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Predictors of gains in inductive reasoning strategies and everyday functioning: Results from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) Study

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Predictors of gains in inductive reasoning strategies and everyday functioning: Results from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) Study

by

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A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

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2013

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ABSTRACT

Prior research demonstrates that some cognitive abilities (i.e., memory, speed of processing and reasoning) decline starting in the sixth decade of life. One mechanism underlying training interventions is cognitive strategies which can maintain or enhance abilities and associated everyday functioning. The present study focused on two research questions. First, does participation in reasoning strategy training lead to increased use of the strategies in performing reasoning tasks? Second, does participation in reasoning strategy training influence subsequent changes in indicators of everyday functioning over a five-year period? To address these issues data were analyzed from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study, a large 10-year investigation of the effects of teaching cognitive strategies to a healthy sample of older adults (Jobe et al., 2001). A total of 601 participants from that study who either received the reasoning training or were assigned to a no-treatment control group were included in the analyses. Regarding the first research question, hierarchical regression analyses indicated that the reasoning training was very effective in enhancing the use of strategies by participants. Additional analyses found that the intervention was most effective for participants who were younger, better educated, and White although all groups benefited from training. Regarding the second research question, the results of growth curve modeling analyses indicated receipt of the reasoning strategy training was not related to change in functioning over the five-year period among participants. These results indicate that, although the intervention was effective in enhancing the use of reasoning strategies, these changes did not generalize to everyday functioning among this sample of older adults. Implications of these results for enhancing the cognitive abilities of older adults and improving their functional status are discussed.
CHAPTER 1. INTRODUCTION

The 65 and older population increased at a faster rate (15.1%) than the general population (9.7%) between 2000 and 2010. This age group represents 12.9% of the total U.S. population or approximately one in every eight Americans (National Institute on Aging, 2012; U.S. Department of Health and Human Services, 2011). This figure is projected to grow to 19% by 2030 or approximately one in every five Americans (U.S. Department of Health and Human Services, 2011). By 2050 the number of Americans aged 65 and older is projected to be 88.5 million which is more than twice the population of 40.2 million in 2010 (Federal Interagency Forum on Aging Related Statistics, 2007). Persons reaching age 65 today have an average life expectancy of an additional 18.6 years. As can be seen in Figure 1, there is a dramatic rise in the number of persons age 65 and older as compared to the previous century.

As shown in Figure 2 there are differences in the life expectancy of older adults by sex. On average females live an additional 19.9 years past age 65 whereas males live an additional 17.2 years (Federal Interagency Forum on Aging Related Statistics, 2007). The number of males has increased disproportionately when compared to the female population, resulting in a narrowing of the ratio of males to females in this age group which is expected to impact the cost of Medicare and Medicaid (U.S. Census Bureau, 2010).

Glen Elder, a prominent researcher in the field of aging, coined the phrase “across the life course” to refer to non-chronological aging (Elder, 1992) and drawing attention to the fact that aging is a developmental, lifelong process. That is, individuals develop not only from birth to young adulthood, but continue to develop over their individual life course.
Their unique life course is viewed as the summation of all their experiences during their lifetime and this process continues until death.

One important issue concerning older adults is their cognitive health and how their cognitive health affects their everyday functioning. There is an extensive research literature related to cognitive functioning, cognitive maintenance, and cognitive change. One of these important abilities is reasoning. A decline of cognitive reasoning often leads to loss of independence for older adults and results in either formal or informal caregiving or residential reassignment.

The possibility of maintaining the ability to reason or to delay the onset of the decline in reasoning ability is therefore of great interest to both researchers and older adults. This interest has led to research on teaching reasoning strategies which could help older adults maintain or enhance their reasoning abilities and thereby delay the onset of cognitive decline. Only a few studies have tried to intervene with older adults by teaching cognitive strategies to determine if increased strategy use can result in better outcomes in their daily lives.

The Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) is one such study. Participants in the ACTIVE study were trained in reasoning and other cognitive strategies over a 5-6 week period of time and then participants were followed over the subsequent 10 years to evaluate long term effects of the intervention. The current investigation conducted secondary analyses of data from the ACTIVE study for individuals who received training in the use of four inductive reasoning strategies. These strategies are unique techniques taught to help participants discern patterns in typical information they find in their everyday lives. For example, older adults would apply these strategies on a daily basis when attempting to find the correct time or place to catch a bus/train when leaving their
homes. Finding the correct time or place allows older adults to reach their important scheduled appointments (i.e., the doctor’s or dentist’s office) or to attend a fitness class, meet a friend, or shop for groceries. Another typical example would be when an older adult needs to take their next medication. This would require them to read often complex instructions on a medication bottle. Learning reasoning strategies to accomplish such everyday tasks helps older adults function successfully and increases the chance that they will maintain independent lives for a longer period of time. Therefore, inductive reasoning clearly is a vital cognitive ability which needs to be maintained or enhanced as it slowly declines during the sixth decade of life.

In order to further study the impact of strategy training on older adults, secondary data were analyzed using participants from both the reasoning and control groups of the ACTIVE study. Two research questions were addressed. First, did participation in the reasoning strategy training lead to increased use of the strategies after training? Second, did participation in the reasoning strategy training influence changes in everyday functioning status over time (i.e., prior to the intervention to 5 years following the intervention)?
CHAPTER 2. LITERATURE REVIEW

As individuals age, cognitive capacities and capabilities develop over time. Cognition and cognitive functioning can occur in both normative and non-normative ways that affect the cognitive health of older adults. “Cognition” refers to a group of processes occurring in the brain whereas “cognitive functioning” refers to “performance-based indicators of cognitive ability or skill” (Dixon, Backman, & Lars-Göran, 2004, p. 3-4).

*Cognitive impairment*, however, is a non-normative aging-related process and includes both memory and non-memory deficits. It involves a group of symptoms currently thought of as a transition phase between healthy cognitive aging and dementia (DeCarli, 2003). Cognition, like physical health, can be viewed along a continuum - from optimal functioning to mild cognitive impairment to severe dementia (U.S. Department of Health and Human Services, 2007).

Cognitive Change and Decline

Cognitive change and decline in some cognitive abilities during older adulthood is normal. However, cognitive impairment is not normal and can result from a variety of causes (i.e., disease, trauma). It is an older adult’s inability to perform cognitively demanding tasks (e.g., driving, taking medications, and managing finances) due to cognitive impairment that frequently motivates them or others (i.e., spouses and adult children) to seek assessment and diagnosis. Studies have reported that Instrumental Activities of Daily Living (IADLs), such as answering the phone and handing finances (Fillenbaum, 1987a,b; Fillenbaum & Smyer, 1981; Lawton & Brody, 1969), decline before reductions in the ability to perform activities found on the Activities of Daily Living scale (ADLs) such as grooming, toileting, dressing, and eating (Fillenbaum & Smyer, 1981; Katz et al., 1963). That is,
activities requiring higher order cognitive functioning are “lost” before other, more basic activities (Ashford, Hsu, Becker, Kuman, & Bekian, 1986; Reisberg, Ferris, de Leon, & Crook, 1982). More recent research has revealed relatively modest declines in the performance of cognitively complex everyday tasks for adults during their 60s, but steeper patterns of decline in their late 70s and 80s (Schaie, 1996).

Not all cognitive abilities decline at the same rate. For example, working memory and spatial orientation appear to decline before vocabulary. Speed of processing tends to decline before abstract reasoning and working memory appears to decline before both speed of processing and abstract reasoning (Ball et al., 2002; Salthouse, 1993). However, it is important to note that these declines vary from individual to individual which leads to large within-group variability in decline (Willis, Jay, Diehl, & Marsiske, 1992; Diehl, Willis, & Schaie, 1995; Willis et al., 2006). Previous research suggests that some individuals are at cognitive risk due to social and/or cultural differences in our society. These social and/or cultural disadvantages (i.e., lower socio-economic status, lower education, and poorer health access) can result in declines in different cognitive abilities (Schaie, 1999).

**Prevalence Rates of Cognitive Decline**

Cognitive decline at the individual level before age 60 is not normative (Siegler, Hooker, Bosworth, Elias, & Spiro, 2010). The prevalence of cognitive impairment among older adults age 65 and older without dementia ranges from 5% to 29%, but research findings also indicate that the majority of older adults will not experience moderate to severe memory impairment in their lifetime (Petersen et al., 1999). The prevalence of cognitive impairment appears to increase steeply with advanced age (Heeringa et al., 2007; Plassman et al., 2007, 2008). The Aging, Demographics, and Memory Study (ADAMS), the first population-based
study which included individuals from all regions of the country to increase the knowledge of cognitive impairment in the United States (Heeringa et al., 2007; Plassman et al., 2007). This study began in the early 1990s and collected data from a subset of participants from the larger, national Health and Retirement Study. Their analyses of the ADAMs data revealed that in the 71- to 79-year-old age group, 16% showed evidence of cognitive impairment without dementia whereas an additional 5% suffered from dementia.

More recent analyses comparing different decades of data on the prevalence of cognitive impairment reveal that these rates have declined. For example, an analysis of the Health and Retirement Study revealed a significant decline in the prevalence of severe cognitive impairment among people aged 70 and older from 6% in 1993 to less than 4% in 1998 (Freedman, Martin, & Schoeni, 2002). This suggests there may be a slowing in the proportion of older adults who develop severe cognitive impairment due to factors such as increases in levels of education and changes in lifestyle. Despite a possible decrease in severe CI, the increase in the number of older adults makes cognitive impairment an important issue for the United States due to the large number of older adults with mild cognitive impairment. Individuals with mild cognitive impairment experience the loss of abilities such as making monetary transactions when shopping, the ability to drive, the ability to do their taxes, and other abilities associated with daily living. A recent report by the Centers for Disease Control and the Merck Company Foundation (2007) identifies the prevention of cognitive decline as a key area where public health interventions can make significant improvements in the quality of life of older adults.
Compression of Cognitive Morbidity

A change in the prevalence rate of cognitive impairment has been noted by recent investigators using data from the Health and Retirement Study (Lang, Rieckmann, & Baltes, 2002). This change is known as “compression of morbidity” due to cognitive impairment occurring much later in the course of the individual’s life. Compression of morbidity results in a more severe decline in cognitive impairment closer to death (Langa et al., 2007). Several factors during the past 15 years, such as better medical care and better health behaviors, may have had an impact by reducing mortality (Crimmins et al., 2010). In addition, older adults in more recent cohorts have received higher levels of education. The proportion of adults aged 65 or older with a high school diploma increased from 53% in 1990 to 72% in 2003, whereas the proportion with a college degree increased from 11% to 17% during this same time period (National Institutes of Health, 2011). Better health behaviors as well as more wealth and social opportunities are associated with delays the decline of cognitive abilities (i.e., compression of morbidity) compared to earlier cohorts (Ferri et al., 2005; Plassman et al., 2006). Finally, greater wealth is associated with lower levels of disability throughout the life course (Breitner et al., 1999; Callahan, Hendrie, & Tierney, 1995).

Theories of Aging

Life Span Theory (LST) deals with individual development from conception to old age (Baltes, 1987; Baltes & Baltes, 1997). This theory originally consisted of three components. First, development occurs throughout life. Second, older adults view life as a series of gains and losses. These gains and losses can occur in different areas simultaneously or sequentially demonstrating that the brain has plasticity (i.e., is malleable). Third, the
world is ever changing and older people see events in the context of their unique historical and cultural lives.

