Predicting BNT Total Score (n = 218) raw scores with Gender, Ethnicity, Age, Years of Formal Education, DRS Total Score, and Occupational Complexity

Step/Predictor	Coefficient	(SE)	*p* value	CI	*F*	R^2	Adj R^2	$R^2 \Delta$
Step 1								
Gender	- 3.54	1.56	.025	(-6.61, 0.47)				
Ethnicity	-13.01	1.56	<.001	(-16.10, -9.94)				
					38.88**	.27	.26	--
Step 2								
Gender	- 2.00	1.45	.168	(-4.87, 0.86)				
Ethnicity	-11.00	1.48	<.001	(-13.9, -8.10)				
Age	- 0.46	0.12	<.001	(-0.70, -0.23)				
Edu	1.11	0.23	<.001	(0.66, 1.56)				
					33.73**	.39	.38	0.12**
Step 3								
Gender	- 3.04	1.18	.011	(-5.40, 0.71)				
Ethnicity	- 8.68	1.23	<.001	(-11.12, -6.25)				
Age	- 0.00	0.11	.970	(-0.22, 0.21)				
Edu	0.35	0.20	.083	(-0.05, 0.75)				
DRS total	0.55	0.05	<.001	(0.45, 0.66)				
					62.64**	.60	.59	0.21**
Step 4								
Gender	- 2.86	1.20	.018	(-5.23, -0.49)				
Ethnicity	- 8.48	1.26	<.001	(-10.95, -6.00)				
Age	- 0.02	0.11	.891	(-0.23, 0.20)				
Edu	0.25	0.23	.280	(-0.21, 0.70)				
DRS total	0.55	0.05	<.001	(0.45, 0.66)				
Occupation	1.35	1.52	.378	(-1.65, 4.35)				

	52.27**	.60	.59	0.00

Note: * Value is significant at the 0.05 level (2-tailed); **. Value is significant at the 0.01 level (2-tailed); SE: Standard Error; CI: Confidence Interval; BNT: Boston Naming Test; DRS: Dementia Rating Scale; Edu: Years of formal education; Occupation: Complexity of occupation; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), ethnicity (EA = 1, AA = 0), and complexity of occupation (high = 1, low = 0).

Research Question 3a: *What is the unique contribution of WRAT-3 Reading raw score to the WASI Vocab subtest raw score?* A Heckman two-step correction model was used to investigate this research question. It was hypothesized that oral word reading ability would uniquely account for a significant increase in explained variance in WASI Vocab raw score beyond age, formal education, ethnicity, gender, and current overall cognitive status. This hypothesis was supported. As shown in Table 9, when entered into the first block of the equation, ethnicity and the Heckman variable contributed a significant amount of variance to the WASI Vocab raw score performance. The variables in the model in the second block accounted for a significant amount of variance in the WASI Vocab raw score, as shown by the significant *F* value in Table 9. Examination of significance of coefficients showed that ethnicity, years of formal education, and the Heckman variable each contributed a significant amount of variance to the WASI Vocab raw score performance, with the addition of age and education resulting in a significant R^2 change. The adjusted R^2 value of .54 indicates that over half of the variability in WASI Vocab raw score is predicted by gender, ethnicity, age, years of formal education, and the Heckman variable. In the third block of the equation, ethnicity, years of formal education, and the DRS total score contributed a significant amount of variance to the WASI Vocab raw score performance, with the addition of the DRS resulting in a significant R^2 change. The adjusted R^2 value of .59 indicates that 59% of the variability in WASI Vocab raw score is predicted by the DRS total score, plus the other five variables in the model.

Lastly, in the fourth and final block of the equation, DRS total score and the variable of interest, the WRAT-3 Reading raw score, contributed a significant amount of variance to WASI Vocab score performance, with the addition of WRAT3 reading resulting in a significant R^2 change. The adjusted R^2 value of .65 suggests that approximately 65% of the variability in WASI Vocab raw score performance is predicted by WRAT-3 Reading raw score and the six other variables in the model at this step of the equation (as shown in Table 9).

Research question 3b: *What is the unique contribution of WRAT-3 Reading raw score to the WASI MR subtest raw score?* A Heckman two-step correction model was used to investigate this research question. It was hypothesized that oral word reading ability would uniquely account for a significant increase in explained variance in WASI MR raw score beyond age, formal education, ethnicity, gender, and current overall cognitive status. This hypothesis was supported. As shown in Table 10, when entered into the first block of the equation, only the Heckman variable contributed a significant amount of variance to the WASI MR raw score performance. The variables in the model in the second block accounted for a significant amount of variance in the WASI MR raw score, as shown by the significant F value in Table 10. Examination of the significance of coefficients showed that years of formal education, and the Heckman variable each contributed a significant amount of variance to the WASI MR raw score performance, with the addition of age and education resulting in a significant R^2 change. The adjusted R^2 value of .23 indicates that less than a quarter of the variability in WASI MR raw score is predicted by gender, ethnicity, age, years of formal education, and the Heckman variable. In the third block of the equation, years of formal education and the DRS total score contributed a significant amount of variance to the WASI MR raw score performance, with the addition of the DRS total score resulting in a significant R^2 change.

The adjusted R^2 value of .31 indicates that 31% of the variability in WASI MR raw score is predicted by the DRS total score, plus the other five variables in the model.

Lastly, in the fourth and final block of the equation, DRS total score and the variable of interest, WRAT-3 Reading raw score, contributed a significant amount of variance to WASI MR score performance, with the addition of WRAT-3 Reading raw score resulting in a significant R^2 change. The adjusted R^2 value of .34 suggests that 34% of the variability is WASI MR score performance is predicted by WRAT-3 Reading raw score and the six other variables in the model at this step (as shown in Table 10).

Table 9

Research Question 3a: Hierarchical Multiple Regression Analysis using the Heckman Model Predicting WASI Vocabulary (n = 162) raw score with Gender, Ethnicity, Age, Years of Formal Education, DRS Total Score, Word Reading Ability, and the Heckman Variable

Step/Predictor		Coefficient	(SE)	*p* value	CI	*F*	R^2	Adj R^2	R^2 *Δ*
Step 1									
	Gender	- 0.48	1.29	.709	(-3.0, 2.3)				
	Ethnicity	- 5.61	1.32	<.001	(-8.2, -3.0)				
	Heckman	-36.01	3.38	<.001	(-42.8, -29.4)				
						54.31**	.51	.50	--
Step 2									
	Gender	- 0.38	1.23	.761	(-2.8, 2.1)				
	Ethnicity	- 4.54	1.29	.001	(-7.1, -2.0)				
	Age	0.22	0.12	.072	(-0.02, 0.5)				
	Edu	0.71	0.21	.001	(-0.29, 1.1)				
	Heckman	-33.38	4.16	<.001	(-41.6, -25.2)				
						39.18**	.56	.54	0.05**
Step 3									
	Gender	- 0.74	1.17	.530	(-3.1, 1.6)				
	Ethnicity	- 4.43	1.22	<.001	(-6.8, -2.0)				
	Age	0.14	0.11	.221	(-0.09, 0.4)				
	Edu	0.89	0.21	<.001	(-0.49, 1.3)				
	DRS total	0.51	0.12	<.001	(0.28, 0.75)				
	Heckman	- 1.43	8.45	.865	(-18.1, 15.3)				
						62.89**	.60	.59	0.05**
Step 4									
	Gender	- 1.47	1.09	.180	(-3.6, 0.7)				
	Ethnicity	- 1.29	1.27	.312	(-3.8, 1.2)				

Age	0.02	0.11	.867	(-0.2, 0.2)				
Edu	0.35	0.22	.109	(-0.1, 0.8)				
DRS total	0.38	0.11	.001	(0.2, 0.6)				
WRAT-3	0.66	0.12	<.001	(0.4, 0.9)				
Heckman	- 3.66	7.8	.640	(-19.1, 11.8)				
					43.66**	.67	.65	0.05**

Note: * Value is significant at the 0.05 level (2-tailed); ** Value is significant at the 0.01 level (2-tailed); SE: Standard Error; CI: Confidence Interval; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest; DRS: Dementia Rating Scale; Heckman: Heckman missingness variable; Education: Years of formal education; WRAT-3: Wide Range Achievement Test-3 Reading Subtest; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), and ethnicity (EA = 1, AA = 0).

