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The Relative Effects of Education and Cognitive Complexity of Employment Experience on the Rate of Cognitive Decline in Elderly Women

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THE RELATIVE EFFECTS OF EDUCATION AND COGNITIVE COMPLEXITY OF EMPLOYMENT EXPERIENCE ON THE RATE OF COGNITIVE DECLINE IN ELDERLY WOMEN

by

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ABSTRACT

The Relative Effects of Education and Cognitive Complexity of Employment Experiences on the Rate of Cognitive Decline in Elderly Women

by

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This thesis examined the lifetime exposure of women's employment on cognitive functioning and cognitive decline in late life.

From the Cache County Study on Memory, Health, & Aging data, a sample of 2,588 women, aged 65 and older gave retrospective occupational history and were screened using the Modified Mini-Mental State Exam at study entry and approximately 3 years later. Non-demented women were used.

Ordinary least squares regression was used cross-sectionally and longitudinally to test the association between cognitive complexity level of the longest job and baseline cognitive status, and rate of cognitive decline over approximately 3 years.

Cross-sectional analysis revealed never-employed homemakers to have cognitive status mid-range. Higher "data" complexity levels were significantly associated with higher cognitive status at baseline net of education.

The results suggest some benefit of cognitively stimulating occupation to late-life functioning for women. Further analyses with additional longitudinal cognitive testing in this population may enhance these findings.

(98 pages)

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Jan Lundahl

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CHAPTER I

INTRODUCTION

Overview

Advancements in medical science during the 20^{th} century have significantly increased the average lifespan of Americans. A Caucasian American born in 1900 was expected to live an average of 47 years; however, by the mid 1990s, the average life expectancy increased to approximately 75 years (National Center for Health Statistics, 1989; U.S. Bureau of the Census, 1992). In fact, those over 85 years old are the fastest growing segment of the United States population today (Selkoe, 1992). This includes a considerable number of women, because on average, women in the United States live longer than men (Christensen, 2001). Due to the aging of the post World War II baby boomers and continuing advancements in medical technology, in the decades to come, there will be a much greater proportion of the entire population who are elderly.

While improvements in medical research have increased length of life, they have not necessarily increased quality of life. With advanced age comes the likelihood of developing many types of diseases specifically related to aging. These diseases, such as diabetes, Parkinson's disease, macular degeneration, and hypertension, may result in disabilities, which restrict mobility, cause anxiety, and reduce quality of life for individuals and their families.

One of the most common changes within the range of normal aging is in cognitive functioning, which includes such dimensions as memory, verbal fluency, abstract reasoning, and spatial perception. Decrements have been reported in both short-term or working memory, and long-term memory in normal aging. However, the possibility of cognitive decline ranging from mild cognitive impairment to more severe cases of dementia, such as Alzheimer's disease (AD), increases with advanced age (Christensen, 2001; Smith & Baltes, 1999).

Association studies of cognition have identified risk and protective factors that influence the onset and rate of cognitive decline in late life. Risk factors may include genes, advancing age, and health status. Genetic factors are biological and not subject to intervention at the present time. The epsilon 4 (ε 4) allele of the apolipoprotein E (APOE) gene has been associated with increased risk for AD (Anstey & Christensen, 2000; Breitner et al., 1999); however, having this gene does not mean inevitable dementia. Obviously, as persons become older, they are more likely to develop medical conditions, which can affect their memory and cognitive functions. As a risk factor, health status includes medical conditions, but these conditions do not operate entirely autonomously. Medical conditions, in conjunction with the quantity of medications and the interactions of different medications, and differences between metabolic processing of medications between individuals, all become risk factors.

Observational studies have suggested that protective factors for rate of cognitive decline and onset of dementia may include greater educational attainment, activities promoting intellectual stimulation, and physical exercise. One area in which intellectual stimulation can occur over long periods of time is through employment. However, the relation between intellectual stimulation from complexity of occupation and subsequent cognitive status in late life has been the least studied (Bosma, van Boxtel, Ponds, Houx,

& Jolles, 2003; Mortel, Meyer, Herod, & Thornby, 1995). It has been suggested that higher education has a life-long protective influence on cognitive functioning, as it provides some cognitive reserve or reserve capacity (Stern et al., 1995). Cognitive reserve or reserve capacity suggests that, "aspects of life experience supply a set of skills or repertoires that allow an individual to cope for a longer time before the effects of the disease become clinically apparent" (Stern et al., p. 55). Cognitive reserve may also result from over-learned cognitive routines, aiding in the compensatory process. In this manner, the brain is "actively attempting to cope with and compensate for pathology" (Stern, 2002, p. 449). Stern also defines a passive model, in which the definition of reserve is the "amount of damage that can be sustained before reaching a threshold for clinical expression" (p. 449).

The reserve gained from higher education is thought to be an increase in neural density and synaptic connections in the brain, resulting from being in a stimulating learning environment. This higher density of connections may allow the brain to compensate for disruptions in neural pathways that accompany disease states (Stern, Albert, Tang, & Tsai, 1999), and counteract the negative factors such as strokes and head injury, associated with increased risk of cognitive decline.

While education may provide a compensatory effect for the onset and rate of cognitive decline associated with brain disease, the time spent attaining an education is relatively short when compared to other activities such as one's lifetime of occupational experiences. This is an aspect of a person's life in which intellectual stimulation can occur (or be absent) over long periods of time. Formal education beyond high school typically takes only 4 to10 years to complete, while paid employment can span several decades and may include the learning of many new skills. It follows that the time spent employed could also be of some benefit in this compensatory process, if the employment is stimulating and cognitively complex (Stern et al., 1995). Increased synaptic connections and neurons require a stimulating, enriched environment, which some occupational activities may provide. In addition, having a higher education often leads to more cognitively complex occupations. In studies demonstrating a strong association between education and cognitive status, the potential confound with occupation history has been consistently overlooked. The magnitude of potential protective effects of a cognitively stimulating work environment has been left virtually unstudied. The questions of the net additional benefit of cognitively complex work history (beyond formal education) and whether or not cognitively stimulating occupations can even offset low to moderate levels of formal education has been left unanswered. Similarly, women who never worked outside of the home but chose to be housewives are repeatedly excluded from studies of occupation since the work they do at home is not classified under any occupational category.

Though the relation between occupational cognitive complexity and old age cognitive status could be studied for both genders, the present work focused on women for three reasons. First, because of women's greater longevity and the higher risk of becoming severely cognitively impaired due to advanced age, they are the majority of institutional care residents, (i.e., assisted-living centers, and nursing homes) and thus contribute significantly to the overall public health burden (Wolinsky & Johnson, 1992).

Second, women historically have had limited work opportunities, thus possibly affecting their opportunity for acquiring cognitive reserve through intellectually stimulating employment. Additionally, senior women who do not have their own pensions or social security due to little or no paid employment and low wages, are placed in a disadvantaged position for financial resources, poverty, depression, and health problems if and when they lose their husbands. These women may place a greater demand on their families and society for support.

Historically, women typically have been relegated to the lower end of the scale regarding the cognitive complexity of occupations. Senior women of today were generally less educated than men, and job opportunities for women were correspondingly less cognitively challenging than those available to men. Pay rates for most women were relatively low, motivating many women to become homemakers, when they married. Married Caucasian women in the workplace were not unheard of especially during times such as the Great Depression and World War II, or when individual families may have had periods of financial difficulties, at which point wives went to work to supplement the family income in jobs of less cognitive complexity. Most senior women of today did not have the opportunity to compete with men for highly complex occupations (Banner, 1974; Blau, 1978; Grimm, 1978; Mintz & Kellogg, 1988). Consequently, the majority of employment experiences of women were in factory and service-oriented settings. Some women of this age cohort achieved higher educational levels, but when they did, attainable careers primarily included nursing and teaching (Banner), and much less frequently careers in engineering, medicine and law. Thus, an interesting question to ask

Fortunately, data necessary for such an investigation are available from the Cache County (Utah) Study on Memory, Health & Aging, also known as the Cache County Study.

Statement of Problem

This thesis discusses the work patterns of the women participants of the Cache County Study on Memory, Health, & Aging. It examines their cognitive function at the beginning of the study, and their rate of cognitive decline over an approximate 3-year period. The effect of occupational complexity on late life cognitive functioning will be tested alone and then controlled for age, health status, education, and APOE genotype. It is hypothesized that employment outside of the home and the level of cognitive complexity in an occupation may affect later life cognitive functioning and the rate of cognitive decline through cognitive reserve for senior women. Whereas most studies exclude housewives, this work uses the women who were never employed as a comparison group to those with differing levels of occupational complexity to determine the relative status of the never-employed women along the continuum of late-life cognitive functioning. Cognitive functioning of the never employed women, it is hypothesized, will be in the mid-range of functioning, due to the various activities involved in running a household. Household work can be extremely routine and non-stimulating, but can also be varied and stimulating as one uses independent judgment on the tasks to be done. It has been found that having a choice in what one does and when, may make routine tasks more stimulating (Schooler, Kohn, Miller, & Miller, 1983). In addition, answering a myriad of questions from young children, keeping them occupied, and planning and organizing schedules and activities may relieve some of the routine and be stimulating. In addition, never employed women may take opportunities for personal study on many topics of interest, and do volunteer work and community service, which can be stimulating.

Summary

Proportionately, the elderly population in the United States is growing and will continue to do so as the baby boomer generation reaches late life. Medical advances have resulted in an increased average lifespan but this does not equate to a sustained high quality of life for everyone. Unfortunately, disease, disabilities, and impairment may become a way of life for many elderly, especially those living to an advanced age. One of the greatest public health concerns for the older population is cognitive decline and cognitive diseases such as Alzheimer's disease. Risk factors, such as genetics and environmental exposures have been identified, which increase the likelihood of cognitive decline. Protective factors, such as education and occupation, have also been identified and may provide reserve capacity in the brain. Today's elderly women had fewer opportunities for higher education and cognitively complex employment and had a more sporadic employment history than men. Women also typically live longer than men, have fewer resources for their advanced years and are the majority of residents in nursing homes. Learning from the lives of previous generations of women can assist future generations of women as they travel along their life course.

The potential protective benefit of lifelong career choices on old age cognitive status has been neglected in the literature. What is needed to increase understanding of this relationship is a large, population-based study of elderly individuals in which both cognitive status and lifelong occupational history were well characterized. It would be important to study this relationship in both a cross-sectional and longitudinal design. The cross-sectional design illustrates the cognitive status of those 65 and over at a specific moment in time. This information provides an overall look at the immediate cognitive functioning of these elderly individuals. The longitudinal design can then reveal cognitive change (or lack of change) over a period of time. Fortunately, a dataset exists that is well-suited to just such an investigation, the Cache County Study on Memory on Memory, Health & Aging, which is a population study of over 5,000 elderly adults, including over 2,800 women. With data from this study, the present thesis examined the relation between intellectual stimulation from lifelong career choices and old age cognitive status and decline.

CHAPTER II

REVIEW OF LITERATURE

Overview

This work investigated the effects of occupational complexity throughout the working years on cognitive decline in old age among women. The present chapter provides a theoretical framework followed by a literature review, which will address the constructs of cognitive functioning and decline – key outcomes in the present work. Next, a discussion of the risk factors for cognitive decline and protective effects as identified by prior scientific studies is given. This is followed by the description of occupational complexity as coded using the *Dictionary of Occupational Titles*. Lastly, the lifetime opportunities for educational attainment and cognitively complex occupations among today's elderly women are discussed. The coverage of these points in the literature review provides the foundation for posing the research questions listed at the end of the chapter.

Theoretical Framework

The life span developmental approach includes the study of change and consistency during the entire lifetime of individuals (Baltes, 1987). In regards to cognitive functioning, life span developmental theorists are interested in cognitive declines that take place as people grow older; yet this theory acknowledges that everyone does not age in exactly the same manner (Christensen, 2001; Smith & Baltes, 1999).

Focus is also directed toward the ability of older persons to learn new behaviors and tasks, and as they compensate for losses, such as motor skills (Smith & Baltes). According to Smith and Baltes, there are four objectives of the life-span approach, which are:

> (a) to provide a framework for understanding the overall structure and sequence of development across the life span; (b) to encourage research on the interconnections between earlier and later developmental events and processes; (c) to identify mechanisms that underlie life course (age) trajectories; and (d) to specify the biological and cultural factors that facilitate and constrain the life-span development and aging of individuals. (p. 48)

Development as a life long process is one of the concepts of the life-span developmental approach. Other concepts include multidirectionality, multidisciplinary exchanges, contextual factors, and plasticity (Baltes; Smith & Baltes).