In 1990 Paul and Margaret Baltes proposed a new theory called Selective Optimization with Compensation Theory (SOC). This theory, now accepted as part of overall Life Span Theory, hypothesizes that the process of “selection, optimization and compensation” takes place throughout the lives of older adults (Baltes & Baltes, 1990). SOC theory proposes that three main factors create a successful environment for older adults and result in successful aging. The theory hypothesizes that a reduction in goals, new goals, or transformation is a process which helps older adults adjust their expectations in order to take control of their lives. The second factor, optimization, posits that older adults can continue at high levels of performance in some areas by employing various strategies (i.e., continuous practice or new technology). The third factor, compensation, is used when an older adult employs a method other than their own ability (i.e., a hearing aid or mnemonic strategy) to overcome a problem. SOC theory includes the notion that adulthood is comprised of many unique individuals instead of one homogeneous group of individuals. Differences between these individuals include chronic stress, dementia, frailty, and life expectancy (Baltes & Smith, 2003). Research has indicated that younger adults are more likely to see their well-being in terms of accomplishments and careers, whereas older adults are more likely to link well-being with good health and the ability to accept change (Baltes & Carstensen, 1996). In analyses of data from the Berlin Aging Study, Baltes and colleagues reported that SOC increased over a four-year period particularly among older adults who were rich in resources versus those with few resources (Freund & Baltes, 2002; Krampe & Baltes, 2003; Lang et al., 2002).
Theories of Cognition

Gerontologists have developed theories suggesting how cognitive decline in reasoning occurs among older adults. One theory developed by Salthouse (1993) hypothesizes that speed of processing declines steadily and affects the ability to reason because it leaves little time for the older adult to complete working memory tasks. Earlier, Miller (1956) proposed that information was organized into units (e.g., social security number [534-77-3251] or phone numbers [312-844-1233]) or “chunks,” and that short term memory is determined by the number of chunks an individual could consciously hold at a time in working memory (e.g., phone numbers or social security numbers). Chunking is necessary for holding information in working memory in order to put bits of information together in various groupings when trying to reason (Naveh-Benjamen et al., 2007). More recent research have indicated that the ability to hold in mind multiple pieces of information necessary for reasoning relies on working memory capacity (Morrison, 2005). Older adults can hold up to four chunks at a time, and older adults take significantly more time to process information than younger adults (Viskontas, Holyoak, & Knowlton, 2005).

A second theory of age-related cognitive decline developed by Craik and Byrd (1982) focuses on how the ability to maintain attention impacts inductive reasoning. This theory hypothesizes that older adult’s experience a decline in the resources necessary to pay attention and focus when reasoning and that this affects their ability to finish the reasoning process in the allotted time for increasingly complex tasks. In support of this model recent research indicates that a task requiring maintenance and manipulation in working memory affects the ability to reason in older adults more than younger adults (Craik & Byrd, 1982; Old & Naveh-Benjamin, 2008a, 2008b).
Hasher and Zacks (1988) proposed a third theory that suggests as people age they have difficulty inhibiting irrelevant stimuli and this interferes with the ability to reason. This theory predicts that as problems become more complex due to the addition of irrelevant information older adults will experience more trouble maintaining sufficient focus to complete the task (Hasher & Zacks, 1988; May, Hasher, & Kane, 1999). The role of inhibition in reasoning is consistent with Baddeley’s (1996) theory characterizing the executive component of working memory as reflecting the capacity to attend selectively to a stimulus while inhibiting the disruptive effects of other stimuli. Other researchers suggest that the ability to inhibit irrelevant information may cause difficulty in reasoning when problem solving (Robin & Holyoak, 1995). Finally, researchers have found that selective attention to color supports the inhibitory deficit hypothesis that the age-related increase in the “Stroop effect” results from a decline in the ability of older adults to inhibit stimuli (West & Alain, 2000).

**Cognitive Decline with Age**

Three cognitive abilities have been shown in longitudinal research to exhibit relatively early age-related decline beginning around 65 years of age (Schaie, 1996). These are working memory, speed of processing, and reasoning. Previous research indicates that the brain is malleable or has the capacity to build neural networks over a lifetime including the later years (Recanzone, 2000). Cognitive stimulation is a predictor of enhancement or maintenance of cognitive abilities. Moreover, sustained engagement in cognitively stimulating activities has been found to impact neural structure in both older humans and rodents (Churchill et al., 2002; Krampe et al., 1996). Some cognitive abilities have been targeted to see if it is possible to delay the impairment (i.e., decline) of the ability to sustain
effective cognitive performance. One of those cognitive abilities is inductive reasoning, which is the focus of the present research.

**Reasoning**

A definition of reasoning that is frequently used in the field of aging has been offered by Salthouse (1996) who describes reasoning as the ability to manipulate different cognitive abilities (i.e., speed of processing, memory, integration of relationships between information) in various combinations when presented with novel situations. The cognitive ability to reason is fundamental to maintenance of an individual’s lifestyle and independence since it is necessary in the decision making process. The two types of reasoning are *deductive* and *inductive*. Deductive reasoning occurs by drawing inferences or reaching conclusions by using formal logic. For example: Premise 1: All humans are mortal. Premise 2: Socrates is a human. Conclusion: Socrates is mortal. Inductive reasoning occurs by making inferences that are based on previous observations. This type of reasoning can result in inaccurate predictions or explanations because the accuracy of the result is based on the truth of the original premise. A common example of this is taken from David Hume, one of the great philosophers of the 19th century. In his written work, “Enquiry Concerning Human Understanding,” he postulates the following premise: The sun has risen in the east every morning until now. Conclusion: The sun will also rise in the east tomorrow (Hume, 1748, p. 4.2). This type of reasoning is used daily but changes over time. Although it is known that reasoning ability declines with age, the underlying mechanisms are not well understood (Salthouse, 1992, 2005). As discussed below several theories have been developed by gerontologists related to the reasoning processes of older adults.
Consequences of Declines in Reasoning

The ability to reason is instrumental in the success or failure of an older adult’s ability to age successfully and maintain his or her independence. Reasoning is used to solve everyday problems and allows older adults to function in the community and avoid the need for assistance from both formal (i.e., assisted living or long term care) or informal (e.g., spouse, other family members or friends) sources. Reasoning is involved in everyday functioning and includes such activities as taking medication, balancing a checkbook, or dressing and grooming. Inductive reasoning allows older adults to gather new information and create new solutions to problems and thereby avoid loss of independence and the serious consequences that follow (i.e., accidents, institutionalization, and hospitalizations). In addition, other losses of specific psychological attributes, such as self-confidence, motivation, and self-esteem, can impact decision making and reasoning with serious consequences (e.g., the individual is unable to understand how to turn off a stove burner resulting in injuries). It is apparent that the loss of the ability to reason can affect all areas of an older adult’s life (e.g., physical, emotional, and psychological).

Assessment of Reasoning Using Measures of Everyday Functioning

There are several approaches to assessing reasoning in relationship to everyday cognitive functioning. One approach is to investigate higher order skills (Marsiske & Margrett, 2006; Marsiske & Willis, 1995). These skills are used by older adults in their everyday lives and assist them in remaining independent in their homes. These day-to-day activities include shopping, taking medications, or using transportation (Willis, 1991). This approach became accepted in the 1980s when a shift in theory led to the view that cognitive functioning was part of an overall functional health model that consisted of three factors:
cognitive, physical and social abilities. Several self-report measures of everyday functioning have been created to assess activities of day-to-day living such as the Duke Older Americans Resources and Services (OARS) measure developed by Fillenbaum (1987a, b), the Activity of Daily Living Scale (ADL) developed by Katz et al. (1963), and the Instrumental Activity of Daily Living Scale (IADL) developed by Lawton and Brody (1969). In addition, observational measures have been created to measure older adult’s ability to carry out tasks in their everyday home setting such as the Observed Tasks of Daily Living (OTDL) scale (Diehl et al., 1995; Diehl et al, 2005). Some researchers point out that observational measures allow a more valid picture of an older adult’s everyday functioning in their real world environment (Marsiske & Margrett, 2006). Both self-report and observational measures are considered valid and are related to the actual performance of activities and ratings of functioning by others such as their spouse (Marsiske & Margrett, 2006; Schaie, 1996).

Cognitive problems are a significant predictor of older adults’ difficulties with basic and instrumental activities of daily living, which can lead to a loss of independence and increased costs associated with institutionalization both to the individual, their families, and society as a whole (Burdick et al., 2005). One approach to helping older adults retain their independence is to implement interventions to delay the onset of decline and/or maintain or enhance cognitive functioning.

**Cognitive Training Interventions (CTIs)**

Cognitive training interventions are structured and repeatable ways to teach abilities (Willis & Schaie, 1986). In general, CTIs have led to improvements in older adult’s cognitive abilities such as reasoning, spatial orientation, memory, and speed of processing
Numerous studies have demonstrated that CTIs can improve older adults’ performance in the laboratory as well as in selected everyday activities outside the laboratory (Berch & Wagster, 2004; Hertzog, Kramer, Wilson, & Lindenberger, 2008; Schaie & Willis, 1999). CTIs have successfully shown that older adults can also benefit from training in collaboration with other older adults (Margrett & Willis, 2006; Saczynski, Margrett & Willis, 2004a). CTIs have led to a better understanding of how training can help older adults in their everyday lives (e.g., taking medicine, reading maps of bus routes, shopping at stores) and have been shown to be specific to the ability on which older individuals received training (Jobe et al., 2001). Many CTIs use several outcome measures in order to better demonstrate a training effect than when using only one measure. This helps increase the validity of the results by demonstrating that individuals who take part in the training can use these new or enhanced abilities and apply them to new situations instead of applying training only “to the test” (Schaie, Willis, Hertzog, & Schulenberg, 1987; Willis & Schaie, 1986).

One important question concerning CTIs involves a better understanding of how training works to improve reasoning ability. Gains in performance following CTIs have been theorized to be due to the increased frequency of strategy use. In other words, training is thought to increase the participant’s ability to apply newly trained strategies to novel situations by use of transfer (Dunlosky & Hertzog, 1998a). In one theoretical model of cognitive transfer, Salomon, Perkins and Globerston (1991) hypothesized that transfer occurred either by several different routes or by a combination of routes which allowed for variation in how the training is applied to new situations. Salomon and colleagues suggested that two types of mechanisms are responsible for transference. One is the result of extensive
practice which increases stimulus control and the efficiency of learning by the individual. The second type of transfer, known as mindful abstraction, requires older adults to consciously apply their reasoning abilities to a deeper level of processing the information (Carson & Langer, 2006; Salomon et al., 1991). Researchers currently in the field of reasoning among older adults suggest that mindful abstraction is the mechanism that is believed to be what occurs during the training process (Dunlosky & Hertzog, 1998b; Rasmussen, Rebok, Bylsma, & Brandt, 1999). Mindful abstraction can be divided into two distinct types of transfer: Forward reaching and backward reaching. Forward reaching is hypothesized to occur when information becomes encoded initially into memory as a general principle. Backward reaching is thought to happen during the transfer process itself instead of during the learning process and occurs when the general principle is applied to new situations. Therefore, it is this transfer process, from training to applying the training to novel situations, which is thought to help older adults maintain, enhance, or delay the loss of their reasoning ability.