Table 10

Research Question 3b: Hierarchical Multiple Regression Analysis using the Heckman Model Predicting WASI Matrix Reasoning (n = 159) raw score with Gender, Ethnicity, Age, Years of Formal Education, DRS Total Score, Word Reading Ability, and the Heckman Variable

Step/Predictor		Coefficient	(SE)	*p* value	CI	*F*	R^2	Adj R^2	$R^2 \Delta$
Step 1									
	Gender	0.77	1.19	.515	(-1.6, 3.1)				
	Ethnicity	- 1.36	1.22	.269	(-3.8, 1.1)				
	Heckman	-22.85	4.44	<.001	(-31.6, -14.1)				
						11.15**	.18	.16	--
Step 2									
	Gender	1.12	1.14	.329	(-1.1, 3.4)				
	Ethnicity	- 0.44	1.20	.714	(-2.8, 1.9)				
	Age	0.03	0.11	.776	(-0.2, 0.2)				
	Edu	0.70	0.17	<.001	(0.3, 1.0)				
	Heckman	-19.57	4.91	<.001	(-29.3, -9.9)				
						10.56**	.26	.23	0.08**
Step 3									
	Gender	0.40	1.11	.715	(-1.8, 2.6)				
	Ethnicity	-0.55	1.15	.632	(-2.8, 1.7)				
	Age	0.06	0.10	.555	(-0.1, 0.3)				
	Edu	0.49	0.17	.005	(0.2, 0.8)				
	DRS total	0.27	0.07	<.001	(0.1, 0.4)				
	Heckman	-3.65	6.07	.549	(-15.6, 8.3)				
						12.53**	.33	.31	0.07**
Step 4									
	Gender	-0.01	1.08	.991	(-2.2, 2.1)				
	Ethnicity	0.99	1.24	.426	(-1.5, 3.4)				

Age	-0.01	0.10	.891	(-0.2, 0.2)				
Edu	0.21	0.19	.277	(-1.7, 0.6)				
DRS total	0.22	0.07	.001	(0.1, 0.4)				
WRAT-3	0.34	0.12	.005	(0.1, 0.6)				
Heckman	-2.89	5.93	.627	(-14.6, 8.8)				
					12.41**	.37	.34	0.03**

Note: * Value is significant at the 0.05 level (2-tailed); ** Value is significant at the 0.01 level (2-tailed); SE: Standard Error; CI: Confidence Interval; WASI: Wechsler Abbreviated Scale of Intelligence; MR: Matrix Reasoning subtest; Heckman: Heckman missingness variable DRS: Dementia Rating Scale; Education: Years of formal education; WRAT-3: Wide Range Achievement Test-3 Reading subtest; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), and ethnicity (EA = 1, AA = 0).

Research Questions 4a*:* *What is the unique contribution of WRAT-3 Reading raw score to WMS-R LM I raw score performance?* A Heckman two-step correction model was used to investigate this research question. It was hypothesized that oral word reading ability would uniquely account for a significant increase in explained variance in LM I raw score beyond age, formal education, ethnicity, gender, and current overall cognitive status. This hypothesis was not supported. As seen in Table 11, when entered into the first block of the equation, both gender and the Heckman variable contributed a significant amount of variance to the LM I raw score performance. The variables in the model in the second block accounted for a significant amount of variance in the LM I raw score, as shown by the significant *F* value in Table 11. Examination of significance of coefficients showed that gender, age, years of formal education, and the Heckman variable each contributed a significant amount of variance to the LM I raw score performance, with the addition of age and education resulting in a significant R^2 change. The adjusted R^2 value of .29 indicates that less than a third of the variability in LM I raw score performance is predicted by gender, ethnicity, age, years of formal education, and the Heckman variable. In the third block of the equation, gender, years of formal education, DRS total score, and the Heckman variable contributed a significant amount of variance to the LM I raw score performance, with the addition of the DRS total score resulting in a significant R^2 change. The adjusted R^2 value of .44 indicates that 44% of the variability in LM I raw score is predicted by the DRS total score, plus the other five variables in the model.

Lastly, in the fourth and final block of the equation, gender, years of formal education, DRS total score, and the Heckman variable contributed a significant amount of variance to the LM I raw score performance. However, the addition of the WRAT 3 Reading raw score did not result in a significant R^2 change at this stage of the model. As shown in Table 11, this suggests that the LM I total score performance is not predicted by the WRAT-3 Reading raw score performance once the contributions of gender, ethnicity, age, education, missing data, and the DRS total score have been taken into account.

Research Question 4b: *What is the unique contribution of WRAT-3 Reading raw score to BNT total score performance?* A standard hierarchical regression was run, without the Heckman correction, to investigate this research question. It was hypothesized that oral word reading ability would uniquely account for a significant increase in explained variance in BNT total score score beyond age, formal education, ethnicity, gender, and current overall cognitive status.. This hypothesis was supported. As seen in Table 12, when entered into the first block of the equation, both gender and ethnicity contributed a significant amount of variance to BNT total score performance. The variables in the model in the second block accounted for a significant amount of variance in the BNT total score, as shown by the significant F value in Table 12. Examination of significance of coefficients showed that ethnicity, age, and years of formal education each contributed a significant amount of variance to BNT total score performance, with the addition of age and education resulting in a significant R^2 change. The adjusted R^2 value of .38 indicates that 38% of the variability in BNT total score performance is predicted by gender, ethnicity, age, and years of formal education. In the third block of the equation, gender, ethnicity, and the DRS total score contributed a significant amount of variance to BNT total score performance, with the addition of the DRS total score resulting in a significant R^2 change. The adjusted R^2 value of .59

indicates that 59% of the variability in BNT total score is predicted by the DRS total score, plus the other five variables in the model.

Lastly, in the fourth block of the equation, gender, ethnicity, DRS total score, and the variable of interest, the WRAT-3 Reading raw score, contributed a significant amount of variance to BNT total score performance, with the addition of WRAT-3 Reading Raw score resulting in a significant R^2 change. The adjusted R^2 value of .61 suggests that 61% of the variability in BNT score performance is predicted by WRAT-3 Reading raw score and the five other variables in the model at this step (as shown in Table 12).

Table 11

Research Question 4a: Hierarchical Multiple Regression Analysis using the Heckman Model Predicting WMS-R Logical Memory I (n = 203) raw scores with Gender, Ethnicity, Age, Years of Formal Education, DRS Total Score, Word Reading Ability, and the Heckman Variable

Step/Predictor	Coefficient	(SE)	*p* value	CI	*F*	R^2	Adj R^2	R^2 *Δ*
Step 1								
Gender	- 4.55	1.57	.004	(-7.6, -1.6)				
Ethnicity	- 2.44	1.58	.123	(-5.6, 0.7)				
Heckman	-38.03	5.75	<.001	(-49.4, -26.7)				
					19.71**	.23	.22	--
Step 2								
Gender	- 3.14	1.52	.040	(-6.1, -0.1)				
Ethnicity	- 1.47	1.55	.343	(-4.5, 1.6)				
Age	- 0.44	0.13	.001	(-0.7, -0.2)				
Edu	0.87	0.26	.001	(0.4, 1.4)				
Heckman	-26.62	6.01	<.001	(-38.5, -14.8)				
					17.59**	.31	.29	0.08**
Step 3								
Gender	-2.99	1.35	.028	(-5.7, 0.3)				
Ethnicity	0.74	1.41	.602	(-2.0, 3.5)				
Age	-0.12	0.13	.322	(-0.4, 0.1)				
Edu	0.70	0.23	.002	(0.3, 1.1)				
DRS total	0.74	0.10	<.001	(0.5, 0.9)				
Heckman	22.43	8.60	.010	(-5.5, 39.4)				
					27.36**	.46	.44	0.15**
Step 4								
Gender	- 3.06	1.37	.027	(-5.8, 0.4)				
Ethnicity	0.98	1.59	.538	(-2.2, 4.1)				