According to lifespan theory, development does not cease with young adulthood but rather continues throughout one's life. Events and changes occurring along the life course influence "the direction and rate of human development" (Smith & Baltes, 1999, p. 50). For example, losing a parent at a young age would affect a child differently than if the loss occurred in a "natural order" after the parent had lived a long productive life and the child had grown to become an adult. While the loss would still be felt, the ramifications for the child are different. This leads into the concept of multidirectionality, meaning the timing or when an event occurs, direction the event takes in the person's life and order of events occurring in a person's life. Suppose again a parent dies. If the death occurred while the child was young, and the surviving parent had to leave the child with someone else on a temporary or permanent basis, the child may feel he/she had lost both parents. This certainly would influence the child's development differently than if the parent had not died or if the child had remained in a familiar environment. In conjunction with multidirectionality, exchanges or the interactions and relations of multiple systems (i.e., biological, emotional, psychological), called multidisciplinary exchanges are significant factors in the growth and decline of individuals, and occur not only across domains such as cognitive and social functioning, but also within domains such as long and short term memory functioning.

The context of one's life, meaning historical and cultural events, is also a factor to be taken into account. Living through economic depressions, world wars or times of prosperity will have an effect on the direction and order of events. For example, a young adult who lived during World War II did not have the same educational opportunities at the same age as a young adult who lived during a time of peace and prosperity. The timing at which these events occurred along an individual's developmental course (i.e., childhood, adolescence, adulthood), also impacts their development.

Plasticity involves the ability to learn new things, and/or compensate for losses in cognitive or physical functioning. In other words, this is the ability of the brain to develop a new way to complete a once-easy task. This concept is similar to a road that has been damaged (or a connection from a dendrite), in which a detour is routed so travelers can get to their destination, thus completing their task. Plasticity is the ability of the brain to "detour" around "damaged" connections to complete the task. It also involves the modification of strategies with practice and training throughout one's life. For example, a once-proficient pianist can modify playing techniques to compensate for a lack of flexibility in the hands. Neural plasticity or the ability to increase connections in brain cells, endures throughout the lifetime (Ball et al., 2002; Selkoe, 1992).

Given these many factors that influence lifelong human development, it becomes important to study potential lifelong influences on such critical areas of functioning as cognitive status.

Analysis of Literature

Cognitive Status

Persons with good cognitive functioning usually maintain autonomy and independent living as they age. In contrast, persons whose cognitive functioning is declining begin to depend on others for care and may eventually reside in a family member's home or in an institution. The capacity to pay bills appropriately, adhere to medical regimens including the proper dispensing of medication, the planning and carrying out of activities and displaying appropriate behaviors such as dressing, eating, bathing and toileting are all subject to adequate levels of cognitive functioning (Barberger-Gateau & Fabrigoule, 1997; Herzog & Wallace, 1997). Any decline or impairment in these activities of daily living may be cause for concern for the older person's safety and well-being. Additional cognitive abilities include time and space orientation, long-term memory, short-term memory, abstract reasoning, visuospatial perception, delayed recall, mental flexibility and expressive language (Norton et al., 1999). By testing an older person with tasks such as naming the current president, following instructions in completing tasks, or recalling the names of body parts, in addition to other batteries of tests, cognitive abilities can be assessed.

Cognitive status can range from "normal" to "severe impairment." Mild forms of cognitive impairment may include slight memory problems, such as being slow in recalling phone numbers and names, while moderate impairment involves difficulties in judgment, akin to taking medications more or less times than prescribed, yet these people still maintain the ability to function in their daily lives. Severe cognitive impairment, one form of which is dementia, involves loss of memory and loss of functioning in social or occupational settings (Barberger-Gateau & Fabrigoule, 1997). Dementia is a primary diagnosis for many residents in institutional care, with nearly 40% in France, 50% in Australia and New Zealand (Barberger-Gateau & Fabrigoule), and 60% in the United States. Women are the majority in care facilities, with three-fourths of 1.7 million nursing home residents being women (Wolinsky & Johnson, 1992). The prevalence of women in institutions creates a public health burden due to increased need for care and the likelihood of their limited resources, such as pensions, insurance, and finances.

It should be noted, however, that cognitive impairment in late life is not an eventuality (Christensen, 2001; Compton, Bachman, Brand, & Avet, 2000; Compton, Bachman, & Logan, 1997), although the probability increases with advanced years (Barberger-Gateau & Fabrigoule, 1997; Christensen; Herzog & Wallace, 1997).

Many elderly adults, including those of advanced years, remain cognitively active and lead independent lives with little impairment.

Cognitive Decline

The term "cognitive decline" refers to a decrease in the level of cognitive functioning over time. To determine whether any amount of decline is significant as assessed on cognitive measures, one must statistically consider the scale and variability of the cognitive test scores at different times and whether the amount of drop is of practical significance.

Risk Factors

Risk factors that may contribute to cognitive decline include low education, occupational exposures, cardio- and cerebrovascular health problems, advancing age, and genetics (Anstey & Christensen, 2000; Barberger-Gateau & Fabrigoule, 1997; Compton et al., 2000; Mortel et al., 1995). Low educational attainment has been reported as being a risk factor for cognitive decline due to factors influenced or simply correlated with education. These factors may have a direct or indirect effect, and include insufficient knowledge of good nutrition, inadequate health care, working conditions reflective of education levels that are routine, non-stimulating, and unhealthy from an environmental perspective (Anstey & Christensen; Jorm et al., 1998; Mortel et al.; Smyth et al., 2004). Low educational achievement does not seem to provide a reserve capacity as is experienced by those with a higher education (Anstey & Christensen; Bosma et al., 2003; Mortel et al.) because of a possible lack of stimulating experiences.

Occupational risk factors may include working with and exposure to toxic substances, and physically demanding labor (Barberger-Gateau & Fabrigoule, 1997), which may directly or indirectly affect cognitive functioning beyond that associated with educational attainment. Barberger-Gateau and Fabrigoule found those who had worked in blue-collar professions, domestic service workers, and farmers had a higher risk of cognitive impairment after age 65. Similar findings were reported from a French study of 3,777 randomly selected participants 65 and over, who were retested longitudinally. In this study, the eight categories listed were housewives, farmers, farm managers, domestic service, blue-collar workers, craftsman/shopkeepers, other employee such as white-collar workers, and intellectual occupations such as professionals, teachers, high-level executives, and managers. Farmers and domestic service categories were combined because of similar scores and they became the reference group. The job of longest duration was coded. Tests included functional assessment, depression and neuropsychological evaluation (Le Carret et al., 2003).

Smyth et al. (2004) also found that those with low occupational demands and high physical demands from employment had a higher incidence of dementia, in which 122 cases were identified with 235 non-cases. These participants were given neuropsychological, neurological and lab analyses. The four longest held occupations were coded using US Census categories but matched with DOT codes. These participants were over 60, enrolled from a clinical setting (AD research registry) and the community for a case/control study. They were asked about their employment by decade, i.e., what job they held between 20-29, 30-39, 40-49, and 50-59 years of age, and their most important activity or duty. If unable to answer due to dementia, a proxy was asked.

Health issues as risk factors may include the potential effect on cognitive functioning of polypharmacy, or drug interactions of multiple medications taken to treat various health conditions (Anstey & Christensen, 2000), such as hypertension and depression. Also, it is known that as persons age, their bodies may become sensitive to certain drugs, including sedatives "and many other depressants and stimulants of the central nervous system" (Selkoe, 1992, p. 140). In conjunction with cognitive functioning decline, the drugs remaining in the body longer and the sensitively to dosage have been identified as concerns for those over 60 when compared to young adults (Selkoe). Other issues include strokes, diabetes, or head injuries, all of which may influence cognition (Mortel et al., 1995; Selkoe). Other diseases have the potential to cause dementia, such as Parkinson's disease, but practices of poor nutrition and alcoholism may also become risk factors for cognition problems (Lyketsos et al., 2002).

In addition, there is also the biological process of aging. Selkoe (1992) found that cells in the limbic system dealing with learning, memory and emotions, disappear as one ages. All the cells themselves may not die, but the message carriers, axons and dendrites, may atrophy (Selkoe, 1992). This occurs each decade during the later years (Dufouil, Alperovitch, & Tzourio, 2003). Thus, advancing age increases the risk of dementia from 2 per 1000 in subjects 65-69 years old to 74 per 1000 in subjects older than 90 years (Barberger-Gateau & Fabrigoule, 1997).

One gene identified as associated with dementia of the Alzheimer's type is the APOE gene. This gene has three alleles, epsilon 2, 3 and 4 (Meyer et al., 1998). The epsilon 4 (ε4) allele has been associated with the highest risk of developing AD (Anstey

& Christensen, 2000; Breitner et al., 1999). The actual mechanism by which the APOE ε4 allele affects cognitive status has yet to be determined; however, those with the genotype are at greater risk of developing problems with cognitive abilities. The "APOE ε4 may be associated with increased deposition of amyloid plaques, which are distinct indicators of Alzheimer's disease, or the increased loss of cholinergic neurons in the brain" (Anstey & Christensen, p. 175), which is also a feature of AD.

Protective Factors

Education. Higher education has been reported as being protective against early onset cognitive decline. Early onset cognitive decline would be those who express memory problems at a younger age than the average, say someone in their 50s or early 60s. Capitani, Barbarotto, and Laiacona (1996) found that those with a low educational attainment attained lower cognitive test scores. In this cross-sectional study of age-related decline, 307 volunteer participants were classified into age groups and their educational attainment was dichotomized into "low" or "high." The mean of low education for the 56-70 year olds was 5.41 years; the mean for the 71-85 year olds was 4.78 years. For high education the means were 13.62 and 13.07 years, respectively. Five tests selected for their capacity to show a linear decline with age were analyzed. The domains assessed were (1) visual attention, (2) verbal fluency, (3) verbal memory, (4) spatial memory, and (5) spatial reasoning and problem solving. Linear regression analysis on all five cognitive tests revealed a significant inverse association between age group and cognitive test score. This association was stronger for those with low education, suggesting a potential protective effect of education on age-related cognitive decline. One limitation of this study was the use of two hundred ten volunteers from another research project with additional persons included to increase statistical power to test the age-by-education interaction. This method of recruitment may have produced a selection bias, as many of the participants were already in a research project, and the additional persons chosen were not randomly selected, but used to fill the cells where needed.

Compton et al. (2000) also report effects of education on cognitive functioning in their cross-sectional study. This study of 102 highly functioning participants (college professors and professionals in Atlanta, Georgia) was divided into four age groups (30-39, 40-49, 50-59, and 60 +) and tested for cognitive abilities. They found those with a higher education used compensation strategies not seen in those with a lower education level. Shimamura, Berry, Mangels, Rusting, and Jurica (1995), in their cross-sectional study of 72 college professors from Berkeley, California, found compensation strategies used by the senior professors (60-71 years old) even as they report age related differences (e.g. memory) between the young (30-44 years old), middle aged (45-59 years old) and senior professors. They maintain that a high level of mental activity compensates for age related or biological decline through the use of skills, knowledge, and expertise.

When a significant effect is found for age (or the interaction of age with other variables) in a cross-sectional study, it is still inconclusive as to whether the effect is actually due to advanced age or different birth cohorts. Rather, it suggests the merits of a longitudinal study to investigate actual decline over time.

Some studies (Christensen et al., 1997; Compton et al., 2000) have suggested that the protective nature of education may derive from a compensatory function during the aging process. Compensation is defined as having the ability or skill to figure out another way of doing things, such as using memory aids (i.e., writing lists), when the memory is declining. Stern (2002) postulated it is the ability to use "a brain network more efficiently, calling up alternate brain networks or cognitive strategies in response to increased demands" (p. 451).