Cognitive Strategy Training Interventions (CSTIs)

These strategy interventions train individuals to maintain or enhance cognitive abilities such as memory, speed of processing, and reasoning. There are only a few cognitive strategy training interventions which are both large in scope and longitudinal in design.

One large ongoing strategy intervention, the Seattle Longitudinal Study (Schaie et al., 1987), is considered to be one of the most extensive studies of how people develop and change throughout adulthood. This study collected data on reasoning and other cognitive abilities among older adults starting in 1956 with 500 adults recruited from the Seattle area who ranged from 20 to 60 years of age (Schaie, 1999). They subsequently assessed older
participants every seven years. As of 2004 a total of 6000 people had participated in the study. Researchers Willis and Schaie (1986) divided the older adults into two groups based on their performance on measures of spatial orientation and inductive reasoning (Willis & Schaie, 1986). One group was the stable group (i.e., scores did not change over time) and the other the cognitive decline group (i.e., scores showed evidence of significant loss in both inductive reasoning and spatial orientation). These two groups were then provided training. Analyses revealed there was improvement in the level of the two abilities for the cognitive decline group and improved performance in the stable group, resulting in significant training effects for both spatial orientation and inductive reasoning abilities (Willis & Schaie, 1986).

In 2004 a secondary analysis revealed there was a gain in strategy use specific to reasoning ability (Saczyński, Willis, & Schaie, 2004b). Training gains were found up to seven years following the intervention. Analyses revealed that younger participants (i.e., age 65 to 74 years) and those with higher levels of education showed the greatest gains in the use of strategies. This suggests that increased strategy use by participants in the reasoning training group may play a role in the gains made by participants on the reasoning measures (Saczyński, Willis, & Schaie, 2004b, p. 52).

A second major CSTI study called the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) was begun in 1999 with 2800 older adult participants aged 65 to 90 years. This study represents the largest randomized CSTI to date (Jobe et al., 2001). Data were collected from participants over a 10 year period. Participants in the ACTIVE study were randomly assigned to one of four groups (i.e., memory, speed of processing, reasoning, or an untreated control group) and received training on several different cognitive strategies to see if these interventions would help them maintain, enhance, or delay the onset of decline.
on the cognitive ability that was the focus of the training. These three cognitive abilities were chosen on the basis of previous research which suggested these skills were the first to show a decline with aging (beginning in the mid-60s). In addition, these three abilities are associated with more complex activities such as balancing a checkbook, doing taxes, or driving a car, all of which are important for everyday functioning (Schaie, 1996).

The reasoning group was trained on strategies for performing everyday activities (i.e., reading a bus schedules, taking medicine and reading food labels). Analyses revealed that the cognitive training gains were approximately equal to the decline in cognitive abilities that would have been expected to occur over a 7 to 14 year period of time (Ball et al., 2002). The reasoning group also had less difficulty performing tasks related to everyday functioning compared to the control group as measured by the IADL (Ball et al., 2002). This suggests that reasoning was associated with competency in performing everyday tasks (Ball et al., 1998, 2002; Diehl et al., 1995, 2005; Willis, 1996).

Results from additional studies examining the effects of the cognitive training strategies were published more recently. For example, in 2012, a study of memory self-efficacy, inductive reasoning and older adults reported that those with the highest levels of self-efficacy benefited the most from inductive reasoning training (Payne et al., 2012).

A second study focused on strategy training for the maintenance or enhancement of memory examining participants with early stage Alzhiemers’ disease (Cherry & Simmons-D'Gerolamo, 2005; Reuter-Lorenz, 2000). Participants were randomly divided into two groups with one group given an orientation task before the memory strategy training whereas the second group was not given the orientation task. Participants were trained in a spaced retrieval technique involving increasing time periods between seeing an object and retrieving
the object. Results revealed that participants given the orientation task performed significantly better than the non-orientation group, suggesting that strategy training may be beneficial to older adults even with cognitive problems due to early stage dementia.

The third study investigated the long-term effects of mnemonic training on episodic memory among adults 60 years of age or older with 112 community participants (O’Hara et al., 2007). Findings revealed that participants who continued use of training strategies demonstrated long-term improvement in memory suggesting that cognitive training was beneficial to older adults. However, intervention gains were negatively affected by age of the participants and duration of the training sessions. That is, those participants who were older and took longer to learn the strategies did more poorly than younger and faster participants. Results also showed that those in the training group did better than the control group and further suggested that strategy training is helpful to the older adult population.

In summary, there have been very few CTSI studies. Most investigations have been small studies with few participants, used non-healthy older adult participants, and did not employ a no treatment control group. Of the two large randomized studies, the ACTIVE intervention was the only one designed to include participants of different races and from different geographic locations. The findings reported from this study have been extensive. However, publications to date have examined the relationship between composite scores on measures of reasoning abilities rather than examining the number of strategies used by participants before and after training.

Recently data related to the use of reasoning strategies became available from three of the six training sites included in the ACTIVE study: Indiana University, Wayne State
University, and Pennsylvania State University. It is noteworthy that the ACTIVE study gathered data on strategies that may benefit reasoning ability. These data are rare because only a handful of randomized strategy studies have been conducted and the participants in the ACTIVE study were screened for sensory problems, cognitive problems, and disease before they were randomized into groups to reduce the possibility of declines in reasoning ability over time due to these problems.

The frequency of reasoning strategies used by participants may be related to proximal (i.e., enhancement of reasoning ability) and distal (i.e., everyday functioning) outcomes of the training program. It is important to identify which groups of participants based on such factors as age, sex, race, or years of education benefit the most from the reasoning strategy training. It is also important to examine whether or not gains in the use of reasoning strategies may transfer to everyday functioning.

Research Questions

To address these issues two research questions were examined in this research. First, did participation in the reasoning training program lead to increased use of strategies taught to participants? Are there demographic characteristics of participants (i.e., age, sex, race, or years of education) that moderated the effectiveness of the training?

Second, did participation in the reasoning training program influence changes in everyday functioning over time (i.e., prior to the intervention to 5 years following the intervention)? That is, did gains in the use of the reasoning strategies predict changes over time on two measures of everyday functional status: the Observed Tasks of Daily Living, an observational measure, and the Instrumental Activities of Daily Living, a self-report measure?
CHAPTER 3. METHODS

Study Design

The data set that was used in the present study was created from a randomized controlled trial (the ACTIVE study) with older adults who were recruited from six states in the United States: Alabama, Massachusetts, Maryland, Michigan, Indiana, and Pennsylvania (Jobe et al., 2001). This geographic dispersion allowed for the inclusion of both rural and urban older adults from multiple regions of the country. Older adults were recruited in 1998 and 1999 from community centers, clinics, senior housing, and other similar sites. A four-group study design was used which included three intervention groups and an untreated control group. The amount of social contact received by the study’s older adults was equal for the three training groups. By contrast, there was no contact between participants who were assigned to the control group. The use of a no-contact control group was based on the findings from other large clinical trials involving older adults indicating that social contact among participants did not affect the results for studies on the cognitive and functional status of participants (Willis et al., 1983, 2006). Each of the six sites randomized their own participants to one of the four groups: control, memory, speed of processing, and reasoning (Jobe et al., 2001). Six assessments of participants over time were conducted: baseline (prior to the intervention), post-intervention (after 10 weeks of training), and annually at 1, 2, 3, and 5, 7, and 10 years after the baseline assessment. In the present analyses data from pre-intervention, post-intervention, and years 1, 2, 3, and 5 were employed.
Participants and Procedures

Participant Eligibility

A total of 5,000 adults 65 years of age and older were contacted regarding participation in the study, with participants required to be living independently and not have any problems in terms of cognition, sensory status, and disease state based on initial screening assessments (Ball et al., 2002). Good cognitive status was determined by a score of 23 or higher on the Mini Mental State Exam (Folstein, Folstein, & McHugh, 1975). Lack of functional problems was reflected by a score of 3 or higher on the Activities of Daily Living (ADL) Scale, a multi-dimensional scale taken from the Older Americans Resources and Services Scale (OARS; Fillembaum & Smyer, 1981). Participants were tested for sensory status in terms of deficits in vision, hearing, or communication; individuals with deficits were excluded from participating to insure that randomized participants would not have sensory difficulties which would interfere with training. Finally, older adults with serious medical conditions associated with “imminent functional decline or death” (Willis et al., 2006) and those who would not be available during the study period were excluded. Eighteen percent of the older adults originally selected to participate were ineligible for the study based on the selection criteria and 25.3% refused to participate, resulting in a final sample of 2832 participants. Thirty of these participants were later dropped from the analyses due to an error during the randomization process at one of the intervention sites.

Differences Between Participants and Nonparticipants

The 2,802 individuals recruited to participate in the study were younger, more likely to be White, married, male, better educated, and less likely to have either diabetes or heart disease than individuals who were found to be ineligible to participate (Willis et al., 2006).
Thus, this sample was not a representative sample, but rather a sample of relatively healthy older adults.

**Interviewer Training**

Interviewers were trained and certified by first attending a 5-day workshop focusing on the study assessment protocol at the Coordinating Center of the New England Research Institute. Interviewers first practiced with each other and then with volunteer older adults in areas where the intervention was to be conducted (Jobe et al., 2001). Interviewers were required to practice a specific number of assessments in which they used volunteer participants who were both younger and older adults. Study coordinators observed and certified the interviewers during their practice training and gave feedback both verbally and in written form (Jobe et al., 2001). Finally, interviewers were observed in the field and given feedback to make sure they were following the protocol (Jobe et al., 2001).

**Pre-Intervention Assessment**

Eligible participants attended two testing sessions where the reasoning measures (letter series, letter sets, and word series) and the two measures of functioning (i.e., the OTDL and the IADL) were administered along with other measures. Completion time for the first session by the participants ranged from 90 to 120 minutes (Ball et al., 2002). In the second session, older adults were placed into small groups of approximately 4 to 6 adults. Assessments of intelligence, cognition, and self-report measures of everyday functioning (IADL) were conducted at that time which took approximately 3 hours to complete.

**Reasoning Strategy Training**

Strategy training took place in small groups of three to five participants. There were a total of 10 sessions that ranged from 60 to 75 minutes in duration which were conducted
over a 5 to 6 week period. The first five sessions focused on strategy instruction and individual and group exercises to practice the strategy (i.e., slash marks, tic marks, underlining and inserting letter). The second five sessions (e.g., 6 through 10) provided additional practice with no additional strategies being introduced (Ball et al., 2002). Two booster training sessions, each lasting 60 to 75 minutes, were conducted at 11 months and 33 months following the baseline assessment for a randomly selected subgroup of the participants in the reasoning strategy training. All sessions were completed at least two years before the 5-year follow-up assessment (Willis et al., 2006).

Older adults were trained to use four individual reasoning strategies so they could apply these strategies later in their everyday functioning tasks. Two measures were used to assess everyday functioning: One self-report measure, the Instrumental Activities of Daily Living (IADL), and one observational measure, the Observed Tasks of Daily Living (OTDL). Each of the four unique strategies helped to assist in inductive reasoning. As can be seen in Appendix B, four reasoning strategies were taught to participants: slash marks, tic marks, underlining, or inserting a letter to help participants to physically denote a pattern in information. During training participants used three measures of inductive reasoning: the Letter Series, the Letter Sets, and the Word Series. These measures provided participants with information by which they could discover unique patterns and apply the four training strategies (i.e., slash marks, tic marks, underlining or letter insertion).