Age	- 0.13	0.13	.301	(-0.4, 0.1)				
Edu	0.66	0.26	.012	(0.1, 1.1)				
DRS total	0.74	0.11	<.001	(0.5, 0.9)				
WRAT-3	0.05	0.14	.739	(-0.2, 0.3)				
Heckman	22.20	8.64	.011	(5.1, 39.3)				
					23.36**	.45	.44	0.00

Note: * Value is significant at the 0.05 level (2-tailed); ** Value is significant at the 0.01 level (2-tailed); SE: Standard Error; CI: Confidence Interval; WASI: Wechsler Abbreviated Scale of Intelligence; WMS-R LM I: Wechsler Memory Scale-Revised Logical Memory I subtest; Heckman: Heckman missingness variable DRS: Dementia Rating Scale; Education: Years of formal education; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), and ethnicity (EA = 1, AA = 0).

Table 12

Research Question 4b: Hierarchical Multiple Regression Analysis Predicting BNT Total Score (n = 218) raw scores with Gender, Ethnicity, Age, Years of Formal Education, DRS Total Score, and Word Reading Ability

Step/Predictor	Coefficient	(SE)	*p* value	CI	*F*	R^2	Adj R^2	$R^2 \Delta$
Step 1								
Gender	- 3.54	1.56	.025	(-6.61, 0.5)				
Ethnicity	-13.01	1.56	<.001	(-16.10, -9.9)				
					38.88**	.27	.26	--
Step 2								
Gender	- 2.00	1.45	.168	(-4.87, 0.9)				
Ethnicity	-13.01	1.56	<.001	(-16.1, -9.9)				
Age	- 0.46	0.12	<.001	(-0.70, 0.2)				
Edu	1.11	0.23	<.001	(0.66, 1.6)				
					33.73**	.39	.38	0.12**
Step 3								
Gender	- 3.04	1.18	.011	(-5.4, 0.7)				
Ethnicity	- 8.68	1.23	<.001	(-11.1, -6.3)				
Age	- 0.00	0.11	.970	(-0.2, 0.2)				
Edu	0.35	0.20	.083	(-0.1, 0.8)				
DRS total	0.55	0.05	<.001	(0.5, 0.7)				
					62.64**	.60	.59	0.21**
Step 4								
Gender	- 3.69	1.17	.002	(-5.99, -1.38)				
Ethnicity	- 6.38	1.36	<.001	(-9.06, -3.70)				
Age	- 0.08	0.11	.448	(-0.30, 0.13)				
Edu	- 0.01	0.22	.956	(-0.44, 0.42)				
DRS total	0.49	0.05	<.001	(0.38, 0.60)				
WRAT-3	0.42	0.12	<.001	(0.19, 0.65)				
					57.33**	.62	.61	0.02**

Note: * Value is significant at the 0.05 level (2-tailed); ** Value is significant at the 0.01 level (2-tailed); SE: Standard Error; CI: Confidence Interval; BNT: Boston Naming Test; DRS: Dementia Rating Scale; Education: Years of formal education; the following variables were dummy coded and given a value of either 0 or 1: gender (men = 1, women = 0), and ethnicity (EA = 1, AA = 0).

Overall, the results show that the first variable of interest, occupational complexity, contributed a small but significant amount of variance to scores on the WASI Vocab and MR subtests, and total LM I score performance over and above background variables, including age, years of formal education, gender, ethnicity, DRS total score, and the Heckman variable. However, occupational complexity did not contribute a significant amount of unique variance to scores on the BNT. An overall summary of the results for each step of the hierarchical multiple regression analysis can be found in Figure 1.

Performance on the WRAT-3 Reading subtest, the second variable of interest, contributed a unique amount of variance to score performance to scores on the WAIS Vocab and MR subtests, and also to total score performance on the BNT over and above the background variables listed above. WRAT-3 Reading score performance did not contribute a significant amount of unique variance to LM I score performance, however. An overall summary of the results for each step of the hierarchical multiple regression analysis can be found in Figure 2.

	Dependent Variables † ‡			
Independent Variables	**WASI Vocab** (n = 162)	**WASI MR** (n = 159)	**BNT*** (n = 218)	**WMS-LM I** (n = 203)
Step 1: Gender, Ethnicity, Heckman	Ethnicity, Heckman	Heckman	Gender, Ethnicity	Gender, Heckman
Step 2: Gender, Ethnicity, Age, Edu, Heckman	Ethnicity, Edu, Heckman	Edu, Heckman	Ethnicity, Age, Edu	Gender, Age, Edu, Heckman
Step 3: Gender, Ethnicity, Age, Edu, DRS Total, Heckman	Ethnicity, Edu, DRS	Edu, DRS	Gender, Ethnicity, DRS	Gender, Edu, DRS, Heckman
Step 4: Gender, Ethnicity, Age, Edu, DRS Total, Occupation, Heckman	Ethnicity, Edu, DRS, Occupation, Heckman	DRS, Occupation	Sex, Ethnicity, DRS	DRS, Occupation, Heckman

Figure 1. Summary of Hierarchical Multiple Regression Analyses Predicting WASI Vocab WASI MR, BNT, and WMS-LM I Score Performance with Occupational Complexity as the Independent Variable of Interest; *Heckman variable not included in analysis as all cases were present; † Entries in columns under Dependent Variables indicate that all independent variables in that cell contributed to the prediction of the dependent variable at that step. ‡ Shading in cell indicates significant R^2 Δ value at that step; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest raw score; MR: Matrix Reasoning subtest raw score; BNT: Boston Naming Test total raw score; WMS-R LM I: Wechsler Memory Scale, Revised, Logical Memory I subtest; DRS: Dementia Rating Scale; Education: Years of formal education; Occupation: Occupational complexity

	Dependent Variables † ‡			
Independent Variables	**WASI Vocab** (n = 162)	**WASI MR** (n = 159)	**BNT*** (n = 218)	**WMS-LM I** (n = 203)
Step 1: Gender, Ethnicity, Heckman	Ethnicity, Heckman	Heckman	Gender, Ethnicity	Gender, Heckman
Step 2: Gender, Ethnicity, Age, Edu, Heckman	Ethnicity, Edu, Heckman	Edu, Heckman	Ethnicity, Age, Edu	Gender, Age, Edu, Heckman
Step 3: Gender, Ethnicity, Age, Edu, DRS Total, Heckman	Ethnicity, Edu, DRS	Edu, DRS	Gender, Ethnicity, DRS	Gender, Edu, DRS, Heckman
Step 4: Gender, Ethnicity, Age, Edu, DRS Total, WRAT-3, Heckman	DRS, WRAT-3	DRS, WRAT-3	Sex, Ethnicity, DRS, WRAT-3	Gender, Edu, DRS, Heckman

Figure 2. Summary of Hierarchical Multiple Regression Analyses Predicting WASI Vocab, WASI MR, BNT, and WMS-LM I Score Performance with the WRAT-3 Reading Subtest raw score as the Independent Variable of Interest; *Heckman variable not included in analysis as all cases were present; † Entries in columns under Dependent Variables indicate that all independent variables in that cell contributed to the prediction of the dependent variable at that step. ‡ Shading in cell indicates significant R^2 Δ value at that step; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest raw score; MR: Matrix Reasoning subtest raw score; BNT: Boston Naming Test total raw score; WMS-R LM I: Wechsler Memory Scale, Revised, Logical Memory I subtest; DRS: Dementia Rating Scale; Education: Years of formal education

CHAPTER IV

DISCUSSION

Overall Findings

The purpose of the current study was to investigate the unique contribution of occupational complexity and oral word reading ability, two proxy measures of cognitive reserve, on measures of fluid and crystallized intelligence and episodic and semantic memory. The unique contribution of occupational complexity and oral word reading ability was hypothesized to exist over and beyond above the influence of age, formal education, ethnicity, gender, and overall cognitive status for all these constructs except for general word knowledge. The results from the current study suggested that, overall, occupational complexity contributed a small, but significant amount of variance to scores on measures of crystallized verbal abilities and general knowledge, fluid reasoning and intelligence, and on an episodic memory task. The contribution of occupational complexity was found to exist beyond the expected impact of key background variables on these measures. However, occupational complexity did not contribute a significant amount of unique variance on a confrontation-naming task, which requires the use of semantic memory.