Christensen et al. (1997) divided 1,135 participants into three levels of education: less than or equal to 9 years, 10-13 years, and greater than or equal to 14 years of education in this longitudinal study. These participants were 70 or more years of age and were sampled from the electoral roll in Canberra and Queanbeyan, Australia. The study was supplemented by inclusion of nursing home residents and additional recruitment of individuals 92 years and older to fill statistical cells. They report that tests indicating expertise and knowledge show a slower rate of change than those tests that reflect vocabulary and information regardless of educational level. Yet, those with a higher education scored higher on the logic and language tests.

Higher education may help to set a higher baseline level of cognitive functioning from which to decline, while those with lower educational attainment have a lower baseline level (Christensen et al., 2001) when the brain begins to deteriorate due to illness, injury, or the aging process. Overall, according to prior studies, there appears to be some protection of education on the rate of cognitive decline either through brain structure or strategies used (Compton et al., 1997; Herzog & Wallace, 1997).

The biases evident in a cross-sectional study compared to the richer data from a longitudinal study may explain the differences. A longitudinal study can reveal individual changes over time rather than the differences between age groups at a specific time.

Dufouil et al. (2003) reported results from a population-based, longitudinal study, where education modified the relationship between white matter lesions and cognition. Lower education attainment and severe white matter lesions were associated with low cognitive performance. They used two educational levels, "low" (less than 11 years), and "high" (11 or more years). The Mini-Mental State Examination, Trail Making Test part B, Digit Symbol Substitution Test, Raven Progressive Matrices, Word Fluency Test, and Finger Tapping Test were administered to assess cognitive function in the areas of attention, verbal fluency, logical intelligence, reasoning, and psychomotor speed. At the four-year follow-up, an MRI was performed and scaled using A = no lesions, B = mild, C = moderate, and D = severe lesions.

The occupation of longest duration was assessed at baseline and classified using the categories of farmers, domestic service employees, blue-collar workers, other employees, craftsmen and shopkeepers, professionals and managerial, and housewives. On the other hand, in a study conducted by Christensen et al. (2001) that included 887 participants followed over a 7-year period, a significant effect of education on rate of cognitive decline was not found, when controlling for age and health status.

The study of education as a protective effect is important, because it is a modifiable factor (unlike genetic heritability, at the present state of clinical practice), and readily. Formal education, as a stimulating environment, may increase one's neural pathways (Stern et al., 1995). As one learns and is stimulated by different subjects, the brain responds by making more connections between dendrites and axons (Selkoe, 1992). With the increased number of pathways, viable neurons manage the loss of older neurons (Selkoe). It is unclear whether this compensation is also relevant for those suffering cognitive decline due to head injuries or strokes.

When studying the compensation provided by a stimulating environment, it is useful to consider research with animal studies, as it illustrates the possible process in humans. The use of mice allows the researcher to investigate brain cells in ways that would not be feasible with living humans. In studies in which mice were moved to a stimulating or enriched environment from standard cages, they were shown to have an increase in new neurons compared to those left in standard cages (Kemperman, Kuhn, & Gage, 1997; van Praag, Kemperman, & Gage, 1999). Living in this enriched environment, which included more littermates (12 rather than 4), nesting materials, paper and plastic tubes, tunnels and a running wheel, had "a survival-promoting effect on the progeny of neuronal precursor cells in the hippocampus of mice and that these neurons add to an increased granule cell number and hippocampal volume in these animals" (Kemperman et al., p. 494). Can these results be generalized to humans?

Stern et al. (1995) reported a reserve capacity in the human brain from "increased synaptic density in the neocortical association cortex acquired on the basis of stimulation, or an acquired set of skills or repertoires" (p. 59) as they researched cerebral blood flow and Alzheimer's disease. Stern et al. hypothesizes that the stimulation results from education and equally as important, from cognitively complex occupations.

Occupation. The years involved in an occupation far outweigh the years spent obtaining a formal education for most individuals. Additionally, hands on training, new skills needed and the shared experience of co-workers add to the formal educational preparation for any profession. Thus, it may be hypothesized that the cognitive complexity of the occupation "may add to the effect of education" (Le Carret et al., 2003, p. 332) by increasing cognitive reserve, possibly by increasing neural pathways in the brain. This conclusion was reached as those in the French study with intellectual occupations such as professions, teachers, high-level executives and managers had a low incidence of dementia (Le Carret et al.). Additionally, Smyth et al. (2004) found those with higher mental demand and lower physical demand requirements in their occupations exhibited less cognitive decline.

In fact, it has been found that "these life activities, [complex occupations, and interpersonal skills] provide a reserve against the clinical expression of AD" (Stern et al., 1995, p. 58). Further, Stern et al. demonstrated that among AD cases, when patients with high occupational experience were matched with others at the same disease severity level but with low occupational experience, the disease was more advanced in the high occupation group. In other words, the high occupational group had more damage evident in the brain, but was functioning at a level comparable to those with less damage (Stern, 2002).

Stern et al. (1995) used employment of longest duration to place the participant in the high or low employment group, (the division of high/low is not reported) using the *Dictionary of Occupational Titles* codes (U. S. Department of Labor, 1991). Regional cerebral blood flow tests were used to express the severity of AD for each participant. Those with high occupational experiences "had greater deficits of parietal blood flow, suggesting that the underlying disease process was more advanced" (Stern et al., p. 58). This suggests the AD pathology was not expressed as early in the progression of the disease, but when the disease was more advanced. This invokes the concept of cognitive reserve and complex compensation abilities of those with higher occupational experiences. By controlling for education, because those with a higher education have the opportunity for more complex occupations, Stern et al. reported a contribution of occupation above that provided by education alone regarding reserve capacity.

Stern et al. (1999) dichotomized occupation in low and high categories using the job of longest duration in a study of Alzheimer's disease patients. In this study, they used the United States census categories of: "student, housewife, unskilled/semiskilled, skilled trade or craft, clerical/office worker, manager business/government, and professional/technical" (p. 1943), with the exception that those who were classified as housewife only were not used in their analysis. These categories were then grouped into low (unskilled/semiskilled, skilled trade or craft, and clerical/office worker) and high (manager business/government and professional/technical) occupations. Education was also dichotomized into low (≤ 8 years) or high (> 8 years). They reported that those persons in the high education and employment categories had longer maintenance followed by more rapid decline in shorter periods of time (Stern et al.). In other words, those with higher education did not manifest the disease until later in its progression, but when it became manifest, they declined rapidly. From this data, they hypothesized that cognitive reserve helped to maintain functioning for longer periods of time, before the disease was expressed (Stern et al.). Thus, patients suffered from the severity of the disease for a shorter time. They conclude the "active" compensation strategies or the integration of knowledge and behaviors used by people as they are faced with cognitive difficulties and decline are more likely to be used, rather than the "passive" model of how much of the brain is affected and lost before the disease is manifest.

Dufouil et al. (2003) included occupation with education in their longitudinal study of white matter lesions and cognition. Occupation was used, with the longest duration job being classified. Their categories were farmers, domestic service employees, blue-collar workers, other employees, craftsman and shopkeepers, professionals and managerial, and housewives. Occupation was not associated with cognition and the severity of white matter lesions.

Jorm et al. (1998) used men in their longitudinal study of occupation and cognitive decline. Occupational classifications developed by Holland were used to classify the participants' main job. These classifications are "realistic" (skilled trades, technical, some service), "investigative" (scientific and some technical), "artistic" (artistic, musical and literary), "social" (educational, social welfare), "enterprising" (managerial and sales), and "conventional" (office and clerical). They found that those in the "realistic" occupations had lower cognitive performance and a higher prevalence of dementia than all other classifications when analyzed cross-sectionally. Those in the "realistic" category had the lowest educational level and lower rates of fluent English speakers than the other categories. However, three and a half years later, no differences in cognitive decline were noted relative to occupation.

Rogers, Meyer, and Mortel's (1990) longitudinal study suggests that mentally and physically active individuals of retirement age (mean age 64 years) had fewer declines in cerebral perfusion and cognition than those who became inactive at retirement. These 53 men and 30 women were divided into three groups; (1) retirement age but working (17 men, 10 women), (2) retired – high activity (19 men, 9 women), and (3) retired – low activity (17 men, 11 women). Activity levels were assessed by an in-depth interview regarding their activities (e.g., biking, walking, dancing, housework, and gardening) and the hours spent doing each activity. Cerebral blood flow values were evaluated by means of 133 Xe (Xenon) inhalant tests. During each annual visit the participant inhaled the mixture for one minute and the isotope was then measured during the ten-minute desaturation interval. Group three, individuals who had retired with low activity, showed significant decrease over the four years in cerebral blood flow that may raise their risk of possible cognitive impairment. Conclusions were that maintaining a stimulating, active environment is necessary as it activates the brain, thus increasing the likelihood of more neurons and synaptic connections (Rogers et al.).

Researchers have found that when a group of participants were asked about certain activities they performed at different ages across the lifespan, a stimulating environment, whether physically or cognitively stimulating, is a necessary ingredient for the building up of cognitive reserve and the possible protection it provides in later life (Wilson, Barnes, & Bennett, 2003; Wilson et al., 2002). A questionnaire was given to 164 participants, 60 years and older, asking about lifetime participation in normal cognitive activities at ages 6, 12, 18, 40 and current age. Their response was rated on a 5-point scale ranging from once a year or less to every day or about every day. Cognitive function was assessed using episodic memory, semantic memory, working memory, perceptual speed and visuospatial ability tests. Education was included and was related to episodic and semantic memory and visuospatial ability (Wilson et al., 2003). Cognitive activities over the lifetime were related to visuospatial ability, semantic memory and perceptual speed, but not the other memory domains of episodic or working memory (Wilson et al., 2003). Activities included reading newspapers, magazines, books, writing letters, and playing games.

Andel et al. (2005) used the DOT complexity codes of dealing with "data," "people" and "things" in their Swedish Twins Study (HARMONY). This study was a case-control and cotwin-control study of 10,079 participants, of whom 52% were women, and 65 or older in 1998 from a registry of twins that began in the 1960s. The participants were screened using a telephone interview beginning in 1998. They used education levels of basic (6-7 years) versus more than basic. Occupation was coded using the major occupation ("What kind of occupation did you have during the major part of your working life?") and compared from the 1980 Swedish Census to the U.S. Census categories. They found those of advanced age, female gender and those with a lower education as having an increased risk for dementia. The data were analyzed two ways, as case control and again with cotwin control. They concluded "that complexity of work, and particularly complex work with people, can influence the risk of dementia and AD later in life . . ." (Andel et al., p. P257) or decrease the risk of dementia.

Women's Employment Patterns

The references used in this section correspond to the employment time frame of today's senior women, as they cite the experiences of women in the workplace up to and including this cohort's employment. According to the lifespan development theory, the history and context of these women's lives had an impact on their development, so it is important to have a general idea of the context in which they lived.

To a large extent, historical social norms in the United States designated acceptable occupations for men and women (Banner, 1974; Blau, 1978; Grimm, 1978). Men were typically able to achieve a higher education that led to cognitively complex employment. Women, on the other hand, did not attain as high an educational level, which consequently led to less cognitively complex employment, if they worked outside of the home at all after marriage (Banner; Blau; Grimm; Mintz & Kellogg, 1988).

Senior women in the United States today represent a group that has historically seen a limited variety of opportunities for education and paid employment outside of the home. This has been especially true for minority women, but also for Caucasian women. Women born prior to 1930 came of age at a time when single earner households were the expected practice as well as the mother staying home after the birth of her children.

However, paid work was not unheard of for the unmarried woman; in fact it was even encouraged by society as a precursor to becoming a wife and mother (Grimm, 1978).

An unmarried young lady of the early to middle 20^{th} century was able to work in occupations that were deemed appropriate for her by societal norms, such as librarian, schoolteacher, social worker, or nurse (Grimm, 1978). These jobs required the skills traditionally associated with women, such as "patience, waiting, and routine; rapid use of hands and fingers; few or no strenuous physical activities; a welfare or cultural orientation; contact with young children; and sex appeal" (Rosenthal, 1978, p. 243). When women were called upon to work outside of the home, such as during World War II, they were often fired or laid off from traditional male dominated jobs after the crisis, so military men could return to their jobs (Banner, 1974). The increase of women in the workforce is indicated by the rise in the proportion of women working outside of the home, which rose from 25% in 1940, to 36% in 1945 (Banner). However, in 1947 at war's end, the participation of women decreased to 28% (Banner). Those who found a niche in working outside the home were left with choices of returning to female dominated occupations or going home. In 1950 when the senior women of today were 20 years and older, 29% of all workers were women, with nursing dominated by women (98%), but only 6.1% of doctors were women (Banner). The 1960 figures show an increase to 33% of all workers being women, with women filling 97% of nurse positions and 6.8% of doctor positions (Banner). In 1970, the percentage of women in the work force increased to 40% (Banner); at this time, the senior women of today would have been 40 years and older. Regardless of the increase of women in the work force, the senior women of today mostly were relegated to occupations with less stimulation and cognitive complexity during their working years.