Participants were taught each of the four training strategies by first finding unique patterns in one of the inductive reasoning measures and then specifically using one of the four strategies to mark the pattern in the next, novel example. Each training strategy reflected a unique inductive reasoning skill. To begin training, staff first showed participants
what a pattern looked like in an example. This demonstration was both verbal and physical in
nature and used knocking and clapping so participants could see and hear the pattern (i.e.,
knock knock, clap clap). After this first demonstration, participants were trained to scan
information and say it out loud themselves. This was followed by participants learning each
individual strategy one at a time over the course of the total training period. That is, after
training and practice of one strategy, another strategy was then introduced and practiced
during a different training session. Training was conducted using a nested design of 4-5 older
adults who were taught reasoning strategies and practiced for the first 5 sessions followed by
practicing the strategies for the next 5 session (i.e., total of 10 sessions).

The order of the strategies that were taught during the training program was as
follows: underlining, slash marks, tic marks, insert a letter. Each individual strategy was
chosen for a specific reason with substantive cognitive theories related to reasoning (i.e.
inhibition, attention, and working memory) directing choice of strategies when the ACTIVE
study was designed. For example, the underlining strategy helped participants to see smaller
patterns within larger sets of information they scanned during training. The slash mark and
tick mark strategy taught participants how to physically denote patterns in scanned
information to reduce the work load in memory. The tic mark strategy also helped
participants to inhibit information that they typically would use as a cognitive schema and
transform it into a visual object. The insert letter strategy served to help inhibit automatic
responses during their search for patterns of information and to insert a letter as a place
holder for a cognitive schema so they could go on to the next part of finding a pattern. This
strategy also served as a reduction in working memory load while participants sought
patterns of information.
Attrition

Willis and colleagues (2006) published information on participation rates for the ACTIVE study over the first five years. The reasoning and control group dropout rates were similar for both pre-intervention and post-intervention assessments as well as for the Year 1, 2, 3, and 5 annual assessments. The reasons participants did not complete interviews included withdrawal from the study, mortality, or the completion of only partial assessments.

Sample

The current study employed data from three of the six sites involved in the ACTIVE study: Indiana University, Wayne State University, and Pennsylvania State University. There were a total of 601 participants selected from these three sites who were either assigned to the reasoning strategy training group (N = 304) or the control group (N = 297). Fourteen of these participants had incomplete data for post-intervention assessment and were therefore not included in the analyses, resulting in a final sample of 587 participants.

Measures

Demographic Variables

The following demographic data were collected and included in the analyses: Age in years, race, sex, and years of educational attainment. In addition, the site from which participants were recruited was used as a control variable.

Measures of Inductive Reasoning

Three measures of inductive reasoning (i.e., Letter Series, Letter Sets, and Word Series) were used during the study to measure the reasoning strategies used by participants before and after training. Assessments of total observed reasoning strategy use were conducted at each of six time points: Pre-intervention, post-intervention, and annually at
years 1, 2, 3 and 5 following the pre-intervention assessment. The present analyses employed data on strategy use pre-intervention and post-intervention.

**Letter Series.** This measure was developed to assess inductive reasoning (Blieszner, Willis, & Baltes, 1981) and consists of 20 items. Participants are required to identify patterns found in a series of letters. They are asked to indicate what the next letter would be in the series after they had made the initial pattern determination. The number of letters in each series ranged from 7 to 15. A series of letters, such as “a b c d e f g h,” was shown on the left side of the questionnaire. Participants were required to look on the right side of the page to determine which letter would come next in the series, such as “a b c d e f g h.” The example given here should result in the correct answer of “i”. Coefficient alpha for the total score for the measure was reported to be .91 by Blieszner and colleagues (1981). The number of correct items is summed to create a total score, with higher scores reflecting better performance on the measure. Participants were given 6 minutes to complete the measure.

**Letter Sets.** This measure was developed to assess cognitive reasoning (Ekstrom, French, Harman, & Derman, 1976) and consists of 15 items. Each participant views several sets of letters and identifies the set that did not use the same pattern rule as the others. Participants view a page with 15 lines of letter sets with each line consisting of five letters. Participants then mark an “x” through the letter in the set which they believe does not fit the rule. For example, if a participant saw a set of five letters such as “acegi bdfhj jlmnp tvxz,” they should have x’d out the letter set “jlmnp.” This letter set, “jlmnp,” does not follow the rule of “every other letter in each set.” This was a timed test which participants had 7 minutes to complete. Coefficient alpha was reported to range from .74 to .84 for the measure
by Ekstrom and colleagues (1976). The number of correct items is summed to create a total score with higher scores indicating better performance.

**Word Series.** This measure was also developed to assess inductive reasoning (Gonda & Schaie, 1985) and consists of 30 items. Participants are asked to determine the pattern in the list or series of related words placed vertically on a page. Once that determination is made they are asked to indicate what word would come next in the series. Each series of words follows a different rule. For example, in a word series of months of the year participants moved down a column containing a list of words such as, “January February February March April April ____”. Participants had to then determine from a separate column of possible answer choices such as “January February March April May June” what word would come next in the series (the answer should be “May”). Participants are given 6 minutes to complete the measure. The number of correct items is summed to create a total score with higher scores indicting better performance on the task. Coefficient alpha was reported as .89 for the total score on the measure by Gonda and Schaie (1985).

**Reasoning Strategies**

As seen in Appendix B four specific strategies were taught to improve participant’s skill in the area of inductive reasoning. The “underlining” strategy trained participants to insert an underline in reasoning problems to indicate repetitions, skips, and replications. The “slash mark” strategy trained participants to insert a slash mark or a series of slash marks to indicate repetitions, skips, and replications. The “tick” mark strategy trained participants to insert a tick mark or series of tick marks to indicate repetitions, skips, and replications. Finally, the “letter insertion” strategy trained participants to insert the appropriate letter into the repetitions, skips, and replications.
**Everyday Functioning**

Two measures of everyday functioning were also administered to participants. These measures were selected because they assess activities older adults perform daily in order to take care of themselves and remain independent.

**Instrumental Activities of Daily Living.** This measure assessed older adults’ higher order (i.e., more complex) abilities that are used in everyday functioning (Lawton & Brody, 1969). Ten common activities of daily living were assessed based on self-reports by participants. Examples of the activities are using a checkbook, shopping, and completing taxes; these are all complex tasks requiring the ability to reason. For each item the individual was asked to indicate who much difficulty they would have completing the activity. They were given three choices: none, a little, or a lot of difficulty. Higher scores on this measure reflected poorer functional status.

**Observed Tasks of Daily Living (OTDL).** The Observed Tasks of Daily Living scale is a performance-based, observational measure assessed three domains of everyday functioning (Diehl, 1995). The domains include medication use, telephone use, food, and finances. Examples of the activities are reading a label from a prescription container, looking up a telephone number in a telephone book, reading a food label; these are all complex tasks requiring the ability to reason. It should be noted that higher scores on this measure reflected better functional status.
CHAPTER 4. RESULTS

Sample Characteristics

Table 1 presents descriptive statistics for the demographic variables that were employed in the analyses for the total sample and each of the three data collection sites (i.e., Indiana University, Wayne State University, and Pennsylvania State University). The average age of participants was 73.81 years ($SD = 5.73$); the average age of participants did not vary significantly across the three sites, $F (2, 584) = 2.33$. There were 78.9% female and 21.1% male participants with the proportion of men and women also not varying significantly across the three sites, $\chi^2 (2, N = 587) = .89$. Overall 35.6% of the research participants were African American. Analyses indicated that the proportion of minority participants varied significantly across the three sites, $\chi^2 (2, N = 587) = 164.99$, $p < .001$. The highest proportion of African American participants was at the Wayne State University site (66%) whereas only 6% of the participants at Pennsylvania State University were African American. Finally, the average level of education for participants was 13.24 years ($SD = 2.59$); 45.8% of participants had graduated from high school. Level of education also varied significantly across the three study sites. Specifically, participants from Pennsylvania State University were significantly less educated than participants from the other two sites, $F (2, 584) = 39.03$, $p < .001$. Wayne State University and the Indiana University’s participants did not differ significantly from one another on education.

Prediction of Strategy Use

The first set of analyses examined correlations among the variables to be employed in the regression analyses predicting strategy use. As can be seen in Table 2, age was found to be negatively correlate with education, whereas being male correlated positively with
education. Race was uncorrelated with age, sex or education. Next, the correlations between the demographic variables and the three dependent variables (i.e., strategy use for the Letter Series, Letter Sets, and Word Series measures) both pre- and post-intervention were examined. The pre- and post-intervention Letter Series measure was positively correlated with race, indicating that blacks used fewer strategies than whites. By contrast, the Letter Sets measure was positively correlated only at post-intervention with race as was the Word Series measure; once again, black participants used fewer strategies than white participants. Finally, correlations among the three dependent variables (both pre- and post-intervention) were examined. As expected, the pre-intervention and post-intervention scores on these three variables were found to be significantly correlated, and the correlations among the measures of strategy use for the three tasks were also found to be significantly correlated.

The next set of analyses examined the relationship between the predictor variables (i.e., demographic characteristics of participants, study site, and treatment condition) and the use of strategies following the intervention. A series of hierarchical regression analyses were conducted with variables entered into the regression equation in the following order: (a) pre-intervention strategy use (i.e., for each type of task, such as letter series), (b) demographic characteristics of participants (i.e., age, sex, education, and race) and study site, and (c) treatment condition (i.e., intervention vs. control). The final step of the regression analyses tested whether or not the effect of the treatment condition on strategy use was moderated by the other predictor variables (e.g., demographic characteristics of participants, study site).

**Letter Series**

The first hierarchical regression analysis examined the effects of treatment condition on the number of strategies that were used in solving the letter series task following the
reasoning strategy training. The results are presented in Table 3. Participant scores on the number of strategies measure that was taken prior to the intervention was entered into the regression analysis in the first step. This measure was found to be a statistically significant predictor, $F(1, 585) = 16.21, p < .001$, accounting for 2.7% of the variance in the post-intervention measure. In Step 2, the demographic variables of age, education, sex, and race were entered into the equation along with two dichotomous variables reflecting the site (i.e., Wayne State University, Indiana University, or Pennsylvania State University) where data were collected. This set of variables was also found to be significantly related to the post-intervention measure of number of strategies that were used by the participant, $F(6, 579) = 6.89, p < .001$, accounting for 6.5% of the variance. As can be seen in Table 3 the participant’s age, years of education, and race were all significantly related to the number of strategies that were used.

In Step 3, the variable reflecting treatment condition (i.e., control versus reasoning strategy training) was entered into the regression equation. There was found to be a statistically significant effect of treatment condition on the post-intervention measure of strategy use after controlling for the effects of the other predictor variables, $F(1, 578) = 191.86, p < .001$, accounting for 22.6% of the variance in the outcome variable. After adjusting for the effects of the control variables the mean number of strategies used by the control group was 0.82, whereas the adjusted mean for the reasoning strategy training group was 21.58.