Oral word reading also contributed a unique amount of variance to score performance on selected neuropsychological measures. Specifically, oral word reading ability contributed a small, but significant amount of variance to scores on measures of crystallized verbal abilities and general knowledge, fluid reasoning and intelligence, and on a confrontation-naming task. In contrast, oral word reading ability did not contribute a significant amount of variance on a measure of episodic memory. Overall, these findings indicate that proxy measures of cognitive reserve, including complexity of occupation and oral word reading ability, are important factors to consider when examining neuropsychological test performance in clinical settings.

Complexity of occupation was a significant predictor of performance on measures of fluid and crystallized intelligence and a measure of episodic memory. The contribution of these predictors was found to exist beyond the expected impact of key background variables. The results of the current study can be compared to several findings from the literature. For example, Baltes et al. (1999) and Richards and Sacker (2003) stated that crystallized intelligence is more affected by early life experiences (e.g., years of formal education) than fluid intelligence, and that fluid intelligence is more affected by later life experiences (e.g., complexity of lifetime employment) than crystallized intelligence. The results of the current study support the finding regarding fluid intelligence, and contrary to the current study hypothesis, also suggest that complexity of occupation can contribute a significant amount of variance to performance on a crystallized intelligence task. These findings indicate an association between engaging in more complex work earlier in life and cognitive functioning, including crystallized abilities, fluid intelligence, and episodic memory abilities, in older adults experiencing cognitive complaints. The current study also is consistent with a finding by Schmand et al. (1997), who determined that working in a managerial position provided an “independent protective effect” against the development of dementia later in life (p. 1341), and a finding by Marquié et al. (2011), who concluded that when individuals engage in high levels of mental stimulation at work, they perform better on several cognitive tasks, including a measure of episodic memory.

Andel, Vigen, Mack, Clark, & Gatz (2006) explored the connection between years of formal education, complexity of occupation, and performance on a brief cognitive screener (Mini-Mental State Examination) in 171 older adults who had been diagnosed with Alzheimer's disease at baseline. Individuals were part of a study of aging and dementia at the University of Southern California Alzheimer Disease Research Center. The study was a longitudinal design, and patients were assessed yearly over the course of 2.5 years. In the vast majority of cases, a spouse, child, or sibling provided information regarding years of educational attainment and past occupational history. Occupations were coded and categorized according to categories from the 1970 US Census. Occupational complexity scores were then derived from the US Dictionary of Occupational Titles and each occupation was rated on complexity of work with data, people, and things. The results showed that even after controlling for several factors (including age, gender, native language, and dementia severity) those individuals with more years of formal education and high complexity of work had a faster rate of decline on their mental status scores than those with fewer years of formal education and those who had engaged in less complex work. While Andel et al. (2006) used the Mini-Mental State Examination as their measure of interest and did not examine specific cognitive domains as the current study did, the results of Andel et al. (2006) still have implications for the current findings: both studies show an association between a history of high complexity of work and better test performance, and, possibly, a longer prodrome before cognitive decline and/or experience of a faster rate of decline once symptoms of Alzheimer's disease begin to occur (Stern et al., 1999).

Several years later, Finkel, Andel, Gatz, and Pedersen (2009) explored the association between complexity of occupation and changes in cognitive abilities as individuals aged. They examined performance in four cognitive domains: verbal reasoning, spatial abilities, working memory, and processing speed, each generated from the Swedish version of the Wechsler Adult Intelligence Scale. The authors investigated data over three points in time from 462 older adults who were part of the Swedish Adoption/Twin Study of Aging. Participants were community-dwelling older adults who were screened for dementia at each meeting; no individuals who developed symptoms of dementia were included in the final coded sample. All lifetime occupations were coded and categorized according to the 1980 Swedish Population and Housing Census and the 1970 US Census. Occupational complexity scores were derived from the US Dictionary of Occupational Titles and each occupation was rated on complexity of work with data, people, and things. Overall, it was found that individuals who engaged in high complex work with people had better processing speed skills than those who engaged in lower complexity work with people. It was also determined that when individuals were engaged in more complex work with people, their performance on verbal tasks improved up until the time of retirement. The latter findings support the findings of the current study. In the current study, complexity of occupation contributed a significant amount of score variance on measures of fluid and crystallized intelligence and a measure of episodic memory – all of which require intact verbal skills to successfully complete.

Oral word reading ability was a significant predictor of performance on measures of fluid and crystallized intelligence and semantic memory. Again, the contribution of these predictors was found to exist beyond the expected impact of key background variables. As several authors have pointed out (e.g., Barnes et al., 2004; Fyffe et al., 2011 Manly et al., 2005), performance on oral word reading measures is correlated highly with several factors, including literacy level, quality of education, and crystallized intelligence. The findings from the current study support this finding, as oral word reading ability contributed a small, but significant, amount of variance to scores on measures of general word knowledge and visual naming over and above key background variables. Each of these measures requires the use of crystallized intelligence. The current study also supports a key finding from a 2004 study conducted by Barnes, Tager, Sarariano, and Yaffe, who determined that individuals with a higher level of literacy (as measured by the North American Adult Reading Test) was associated with higher performance on measures of executive functioning and attention, verbal memory, verbal fluency, and global cognitive function, even after accounting for multiple demographic factors. Schneider and Lichtenberg (2011) found that oral word reading ability (as measured by the WRAT-3) accounted for a significant portion of variance on a measure of verbal fluency. Crystallized intelligence is necessary to successfully complete this verbal fluency task. This additional variance was present even after controlling for age, gender, and years of formal education. Schneider and Lichtenberg’s sample was comprised entirely of community-dwelling, African American older adults, and their findings support the results of the current study, which focused on a population from the same metropolitan area.

The results of the current study also determined that gender and ethnicity contributed a significant amount of variance to scores on a measure of semantic memory, even after scores on an index of cognitive functioning, word reading ability, age and years of formal education were entered into the hierarchical regression equation. Prior research has examined performance on the Boston Naming Test, a measure of semantic memory and confrontation-naming, in community-dwelling older adults from a wide range of ethnic groups. The results of the current study relate to the findings of Baird, Ford, and Podell (2007), who examined confrontation-naming performance in a clinical sample of community-dwelling older adults. This group determined that semantic memory scores were higher for European American than African Americans even after controlling for multiple factors, including reading levels, age, and years of formal education. As well, Krasean (Unpublished MA Thesis, 2008) found that adjusting for oral word reading did not eliminate ethnic and gender group differences on a semantic memory task in a sample of urban-dwelling European and African American seen for neuropsychological assessment due to suspected cognitive impairment. Specifically, European American men had significantly higher confrontation-naming scores than African American men and women, and European American women, even after controlling for age, years of formal education, level of cognitive impairment, and word reading ability.