Twenty-one percent of women in 1940 were in clerical positions with an increase to 26% in 1950 and 31% in 1962 (Banner, 1974). The manufacturing industry supported 1% of working women, and managerial positions were held by a constant 5% during those same years (Banner). Nursing and educational professions made up the majority of women's employment during those years. In 1973, women of this cohort aged 43 and older remained in female-dominated fields. Eighty-two percent of librarians, 98% of nurses, 61% of social workers, and 70% of elementary and secondary school teachers were women (Grimm, 1978), as compared to only 7% of doctors, and 3% of lawyers (Patterson & Engelberg, 1978).

Historical societal practices of considering women unfit for certain careers stymied their educational opportunities and a cognitively complex professional career by refusing women admission into specialized schools. In fact, the first woman was accepted by Harvard University for medical training in 1945. Jefferson Medical College was the last holdout, not allowing women to enroll until 1960 (Patterson & Engelberg, 1978). The startling admission policies of law schools are similar to medical schools in that Harvard Law School did not allow women to enroll until 1950. Neither Notre Dame University, nor Washington and Lee University had admitted a woman into their schools by the fall of 1969 (Patterson & Engelberg) at a time when this cohort of women were 39 years and older. Even after these dates of admission, women who finished and gained employment were encouraged to specialize in family and children oriented fields, such as pediatrics or women's and adolescent's legal problems (Patterson & Engelberg).

The cognitively complex educational and occupational opportunities available to women born in the early part of the 20th century have been minimal. For many of these women, single or married, they worked because the family needed their income, however minimal the wages (Mintz & Kellogg, 1988). These women are now our senior citizens with a life span exceeding that of men by approximately seven years (National Center for Health Statistics, 1989; U.S. Bureau of the Census, 1992). Living longer, but without the benefits of a cognitively complex educational and occupational environment, women may be at higher risk than men of this generation of developing cognitive impairment due to age, illness, and injury.

Occupational Complexity

In many studies, census occupational categories were used as a measure of occupational complexity and are a nominal grouping of occupations into discrete categories, with some categories presumed to have associated complexity at higher levels than others. A more sophisticated method is found in the *Dictionary of Occupational Titles* (*DOT*; U. S. Department of Labor, 1991) that uses a nine-digit code to classify job aptitude and performance. The first three digits state the occupational group (i.e., **160** 162018, is an accountant in the professional, technical and managerial category). The next three digits represent the worker functions relating to dealing with data, people and things (i.e., 160 **162** 018, an accountant coordinates data, speaks or signals people, and operates and controls things). The last three digits serve to differentiate a particular occupation from all others (i.e., 160162 **018** is a specified accountant, but not a tax, budget, or cost accountant which have different digits). With this system, no two jobs will have exactly the same code. The fourth (complexity of dealing with data), fifth (complexity of dealing with people) and sixth (complexity of dealing with things) digits each have their own range of values. The "complexity of dealing with data" scale ranges from 0 to 6, with zero representing high complexity. This means that an occupation with a zero as the fourth digit would be integrating data, while a six, as the fourth digit would be simply comparing data. On the "complexity of dealing with people" scale, the range is from 0 to 8, with zero representing high complexity, (i.e., mentoring) and eight as the fifth digit represents taking instruction/helping. For the "complexity of dealing with things" scale, the range is from 0 to 7, with zero as the sixth digit representing someone who sets up machines to a seven as the sixth digit being someone who handles materials. Cognitive complexity can be ordered in a hierarchy as done by Gottfredson (1986) in her clustering of occupations for aptitude mapping using the *DOT* coding system. As examples, a high level of cognitive complexity would be seen in professional employment such as chemist, physician, or engineer as opposed to a lower level of cognitive complexity employment of stewardess (term used to depict the culture of the times), nurse's aide or baker's helper (Gottfredson). From a historical perspective, these occupations were considered somewhat gender specific; men were primarily the chemists and physicians while women were primarily the teachers, secretaries and nurses. Thus, because of differing patterns of employment throughout the post-industrial history in the

United States, men and women did not have equal access to various levels of cognitive complexity (Mintz & Kellogg, 1988).

Research Questions

With the public health importance of understanding factors that affect better cognitive functioning into late life, the potential protective benefits of cognitively complex occupations, and the restricted employment opportunities of today's senior women, it is apparent that an investigation into these potential protective effects is timely. To this end, this thesis examined the following research questions in a community sample of elderly women who were diagnosed as non-demented at the baseline interview:

1. How does the cognitive status of women in late life compare for women who never experienced paid employment and women whose primary occupation was either professional/technical/managerial; clerical/ sales; service; agriculture; or machine/miscellaneous? (to be tested alone and then controlling for confounding effects of age, number of health problems, current health status, education and APOE genotype)
2. Among women who experienced paid employment, what is the nature of the relation between the magnitude of cognitive complexity (with "data," "people," and "things") experienced in the workplace and cognitive status in later life? (to be tested alone and then controlling for confounding effects of age, number of health problems, current health status, education and APOE genotype)

3. How does the rate of cognitive decline of women in late life compare for women who never experienced paid employment and women whose primary occupation was either professional/technical/managerial; clerical/ sales; service; agriculture; or machine/miscellaneous? (to be tested alone and then controlling for confounding effects of age, number of health problems, current health status, education and APOE genotype)
4. Among women who experienced paid employment, what is the nature of the relation between the magnitude of cognitive complexity (with "data," "people," and "things") experienced in the workplace and rate of cognitive decline in later life? (to be tested alone and then controlling for confounding effects of age, number of health problems, current health status, education and APOE genotype)

Research questions 1 and 2 were tested using the entire sample of non-demented women at the baseline interview. Research questions 3 and 4 were tested using the entire sample of women diagnosed as non-demented at the baseline interview who also participated at the wave 2 interview. Finally, research questions 3 and 4 were retested, excluding those who became demented during the interval between the baseline and wave 2 interview. The purpose of excluding the incident demented in the re-analysis was to determine if the effect of occupational complexity on cognitive decline was primarily among the incident demented or was more universal.

Summary

Using the lifespan developmental approach to living and learning, one can appreciate the importance of being in a stimulating environment whether through education, employment, or other activities. The protection it offers in increased neuronal connections may influence cognitive functioning throughout one's life. Cognitive impairment and decline are more likely to occur in later life, which affects a large number of women who are living to an advanced age. Older age, the APOE gene, health problems, and low educational attainment are considered risk factors. Higher education and more complex occupational status are potential protective factors. Continuing research focuses on the importance of education to provide a stimulating environment, thus increasing the reserve capacity of the brain.

Occupational complexity may also provide some additional reserve capacity, but the occupational opportunities of today's senior women were limited during their lifetime. With the sporadic employment patterns of today's senior women, their limited occupational complexity including large numbers of lifelong homemakers, we have an opportunity to examine the effect of women's occupational history on their cognitive functioning, cognitive decline and reserve capacity.

CHAPTER III

METHODS

Overview

This chapter gives the background of the population study from which the secondary analyses of data were conducted to address the research questions. An overall description of the study, including subjects and methodology is given, followed by a description of the variables used for this analysis. Finally, the present chapter discusses the statistical analysis used for completion of this project.

Participants

The Cache County Study on Memory in Aging, newly renamed The Cache County Study on Memory, Health, and Aging (CCSMHA), is an ongoing longitudinal population study of the genetic and environmental factors related to cognitive function in old age. Eligible participants' names were provided by the Health Care Financing Administration and included permanent residents of Cache County, Utah aged 65 years and older as of January 1, 1995. The National Institute on Aging provided funding for this study (NIA AG 11-380), with supplemental funding provided by the National Institute on Environmental and Health Sciences. The CCSMHA study achieved a participation rate of 90% (Breitner et al., 1999). Five thousand ninety-two permanent residents, of whom 717 were 85 years and older (Steffens et al., 2000), were enrolled in this study.

Study Design

The CCSMHA study included two waves of assessment for dementia. Wave 1 began in 1995 with 5,677 eligible participants of both genders. There were 3,429 eligible women; of those, 305 refused to participate, 121 died before testing began, 74 were classified as "other" for reasons of non-participation and included those who had either permanently moved out of the area, were temporarily out of the area or were otherwise unreachable (e.g. only address available was a P.O. Box number and the person did not contact the study to provide a residential address and phone number). Thus, the initial baseline sample consisted of 2,929 women. Those whose information came from a proxy (n = 240), and those who were diagnosed as demented at baseline (n = 90), were eliminated from this sample of women. The data would be questionable from those who were diagnosed as demented at baseline and the proxy informant knowledge may have been problematic and incomplete, as the proxy may not have known the information asked, not known the participant very long, or had limited contact with the participant over the entire lifetime. Proxies included family members, friends, and/or associates who had known the participant for a number of years, where possible. For these reasons, they are eliminated from this analysis. These remaining 2,599 women participated in the interview, but 11 of these had incomplete interviews, for a total sample in this thesis project of 2,588 women.

A multi-stage dementia ascertainment protocol was followed to identity prevalent cases of dementia (Breitner et al., 1999). This included an initial cognitive screening test, the Modified Mini-Mental State Exam (3MS-R; Tschanz et al., 2002) or Jorm's Informant Questionnaire on Cognitive decline in the Elderly (IQCODE; Jorm, 1994). The latter test was used for those who were either untestable on the 3MS-R or whose total score was below 60 out of 100 or whose orientation sub-score was below 15 out of 20, (suggesting a need for proxy interview). Those who screened positive for possible dementia were given the dementia questionnaire (DQ; Gallo & Breitner, 1995), a telephone semi-structured interview with a proxy informant to elucidate history of change in cognitive abilities. Those with a DQ rating of either moderate or severe dementia (rating of 4 or 5 on a 5-point scale) were then given an in-depth clinical assessment, including a battery of neuropsychological tests, a brief neurological exam and a detailed clinical history obtained from a collateral informant. A randomly selected subsample was selected to complete all three stages, regardless of cognitive status, which yielded a few additional dementia cases from among the false negative screening results. Clinicians who were blinded to APOE and designated control status assigned a research diagnosis, which was later consensed at expert panel review. For the purposes of this study, diagnoses were dichotomized as demented or non-demented, with those diagnosed as demented at baseline eliminated from all analyses.

At the baseline interview, where the initial screening for cognitive functioning occurred, a risk factor interview was also administered. The baseline risk factor interview included demographic information, medical history, current and prior medication use, occupational history, including exposure to toxic materials, activities of daily living, family history of memory problems, and lifestyle practices such as smoking and alcohol use. Variables collected in the risk factor interview utilized in the present study include educational attainment, occupational history, age, and health status. In addition, buccal scrapings were taken for DNA testing from 96% of the women. A cytology brush was used on the inside lining of the cheek to collect a DNA sample. From these buccal scrapings, following the method of Richards et al. (1993), APOE genotype was determined using PCR (polymerase chain reaction) amplification and a restriction isotyping method described by Saunders et al. (1993).

Approximately three years after the baseline interview, the surviving cohort deemed to be non-demented at wave 1 were reinterviewed with a similar protocol, that is, the 3MS-R was repeated, and interval risk factor information was collected for 1,930 women. This number reflects a drop from the 2,588 women in the cross-sectional sample due to 228 deceased women, 218 who refused further participation, 98 who had moved from the area, and 123 for various "other" non-participation reasons including a temporary move from the area, or not being able to locate them with the information at hand, i.e., incorrect phone number, P.O. Box number rather than a residential address. Within the 1,930 participants, 119 were identified as incident demented, meaning they were now diagnosed with possible or probable dementia, developed over the 3-year interval since baseline. Also, 54 participants were missing one or more independent variables for a final longitudinal sample of 1,876. The key independent variables in the present study, namely education and occupational history, were not recollected at wave 2, so any additional formal education or employment experience was not recorded

In summary, the sample for cross-sectional analysis consists of 2,588 women while the longitudinal sample consists of women who also participated at the 3 year follow-up and completed the 3MS-R at both interviews, totaling 1,876 women.