Variables reflecting interactions between the demographic variables and treatment condition were entered into the regression equation in Step 4. These interaction terms were also found to be significantly related to the post-intervention measure of number of strategies
that were used by the participant, $F(6, 572) = 7.39, p < .001$, accounting for 4.9% of the variance in the dependent variable. The interactions of age, education, and race with treatment condition were all found to be statistically significant.

A series of simple effects analyses was conducted to examine these significant interactions. For the dichotomous variable of race the effect of treatment on the outcome variable was examined for White and Black participants. There was a statistically significant difference between the control and reasoning strategy training conditions for both racial groups. However, the effect of treatment condition on the post-intervention strategies measure was significantly greater for White participants, $b = 23.96, t(577) = 12.99, p < .001$, than for Black participants, $b = 14.74, t(577) = 5.91, p < .001$.

For the two continuous variables of age and education the simple effects of treatment condition was evaluated for high (i.e., +1 SD) and low (i.e., −1 SD) levels of the demographic variables. The results for education indicated that the effect of the reasoning strategy training was significantly greater for participants who were more highly educated, $b = 20.16, t(577) = 5.19, p < .001$, than for participants who were less educated, $b = 9.43, t(577) = 2.57, p = .01$, although there was a statistically significant effect of the intervention for both levels of education. The results for age indicated that the effect of the reasoning strategy training was significantly greater for participants who were younger, $b = 20.48, t(577) = 5.19, p < .001$, than for participants who were older, $b = 9.11 t(577) = 2.57, p = .001$, although once again there was a statistically significant effect of the intervention for both levels of age.

**Letter Sets**

The second hierarchical regression analysis examined the effects of treatment condition on the number of strategies that were used in solving the letter sets task following
the conclusion of the reasoning strategy training. The results are presented in Table 4. Participant scores on the number of strategies measure that was taken prior to the intervention was entered into the regression analysis in the first step. The pre-intervention measure of strategy use was found to be statistically significant, $F(1, 585) = 38.94, p < .001$, accounting for 6.2% of the variance in the post-intervention measure. In Step 2, the demographic variables and study site were entered into the regression equation. This set of variables was also found to be significantly related to the post-intervention measure of number of strategies that were used by the participant, $F(7, 579) = 13.76, p < .001$, accounting for 8.0% of the variance. As can be seen in Table 4, the participant’s years of education was significantly related to the number of strategies that were used.

In Step 3, the variable reflecting treatment condition was entered into the regression equation. There was found to be a statistically significant effect of treatment condition after controlling for the effects of the other predictors, $F(8, 578) = 26.07, p < .001$, accounting for 12.2% of the variance in the outcome variable. After adjusting for the effects of the control variables the mean number of strategies that were used by the control group was 0.78 whereas the adjusted mean for the reasoning strategy training group was 9.11.

Variables reflecting interactions between the demographic variables and treatment condition were entered into the regression equation in Step 4. These interaction terms were found to be significantly related to the post-intervention measure of number of strategies used, $F(14, 572) = 19.85, p < .001$, accounting for 6.2% of the variance. The interaction of years of education with the treatment condition was found to be statistically significant.

A simple effects analysis was conducted to further examine this significant interaction. The effect of the treatment condition was evaluated for high (i.e., +1 SD) and
low (i.e., –1 SD) levels of education. The impact of the reasoning strategy training was significantly greater for participants who were more highly educated, $b = 11.49, t (577) = 5.32, p < .001$, than for participants who were less educated, $b = .924, t (577) = .45, p = .65$, with the effect for the less educated group being non-significant.

**Word Series**

The next analysis examined the effects of treatment condition on the number of strategies that were used in solving the word series task following the reasoning strategy training. The results are presented in Table 5. In Step 1 of the regression, the pre-intervention measure of strategy use was found to be statistically significant, $F (1, 585) = 30.55, p < .001$, accounting for 5% of the variance in the post-intervention measure. In Step 2, the demographic variables and study site were found to be significantly related to the post-intervention measure of number of strategies that were used by the participant, $F (7, 579) = 8.38, p < .001$, accounting for 4.2% of the variance. As can be seen in Table 5 the participant’s education, race and site were all significantly related to the number of strategies that were used.

In Step 3, the variable reflecting treatment condition was entered into the regression equation. There was a statistically significant effect of treatment condition on the post-intervention measure of strategy use after controlling for the effects of the other predictor variables, $F (8, 578) = 16.60, p < .001$, accounting for 9.5% of the variance. After adjusting for the effects of the control variables the mean number of strategies that were used by the control group was 0.40 whereas the mean for the reasoning strategy training group was 7.42.

Variables reflecting interactions between the demographic variables, site, and treatment condition were entered into the regression equation in Step 4. These interaction...
terms were also found to be significantly related to the post-intervention measure of number of strategies that were used by the participant, $F(14, 572) = 11.79, p < .001$, accounting for 3.7% of the variance in the dependent variable. The interactions of race and site with treatment condition were all found to be statistically significant.

Simple effects analyses were conducted to examine these significant interactions. For the dichotomous race variable the effect of treatment condition on the outcome variable was examined for White and Black participants. There was a statistically significant difference between the control and reasoning strategy training groups for both racial groups. However, the effect of treatment condition on the post-intervention strategies measure was significantly greater for White participants, $b = 11.77, t(577) = 6.34, p < .001$, than for Black participants, $b = 6.01, t(577) = 2.97, p < .01$. Next, the effect of treatment condition on the outcome variables was examined for the three sites. The results of the simple effects analyses indicated that the effect of the reasoning strategy training was significantly greater for participants who were from the Indiana University, $b = 6.01, t(577) = 2.97, p < .01$, than for participants from Wayne State University, $b = 1.31, t(577) = .75, p = .45$, or Pennsylvania State University, $b = 1.24, t(577) = .47, p = .64$, with the effect of the intervention being non-significant for the latter two sites.

**Summary**

The results of the analyses indicated that the reasoning strategy training was very effective in enhancing the use of strategies that were included in the training. Characteristics of participants such as age, education, and race were also predictive of strategy use following the intervention. These participant characteristics were found to interact with the treatment condition in predicting use of the strategies following the intervention, indicating that the
intervention was more effective for participants who were younger, better educated, and White.

**Prediction of Functioning Over Time**

The hypothesized model shown in Figure 3 was tested by conducting two latent growth curve modeling analyses. These analyses examined whether the reasoning strategy training predicted functional status across time (i.e., prior to the reasoning strategy training and then 1, 2, 3, and 5 years following the baseline assessment). There were three groups of participants: (a) the control group, (b) participants in the reasoning strategy training group who did not receive booster training, and (c) participants in the reasoning strategy training group who also received booster training at 11 and 33 months following completion of the intervention. The two measures of functional status were the Instrumental Activities of Daily Living (IADL), a self-report measure, and the Observed Tasks of Daily Living (OTDL), an observational measure.

**Instrumental Activities of Daily Living**

The first set of growth curve modeling analyses was conducted to evaluate the pattern of change over time for the self-report Instrumental Activities of Daily Living (IADL) measure. Average scores over time on this measure are presented in Figure 4. Growth curve modeling analyses were conducted using the Mplus 7.0 program (Muthén & Muthén, 2004). The intercept (i.e., participant’s status on the dependent variable at baseline), linear, and quadratic terms were estimated. An initial unconditional model was tested, where these three latent variables were included in the model but there were no predictors. Based on the criteria described by Hu and Bentler (1999), the results indicated that this model provided a good fit to the data, $\chi^2(6, N=587) = 26.04, p < .001$, RMSEA = .08, CFI = .97. The mean of
the intercept term ($M = 1.46$) was significantly greater than zero, $t (587) = 14.31$, $p < .001$; this value reflects the average score of participants on the IADL measure prior to the intervention. For the linear term the mean value for the sample was $-.10$; this indicates that scores on the IADL measure declined by $.10$ points each year following the baseline assessment. However, this average value did not differ significantly from zero, $t (587) = -1.11$, $p = .27$. Finally, the average for the quadratic term was $.03$ which also did not differ significantly from zero, $t (587) = 1.54$, $p = .12$.

These results indicate that we cannot reject the hypothesis that there was no significant change on the IADL measure over this 5-year period for the sample as a whole. However, it is also important to evaluate whether or not there are significant individual differences in the pattern of change over time. An analysis of the variability of the intercept ($s^2 = 4.04$), linear ($s^2 = 1.70$), and quadratic ($s^2 = .08$) terms indicated they were all statistically significant ($p < .001$). Therefore, it appears there were significant individual differences in the pattern of change over time on the IADL measure.

The next set of analyses examined the association among these three indicators of change on the IADL over time as well as their correlation with each of the predictor variables (see Table 6). Participant’s scores on the IADL assessment at baseline (i.e., the intercept term) were not significantly correlated with the linear or quadratic change over the next 5 years. However, as expected there was a strong correlation between the linear and quadratic terms indicating that participants who showed the highest rate of linear change over time were also found to have the lowest level of quadratic change over time (i.e., they were less likely to show evidence of nonlinear decline over time). The only predictor variable that was found to be significantly correlated with baseline scores on the IADL measure was age, with
older participants reporting greater problems in performing the IADL tasks at the initial assessment prior to the intervention. Participant education was found to be significantly related to linear change over the subsequent five years on the IADL measure; higher levels of education were associated with a lower rate of change. Education was also significantly related with the quadratic term, with more educated participants found to demonstrate greater evidence of nonlinear change over time on the IADL measure.

The final set of growth curve analyses on the IADL measure tested the hypothesized causal model. This model provided a very good fit to the data, $\chi^2 (22, N=587) = 47.09, p = .001$, RMSEA = .04, CFI = .97. The results of these analyses are presented in Tables 7 through 9 and in Figure 5. The predictor variables were found to be significantly related to the intercept term, $t (587) = 2.51, p = .01$, accounting for 6.6% of the variance in the baseline scores. The IADL intercept was significantly predicted by the participant’s age, $t (587) = 4.15, p < .001$, and whether or not the participant was from the Wayne State site, $t (587) = –2.08, p = .04$. Older participants received higher scores on the IADL whereas participants from the Wayne State received lower scores relative to participants from the other two sites. The relationship between these predictor variables and linear change on the IADL measure over time was also statistically significant, $t (587) = 1.98, p = .05$, accounting for 6.9% of the variance. The linear term for the IADL measure was significantly related to participant race, $t (587) = –2.01, p = .04$, indicating that black participants declined in functioning over time more quickly than did white participants. Being recruited from the Wayne State site was also significantly related to linear change on the IADL measure over time, $t (587) = –2.71, p = .01$; the decrease in functioning over time was greater for participants from Indiana University and Pennsylvania State University than for participants from Wayne State.
University. Finally, the relationship between the predictor variables and the quadratic term from the growth curve analysis was non-significant, \( t (587) = 1.66 \).