Overall, the findings from the literature and the current study suggest that, despite living in the same geographic area, European American and African Americans differ in their ability to name pictured objects. There have been numerous explanations put forth to help explain these differences, including years of formal education, levels of acculturation, and English as a second language (Boone et al., 2007; Manly et al., 1998; Teng & Manly, 2005). In the current study, years of formal education was taken into account and included in the statistical analysis, and individuals whose first language was not English were excluded from the final coded sample. The current data set did not include a self-report measure for level of acculturation, and is a study limitation. After determining that European American individuals scored 9-10 points higher on a confrontation naming task than African American and Hispanic individuals in the same clinical sample, Boone et al. (2007) hypothesized that, "the test stimuli themselves may be systematically biased against those groups" (p. 361). Teng and Manly (2005) have proposed that older adults from minority ethnic groups may lack familiarity with test-taking in general. This lack of familiarity with test taking could result in fewer test-taking skills and an increase in feelings of anxiety, two factors that could negatively impact how well individuals perform on neuropsychological tests. Lastly, Henderson et al. (1998) has proposed that the Boston Naming Test includes items (e.g., *yoke, trellis,* and *abacus)* that are familiar to individuals only if they have a comprehensive reading vocabulary. While the current study did not examine the specific influence that vocabulary knowledge could have on confrontation naming score, this is a direction for future research.

Results from the present study also support the work of Manly et al. (1999), as her group determined that literate individuals performed higher on a measure of visual naming as compared to illiterate individuals. When discussing possible explanations for these findings, Manly et al. (1999) concluded that those with functional literacy performed better than those without functional literacy because the functionally literate individuals were more skilled in mentally organizing and analyzing information. I also determined that oral word reading ability contributed a small, but significant, amount of variance to scores on a measure of non-verbal reasoning and fluid intelligence, over and above the key background variables. Similar to the findings of Manly et al. (1999), a possible explanations for our findings is that those individuals with higher word reading abilities were also better at organizing and analysing information in order to successfully complete the fluid intelligence task.

Manly et al. (2003) measured immediate and delayed memory performance and reading level for 136 community dwelling European, African, and Hispanic American individuals aged 65 and over, as part of the Washington Heights-Inwood Columbia Aging Project. The study was a longitudinal design, and participants were followed for about five years, on average. Participants were given the same neuropsychological measures at each follow up visit. At baseline, participants were administered a word reading tasks (the WRAT-3), and stratified into “high” and “low” literacy groups. At each follow up, immediate and delayed memory performance was assessed using a list-learning task. Her group determined that, over time, there was a decrease in immediate and delayed memory performance for older adults in both the “high” and “low” literacy groups. However, individuals in the “low” literacy group experienced a more rapid rate of decline, indicating that higher literacy skills “do not provide complete preservation of memory skills but rather a slowing of age-related decline” (p. 685). The authors also stressed that the decline in the immediate and delayed memory scores was not associated with the development of a dementia disorder.

The findings of Manly et al. (2003) are different from the findings of the current study. I determined that oral word reading ability did not contribute a significant amount of variance to performance of an episodic memory task over and beyond key background variables. However, Manly et al. (2003) did not examine the unique contribution of oral word reading ability to performance on the episodic memory task; it was simply determined that the individuals in the 'high' literacy group had a better performance on an episodic memory task over time compared to the 'low' literacy group. As Manly et al. (2003) correctly conclude, there are numerous factors that contribute to an individual's level of literacy, including native ability and educational experience.

Other differences exist between our two studies. While both studies examined immediate episodic memory performance, Manly et al. (2003) used a list-learning task, whereas the recall of a short story was required in the current study. Also, the current study involved a clinical sample, that is, individuals who were seen for neuropsychological assessment because someone (e.g., themselves, a family member, or physician) expressed concern about their memory, or other problems in thinking. In contrast, Manly et al. (2003) used a sample of community-dwelling older adults, all of whom were evaluated for the presence of dementia, and were found to be dementia free at all stages of the study. Investigating the unique contribution of oral word reading to immediate and delayed performance on a list-learning task is a possible direction of future research.

Fyffe et al. (2011) examined proxy measures of cognitive reserve in order to help determine what factors helped explain differences in episodic memory performance among African American and European American older adults. Individuals from the Memory and Aging Project and the Minority Aging Research Study were included in the study; all were community dwelling and dementia free at study baseline (993 individuals, 27.5% African American). Performance on several episodic memory tasks (including the Logical Memory subtest from the WMS-R) was evaluated. Fyffe et al. also examined several proxy measures of cognitive reserve, including self, maternal, and paternal educational level, frequency of cognitive activity during childhood, level of income at age 40, and reading level, which served as a measure of educational quality. The authors also wanted to control for several demographic, health, and sociocultural factors (including educational quality, familiarity with test-taking, and stereotype threat) that could impact performance on the episodic memory tasks. Differential item functioning analyses were used to determine “whether individual characteristics exaggerate or attenuate the probability of successful responses to episodic memory items, given a particular level of episodic memory functioning” (p. 626). Overall, Fyffe et al. determined that the differences in score performance on episodic memory performance between African American and European American older adults could be explained by differences in educational quality, as measured by word reading ability. The authors stressed the importance of considering educational quality (as measured by reading level) when examining the neuropsychological test scores of older adults of diverse backgrounds, observing that, “Our analysis suggest that reading test scores alone – and not other factors considered here – are able to explain these differences, suggesting that there is something unique about reading test scores not shared by these other factors” (p. 634).

Contrary to the findings of Fyffe et al. and Manly et al. (2003), the current study determined that oral word reading ability did not contribute a significant amount of variance to performance of an episodic memory task over and beyond key background variables. There are potential explanations for these discrepant findings. Individuals in the current study were part of a clinical sample, rather than research volunteers. Impaired memory for recent information is one of the most common cognitive complaints when individuals are seen for neuropsychological assessment (Jonker, Geerlings, & Schmand, 2000) and individuals in the current study could have been more cognitively impaired than the samples comprised of research volunteers. In the current study, the Dementia Rating Scale, an index of cognitive functioning, is included as a background factor. The Dementia Rating Scale shares variance with the neuropsychological variables predicted here, including episodic memory. It is also possible that my findings were a statistical abnormality. It is entirely possible that, should the current study be replicated (e.g., including individuals from multiple geographic areas, or including more individuals in the sample) a different result would be determined for performance on the episodic memory task.

Reed et al. (2011) used the decomposition approach to investigate how participating in cognitively stimulating activities throughout adulthood could impact the level of cognitive reserve in older adults. Older adults in their study were asked how frequently they participated in several cognitively stimulating leisure activities, including reading, writing letters or in a journal, visiting a library, or going to a concert. While reading was only one of the activities mentioned, it still provides some evidence that the act of reading can have some cognitive benefits. However, it is important to stress, as Stern (2011) does, that the presence of a relationship between two variables (e.g., word reading and cognitive processing) does not ensure that the experience of reading will lead to cognitive reserve that will protect against changes in the brain, or neuropathology. Stern (2011) notes, "We would assume that variables that are associated with cognitive reserve achieve this status because they influence cognitive development in a way that is important for coping with brain damage" (p. 639). It is also important to consider what factors can influence an individual's reading level as an adult. For example, Richards and Sacker (2003) used path analysis to determine how several factors, including parental occupation, IQ at age 8, educational attainment, and lifetime occupation contributed to performance on the NART, which they considered to be a proxy measure of cognitive reserve. They found that the strongest path was from childhood IQ. Thus, Stern (2011) argues that there are many factors that can contribute to levels of cognitive reserve later in life.

In the current study, word reading ability contributed a significant amount of variance to score performance on several cognitive tasks, including measures of fluid and crystallized intelligence and semantic memory. Our results thus support the idea that better word reading ability can have a positive impact on an individual's cognitive functioning. As Stern (2009) highlights, higher IQ (as estimated by an oral word reading test) may be associated with more efficient neural networks, which would lead to higher levels of reserve later in life. Wilson et al. (2007) hypothesized that better reading skills in an individual lead to more efficient and flexible neural systems, which therefore lowers the risk of functional impairment in older adults. The results of the current study appear to add additional support to these theories.