Measurement

Cognitive Status

Cognitive status was measured using the 3MS-R (Tschanz et al., 2002), whose score reflects the cognitive ability of the participant on the day of testing. This is a 100-point test covering the domains of memory (long- and short-term), mental flexibility, orientation to time and place, language expression and comprehension, abstract reasoning, visuospatial conceptualization, and following commands (Norton et al., 1999).

In order to remove the confound of sensory impairment, each score was adjusted for the number of points the participant could not attempt due to said sensory impairments (e.g., visual, auditory). The number of points earned, divided by the number of points attempted, was multiplied by 100 to compute the sensory adjusted score. This cross-sectional analysis is an effort to characterize any effect of occupational complexity on old age cognitive status (i.e., amount of cognitive ability), after adjustment for sensory impairments.

Cognitive Decline

Those who participated in both the baseline and wave 2 interviews have two scores on the 3MS-R (Tschanz et al., 2002). The time interval between the two cognitive tests was approximately 3 years (range 1.9 to 4.5 years). To reduce measurement error, three versions of the 3MS-R (Tschanz et al.) were used at both interviews, corresponding to three different sets of words for the word recall portion of the test. This was done to minimize "contamination" of participants' scores from having been told by others who completed the test before them, what the three words actually were on the test. Further, having different versions of the test permitted study protocol to assign to each participant a different version of the test at baseline and wave 2 interviews. Rate of cognitive decline was computed for each participant by subtracting wave 2 3MS-R score from wave 1 3MS-R score, and dividing by the time interval in years between interviews. This was done to standardize the cognitive decline measure among the entire sample, whose interval between waves varied due to field logistics. Longitudinal analyses examined the effect of occupational complexity on the rate of cognitive decline.

Occupational Complexity

Questions asked in the occupation section of the interview included the reporting of any paid employment with an answer to the question, "Have you ever held a job to support yourself or your family?" Three questions were then asked about each job, namely, the job title, the industry, and the tasks and skills involved. A total of 2,204 women reported paid employment, while 395 women indicated that they had never been employed. An occupational health nurse (MS level) interpreted these three descriptors and made a determination as to the appropriate job code using the *Dictionary of Occupational Titles* (DOT; U. S. Department of Labor, 1991). These occupations were classified according to occupation group, with the complexity of dealing with data, people and things indicated by the fourth (data), fifth (people) and sixth (things) digits of the nine-digit code. "Data" indicates observing, investigating, interpreting, visualizing, and mentally creating information, knowledge and conceptions (Kohn & Schooler, 1983). "People" indicates mentoring, supervising, instructing, negotiating and persuading (Kohn & Schooler). The "things" category indicates handling materials, tending machinery, operating, and setting up machines (Kohn & Schooler). *DOT* (U. S. Department of Labor) coding of "data" complexity ranges from 0 to 6 levels with zero indicating high complexity. "People" complexity ranges from 0 to 8, with zero indicating high complexity. "Things" complexity range is from 0 to 7, with zero indicating high complexity. These ranges have been reverse coded and the quantity "1" added to each code, so that increasing complexity is indicated by higher values, and starts with the value "1" to reflect the lowest level of complexity.

The key independent variable in these analyses, occupational complexity, was operationalized in two ways. To address Research Questions 1 and 3, the job of longest duration was categorized according to the *Dictionary of Occupational Titles* (U. S. Department of Labor, 1991) into nominal categories of (1) professional, technical, managerial; (2) clerical and sales; (3) service; (4) agricultural; (5) processing; (6) machine trades; (7) benchwork; (8) structural work, and (9) miscellaneous. A tenth category was added for women never employed outside of the home. Due to the similar nature of physical labor while working with tools, and the small number of women who were employed in the processing (n = 57), machine trades (n = 8), benchwork (n = 118), structural work ($n = 12$), and miscellaneous ($n = 35$), these categories were collapsed together into machine/miscellaneous, thus leaving six categories of (1) professional, technical, managerial; (2) clerical and sales; (3) service; (4) agricultural; (5) machine/miscellaneous and (6) never employed.

To address Research Questions 2 and 4, complexity scores of the two jobs of longest duration were averaged within each complexity dimension, yielding three composite complexity variables, one each for data, people, and things.

Within each of the three complexity domains, the complexity code for the two jobs of longest duration, were averaged to compute the composite complexity variable. This was felt to be a reasonable compromise between ignoring all but the longest held job (though this is common practice, it was felt that it would be discarding too much data), and averaging over all jobs held (which would have weighted jobs of much shorter duration as heavily as jobs lasting for decades).

Control Variables

Questions about health problems were included in baseline and wave 2 interviews. The baseline questions asked about lifetime problems up to the interview, while the wave 2 questions asked about new medical events or diagnoses in the approximate 3-year interval since the baseline interview. Specific health problems queried at both interviews were strokes, heart attacks, head injury, seizures, diabetes, Parkinson's disease and hypertension. When participants gave an affirmative answer, they were further asked if medical personnel had confirmed the health problem. Only if medical personnel had documented the health problem was it used in this analysis. These specific health problems have putative relationships with cognitive assessment. Health status at each interview was computed as the number of health problems endorsed at these two interviews. This created two variables, (1) lifetime health status to baseline, and (2) interval health status. Each variable ranged from 0 - 7. An additional health status measure was the question "How are you feeling today?" This variable was coded 1 = excellent, 2 = good, 3 = fair, and 4 = poor.

Education was recorded as the number of years of formal education completed. Age was recorded in years as of the baseline interview.

Genetic Factor

Apolipoprotein E (APOE) genotype was determined from buccal scrapings. Of the three alleles on APOE, ε2, ε3 and ε4, the ε4 allele is most significantly associated with the risk of Alzheimer's disease (Breitner et al., 1999). Ninety-five percent of the 5092 participants provided DNA samples and were genotyped. Of the entire sample of women, those genotyped totaled 96%. The ε4 allele may be present in combinations of ε2/ε4, ε3/ε4 or ε4/ε4. The presence of any ε4 allele is the genotype variable used in this study, i.e., the six possible genotypes were dichotomized into "ε4 present" (ε2/ε4, ε3/ε4, ε4/ε4) and "ε4 absent" (ε2/ε2, ε2/ε3, ε3/ε3). Homozygosity (ε4/ε4) could not be examined separately due to small numbers.

Statistical Analysis

By using SPSS version 11, a cross-sectional analysis and a longitudinal analysis were completed using the 3MS-R sensory adjusted score (referred to hereafter as simply 3MS-R) as the dependent variable. The two main independent variables were (1) categorical job of longest duration, and (2) the average level of complexity from the two jobs of longest duration for the three domains (data, people, and things). Within these analyses, ordinary least squares regression was used to test for the relation between occupational complexity and (1) cognitive status (cross-sectional) and (2) cognitive decline (change score derived from subtraction of wave 2 score from wave 1 score on 3MS-R). The simple model included only occupational complexity variable(s) and the full model added in control variables of age, the number of health problems, current health status, education, and APOE ε4 allele, to determine whether any effect of occupational complexity remained after controlling for other factors known for their relation to cognitive status. Longitudinal analyses were conducted with and without incident dementia cases to determine if the association between occupational complexity and late-life cognitive decline is robust, whether or not incident dementia cases are included.

CHAPTER IV

RESULTS

Overview

This chapter will report the results of analyses designed to test the impact of occupational complexity on cognitive status and rate of cognitive decline in elderly women. An overall description of the participants will be given with descriptive statistics on several demographic variables The cross-sectional analysis of cognitive status with the job category and occupational complexity scores, both with and without control variables will then be reported. An analysis of attrition will follow, comparing baseline variables between subjects who did and did not participate at wave 2. This is followed by the longitudinal analysis of cognitive decline with the job category and occupational complexity score, both with and without control variables. Finally, the longitudinal analyses will be repeated with the incident dementia cases removed.

Description of the Participants

The mean age (and standard deviation) of this group of women is 75.50 (*SD* = 6.96) at baseline with an increase to 78.16 (*SD* = 6.73) at wave 2, reflecting the approximate three-year interval between waves (Table 1). The sensory adjusted modified mini-mental state exam score (3MS-R) means are 90.98 (*SD* = 6.71) at baseline and 91.55 (*SD* = 8.30) at wave 2. The increase in the mean score is counter intuitive, but may be a result of practice effects and recognition of the questions. The mean number of health problems, with the possible score ranging from 0 to 7, is 0.88 (*SD* = 0.87) for lifetime problems up to baseline and 0.65 (*SD* = 0.72) for interval problems reported at wave 2. The codes for the current health question, worded "how are you feeling today" are 1 = excellent, 2 = good, 3 = fair, and 4 = poor. The means are 1.93 (*SD* = 0.69) and 2.05 (*SD* = 0.70) respectively, showing a group of individuals who generally rate themselves as feeling good both at baseline and wave 2. Mean education level was 12.78

Table 1

Descriptive Statistics on Continuous Variables

	N	Mean	Std. Deviation
Age, years			
Baseline	2588	75.50	6.96
Wave 2	2311	78.16	6.73
Sensory adjusted 3MS-R score			
Baseline	2588	90.98	6.71
Wave 2	1930	91.55	8.30
Number of health problems (0-7)			
Baseline	2588	0.88	0.87
Wave 2	1889	0.65	0.72
How are you feeling today? (1 = excellent, 2 = good, 3 = fair, 4 = poor)			
Baseline	2586	1.93	0.69
Wave 2	1931	2.05	0.70
Education, years	2586	12.78	2.28
Time interval, years	2387	3.23	0.25

(*SD* = 2.28) thus revealing a group of women with a high school or higher educational level.

Frequencies of continuous variables categorized into ordinal variables to provide a more in-depth description include age, 3MS-R, number of health problems, current health status, education, APOE genotype, and job category are shown in Table 2. This table provides an overview of both baseline (cross-sectional) sample and wave 2 (longitudinal) sample by giving frequencies and percentages for each variable.

The 3MS-R scores have been grouped into approximate quartiles except for those who scored under 60 points, (indicating the need for a proxy informant), and the trend of high 3MS-R scores at both testing times remains evident.

At each testing time, relatively few health problems were reported. Thirty nine percent at baseline reported no problems with 47.9% reporting no additional health problems during the approximate 3 year interval, which is understandable as the former covers a much longer time interval (i.e., lifetime up to baseline). Having one problem was reported by about the same number of people, 40.6% at baseline and 40.7% at wave 2.

This population of elderly women generally reported feeling excellent to good on the day of testing (83.4% and 79.3% at baseline and wave 2, respectively). Very few women, 2.1% and 3.3%, reported feeling "poor" on the day of testing at baseline and wave 2, respectively.

The education mean was 12.78 (SD = 2.28) years for this group of women. Forty-two percent of these women finished high school and continued with some college, and of those, about 14% earned degrees.

Having a genotype with an ε4 allele increases the likelihood of developing

Table 2

Frequencies of Categorical Variables

	Baseline		Wave 2	
	N = 2588		N = 1930	
	N	%	N	%
Age				
64-69	614	23.7	163	7.1
70-79	1253	48.4	1230	53.2
80-89	633	24.5	761	32.9
90-99	87	3.4	154	6.7
100+	1	0.0	3	0.1
Sensory Adjusted 3MS-R score				
Below 60[a]	5	0.2	29	1.5
61-87	591	22.8	476	24.7
88-92	675	26.1	394	20.4
93-95	622	24.0	491	25.4
96-100	695	26.9	540	28.0
Number of health problems				
No problems	1001	23.7	904	47.9
One	1051	48.4	770	40.7
Two	415	24.5	188	10.0
Three	100	3.4	23	1.2
Four	19	0.0	4	0.2
Five	2			

(table continues)

	Baseline		Wave 2	
	N = 2588		*N* = 1930	
	N	%	*N*	%
How are you feeling today?				
Excellent	660	25.5	363	18.8
Good	1498	57.9	1168	60.5
Fair	373	14.5	337	17.4
Poor	55	2.1	63	3.3
Education				
None to eighth	91	3.5	53	2.7
Ninth to HS: GED	1403	54.3	1035	53.7
Some college	675	26.1	515	26.7
BS; BA	248	9.6	198	10.3
Some graduate	73	2.8	58	3.0
MS: MA	65	2.5	52	2.7
Some doctoral	10	0.4	5	0.3
PhD	21	0.8	14	0.7
APOE Genotype				
2/2	20	0.8	17	0.9
2/3	337	13.2	261	13.5
3/3	1420	54.9	1055	54.7
2/4	93	3.6	75	3.9
3/4	628	24.3	469	24.3
4/4	52	2.0	39	2.0
Job category				
Profess, tech, mgr	681	26.3	520	26.9
Clerical, sales	813	31.4	618	32.0
Service	388	15.0	273	14.1
Agriculture	83	3.2	66	3.4
Machine/misc	228	8.8	167	8.7
Never employed	395	15.3	286	14.8

[a] Interviewers were given clinical judgment for those who scored <60 on 3MS regarding self-report versus proxy interview, thus a small number of subjects scoring below 60 were allowed to continue with the interview.