**Observed Tasks of Daily Living**

The second set of growth curve modeling analyses was conducted to evaluate the pattern of change over time for the Observed Tasks of Daily Living (OTDL) measure. Average scores over time on this measure are presented in Figure 6. An initial unconditional model was tested, where three terms (i.e., intercept, linear, and quadratic) were included but there were no predictors of these latent variables included in the model. The results indicated that this model provided a good fit to the data, \( \chi^2 (6) = 38.19, p < .001 \), RMSEA = .10, CFI = .97. The mean of the intercept term (\( M = 17.28 \)) was significantly greater than zero, \( t (587) = 95.75, p < .001 \); this value reflects the average score of participants on the OTDL measure at baseline prior to the intervention. For the linear term the average value for the sample was \(-.74\), which was significantly different from zero, \( t (587) = -3.88, p < .001 \). This result indicates that scores on the OTDL measure decreased by an average of .74 points each year for the sample following the baseline assessment indicating that the level of functioning decreased over time for the sample as a whole. Finally, the average for the quadratic term was -.07 which also differed significantly from zero, \( t (587) = -2.01, p = .04 \). This latter result indicates there was some evidence of a curvilinear change on the OTDL measure over time. As can be seen in Figure 6, scores on the OTDL measure increased from the baseline to the Year 2 assessment, indicating improvements in functioning. However, scores decreased between the Year 2 and Year 3 assessment, reflecting the non-linear change in functional status over time.
An analysis of the variability of the intercept \( S^2 = 14.46 \), linear \( S^2 = 10.87 \), and quadratic \( S^2 = .23 \) terms indicated that they were all statistically significant \( p < .001 \). Therefore, it appears there are significant individual differences in the pattern of change over time on the OTDL measure for study participants.

The next set of analyses examined the association among these three indicators of change on the OTDL over time as well as their correlation with the predictor variables. The results are presented in Table 10. Participant’s scores on the OTDL assessment at baseline (i.e., the intercept term) were not significantly correlated with the linear or quadratic change over the next five years. However, as expected there was a strong correlation between the linear and quadratic terms indicating that participants who showed the highest rate of linear change over time were also found to have the lowest level of quadratic change over time (i.e., they were less likely so show evidence of nonlinear change). Participant age, education, race, and receiving the reasoning strategy training along with the booster sessions were significantly correlated with scores on the OTDL measure as baseline (i.e., the intercept term). Older participants received lower scores on the measure at baseline; as expected this indicates poorer functional status for this group of participants. By contrast, being White and better educated were associated with better functional status on the OTDL. Finally, participants who were assigned to receive the intervention with the booster sessions had higher scores on the OTDL at baseline prior to intervention.

Participant age was the only predictor variable that was found to be significantly related to linear change over the subsequent five years on the OTDL. Older participants demonstrated a slower rate of change on the OTDL measure. Finally, none of the predictor variables were significantly correlated to the quadratic term.
Growth curve analyses for the OTDL measure tested the hypothesized causal model. This model provided a very good fit to the data, $\chi^2(22) = 62.79, p < .001$, RMSEA = .06, CFI = .97. The results for the model are presented in Tables 11 through 13 and Figure 7. The predictor variables were found to be significantly related to the intercept term, $t(587) = 6.36, p < .001$, accounting for 36% of the variance in the baseline scores. The OTDL intercept was significantly predicted by participant’s age, $t(587) = -7.53, p < .001$; race, $t(587) = 4.97, p < .001$; and education, $t(587) = 8.81, p < .001$. Older participants performed more poorly on the tasks included in the OTDL measure, whereas White and better educated participants received higher scores. The relationship between these predictor variables and linear or quadratic change on the OTDL measure over time were non-significant.

**Summary**

The results of the growth curve modeling analyses indicated there was no evidence of significant change over time for the sample as a whole on the IADL measure. However, there was evidence of a significant change over time for the OTDL measure, with the results indicating that there was evidence of an improvement in functional status from the baseline to the Year 2 assessment, followed by a decline in functioning over the next three years. There was also evidence of significant variability across individuals in the change in functioning over time. The results indicated that age, education, and race were significantly related to the level of functioning at the pre-intervention assessment and change in functioning over time. There was no evidence that the reasoning strategy training had an effect on the change in the functional status of these individuals over time. Therefore, it does not appear that the increase in use of the reasoning strategies by participants who received the intervention had an effect on their daily functioning.
CHAPTER 5. DISCUSSION AND CONCLUSIONS

The present study analyzed data from participants who were trained in inductive reasoning strategies in the ACTIVE study, the largest randomized, geographically dispersed, longitudinal study of older adults at the time it was begun in 1999. This investigation randomly assigned participants to one of three intervention conditions that focused on different cognitive abilities (i.e., memory, speed of processing, or reasoning) or to a no treatment control condition.

Analyses reported here employed data from participants assigned to the reasoning strategy training or the control condition. Using these data two issues were addressed. First, what was the effect of the reasoning strategy training on the use of strategies? Second, did the reasoning strategy training have an impact on the functional status of participants over the course of five years?

Impact of the Reasoning Strategy Training on Strategy Use

The results of the analyses indicated that the reasoning strategy training was very effective in enhancing the use of strategies that were included in the training. Although the results varied somewhat across the three reasoning tasks employed in the study (i.e., letter series, letter sets, and word series), participants in the reasoning strategy training condition were significantly more likely to use the strategies than individuals in the control condition. Specifically, from 31% to 62% of individuals who received the training employed the strategies in performing the tasks following the intervention whereas only 2% to 4% of the control participants used these strategies.

Characteristics of participants such as age, education, and race were also predictive of strategy use following the intervention. As expected, older age was associated with lower
strategy use. Similarly, participants with greater education were more likely to employ these strategies. Finally, there were racial differences found on the use of strategies for two of the tasks (i.e., letter series and word series), indicating that Black participants were less likely to use these reasoning strategies than White participants.

**Effect of the Reasoning Strategy Training on Functional Status**

Two measures of participant functional status (i.e., the IADL and OTDL) were administered to participants prior to receiving the intervention and then one, two, three, and five years later. Growth curve modeling analyses were conducted to evaluate the ability of the reasoning strategies and demographic characteristics of participants to predict change over time on these measures. For these analyses the reasoning training group was divided into two groups as some members of the intervention group ($N = 167$) were randomly assigned to receive booster training at 11 and 33 months following the pre-intervention assessment whereas the remaining members of the intervention group ($n = 122$) did not. There was no evidence of changes in functional status on the IADL measure for the sample as a whole, whereas there appeared to be an improvement on the OTDL measure from baseline to Year 2 followed by a decline in functioning by Year 3. In previous findings from the ACTIVE study published in 2006, Willis and colleagues found that the reasoning group reported significantly less difficulty (effect size, 0.29; 99% confidence interval [CI], 0.03-0.55) in the instrumental activities of daily living (IADL) than the control group, and no booster effects for everyday functioning. In the 2006 findings, the reasoning group maintained effects on its specific targeted cognitive ability (i.e., effect size, 0.26 [99% CI, 0.17-0.35]) through 5 years (Willis et al, 2006).
For both measures of functional status there was significant variability across individuals in change over time, indicating that some participants increased in functional status, some individuals decreased in functional status, and some participants did not change in functional status over time. The results indicated that age, education, and race were significantly related to both initial level and change in functioning over time. As expected, participants who were older, less educated, and Black were lower in functional status at the pre-intervention assessment and declined more quickly in functioning over time. However, in contrast to predictions there was no evidence that the reasoning strategy training was related to change over time on the measures of everyday functioning.

**Implications for Reasoning Strategy training**

Although only 2% to 6% of participants used the reasoning strategies at the pre-intervention assessment, training led to 31% to 62% of participants who received the intervention using the strategies at the post-intervention assessment. These results suggest that, as predicted by SOC theory, older adults can optimize their performance through continuous practice (i.e., optimization) of strategies and thereby enhance their reasoning abilities. In addition, the results suggest that the participants were able to compensate for any deficits they had in their cognitive abilities. However, this enhancement in the use of these reasoning strategies did not lead to a significant change in their functional status after training as measured by the IADL and the OTDL. SOC theory proposes that the individual trajectories of participants who received the training should vary since older adults represent a heterogeneous group of individuals due to their life course experiences, genetics, and health (Baltes & Smith, 2003).
In addition, older adults are known to strive for control in their lives and making choices regarding what they wish to optimize and compensate for is basic to SOC theory by choosing strategies in the face of illness, disease, and normal declines in everyday functioning (Heckenhouse, 2011; Rozario, Kidahashi, & DeRienzis, 2011). It should also be noted that the use of the individual strategies may have affected aspects of cognitive functioning beyond reasoning abilities. First, it may be that the strategies allowed the older adults to find patterns in information helping them to chunk information more swiftly than before training. This may have reduced the load on working memory and freeing up extra time for processing and manipulation of information during the reasoning process (Morrison, 2005; Salthouse, 1996). The strategy training may have also allowed participants to learn how to both focus their attention and inhibit other irrelevant information (Hasher & Zacks, 1988; Persad et al., 2002) which may also have enhanced performance of the reasoning tasks.

Finally, it is possible that some participants were able to internalize their training as they practiced and may therefore have appeared to not be using the reasoning strategies following training. Such individuals may no longer need to find answers to the reasoning problems by consciously using marks to answer their questions, but rather used “mindful abstraction” reflecting a deeper level of reasoning ability (Salomon et al., 1991). They may have become very good at doing these tasks and no longer needed to mark down on paper the patterns they found when performing the reasoning tasks. If true the results of reasoning strategy training may have been greater than found here based on the observed strategy data.

**Education**

The analyses revealed that those with higher education made greater gains in observed strategy use. There may be both biological and environmental reasons for this finding. Prior
research with older adults into the biological relationship between education and the brain has demonstrated that different areas of the brain are activated by different levels of education (Springer et al., 2005; Stern, 2002). Prior research into the environmental relationship between education and aging has demonstrated that there is a large difference between the years of education reported by older adults and the quality of that education, especially among minorities (Elo, 1997; Kirsch et al., 1993; Manly, 2006; National Research Council on Race and Health Mortality, 2004). In addition, other studies have found that Black older adults in the United States have reading skills far below their self-reported levels of education (Albert & Teresi, 1999; Baker et al., 1996; Kave et al., 2012; Manly et al., 2002). It may be that the levels of education levels reported by participants in this study did not adequately reflect the same educational abilities across participants.

**Cognitive Reserve**

Research studies of healthy older adults have previously established that the volume of white matter in the brain is negatively associated with cognitive tests including those involving executive functioning (Brickman & Buchsbaum, 2008; Gunning-Dixon et al., 2008). In a recent study researchers investigated the relationship between cognitive functioning, brain reserve, and cognitive reserve. Brain reserve is believed to compensate for pathological change before symptoms are detected and allow individuals to function better in daily life than those without this reserve. Analyses revealed that brain reserve and lower volumes of white brain matter were associated with worse cognitive functioning whereas greater brain reserve and higher volumes of white matter in the brain were associated with better cognitive functioning and brain reserve (Brickman et al., 2011). When cognitive functioning was controlled for, individuals with higher brain reserve had significantly greater
white matter volume. This suggests that both brain reserve and cognitive reserve appear to help individuals with their cognitive functioning and to undermine illness and disease in the brain.

**Screening Protocols for Recruitment of Participants**

Although strict protocols in screening participants were followed at all locations the criteria that were employed may have been insufficient to eliminate individuals who were experiencing mild cognitive impairment. The Mini-Mental State Exam (MMSE) was used for screening purposes in the ACTIVE study. This measure is actually a mental status measure and not a measure meant for the purpose of identifying cognitive impairment (Wadley et al., 2007). One reason individuals experiencing cognitive impairment are tested by a battery of measures over the course of several days is that multiple assessments help to better identify persons experiencing even a mild level of cognitive impairment. Although the MMSE is commonly used in screening for cognitive impairments in community settings, it may not have been adequate for the recruitment of cognitively intact participants in the ACTIVE study since it was given only at one point in time. Given that the literature shows that higher order tasks are lost before lower order tasks (Ashford et al., 1986; Reisberg, Ferris, de Leon, & Crook, 1982), it may have been more prudent to administer another measure that evaluated performance on higher order cognitive tasks during the screening and recruitment process.