The brain reserve capacity model and the cognitive reserve model have both been discussed in the literature as possible mediators between neurological damage and clinically significant cognitive impairment. The brain reserve capacity model proposes that the brain is protected against neurological damage, in part, by relatively enduring structural factors, such as cortical size (Satz, 1993). In contrast, the cognitive reserve model hypothesizes that the brain uses preexisting cognitive processes or compensatory approaches in order to protect against cognitive decline (Stern, 2007). These models indicate that there is a distinct difference between brain reserve capacity and cognitive reserve, and that each has the potential to have impact on cognitive functioning over the course of the lifespan. While brain reserve capacity is thought to be influenced by experiences early in life, such as developmental differences and years of formal education (Ngandu et al., 2007), cognitive reserve is likely influenced by factors across the lifespan, such as social engagement, physical activity, complexity of work, and word reading ability. The theory of cognitive reserve is supported by the current study. However, questions remain regarding whether or not structural factors that impact cognitive functioning at both the beginning, and end of life are changeable. This question has further implications for the genetic influence on cognitive functioning, and the way that genes interact with the current environment, including access to electronic media, such as the Internet. The majority of literature published in the last decade, however, adds support to the theory of cognitive reserve, rather than brain reserve capacity.

Missing Data

The importance of adequately assessing and addressing the problem of missing data is also highlighted by this study, and the process for dealing with data that is missing in a non-random, non-ignorable way was also reviewed. In the current clinical sample, individuals with missing data scored lower on measures of oral word reading and semantic memory, were older, more cognitively impaired, and had fewer years of formal education in comparison to individuals who were not missing any data. Addressing the missing data problem was of key importance because erroneous conclusions can result from inadequate solutions to the problem (Walton, 2009). Several methods of dealing with missing data were explored, although ultimately the Heckman correction was used. The limitations of this correction are described below. No method to correct for missing data is perfect, however, and as Molenberghs and Kenward note, “There is a broad consensus that no single modeling approach, no matter how sophisticated, can overcome the limitation of simply not have access to the missing data” (Molenberghs & Kenward, 2007, p. xvi).

In order to determine if the pattern of missing data was associated with any of the other variables used in data analysis, a missing value analysis was run with all categorical and interval variables. An investigation of the pattern of missing data had some surprising results. First, the pattern of missing data revealed that missing data was not random: The characteristics of those with missing data differed from those who had completed all of the tests included as independent and dependent variables. The data was also missing in a way that simply removing data of a participant from the final coded sample would not have been an acceptable course of action: Simply removing these individuals from the data set would have changed the characteristics of the sample in a fundamental way. It was determined that participants who were missing data had lower scores on a measure of semantic naming, and scored lower on a measure of oral word reading ability compared to participants for whom data were not missing. Those missing data were also more cognitively impaired, older, and had fewer years of formal education. It is interesting to note that those who were missing data were no more likely to be male than female, and no more likely to be African American than European American. From this, it can be concluded that the neuropsychologists who made the decision to administer tests to participants did not discriminate on the basis of ethnicity or gender when deciding which tests were to be administered during neuropsychological testing.

The impact of missing data has been examined in the literature. For example, Brayne, Spiegelhalter, Dofouil, and Chi, et al. (1999) examined change in cognitive status over a nine year period in a sample of community dwelling older adults from the U.K. Cognitive status was measured using the Mini Mental State Exam. Brayne et al. (1999) found that when they ignored the presence of missing data, there was an underestimation of cognitive impairment within the sample. As well, Boersma, Eefsting, Van Den Brink, and Van Tilburg (1997) found that individuals who did not respond to a follow-up dementia screening due to illness or death were more likely to be male, older, and in a long-term care facility. In the current study, individuals with missing data were no more likely to be male than female, but participants with missing data were significantly older than those without missing data, replicating the findings of Boersma et al. (1997). However, their clinical sample differs from the current study in that I excluded individuals who were hospital inpatients or in hospice care from the final coded sample. It is possible that including hospital inpatients, or individuals in hospice care could exacerbate the differences in test scores between those with missing data and those without missing data, and future research could potentially address this question. Overall, Boersma et al. (1997) concluded that it was of vital importance to consider how an individual’s inability to complete neuropsychological measures, and the subsequent missing data, can have adverse effects on study findings and “seriously threaten the validity of the results.” (p. 1601).

Anstey et al. (2001) evaluated cognitive and sensory motor performance in a group of community-dwelling older adults as part of the Australian Longitudinal Study of Ageing. Participants (1,947 at baseline; 53% men) were aged 70 and above, and completed a telephone interview and/or clinical and cognitive assessment every 12 months, on average. Cognitive testing included measures of memory, verbal abilities, and processing speed. Anstey et al. found that participant mortality was predicted by two factors: a decline in cognitive test performance and the presence of missing data (e.g., the inability to complete one or more cognitive tests during one or more stages of the study). The current study findings support this idea, as individuals with missing test data had lower scores on a wide array of measures including a word-reading measure, a visual naming task, and an overall measure of premorbid intellectual functioning and cognitive impairment.

Overall, the findings of Anstey et al. (2001) and the current study have clinical utility because both demonstrate that the inability to complete cognitive tasks and the presence of missing data may predict clinically relevant factors, such as an increased risk of mortality. The authors also point out that their findings "strongly suggests that missing data in very old samples is unlikely to be random … [leading] to an underestimation of the size of the observed association between the size of the observed association between cognitive performance and subsequent mortality in the present study" (p. 10). The current study attempts to correct the problem of non-random, non-ignorable missing data through use of the Heckman correction.

As Anstey and Luszcz (2002) note, one of the downsides of using longitudinal studies to investigate change in cognitive status over time is that a large number of participants will be lost over time due to several factors, including mortality and morbidity. As a result, missing data is a common issue when conducting longitudinal research. As part of the Australian Longitudinal Study of Ageing, Anstey and Luszcz (2002) evaluated the cognitive status of participants who were missing data at one of two points over the course of their longitudinal study. There were six waves of data collection, but presence of missing data was analyzed at two points during the study: during the first wave (baseline), and during the third wave of the study, approximately 24 months later. Seven years after the first wave of the study, Anstey and Luszcz used public records (e.g., death certificates), medical records and an informant interview to estimate dementia status and degree of cognitive decline, and/or determine if a participant had passed away. At baseline, all study participants were community dwelling older adults aged 70 and older who were randomly selected from a larger Australian Longitudinal Study of Ageing sample. During the first and third wave of the study, individuals completed a two-hour in-home interview and a clinical assessment). Measures of verbal reasoning, processing speed, confrontation naming, word reading, and a brief dementia screening measure were used. The authors used medical records and an informant interview (a 26-item questionnaire called the Informant Questionnaire of Cognitive Decline in the Elderly) in order to estimate an individual's dementia status (e.g., mild, moderate or severe) and degree of cognitive decline. The authors then compared dementia status and cognitive status of individuals in three different groups. The first group was comprised of individuals who completed the interview and clinical assessment at Waves 1 and 3. The second group was comprised of individuals who completed the interview and clinical assessment at Wave 1, but only the clinical interview at Wave 3.

The third group was comprised of individuals who completed the clinical interview only during both Wave 1 and Wave 3. Overall, individuals who were missing clinical assessment at either Wave 1 or Wave 3 were less healthy, had higher rates of mortality, and were more likely to develop dementia. While the current study was not longitudinal in nature, our findings that those with missing data were more likely to be cognitively impaired are in keeping with the findings of Anstey and Luszcz (2002).

There has been a wide array of methods utilized to help correct the problem of missing data. For example, Burns et al. (2011) used the multiple imputation method to help correct missing item-level data from the Mini Mental State Exam, a brief screening measure of dementia. The multiple imputation method involves "imputing or estimating a missing value with a set of plausible values" (p. 788), and is used over excluding cases with item-level data, as removing these cases is "not appropriate" (p. 788). Similar to the current study, Burns et al. (2011) found an association between the presence of missing data and advancing age. The authors also determined that participants with item-level missing data on the Mini Mental State Exam were significantly older, and had fewer years of formal education than those without missing data. Consistent with the current study results, Burns et al. did not find a significant association between gender and missing data.