Alzheimer's disease in one's lifetime. For the women in this study at baseline, 30% have at least one ε4 allele. At wave 2, 30% also have at least one ε4 allele, which is interesting, as the percentages remain very similar between both testing times for all APOE genotypes, and one would expect those with ε4 would be more likely to develop dementia and need proxy information.

This trend of similar percentages between baseline sample and wave 2 sub-sample remains consistent with job categories. The clerical, sales category has the highest number of employed women (813 and 618, for baseline and wave 2, respectively) yet the professional, technical, managerial category is not far behind (681 and 520, for baseline and wave 2, respectively). There were 395 who reported never having worked to support their family outside of the home, with 286 of those remaining in the study at wave 2. This is the comparison group, to which all job categories are contrasted.

Research Question One

In order to test the research question of whether employment outside of the home affects the cognitive status of women in late life, baseline cognitive status was regressed on job category of longest duration, and was tested by contrasting each of the job categories with the never employed category. Those in the professional, technical, managerial category (B = 2.62, SE = 0.42, $p < .001$) and the clerical, sales category (B = 1.75, SE = 0.40, $p < .001$) had higher 3MS-R scores than those who were never employed Table 3 illustrates this under the heading of Model 1. The never employed (B = -1.33, SE = 0.47, $p = .005$) had higher scores than those in the service and machine/miscellaneous categories (B = –1.06, SE = 0.54, p = .052). Model statistics include R^2 = .049, F = 26.8 and p < .001 for employment alone, indicating that 5% of the variance in cognitive scores is accounted for by job category alone.

After controlling for age, the number of health problems, current health status, education, and APOE, (Model 2 in Table 3) job category was no longer significant. Younger age, a current health status of feeling good, higher education and no e4 alleles are significant. Model statistics include R^2 = .300, F = 108.9 and p < .001. Thus, the net increase of 25% of the variance in scores was due to the control variables, while 5% is occupation alone. After covariate adjustment, clerical, sales category had a trend (B = 0.60, SE = 0.35, p = 0.086) for higher 3MS-R scores than the never employed.

Table 4 provides the mean 3MS-R scores for each of the six job categories. The professional, technical, managerial category had a mean of 92.64 (*SD* = 6.25) while the clerical, sales category mean was 91.77 (*SD* = 6.21) compared to the never employed mean score of 90.02 (*SD* = 7.13). The service category had a mean of 88.69 (*SD* = 6.87) and the machine/miscellaneous category had a mean of 88.96 (*SD* = 6.96). Those who worked in the agriculture category had a mean score of 90.41 (*SD* = 6.70).

Research Question Two

To test the research question of whether the cognitive complexity of paid employment acted as a protective factor on cognitive status, baseline cognitive status was regressed on the three variables indicating the complexity domains of dealing with data, people, and things. Women of this cohort generally held multiple jobs. Two thousand

Table 3

Hierarchical Linear Regression of Cross-Sectional Modified Mini-Mental State Exam with Job of Longest Duration Versus the Never Employed

	Model 1			Model 2		
	B	SE (B)	Sig	B	SE (B)	Sig
Job category [a]						
Profess, tech, mgr	2.62	.42	< .001	.58	.38	.124
Clerical, sales	1.75	.40	< .001	.60	.35	.086
Service	-1.33	.47	.005	-.63	.41	.121
Agriculture	0.39	.79	.618	.43	.67	.529
Machine/misc	-1.06	.54	.052	-.60	.47	.189
Age, years				-.40	.02	< .001
Number of health problems				-.20	.13	.132
How are you feeling today?				-.83	.17	< .001
Education, years				.58	.06	< .001
APOE				-1.14	.24	< .001

[a]each category is contrasted with never employed as comparison group

five hundred ninety-nine women answered the question "Have you ever held a job to support yourself or your family?" Two thousand two hundred four answered yes to the question, 395 reported no, they had not held a job. When asked about subsequent jobs lasting five years or longer, 945 reported a second job, 245 reported a third job, 53 reported a fourth job, 7 reported a fifth job and 3 reported having a sixth job during their lifetime.

Table 4

Dictionary of Occupational Titles (DOT) Job Categories with Sensory Adjusted Modified Mini-Mental State Exam Score at Baseline (n=2588)

Job Category	*N*	Mean	Std. Deviation
Profess, tech, mgr	681	92.64	6.25
Clerical, sales	813	91.77	6.21
Service	388	88.63	6.87
Agriculture	83	90.41	6.70
Machine/misc.	228	88.96	6.96
Never employed	395	90.02	7.13

Table 5 (Model 1) provides regression analysis results of 3MS-R regressed on the complexity domains of dealing with data, people, and things (where complexity scores were averaged for the two longest-held jobs). Dealing with "data," (B = 0.45, SE = 0.12, $p < .001$) and "people" (B = 0.34, SE = 0.11, $p = .001$) are significant, while dealing with "things" is not significant (B = 7.41, SE = 0.07, $p = .290$). Model summary statistics are: $R^2 = 0.03$, F = 16.6, and $p < .001$, indicating that the three complexity domains account for approximately 3% of the variance in 3MS-R scores.

When control variables are added to Model 2 (Table 5), the complexity of dealing with data remains significant, B = 0.31, SE = 0.10, and $p = .003$, while the complexity of dealing with people and things are not significant (B = -0.03, SE = 0.10, $p = .742$ and B = 0.02, SE = 0.06, $p = .772$, respectively). Model summary statistics are: $R^2 = 0.30$, F = 100.7, and $p < .001$, indicating an increase of 27% of variance accounted for with the addition of the control variables. As with the analysis of job category, the control variables significantly related to 3MS-R score were age, current health status, education, and APOE.

In summary, when contrasted with the never employed group, significantly higher average 3MS-R scores were observed in the professional/technical/managerial and the clerical/sales/categories and significantly lower 3MS-R scores were observed in the service and machine/miscellaneous categories. However, when the control variables are included, the job category did not significantly affect the cognitive status of elderly women.

As we look at the cross-sectional analysis of cognitive complexity in employment, the complexity of dealing with data and people was significant in the simple model. When the control variables were added, the complexity of dealing with people was reduced to non-significant, while the complexity of dealing with data remained significant. Thus, it appeared that the dimension of occupational complexity, particularly "data" complexity, contained more information concerning potential benefit to cognitive reserve capacity than the more traditional job category approach.

Attrition Analysis

The magnitude of potential attrition bias due to some baseline participants failing to participate at wave 2 was assessed (Table 6). Women who continued to participate in the study, meeting inclusion criteria for this thesis, total 1930. Of the 2588 participants at baseline, 283 refused to continue, 227 died during the interval, and we were unable to locate 124, thus defining four wave 2 disposition groups: participants, refusals, deceased

Table 5

Hierarchical Linear Regression of Cross-Sectional Modified Mini-Mental State Exam with Average Occupational Complexity of the Two Longest Held Jobs (n=2,588)

	Model 1			Model 2		
	B	SE (B)	Sig	B	SE (B)	Sig
Occupational Complexity						
Data	.44	.12	< .001	.31	.10	.003
People	.34	.11	.001	-.03	.10	.742
Things	.07	.07	.290	.02	.06	.772
Age, years				-.40	.02	< .001
Number of health problems				-.24	.14	.088
How are you feeling today?				-.82	.18	< .001
Education, years				.58	.06	< .001
APOE				-1.04	.26	< .001

and no locates. One-way ANOVA was used to compare the means of baseline continuous variables between the four groups, including age, 3MS-R score, education, and number of health problems. Chi-square tests assessed independence between how subject was feeling on testing day, APOE status, and wave 2 disposition groups.

The mean age of the participants at 74.6 (SD = 6.6) years was lower than both the deceased group at 80.2 (SD = 7.4) years and the no locate group at 78.9 (SD = 7.3) years. The ages if those who refused to participate were slightly older than the participants 75.9

(*SD* = 6.5). The participants were the youngest group with the deceased being the oldest group. The mean baseline 3MS-R test score is higher for the participants than any other group with a score of 92.1 (*SD* = 5.7). Thus, the participants are functioning on a higher level than those who refused, died or could not be located.

The number of health problems for the four groups are quite similar, with the means ranging from 0.81 for the wave 2 participants to 1.2 for the deceased and the no locate non-participants. Education levels remain around 12 years with the participants having a mean of 12.9 (*SD* = 2.2) years, the mean of those who refused was 12.3 (*SD* = 2.2) years, the mean of those deceased was 12.5 (*SD* = 2.5) years, and the mean of those not located was 12.8 (*SD* = 2.6) years.

Of those who remained with the study, 86% reported feeling "good" to "excellent" at the baseline interview. Of those who refused further participation, 79.5% reported feeling "good" to "excellent," of those who were not located 75% reported feeling "good" to "excellent" at the baseline interview. Approximately 70% of those who were deceased by wave 2 had reported feeling "good" to "excellent" at the baseline interview.

The presence of APOE ε4 was ascertained in approximately 30% of the participants. Approximately, 28% of those who refused carried the ε4 allele, as did 28.5% of those who were deceased and 28% of those who were not located.

The participants of wave 2 were younger, with higher 3MS-R baseline scores, but the education levels, health problems, and current health status were similar. Even the presence of the APOE ε4 allele is similar. Because of the higher functioning and younger age of the wave 2 participants, this may present a bias in the analysis, as they are somewhat different than those who did not participate at wave 2. Thus, any cognitive decline in the longitudinal analysis may be diminished, as older age is a common known factor related to declining cognitive function.

Research Question Three

Research Question Three examined whether employment outside of the home affected the rate of cognitive decline of women in late life compared to the never employed women. Rate of cognitive decline was regressed on job category (Table 7). Again, each job category was contrasted with the never employed group of women. The negative regression coefficients in this table represent less decline for those in the various job categories as compared to the never employed. This table shows the trend of the professional, technical, managerial category (B = -0.26, SE = 0.14, p = .060), and the clerical, sales category (B = -0.27, SE = 0.13, p = .047) as having less decline when contrasted with the never employed women. The machine/miscellaneous category (B = -0.31, SE = 0.18, p = .090), the service category (B = 0.18, SE = 0.16, p = .263) and the agriculture category (B = -0.01, SE = 0.26, p = .970) are nonsignificant when contrasted with the never employed in this model. In other words, the amount of cognitive decline over approximately 3 years was comparable for the never employed women and those who worked in the service and agriculture categories. Model statistics include $R^2 = 0.01$, $F = 3.2$, and $p = .007$ for this simple model, demonstrating only 1% of variance is accounted for by job category alone.