**Influence of Reasoning Strategies on Everyday Functioning**

Overall, these analyses of the reasoning and control groups from the ACTIVE study demonstrated that this cognitive intervention helped generally healthy older adults to improve their ability to apply reasoning strategies successfully after approximately 5 to 6
weeks of training. Like the larger study sample of 2,802 participants, the current study results did not demonstrate that the participants were able to apply improved strategy use to enhance their everyday functioning as measured by both a self-report measure (IADL) and an observation measure (OTDL) over the first five years of assessments.

It is interesting to note that the self-report measure showed that the older adults perceived themselves to be maintaining their everyday functioning over time on more complex tasks of daily living (IADL) rather than showing the expected decline in functioning with age. However, the perceptions of trained staff in evaluating the participants’ performance on the everyday functioning measure (OTDL) indicated there were improvements in functional status during the first two years following the baseline assessment followed by a steep drop in performance between the 2nd and 3rd annual assessments. The self-reports of the participants appear to be biased toward reporting no change in their everyday functional status over time. It may be that despite the gains in strategy use, participants were not applying these new strategies in their daily lives and so no discernible improvements over time were observed as a function of the training intervention.

It should also be noted that these analyses employed data from the first 5 years of the 10 year ACTIVE study. More time may be necessary to show the effects of the intervention on the everyday functioning of participants. As previously mentioned, participants were recruited into the study based on meeting criteria that ensured a high probability of good health (i.e., good vision and hearing, MMSE score of 23 or higher, living independently). This screening may have ensured that the participants also had protective characteristics (i.e., better cognitive and brain reserve) that lessened the likelihood of declines in functioning over time. As a consequence, these participants may not have needed to employ these new
strategies in their everyday functioning following the intervention. However, this does not negate the possibility that the strategy training helped participants in their daily lives. Prior research into problem solving (i.e., reasoning) with participants suffering from clinical levels of depression has revealed that improved problem solving skills are associated with the remediation of depression (D’Zurilla et al., 1998). Other important qualitative factors in the everyday lives of older adults, such as life satisfaction and well-being, may be dependent upon reasoning abilities and problem solving. That is, the fact that the quantitative analyses in this study does not show an association between training gains and everyday functioning does not mean there were not benefits in the lives of the participants who received the training. Perhaps questions of a qualitative nature would be beneficial before and after training to determine if there were changes in everyday function on the IADL and the OTDL.

**Limitations**

One limitation of this study was that we did not examine improvements in performance on the reasoning measures and how those improvements may have been related to strategy use. Were there improvements in performance if participants increased their use of these strategies? Since not all participants who received the intervention also increased their use of the strategies, it is important to also examine this relationship among those who received the training. Related to this point, it is unclear if the increased use of these strategies is related to performance of daily tasks (i.e., shopping, handling finances, driving) that require the use of reasoning ability. As it stands, we know nothing about the external validity of this intervention.

Another limitation and future direction is investigating the characteristics of those participants who did benefit most from the intervention. That is, an investigation into initial
functional level, strategy use at baseline, and other characteristics of participants may help to elucidate how they differ from those who did not benefit from the strategy training. Although several characteristics of participants affected the amount of observed strategy use after training, other factors may also moderate these gains such as specific health conditions or initial pre-intervention scores on the MMSE. In addition, initial everyday functioning status may also be predictive of the amount of observed strategy gain.

Not all participants benefited from the training to the same degree as other participants. That is, those who were White, better educated, and in the younger-old (i.e., age 65-74) age group benefited more than Blacks, less educated, and the oldest-old participants. It may be that having similar characteristics between training staff and participants may be one way that training to enhance the effectiveness of the training for some of these groups of individuals.

**Future Research**

Future research should examine which of the four reasoning strategies (i.e., slash marks, tic marks, underlining and letter insertion) were used the most by individuals who demonstrated the greatest gains in performance on the reasoning tasks. It is possible that some of the four strategies may be used more often by participants and have a greater impact on gains in reasoning and daily functioning. This information could be used to target future efforts and help to focus training on specific groups of individuals in the population.

One possibility is that older adults may use a hierarchy of strategies as they go about trying to solve problems with their inductive reasoning abilities. The strategies which participants employed in the ACTIVE study may have been used in a specific order or in different sequences instead of individuals choosing only one to apply to a problem.
Although different sequences are important to investigate, combinations of strategies may be more powerful than using one strategy in a particular sequence at a time. Therefore, it would be important in future investigations to evaluate if different combinations of strategies were employed by older adults. Doing this could enhance training sessions for older adults by making them more efficacious. In addition, certain groups of participants (i.e., younger age versus older age or less educated versus more educated) may have found one specific strategy to be most helpful in comparisons to other strategies. As Selection, Optimization, and Compensation (SOC) theory suggests, older adults may choose particular areas to optimize and compensate for their declines in functioning based on their own unique history and environment. This suggests that programs targeting the enhancement of reasoning ability could benefit from a better understanding of strategy use and choosing those strategies that older adults prefer in order to age successfully.

**Conclusions**

Thirty years of research on cognition among the elderly has led to the development of cognitive strategy interventions in an attempt to maintain or enhance cognitive abilities. Delaying cognitive decline and impairment is now better understood because of such interventions. The study of reasoning strategies has important implications for the everyday functioning of older adults. Results from the current analyses suggest that reasoning training can create dramatic improvements in the use of reasoning strategies by older adults regardless of age, race, sex, and education. The extent to which participants may benefit from training appears to be moderated by these individual characteristics, indicating that the amount of gain in the use of reasoning strategies depended on these characteristics of participants. Although transfer of training gains to everyday function does not appear to have
occurred during the first five years of the ACTIVE study, it may require a longer period of
time to observe the impact of training gains on everyday functioning in this population. The
results have been supportive of SOC theory by demonstrating that older adults can both
optimize and compensate for a decline in cognitive abilities through strategy training. Older
adults want to age successfully and make adaptations which continue to make their lives
better not just at the immediate moment but throughout their lives.
Figure 1. Population age 65 and over and age 85 and over for, selected years 1900-2008 and projected from 2010-2050. U.S. Census Bureau Decennial Census, 2010.
Figure 2. Life expectancy from 1900 to 2006 at ages 65 and 85, by sex. *Federal Interagency Forum on Aging-Related Statistics*, 2007.
Figure 3, Impact of observed strategy gains due to reasoning training on everyday functioning
Figure 4. Instrumental Activities of Daily Living over time
Figure 5. Causal model for the Instrumental Activities of Daily Living (IADL).
Figure 6. Observed Tasks of Daily Living measured over time
Figure 7. Causal model for the Observed Tasks of Daily Living (OTDL).
### Table 1

**Demographic Characteristics of ACTIVE Participants by Intervention Site**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total sample (N = 587)</th>
<th>Indiana University (n = 187)</th>
<th>Wayne State University (n = 181)</th>
<th>Pennsylvania State University (n = 219)</th>
<th>Differences across sites</th>
</tr>
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<tbody>
<tr>
<td>Age(^a)</td>
<td>73.81 (5.73)</td>
<td>73.70 (5.73)</td>
<td>73.21 (5.26)</td>
<td>74.39 (5.54)</td>
<td>F(2, 584) = 2.33</td>
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<td>Sex</td>
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<td></td>
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<td></td>
<td>(\chi^2(5) = .98)</td>
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<td>Women(^b)</td>
<td>463 (78.9%)</td>
<td>147 (78.6%)</td>
<td>139 (76.8%)</td>
<td>177 (80.8%)</td>
<td>(\chi^2(5) = 162.79***)</td>
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<tr>
<td>Men(^b)</td>
<td>124 (21.1%)</td>
<td>40 (21.4%)</td>
<td>42 (23.2%)</td>
<td>42 (19.2%)</td>
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<tr>
<td>Race</td>
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<td>White</td>
<td>380 (64.7%)</td>
<td>116 (61.0%)</td>
<td>60 (33.1%)</td>
<td>206 (94.1%)</td>
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<tr>
<td>Black</td>
<td>207 (35.3%)</td>
<td>73 (39%)</td>
<td>121 (66.9)</td>
<td>13 (5.9%)</td>
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</tr>
<tr>
<td>Education (years)(^a)</td>
<td>13.24 (2.59)</td>
<td>13.86 (2.80)</td>
<td>13.99 (2.75)</td>
<td>12.09 (1.73)</td>
<td>F(2,584) = 39.03***</td>
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</tbody>
</table>

\(^a\)Mean (standard deviation).

\(^b\)Frequency (standard deviation).

***\(p < .001\).
Table 2

*Correlations Between Variables*

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<td>.136**</td>
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<td>—.038</td>
<td>.099*</td>
<td>.116**</td>
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<td>—</td>
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<td>.050</td>
<td>.092*</td>
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<td>.239**</td>
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<td>8. Letter set, post</td>
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<td>.130**</td>
<td>.136**</td>
<td>.170**</td>
<td>.509**</td>
<td>.223**</td>
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*a* Sex was as coded 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; age and education are centered variables; pre = pre-intervention; post = post-intervention.

*p < .05. **p < .01.
Table 3

Hierarchical Linear Regression Results for Letter Series Strategy Use

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*Note. Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.

*p < .05. ***p < .001.
Table 4

**Hierarchical Linear Regression Results for Letter Sets Strategy Use**

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*Note.* Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.

* $p < .05$. ** $p < .01$. *** $p < .001$. 
### Table 5

**Hierarchical Linear Regression Results for Word Series Strategy Use**

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*Note.* Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.

* *p < .05. **p < .01. ***p < .001. 
Table 6

Correlations Among the Instrumental Activities of Daily Living (IADL) Model Variables

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<td>-.14*</td>
<td>.15*</td>
<td>-.13**</td>
<td>.14***</td>
<td>-.04</td>
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<td>7. WSU</td>
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<td>-.07</td>
<td>.03</td>
<td>.03***</td>
<td>.19***</td>
<td>—</td>
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<td></td>
</tr>
<tr>
<td>8. PSU</td>
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<td>-.02</td>
<td>-.01</td>
<td>.08*</td>
<td>-.04</td>
<td>.03***</td>
<td>-.34***</td>
<td>-.52***</td>
<td>—</td>
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<tr>
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<td>-.02</td>
<td>.02</td>
<td>-.04</td>
<td>-.05</td>
<td>-.05</td>
<td>-.01</td>
<td>.01</td>
<td>-.04</td>
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<td>-.011</td>
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<td>.06</td>
<td>.00</td>
<td>.01</td>
<td>.04</td>
<td>-.32***</td>
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Note. IADL-I = IADL-intercept; IADL-L = IADL-linear; IADL-Q = IADL-quadratic; sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.