Study Limitations and Strengths

Limitations exist within the current study. First, the use of "high" and "low" occupational complexity groups could be considered a bit unrefined. However, despite the use of this crude variable, I determined that occupational complexity still contributed a significant amount of test score variance on three of four neuropsychological measures examined, with the exception being a measure of semantic naming. Occupational complexity, along with premorbid functioning and dementia severity (as measured by the Dementia Rating Scale) may help explain some of this variance. However, using more specific occupational categories, such as measuring complexity of occupation in terms of complexity of work with people, data and things (Andel et al., 2005; Andel et al., 2007) would be beneficial in future studies. As well, occupational status was coded using information from the neuropsychological report, as opposed to conducting a structured inquiry about past occupation(s). Should this study be replicated, the latter method is preferable. With regard to missing data: Burns et al. (2011) did not find a significant association between clinical dementia diagnosis and the number of missing items on the Mini Mental Status Exam. While this suggests that individuals with dementia were no more likely to have missing item-level data than those without dementia, it would be beneficial to see if this pattern remains on other neuropsychological test measures. The diagnostic status of the current study participants was unknown and not included in data analysis, and is a limitation of the current study.

Lastly, the data were collected from one location: an outpatient neuropsychology clinic located in a hospital in an urban area (Detroit, MI, USA). The use of only one geographic location may limit the generalizability of the findings, as could the fact that the current study focused only on European and African American individuals. It is recommended that future studies use a more geographically diverse sample (e.g., from more locations across the US and Canada) and a more ethnically diverse sample (e.g., also including data from Hispanic or Asian Americans).

The current study has several notable strengths. To the best of my knowledge, this is the first study in the field of neuropsychology to use the Heckman correction to address the issue of data that is missing at random and is not ignorable. Missing data of this type is common in clinical settings, and this study may provide guidance for researchers who encounter this problem in the future. Extensive research and consultation with statistical experts (e.g., Scott Millis, Ph.D., MEd, CStat, Joanna Kraft, Ph.D., and Dan Edelstein) was completed in order to ensure that the missing data problem was adequately addressed. At the suggestion of Scott Millis, I also ran a sensitivity analysis by using alternative statistical methods, which generated similar, but not identical results to running the analyses with the Heckman correction. As well, it was useful to use hierarchical regression to help answer the research questions, as this method allowed me to see the unique contribution of the demographic variables, and the variables of interest, to neuropsychological test scores at each stage of the regression analysis.

Lastly, there are both strengths and possible limitations to using the WRAT-3 Reading subtest, the oral-word reading test used in the current study. The WRAT-3 Reading subtest is comprised of phonetically regular and irregular words (Wilkinson, 1993); thus, in the current study, it was possible that an individual was able to use the phonetic cues and sound out a word even if he/she was not familiar with it. One possible alternative to the WRAT-3 Reading subtest is the North American Adult Reading Test (NAART). The NAART is an oral word-reading test comprised of phonetically irregular words. Because of the phonetically irregular spellings, it is highly unlikely that an individual unfamiliar with the word will pronounce it correctly (Blair & Spreen, 1989). Barnes, Tager, Satariano and Yaffe (2004) measured literacy level using the NAART, and concluded that the NAART also may provide an indirect index of a person's crystallized intelligence, because it reflects, "in part, the effects of formal and informal educational experiences during a person's lifetime" and the frequency and level in which a person engages in cognitively stimulating activities (Barnes et al., 2004, p. 393). However, performance on the NAART is correlated with years of education and social class, and performance on the NAART has been shown to decrease as individuals age (Strauss et al., 2006). The WRAT-3 Reading subtest is generally easier, is more sensitive to individuals of a lower educational level, and is better at predicting IQ in individuals with below-average intelligence when compared to other reading tests (e.g., the NAART; Strauss et al.). Due to the demographic characteristics of the current sample, it is therefore argued that the use of the WRAT-3 Reading subtest is a strength of the current study, as opposed to a limitation.

Implications and Recommendations for Future Research

Overall, it was determined that occupational complexity contributed a small but significant amount of variance to scores on measures of crystallized verbal abilities fluid reasoning and intelligence, and on an episodic memory task, over and above the contribution of key background variables. Oral word reading ability also contributed a unique amount of variance to scores on measures of the aforementioned crystallized and fluid intelligence measures, and on a measure of semantic memory, again, over and above the contribution of several key background variables. The findings of the current study have several key implications for both training and clinical practice. First, it is important that clinicians and neuropsychology students be aware that lifetime experiences, such as an individual's word reading ability and their lifetime occupational status, can impact performance on a variety of neuropsychological measures across several cognitive domains. Thus, occupational complexity and word reading ability are important factors to consider when examining neuropsychological test performance in a clinical setting, along with traditional demographic variables. Second, this finding adds support to the extensive literature (e.g., Fyffe et al., 2011; Stern, 2009) indicating that lifetime experiences can serve a protective factor in the cognitive status of older adults, and that word reading and occupational complexity can serve as proxy measures of cognitive reserve.

Third, the findings of the current study stress the importance of conducting the necessary statistical techniques to both identify and address the presence of missing data. In this case, the information provided by conducting a missing value analysis led to the use of the Heckman correction, a method of working with data that is missing not at random, and is not ignorable. An execution of a sensitivity analysis, using two other methods, yielded similar, but not identical results.

The results of the current study may also have some implications for social policies and expectations regarding aging. It could be quite beneficial to educate older adults about the benefit of engaging in cognitively stimulating leisure activities, including reading, throughout life. The current findings support the implementation of several broad social policies, including adult literacy training, and putting non-discriminatory hiring practices into place. In the United States, African American individuals often receive a poorer quality of initial education compared to European American individuals (Manly et al., 2005), and African American individuals have a harder time getting work that is commensurate with their level of education (DiTomaso, 2012). These results also suggest the underlying, far-reaching implications of both literacy and complexity of occupation, both of which are built on cognitively challenging experiences earlier in life. For many adults, their greatest source of cognitive stimulation is their occupation.

In summary, complexity of occupation was a significant predictor of performance on measures of fluid and crystallized intelligence and a measure of episodic memory. Oral word reading ability was a significant predictor of performance on measures of fluid and crystallized intelligence and semantic memory. This study highlights the far-reaching effects of early life experiences and opportunities on cognitive abilities even when those abilities are measured late in life, and even when the sample is restricted to those suspect of having cognitive impairment. The importance of adequately assessing and addressing the problem of missing data is also highlighted by this study.