Table 6

Comparison of Wave 2 Participants and Non-Participants on Baseline Measures

	Participant		Refusals		Deceased		No Locate			
	N = 1930		*N* = 283		*N* = 227		*N* = 124			
	M	*SD*	M	*SD*	M	*SD*	M	*SD*	F(3,2584)	
Age	74.6	6.6	75.9	6.5	80.2	7.4	78.9	7.3	59.9	<.001
3MS-R	92.1	5.7	89.2	7.2	86.3	8.8	88.7	7.7	74.7	<.001
Number of health problems	.81	.83	.91	.83	1.2	1.0	1.2	1.0	15.8	<.001
Education	12.9	2.2	12.3	2.2	12.5	2.5	12.8	2.6	7.1	<.001
	N	%	N	%	N	%	N	%		
How are you feeling today?										
Excellent	533	27.6	54	19.1	38	16.8	26	20.8		
Good	1127	58.4	171	60.4	120	53.1	68	54.4		
Fair	244	12.6	46	16.3	56	24.8	27	21.6		
Poor	25	1.3	12	4.2	12	5.3	4	3.2		
APOE										
2/2	17	.9			3	1.4				
2/3	261	13.6	25	9.2	29	13.3	22	18.2		
3/3	1055	55.1	171	62.9	124	56.9	64	52.9		
2/4	75	3.9	11	4.0	3	1.4	2	1.7		
3/4	469	24.5	62	22.8	54	24.8	31	25.6		
4/4	39	2.0	3	1.1	5	2.3	2	1.7		

Table 7

Cognitive Decline with Job of Longest Duration Versus the Never Employed (n = 1876)*

	Model 1			Model 2		
	B	SE (B)	Sig	B	SE (B)	Sig
Job Category [a]						
Profess, tech, mgr	-.26	.14	.060	-.15	.12	.232
Clerical, sales	-.27	.13	.047	-.15	.11	.182
Service	.18	.16	.263	.01	.13	.964
Agriculture	-.01	.26	.970	-.09	.22	.647
Machine/misc	-.31	.18	.090	-.32	.15	.033
Age, years				.05	.01	< .001
Number of health problems						
Baseline				.05	.05	.389
Wave 2				-.07	.06	.239
How are you feeling today?						
Baseline				-.04	.06	.441
Wave 2				.12	.06	.032
Education, years				.01	.02	.499
APOE				.07	.08	.361

[a]change in 3MS-R score per year, over an approximately 3-year interval

When the control variables were added in Model 2 (Table 7), older age (B = 0.05, SE = 0.01, $p < .001$) and feeling less well (B = 0.11, SE = 0.05, $p = .045$) were significantly associated with more decline. The machine/miscellaneous category, previously only with a trend toward less decline, was significant after inclusion of control variables (B = -0.32, SE = 0.15, and $p = .035$). Those in this category exhibited less decline relative to the never employed job category. However, the other two categories of professional, technical, managerial, (B = -0.15, SE = 0.12, p = .215) and clerical, sales (B = -0.14, SE = 0.11, p = .190) became non-significant after inclusion of control variables. Model statistics are: $R^2 = 0.05$, $F = 0.89$, and $p < .001$ for the full model, demonstrating an increase in variance explained of 4%.

Table 8 provides descriptive statistics for the change in 3MS-R scores over an approximate three-year interval, unadjusted for covariates. The professional, technical, managerial category had 520 participants with a mean of 0.06 (SD = 1.67) and the clerical, sales category had a mean of 0.05 (SD = 1.73) for the 618 participants. The decline shown in these two categories was minimal. The 286 never employed had a mean of 0.16 (SD = 2.03). Thus, the never employed were third in the amount of cognitive decline assessed. The 167 participants in the machine/miscellaneous and the 66

Table 8

Dictionary of Occupational Titles (DOT) Job Categories with Cognitive Decline Scores (n = 1930)

Job Category	*N*	Mean	Std. Deviation
Profess, tech, mgr	520	.06	1.67
Clerical, sales	618	.05	1.73
Service	273	.50	2.28
Agriculture	66	.31	1.76
Machine/misc.	167	.32	2.02
Never employed	286	.16	2.03

participants in the agriculture category had means of 0.32 (*SD* = 2.02) and 0.31 (*SD* = 1.76), respectively. These two categories experienced decline which was more than the never employed, but the 273 participants in the service category had the greatest decline with a mean of 0.50 (*SD* = 2.28).

Research Question Four

Research Question Four addressed the question of which domains of cognitive complexity were significantly associated with cognitive decline, among women who reported paid employment. The complexity domains of dealing with data, people, and things were the occupational variables used. These cognitive complexity domains were not significantly related to cognitive decline over the approximate three-year interval. This is reported under the heading Model 1 in Table 9. For "data" complexity, B = 0.05, SE = 0.03, and $p = .151$. For "people" complexity, B = 0.02, SE = 0.03, and $p = .384$. For "things" complexity, B = 0.01, SE = 0.02, and $p = .564$. The R^2 for this simple model was 0.004, with $F = 1.7$ and $p = .142$. The cognitive domains of dealing with data, people, and things accounts for less than 1% of the variance in cognitive decline.

There was a trend toward significance in the "data" domain when the control variables were added to the model, as reported under the heading of Model 2 in Table 9 with B = 0.06, SE = 0.03 and $p = .063$. Age was also significant with older age associated with more decline (B = 0.04, SE = 0.01, $p < .001$), however, none of the other control variables were significant.

Retested Research Question Three

Research Question Three was reexamined by excluding those who had become demented during the approximate 3-year interval (final $n = 1843$ after having eliminated the 119 incident demented). By removing those who had been diagnosed with dementia during the interval, the effect of occupational complexity on cognitive decline was tested to see if it was a universal effect or was primarily among those who became demented. Job category was not significantly related to cognitive decline (Table 10). Model summary statistics are: $R^2 = .003$, $F = 1.26$, and $p = .279$. Again, the model explains less than 1% of variance.

With control variables included, Model 2 (Table 10), we continue to see no significance for any variable except more decline with older age, (B = 0.03, SE = 0.01, and $p < .001$). However, there is a trend toward significance with the machine/misc job category exhibiting less decline than the never employed (B = -.25, SE = .14, $p = .079$). Model statistics included $R^2 = 0.03$, $F = 4.20$ and $p < .001$ for this full model. Approximately 3% of variance is accounted for after inclusion of the control variables.

When comparing these results with table 7, age is significant both with and without the incident demented. The trend toward significance for the professional, technical, managerial category, and the clerical, sales category is not observed when the incident demented are excluded. The machine/miscellaneous category's trend toward significance of less decline remains both with and without incident demented. In addition, the current health status at follow-up was important when considering the

Table 9

Cognitive Decline[a] with Average Occupational Complexity of the Two Longest Held Jobs (n = 1876)

	Model 1			Model 2		
	B	SE (B)	Sig	B	SE (B)	Sig
Occupational Complexity						
Data	.05	.03	.151	.06	.03	.063
People	.02	.03	.384	.02	.03	.484
Things	.01	.02	.564	.01	.02	.476
Age, years				.05	.01	< .001
Number of health problems						
Baseline				-.01	.05	.917
Wave 2				-.03	.06	.644
How are you feeling today?						
Baseline				-.06	.06	.326
Wave 2				.11	.06	.074
Education, years				-.01	.02	.714
APOE				.08	.08	.298

[a]average decline in 3MS-R score per year

cognitive decline for the total sample and the non-demented subsample.

Retested Research Question Four

Cognitive decline with occupational complexity was retested on those who did not become demented during the approximate 3 year interval. Each of the three

Table 10

Cognitive Decline[a] with Job of Longest Duration Versus the Never Employed Excluding Incident Demented[b]

	Model 1 (n = 1843)			Model 2 (n = 1818)		
	B	SE (B)	Sig	B	SE (B)	Sig
Job Category						
Profess, tech, mgr	-.10	.12	.380	-.12	.12	.302
Clerical, sales	-.07	.12	.533	-.08	.11	.449
Service	.11	.14	.429	.06	.13	.626
Agriculture	.06	.22	.765	.01	.20	.939
Machine/misc	-.24	.16	.121	-.25	.14	.079
Age, years				.03	.01	< .001
Number of health problems						
Baseline				.03	.05	.435
Wave 2				-.02	.05	.678
How are you feeling today?						
Baseline				-.05	.06	.369
Wave 2				.10	.05	.060
Education, years				.01	.02	.704
APOE				.02	.07	.831

[a]average decline in 3MS-R score per year

[b]compare to Table 7.

occupational complexity domains was not significant relative to cognitive decline (Table 11). R^2 = 0.003, F = 1.13, and p = .339. Less than 1% of variance is accounted for in this retested simple model.

Age was again the only control variable significantly related to cognitive decline as shown by Model 2 in Table 11 (B = 0.03, SE = 0.01, and $p < .001$). $R^2 = .023$, $F = 3.66$, and $p < .001$). With the control variables included 2% of variance is accounted for in the full model.

Table 11

Cognitive Decline[a] with Average Occupational Complexity of the Two Longest Held Jobs Excluding Incident Demented[b]

	Model 1			Model 2		
	B	SE (B)	Sig	B	SE (B)	Sig
Occupational Complexity						
Data	.03	.03	.228	.05	.03	.127
People	.01	.03	.618	.02	.03	.472
Things	.01	.02	.592	.01	.02	.516
Age, years				.03	.01	< .001
Number of health problems						
Baseline				.01	.05	.854
Wave 2				.003	.06	.955
How are you feeling today?						
Baseline				-.06	.06	.318
Wave 2				.07	.06	.204
Education, years				-.02	.02	.394
APOE				.04	.08	.602

[a]average decline in 3MS-R score per year

[b]compare to Table 9

The occupational complexity of "data," while presenting a trend toward significance in Table 9, shows no trend in Table 11 when the incident demented have been removed. Age was the only significant predictor both for the non-demented and the full sample, when using the occupational complexity domains of "data," "people," and "things."

Summary of Findings

In the cross-sectional analysis, the professional, technical, managerial category, and the clerical sales category scored higher on the 3MS-R score when contrasted with the never employed, yet this relationship became non-significant when control variables were added to the model. The never employed women scored higher on the 3MS-R than those employed in the service or machine/miscellaneous categories. The complexity of dealing with "data" and "people," rather than "things," appear to be more protective.

As regards rate of cognitive decline, only the clerical/sales category showed significantly less decline than career homemakers, though this effect became non-significant after addition of control variables. Cognitive decline was not significantly related to occupational complexity in dealing with "data," "people" or "things."

With the incident dementia cases removed from the analysis, no significance was found for either the job of longest duration or the occupational complexity of dealing with "data," "people," or "things." Very little variance was accounted for with all control variables added.

CHAPTER V

DISCUSSION

Overview

In this chapter, the findings of the study are discussed in the context of the theoretical framework. The limitations of this study and implications for future research are then discussed, followed by the conclusion.

Significant Findings

Two job categories were identified in which women scored higher on the cognitive test than the never employed women. These were the professional, technical, managerial category, and the clerical, sales category. However, because this significant effect disappeared when control variables were added. This suggests that job category is confounded with one or more of the control variables and may not confer vast amounts of net additional cognitive protection beyond educational attainment, at least over a short 3-year interval.

Jorm et al. (1998) also found cross-sectional differences in cognitive decline among men aged 70 and older when participants' occupational categories were used. Their longitudinal results paralleled these results with little to no association between occupation and cognition when controlling for education. They surmised that pre-morbid intelligence accounted for the differences rather than cognitive decline. Holland's categories of "realistic," "investigative," "artistic," "social," "enterprising" and "conventional" may be so broadly defined that assignment of specific occupations into categories may not parallel the categories used for this thesis. Given that the present study did not take into account job duration, it may be that women's shorter duration in the various occupational categories might explain the difference between Jorm and colleagues' findings for men and the findings in this research for women.

While education certainly has an effect on cognition, Le Carret et al. (2003) also found that different stimulating activities, including occupation, give the impression of influencing elderly participants' cognitive performance. They also mention that many in their study who had attained an intellectual occupation did not have a higher educational degree, but were self-educated. Thus, mental stimulation after the educational years could enhance cognitive reserve and help in the process of cognitive decline.

Stern et al. (1999) found similar results with the more complex job categories providing possible protection against cognitive decline, either through compensation strategies or increased dendritic brain structure. They, however, used diagnosed Alzheimer's patients while this research reports data from a population of non-demented women, with few being diagnosed as demented during the approximate three-year interval.

In an earlier study, Stern et al. (1995) report occupational experience as having an effect on the clinical expression of Alzheimer's disease over and above any effect of education as they controlled for age, clinical dementia severity, and education. Housewives were excluded from this study.

Mortel et al. (1995) included housewives in their study of dementias. They found they were at increased risk for AD when compared to professionals. Women were also at higher risk in blue collar, white collar, and craftsman/shopkeeper professions. They stated, "that women with both limited education and working skills are at greatest risk for dementia" (p. 61).