*p < .05 **p < .01 ***p < .001.
Table 7

Growth Curve Modeling Results for the Instrumental Activities of Daily Living Intercept

<table>
<thead>
<tr>
<th>Predictor</th>
<th>( b )</th>
<th>( SE )</th>
<th>( \beta )</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
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<td>0.02</td>
<td>0.21</td>
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<td>Sex</td>
<td>0.26</td>
<td>0.25</td>
<td>0.05</td>
<td>1.06</td>
</tr>
<tr>
<td>Race</td>
<td>-0.07</td>
<td>0.25</td>
<td>-0.02</td>
<td>-0.27</td>
</tr>
<tr>
<td>Education</td>
<td>-0.05</td>
<td>0.04</td>
<td>-0.06</td>
<td>-1.06</td>
</tr>
<tr>
<td>Intervention site: WSU</td>
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<td>-0.10</td>
<td>-1.44</td>
</tr>
<tr>
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<td>0.26</td>
<td>0.04</td>
<td>0.80</td>
</tr>
<tr>
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<td>0.23</td>
<td>0.06</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Note. Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.

\*p < .05. ***p < .001.
Table 8

_Growth Curve Modeling Results for the Instrumental Activities of Daily Living Linear Term_

<table>
<thead>
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<th>$b$</th>
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</thead>
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<td>.82</td>
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<tr>
<td>Sex</td>
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<td>.21</td>
<td>.05</td>
<td>.69</td>
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<tr>
<td>Race</td>
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<td>.21</td>
<td>−.16</td>
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<tr>
<td>Education</td>
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<td>.04</td>
<td>−.13</td>
<td>−1.75</td>
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<tr>
<td>Intervention site: WSU</td>
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<td>.22</td>
<td>−.21</td>
<td>−2.71**</td>
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<td>Intervention site: PSU</td>
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<td>−.10</td>
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</tr>
<tr>
<td>Intervention: no booster</td>
<td>−0.11</td>
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<tr>
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<td>.20</td>
<td>−.02</td>
<td>−.26</td>
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</tbody>
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*Note.* Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.

*$p < .05$. **$p < .01$. 
Table 9

*Growth Curve Modeling Results for the Instrumental Activities of Daily Living Quadratic Term*

<table>
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<th>( \beta )</th>
<th>( t )</th>
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</thead>
<tbody>
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<td>Sex</td>
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<td>0.05</td>
<td>-0.05</td>
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</tr>
<tr>
<td>Race</td>
<td>0.07</td>
<td>0.05</td>
<td>0.12</td>
<td>1.50</td>
</tr>
<tr>
<td>Education</td>
<td>0.02</td>
<td>0.01</td>
<td>0.14</td>
<td>1.99*</td>
</tr>
<tr>
<td>Intervention site: WSU</td>
<td>0.10</td>
<td>0.05</td>
<td>0.15</td>
<td>1.99*</td>
</tr>
<tr>
<td>Intervention site: PSU</td>
<td>0.04</td>
<td>0.05</td>
<td>0.06</td>
<td>.77</td>
</tr>
<tr>
<td>Intervention: no booster</td>
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<td>0.05</td>
<td>0.02</td>
<td>.34</td>
</tr>
<tr>
<td>Intervention: booster</td>
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<td>0.04</td>
<td>-0.02</td>
<td>-0.27</td>
</tr>
</tbody>
</table>

*Note.* Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University. 

*\( p < .05 \).
Table 10

*Correlations Among the Observed Tasks of Daily Living (OTDL) Model Variables*

<table>
<thead>
<tr>
<th></th>
<th>IADL-I</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<tbody>
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<td>1. IADL-L</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. IADL-Q</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3. Age</td>
<td>−.35***</td>
<td>−.16**</td>
<td>.10</td>
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<td></td>
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<td>4. Sex</td>
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<tr>
<td>5. Race</td>
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<td>.09</td>
<td>−.05</td>
<td>.05</td>
<td>.07</td>
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<td></td>
<td></td>
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<tr>
<td>6. Education</td>
<td>.43***</td>
<td>−.04</td>
<td>.01</td>
<td>−.13**</td>
<td>.14***</td>
<td>.04</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>7. WSU</td>
<td>−.01</td>
<td>−.05</td>
<td>−.04</td>
<td>−.07</td>
<td>.03</td>
<td>−.44***</td>
<td>.19***</td>
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<td></td>
</tr>
<tr>
<td>8. PSU</td>
<td>.02</td>
<td>.01</td>
<td>.05</td>
<td>.08*</td>
<td>−.04</td>
<td>.47***</td>
<td>−.34***</td>
<td>−.52***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. No booster</td>
<td>−.05</td>
<td>.07</td>
<td>−.12</td>
<td>−.04</td>
<td>−.05</td>
<td>−.05</td>
<td>−.01</td>
<td>.01</td>
<td>−.04</td>
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<tr>
<td>10. Booster</td>
<td>.10*</td>
<td>−.06</td>
<td>.13</td>
<td>−.04</td>
<td>−.03</td>
<td>.06</td>
<td>−.00</td>
<td>.01</td>
<td>.04</td>
<td>−.06***</td>
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</tr>
</tbody>
</table>

*Note. IADL-I = IADL-intercept; IADL-L = IADL-linear; IADL-Q = IADL-quadratic; WSU = Wayne State University; PSU = Pennsylvania State University; age and education are centered variables.*

* *p < .05 **p < .01 ***p < .001.*
Table 11

*Growth Curve Modeling Results for the Observed Tasks of Daily Living Intercept*

<table>
<thead>
<tr>
<th>Predictor</th>
<th>$b$</th>
<th>SE</th>
<th>$\beta$</th>
<th>$t$</th>
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</thead>
<tbody>
<tr>
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<td>-0.31</td>
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</tr>
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</tr>
<tr>
<td>Race</td>
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<td>.39</td>
<td>0.25</td>
<td>4.97***</td>
</tr>
<tr>
<td>Education</td>
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<td>.07</td>
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<td>8.81*</td>
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<tr>
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<td>-0.02</td>
<td>-0.52</td>
</tr>
<tr>
<td>Intervention: booster</td>
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<td>0.06</td>
<td>1.42</td>
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</table>

*Note.* Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.

* $p < .05.$
Table 12

*Growth Curve Modeling Results for the Observed Tasks of Daily Living Linear Term*

<table>
<thead>
<tr>
<th>Predictor</th>
<th>b</th>
<th>SE</th>
<th>β</th>
<th>t</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>−0.10</td>
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<td>−.17</td>
<td>−2.94**</td>
</tr>
<tr>
<td>Sex</td>
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<td>−.09</td>
<td>−1.40</td>
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<td>−.07</td>
<td>−0.97</td>
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*Note.* Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.

**p < .01.**
### Table 13

*Growth Curve Modeling Results for the Observed Tasks of Daily Living Quadratic Term*

<table>
<thead>
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<th>Predictor</th>
<th>$b$</th>
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</thead>
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<td>1.48</td>
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<td>Sex</td>
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<td>1.07</td>
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<td>-.06</td>
<td>-0.72</td>
</tr>
<tr>
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<td>.10</td>
<td>.09</td>
<td>0.99</td>
</tr>
<tr>
<td>Intervention: no booster</td>
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<td>.09</td>
<td>-.08</td>
<td>-1.09</td>
</tr>
<tr>
<td>Intervention: booster</td>
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<td>.08</td>
<td>.11</td>
<td>1.46</td>
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*Note.* Sex was coded as 0 = female, 1 = male; race was coded as 0 = Black, 1 = White; intervention site was coded as 1 = Wayne State University (WSU) and 2 = Pennsylvania State University (PSU), reasoning strategy training was coded as 0 = control group and 1 = reasoning group; age and education are centered variables; the sites of WSU and PSU are compared to Indiana University.
APPENDIX A. INSTITUTIONAL REVIEW BOARD APPROVAL

SECTION I: GENERAL INFORMATION

Principal Investigator (PI): Joan Baenziger
Phone: 515-337-3895
Fax:

Degrees: M.S.
Correspondence Address: 96 Le Baron Hall
Department: HDFS
Email Address: jbaenzig@iastate.edu
Center/Institute: College: CHS
PI Level: Faculty
Alternate Contact Person:
Correspondence Address:
Email Address:

Title of Project: Title of my dissertation is: "Assessing Causal Inferences between Depression and Cognition among Older Adults: Longitudinal Results from the ACTIVE Study"

Project Period (Include Start and End Date): [10/29/11] to [10/29/12]

FOR STUDENT PROJECTS

Name of Major Professor/Supervising Faculty: Dr. Jennifer Margrett/Dr. Dan Russell
Phone: 294-3028/294-4187
Department: HDFS
Email Address: margrett@iastate.edu/drusell@iastate.edu

Signature of Major Professor/Supervising Faculty: [Signature]
Campus Address: 2354 Palmer/2352 Palmer

Type of Project: (check all that apply)
Research
Thesis
Dissertation
Independent Study (490, 590, Honors project)
Other—Please specify: ______

KEY PERSONNEL

List all members and relevant experience of the project personnel. This information is intended to inform the committee of the training and background related to the specific procedures that each person will perform on the project.

<table>
<thead>
<tr>
<th>NAME &amp; DEGREE(S)</th>
<th>SPECIFIC DUTIES ON PROJECT</th>
<th>TRAINING &amp; EXPERIENCE RELATED TO PROCEDURES PERFORMED, DATE OF TRAINING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joan Baenziger, M.S.</td>
<td>Dissertation analyses and writing</td>
<td>Mar. 2008</td>
</tr>
<tr>
<td>Jennifer Margrett, Ph.D.</td>
<td>Major professor overseeing work</td>
<td>Aug 2006; 12 years as independent researcher</td>
</tr>
<tr>
<td>Daniel Russell, Ph.D.</td>
<td>Major professor overseeing work</td>
<td>Aug 2008; 30+ years as independent researcher</td>
</tr>
</tbody>
</table>

If you don't know your training date, contact the Office for Responsible Research for assistance.

FUNDING INFORMATION

☐ Internally funded, please provide account number:
Office for Responsible Research: IRB 08/03/2011
COLLECTION OR RECEIPT OF SAMPLES

Will you be: (Please check all that apply.)

☐ Yes ☒ No Receiving biological samples from outside of ISU? See examples below.
☐ Yes ☒ No Sending biological samples outside of ISU? See examples below.

Examples include: genetically modified organisms, body fluids, tissue samples, blood samples, pathogens.

If you will be receiving samples from or sending samples outside of ISU, please identify the name of the outside organization(s) and the types of samples you will be sending or receiving outside of ISU:

ASSURANCE

- I certify that the information provided in this application is complete and accurate and consistent with any proposal(s) submitted to external funding agencies.
- I agree to provide proper surveillance of this project to ensure that the rights and welfare of the human subjects or welfare of animal subjects are protected. I will report any problems to the appropriate assurance review committee(s).
- I agree that I will not begin this project until receipt of official approval from all appropriate committee(s).
- I agree that modifications to the originally approved project will not take place without prior review and approval by the appropriate committee(s) and that all activities will be performed in accordance with all applicable federal, state, local, and Iowa State University policies.

SIGNATURES
# Appendix B. Four Reasoning Training Strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Example of Training Strategy</th>
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</tr>
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<td>Tick Marks</td>
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REFERENCES


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http://www.ncbi.nlm.nih.gov/books/NBK25528/


Willis, S. L., Tennstedt, S. L., Marsiske, M. M., Ball, K., Elias, J., Koepke, K. M., . . .