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Appendix A

Standard Occupational Classification Major Groups

High Complexity

Management Occupations

Business and Financial Operations Occupations

Computer and Mathematical Occupations

Architecture and Engineering Occupations

Life, Physical and Social Science Occupations

Community and Social Service Occupations

Legal Occupations

Education, Training and Library Occupations

Arts, Design, Entertainment, Sports and Media Occupations

Healthcare Practitioners and Technical Occupations

Low Complexity

Healthcare Support Occupations

Protective Service Occupations

Food Preparations and Service Related Occupations

Building and Grounds Cleaning and Maintenance Occupations

Personal Care and Service Occupations

Sales and Related Occupations

Office and Administrative Support Occupations

Farming, Fishing and Forestry Occupations

Construction and Extraction Occupations

Installation, Maintenance and Repair Occupations

Production Occupations

Transportation and Material Moving Occupations

Military Specific Occupations

Appendix B

List of Acronyms Listed in the Text

BNT	Boston Naming Test
DRS	Dementia Rating Scale
fMRI	Functional Magnetic Resonance Imaging
IALS	International Adult Literacy Survey
ILS	Independent Living Scales
MOAANS	Mayo's Older African Americans Normative Studies
MRI	Magnetic Resonance Imaging
MVA	Missing Value Analysis
NAAL	National Assessment of Adult Literacy
NAART	North American Adult Reading Test
NAS - NRC	National Academy of Sciences – National Research Counsel
NINCDS-ADRDA	National Institute of Neurological and Communicative Disorders and Stroke - Alzheimer's Disease and Related Disorders Association
PFC	Prefrontal Cortex
SES	Socioeconomic Status
VIF	Variance Inflation Factor
WASI	Wechsler Abbreviated Scale of Intelligence
WHICAP	Washington Heights-Inwood Columbia Aging Project
WMS-R LM I	Wechsler Memory Scale-Revised Logical Memory I subtest
WRAT-3	Reading subtest of the Wide Range Achievement Test -3

Appendix C

Results of the Hierarchical Multiple Regression Analyses using the Full Information Maximum Likelihood Method

	Dependent Variables †		
Independent Variables	**WASI Vocab** (n = 218)	**WASI MR** (n = 218)	**WMS-LM I** (n = 218)
Step 1: Gender, Ethnicity	**Ethnicity**	Ethnicity	**Gender**, Ethnicity
Step 2: Gender, Ethnicity, Age, Edu	**Ethnicity**, Age **Edu**	**Edu**	**Age, Edu**
Step 3: Gender, Ethnicity, Age, Edu, DRS Total	**Ethnicity**, **Edu, DRS**	**Edu, DRS**	**Gender, Edu, DRS**
Step 4: Gender, Ethnicity, Age, Edu, DRS Total, OC*	**Ethnicity, Edu, DRS, OC**	**DRS**	Gender, **DRS, OC**

Summary Table C1: Summary of Hierarchical Multiple Regression Analysis Using Full Information Maximum Likelihood Method Predicting WASI Vocab WASI MR, and WMS-LM I Score Performance with Occupational Complexity as the Independent Variable of Interest; † Entries in columns under Dependent Variables indicate that all independent variables in that cell contributed to the prediction of the dependent variable at that step. **Bold entries** indicate this variable was also a significant predictor at the same step in the analysis with the Heckman Correction; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest raw score; MR: Matrix Reasoning subtest raw score;; WMS-R LM I: Wechsler Memory Scale, Revised, Logical Memory I subtest; DRS: Dementia Rating Scale; Education: Years of formal education

	Dependent Variables †		
Independent Variables	**WASI Vocab** (n = 218)	**WASI MR** (n = 218)	**WMS-LM I** (n = 218)
Step 1: Gender, Ethnicity	**Ethnicity**	Ethnicity	**Gender**, Ethnicity
Step 2: Gender, Ethnicity, Age, Edu	**Ethnicity**, Age **Edu**	**Edu**	**Age, Edu**
Step 3: Gender, Ethnicity, Age, Edu, DRS Total,	**Ethnicity**, **Edu, DRS**	**Edu, DRS**	**Gender, Edu, DRS**
Step 4: Gender, Ethnicity, Age, Edu, DRS Total, WRAT-3	Edu, **DRS, WRAT-3**	**DRS, WRAT-3**	**Gender, Edu, DRS**

Summary Table C2: Summary of Hierarchical Multiple Regression Analysis Using Full Information Maximum Likelihood Method Predicting WASI Vocab WASI MR, and WMS-LM I Score Performance with WRAT-3 Reading Subtest raw score as the Independent Variable of Interest; † Entries in columns under Dependent Variables indicate that all independent variables in that cell contributed to the prediction of the dependent variable at that step. **Bold entries** indicate this variable was also a significant predictor at the same step in the analysis with the Heckman Correction; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest raw score; MR: Matrix Reasoning subtest raw score;; WMS-R LM I: Wechsler Memory Scale, Revised, Logical Memory I subtest; DRS: Dementia Rating Scale; Education: Years of formal education

Appendix D

Results using the Likelihood-Ratio Test of the Linear Hypothesis

The likelihood-ratio test of the linear hypothesis was run to test the full model (i.e., all variables included, including the variable of interest) against the reduced model (i.e., all variables except the variable of interest; Tabachnick & Fidell, 2007). The likelihood-ratio test was run to compare the fit of the full model and the reduced model.

When occupational complexity was the variable of interest, the results using the likelihood-ratio test of the linear hypothesis demonstrated that the fit of the models was significantly different for the WASI Vocab ($\chi 2 = 9.15$, $p < 0.05$) and WMS LM I subtests ($\chi 2 = 4.10$, $p < 0.05$).

When WRAT-3 raw score was the variable of interest, the results using the likelihood-ratio test of the linear hypothesis demonstrated that the fit of the models was significantly different for the WASI Vocab ($\chi 2 = 27.08$, $p < 0.01$), WASI MR (($\chi 2 = 9.12$, $p < 0.01$) and BNT subtests ($\chi 2 = 13.07$, $p < 0.01$).

Appendix E

Results of the Standard Hierarchical Multiple Regression Analyses

	Dependent Variables †		
Independent Variables	**WASI Vocab** (n = 162)	**WASI MR** (n = 161)	**WMS-LM I** (n = 203)
Step 1: Gender, Ethnicity	**Ethnicity**	Ethnicity	**Gender**, Ethnicity
Step 2: Gender, Ethnicity, Age, Edu	**Ethnicity,** Age, **Edu**	**Edu**	**Age, Edu**
Step 3: Gender, Ethnicity, Age, Edu, DRS Total	**Ethnicity, Edu, DRS**	**Edu, DRS**	**Gender, Edu, DRS**
Step 4: Gender, Ethnicity, Age, Edu, DRS Total, OC*	**Ethnicity, Edu, DRS, OC**	**DRS**	**DRS, OC**

Summary Table E1: Summary of Hierarchical Multiple Regression Analysis Predicting WASI Vocab WASI MR, and WMS-LM I Score Performance with Occupational Complexity as the Independent Variable of Interest; † Entries in columns under Dependent Variables indicate that all independent variables in that cell contributed to the prediction of the dependent variable at that step. **Bold entries** indicate this variable was also a significant predictor at the same step in the analysis with the Heckman Correction; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest raw score; MR: Matrix Reasoning subtest raw score; WMS-R LM I: Wechsler Memory Scale, Revised, Logical Memory I subtest; DRS: Dementia Rating Scale; Education: Years of formal education

	Dependent Variables †		
Independent Variables	**WASI Vocab** (n = 162)	**WASI MR** (n = 161)	**WMS-LM I** (n = 203)
Step 1: Gender, Ethnicity	**Ethnicity**	Ethnicity	**Gender,** Ethnicity
Step 2: Gender, Ethnicity, Age, Edu	**Ethnicity,** Age, **Edu**	**Edu**	**Age, Edu**
Step 3: Gender, Ethnicity, Age, Edu, DRS Total,	**Ethnicity, Edu, DRS**	**Edu, DRS**	**Gender, Edu, DRS**
Step 4: Gender, Ethnicity, Age, Edu, DRS Total, WRAT-3	**DRS, WRAT-3**	**DRS, WRAT-3**	**Gender, Edu, DRS**

Summary Table E2: Summary of Hierarchical Multiple Regression Analysis Predicting WASI Vocab WASI MR, and WMS-LM I Score Performance with WRAT-3 Reading Subtest raw score as the Independent Variable of Interest; † Entries in columns under Dependent Variables indicate that all independent variables in that cell contributed to the prediction of the dependent variable at that step. **Bold entries** indicate that this variable was also a significant predictor at the same step in the analysis with the Heckman Correction; WASI: Wechsler Abbreviated Scale of Intelligence; Vocab: Vocabulary subtest raw score; MR: Matrix Reasoning subtest raw score; WMS-R LM I: Wechsler Memory Scale, Revised, Logical Memory I subtest; DRS: Dementia Rating Scale; Education: Years of formal education

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