Smyth et al. (2004) studied occupation across age decades. They found occupations with mental demands increasing between 20s and 30s for controls, but this was not true for cases. Instead they found that high physical demand occupations were more likely with those who were cases. As with this research, they did not report significant differences in cognitive performance in the 3- to 5- year interval follow-up.

In the Kungsholmen Project, Qiu et al. (2003) found there was a higher risk for women to develop Alzheimer's disease if they worked in goods production. This was true for men also, but was significant for women. They differed from this research by dichotomizing occupations into manual versus non-manual occupations and then sub grouping those in the manual category. Incident dementias were noted in those in manual labor occupations.

Blue collar occupations were more likely to include those with prevalence dementia according to Callahan et al. (1996) in their community-based sample of African Americans. In this study, occupation was dichotomized as low (blue collar) versus high (white collar). Women were 65% of the subjects.

In the use of the complexity variables of dealing with data, people and things, there was significance with "data," and "people" at the initial interview. However, the significance with people became non significant as the control variables were added. In order to ascertain which control variables may have reduced this significance, a correlation matrix was analyzed (see Appendix). Education was the control variable most highly correlated with occupational complexity and the cognitive variables, which reveals that it was education that accounts for most of the loss in significance of complexity in the final model.

Recently, the Swedish Twins Study (Andel et al., 2005) reported an interesting finding as they too studied the complexity of dealing with "data," "people" and "things." They found a lower risk of prevalent dementia in those with a high complexity score of dealing with "people" for the case-control portion of their study. In the Co-twin portion of their study, they found those with higher scores of dealing with "people" had a lower risk of dementia than the co-twin. Additionally they found those with higher scores of dealing with "data," also had a lower risk of AD than their twin, consistent with the present study's finding of higher "data" complexity being associated with higher 3MS-R scores, even after addition of control variables. Those with high complexity scores of dealing with "things" seemed to show an increased risk of dementia.

Promising may be the news that particular aspects of the cognitive stimulation in the work environment, in particular complexity dealing with "data," may be linked to enhancing cognitive reserve capacity, as evidenced by the present study and the Swedish Twins Study. This positive association remained in the presence of control variables, suggesting some protection of "data" complexity derived through employment above and beyond education. "Data" complexity is not just the use of numbers, facts and figures but is also the observing, investigating, interpreting, visualizing, and mentally creating information, knowledge and conceptions (Kohn & Schooler, 1983). This would imply that integrating knowledge, information and concepts is also a good way of keeping one cognitively competent and may be a protective element in aging. One need not work outside of the home in order to gather knowledge and information while integrating new ideas. This can be done during an entire lifetime, through a variety of activities. The identification of alternative protective activities is, however, beyond the scope of the present research.

The restated research questions, which excluded the incident demented to test the universality of cognitive decline was no longer relevant as no significance was found when including all participants. Further research with additional data may be needed.

Theoretical Framework

The lifespan developmental perspective includes the concepts of multiple causality and multidirectionality. Age is an influential factor in cognitive status, as is education, physical health, occupation and genotype. Any one variable or a combination of any of these variables may play a part in the retention or decline of cognition because aging is a process of gains and losses.

With this cohort of women, especially those who continue to function at a reasonable level of cognition, it is likely they have adapted to aging through cognitive coping mechanisms. These may include such practices as using additional memory aids (i.e., rehearsal, list writing, or priming), or behavioral changes (i.e., playing a few well practiced musical pieces rather than having a large repertoire, or when playing an instrument, slowing down prior to increased tempo to give the illusion of faster tempo). However, data as to use of these strategies is not available in the present cohort, so this notion cannot be tested with the current dataset. Women in the Cache County Study on Memory, Health & Aging live long lives, most said their health was good to excellent, and they reported few health problems.

Considering the historical context of these women, it is possible that they have been both influenced by history and have influenced history and others at the same time. These women worked during troubling times in the country in occupations that were open to them. Thereafter, many were asked to leave the male-dominated jobs so the returning military men would have employment (Banner, 1974). Some worked for a good deal of time outside of the home during times when single-earner households were the accepted practice, thus opening doors for future generations of women to work. Some even broke through the barriers of previously male-dominated occupations, again opening doors for their daughters and granddaughters (Patterson & Engelberg, 1978).

According to a lifespan developmental framework, these women continue to develop as they continue to learn, and integrate what they have learned, thus adapting to losses and gains. The losses may be more physical, such as hearing and eyesight, while the gains may be more cognitive, such as devising strategies to aid with the physical losses. They are involved in everyday life, evidenced by their continuing participation in this study. The multidisciplinary lifespan developmental framework supports the exploration of the many inter-related aspects of aging included in this study, namely, education, genotype, employment, health, chronological age, and cognitive status. These fields of study dovetail to reveal a more complete picture of the process of aging.

Limitations

Unexpectedly, a higher mean cognitive score was found at the three-year follow-up compared to the baseline interview. There are several potential explanations for this result including a higher performing younger group who remained in the study, practice effects, and participants discussing the test with one another, given that so many participants live in a relatively small geographic area. It may be that the women were more relaxed during wave 2 and knew the questions were not terribly difficult. Alternatively, many of those who did not do well at baseline refused to continue in wave 2. Because participants in wave 2 were younger, and slightly more educated, this may also account for the higher 3MS-R scores.

As regards limitations in measurement of occupational complexity, there is the potential that subjects may have misinterpreted the initial occupation history question. Participants were asked if they had worked to support themselves or their family. If a woman did not feel she was working "to support" the family (her husband's role), she may have answered "no," when in fact she was working for an income. Thus, some women may have been misclassified in terms of job category in these analyses, specifically, some employed women may have been classified as never employed because they did not consider their employment for the purpose of "supporting" the family. Additionally, Cache Valley was a rural community during the timeframe these women were raising their families. Working on farms was something many women did, usually without a paycheck and it is unknown whether these women considered this work outside of the home or in support of their family. Mild cognitive impairment in some of the women in this sample may have also impaired their recall of lifetime occupational history.

As this project utilized extant data, there are additional aspects to occupational history that may have shed more light on the research questions considered in this thesis, had they been available. Women were not asked during what period of their life they worked, such as in the early, middle, or late years. It is not known whether the timing of their occupational experience would play a significant role. We also do not know if women found the jobs and environment stimulating, or if they worked in particular jobs because those were the available jobs at the time. Finally, the extent to which these women changed occupations across complexity levels and in what order those changes occurred is also unknown. Changing jobs from one complexity level to another is a possible protective factor we cannot examine due to the interview protocol. In the animal studies, changing environments provided more growth of brain cells than remaining in a highly complex environment that may become routine (Kemperman et al., 1997).

As regards the lack of significant findings with respect to cognitive decline, with the younger age of the wave 2 participants, it is possible that a longer interval is needed for enough cognitive decline to occur to have sufficient variability in the longitudinal outcome. There was significance at the cross-sectional analysis, and it may be that three years is not a long enough interval to see any significant decline in fully functioning women. Generally, dementia is not a disease in which decline comes rapidly, but rather is a slow progression of losses. Further follow up with this cohort may reveal greater decline in cognition at longer intervals, permitting a re-examination of these analyses after the next wave of data is collected.

As this study was performed in a community in northern Utah, it is not generalizable to minority women, as the population is predominately Caucasian. It may be generalizable to Caucasian senior women living in a variety of settings as they worked in the professions open to women, and dealt with the attitudes toward women of their day.

Future Directions

The implications for future research are significant. Cognitive reserve and any protection it provides for cognitive decline in later years may be a result of much more than education attained and occupational complexity. Activities outside of both of these realms may also provide stimulating, learning environments that enhance brain cell proliferation. Compensation for a routine job may be a leisure lifestyle full of stimulating activities, which may provide brain cell growth above and beyond education or occupation. Do intelligence, interests, and personality provide any answers to the question of cognitive reserve? Little is known of the stimulating environment of women who do not work outside of their homes, who are raising children, and possibly participating in community and volunteer projects. The effect of number of children on a woman's ability to obtain cognitive stimulation through supplemental activities also has yet to be studied. Similarly, the effect of cognitive stimulation from living with a spouse who may have a career that generates thought-provoking discussions, interesting companions, travel, better medical care, and socioeconomic status should be studied. As women move from the work place to home, and back to the work place, does this sporadic involvement provide stimulating, learning environments for brain cell growth? Further investigation is needed to respond to these questions.

Still to be investigated would be a comparison of specific occupations, within these categories. Professional jobs of doctor, attorney, accountant, and engineer could be contrasted with other jobs, more commonly held by women, such as teacher, or nurse.

Another possibility is to research the effect of changing levels of complexity in employment. In today's society it is not unheard of to have multiple careers, while career changing was less likely for older generations. Will changing careers be more beneficial to younger generations in providing protection against cognitive decline? Are changes in complexity level of a single domain as beneficial as changes across all three domains of "data," "people," and "things"? Is time spent in a low level of complexity as protective as a highly complex job held for fewer years? Further research may also focus on those who have lower education yet have worked into positions of high complexity and visa versa, those with high education who choose to work in low complexity occupations. Are the benefits equal? Many questions are still left answered regarding the interaction of occupational complexity and cognitive status and decline.

I have researched the women of this cohort for the reason that they were more limited than men in their educational and occupational opportunities. This brings to mind three other research possibilities. Do men have the same possible protection against cognitive decline in late life due to their occupational history? Were men's occupations stimulating for their wives as aspects of the occupation were discussed or family travel was involved for the occupation? Will future generations of women who are able to achieve higher complexity of employment, be more protected than their mothers and grandmothers against cognitive decline? Longitudinal studies involving generations of the same family would help to answer some of these questions as well as any potential moderating effects of genes associated with cognition.

Conclusion

Being involved in life, being stimulated, and continuing to learn in all aspects of one's life are beneficial for cognitive status in late life. Job category and the complexity domains of dealing with "data," "people," and "things" have been studied with mixed results.

The professional, technical, managerial category and the clerical, sales category were associated with higher cognitive test scores in cross-sectional analysis. The never employed women had higher 3MS-R scores than the remaining categories. Trends toward significance were shown in the longitudinal data with those categories mentioned above and included the machine/miscellaneous category. The trend toward significance remained in the machine/miscellaneous category with the control variables added.

The complexity of dealing with "data" (observing, investigating, integrating, visualizing, and mentally creating information, knowledge and conceptions) was initially significant above and beyond age, education, the effects of health and genes.

The mid-range placement of the homemakers within the occupational categories suggests that cognitively stimulating activities through leisure activities, hobbies, or volunteer experiences may be beneficial to all women, including those who have a career outside of the home. Of course, the choice of a stimulating career may confer greater benefits than would careers with mundane and repetitive tasks. In addition, cognitively stimulating activities of the "data" type cognitive processing may be important particularly for those in occupations that do not offer as much stimulation.

There are many factors that may affect cognition in late life. This research has examined in elderly women one factor in depth, namely, occupational history, and operationalized it in a variety of ways. To this end, this work is a good first step in a continuing process of finding protective factors against cognitive decline in the elderly.

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APPENDIX

Correlation Matrix

3MS Scores and Job Complexity with control variables

	3MS Baseline	3MS W1-W2	Data Complex	People Complex	Things Complex
Age					
Pearson	-.475	.253	.039	-.009	.027
Sig.	.000	.000	.069	.662	.200
N	2588	1930	2204	2204	2204
APOE					
Pearson	-.026	.013	-.023	-.038	.019
Sig.	.197	.573	.286	.078	.366
N	2550	1916	2169	2169	2169
Education					
Pearson	.302	-.045	-.354	-.524	.177
Sig.	.000	.046	.000	.000	.000
N	2586	1930	2202	2202	2202
Baseline Health					
Pearson	-.126	.061	.055	.087	-.017
Sig.	.000	.007	.010	.000	.423
N	2588	1930	2204	2204	2204
Interval Health					
Pearson	-.057	.010	.054	.088	-.007
Sig.	.014	.651	.029	.000	.791
N	1889	1889	1611	1611	1611
Feeling today Wave 1					
Pearson	-.210	.063	.063	.069	.009
Sig.	.000	.006	.003	.001	.656
N	2586	1929	2201	2201	2201
Feeling today Wave 2					
Pearson	-.194	.091	.095	.071	-.028
Sig.	.000	.000	.000	.004	.251
N	1931	1929	1647	1647	1647