THE RELATIONSHIP BETWEEN BASIC COGNITION, EVERYDAY COGNITION AND EVERYDAY FUNCTION: A LONGITUDINAL APPROACH

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
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To my Grandmothers

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I thank my mentor, Dr. Michael Marsiske, whose guidance accounts for a significant proportion of variance in my academic functioning, and whose overall positive influence is too great to concretize. I also thank Shannon Sisco, for all her help and support, as well as Jennifer Rosado and Eileen Davis, for making me feel at home.

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Elders' ability to perform instrumental activities of daily living (IADL), such as managing finances, telephone use, and meal preparation, is a key determinant of their ability to live independently. Traditional neuropsychological measures of "basic" cognition (e.g., memory, processing speed, and reasoning) are often only modest predictors of ADL. Several studies have argued that measures of everyday cognition, which simulate cognitive challenges encountered in everyday life, might be more predictive of IADL, and account for the effects of basic cognitive abilities in older adults' everyday functioning. To date, most studies have focused on cross-sectional associations. The present study used the no-treatment control group of the ACTIVE trial (N=698, 74% female, mean age = 74 years, mean education = 13 years), which had five occasions of measurement (baseline, and follow-up assessments after 1-, 2-, 3-, and 5-years). Isolating this group permitted us to use ACTIVE as a large, 5-year longitudinal trial of cognitive change. Mixed effects longitudinal models revealed a quadratic decline trend for all constructs, with steeper decline for basic cognitive measures than everyday cognition or IADL functioning. Individual differences in memory, processing speed and everyday cognition emerged as significant unique predictors of IADL level. In addition, intra-individual changes in memory and everyday cognition were uniquely and significantly coupled with changes in IADLs over the 5-year period. Implications for the predictive validity of the assessment of older adults, and for longitudinal aging research will be discussed.

CHAPTER 1
LITERATURE REVIEW

Overview

Most of gerontological science is formed around the question of what keeps older adults functioning well into advanced old age? How can we conceptualize, measure, and promote independence and continued self-care? Although effective functioning in daily life has many components (e.g., physical, emotional, financial, social, spiritual) (Willis, 1996), the current proposal focuses particularly on cognitive contributions to everyday function in late life. In the past several decades, a growing body of literature has attempted to explicate how traditional and largely acontextual measures of cognition (measures designed for use in experimental, laboratory, and clinical applications) might be related to elders' ability to maintain independence and well being in later life (Allaire & Marsiske, 1999; Cornelius & Caspi, 1987). One part of this line of scholarship has been the identification of a "bridge" construct, "everyday cognition" that may be seen as the mediator between more basic cognitive abilities and everyday functioning. That is, everyday cognition is viewed as the instantiation of "basic" abilities (e.g., information processing skills like memory, reasoning, speed, attention, working memory, etc.) in real-world contexts (Schaie & Willis, 1986, Willis & Marsiske, 1991). In other words, everyday cognition encompasses tasks such as reading a nutrition label or understanding a medication regimen using cognitive skills like attention and working memory. Considerable work has been done with the aim of validating these everyday approaches (see More, Palmer, Patterson, & Jeste, 2007, for a review). Validation would necessarily entail demonstrating significant relationships with everyday function and capturing at least as much variance in everyday function as basic cognitive approaches.

If appropriately validated, everyday cognition approaches would offer a more parsimonious and ecologically valid approach to the assessment and prediction of older adults' everyday function, which in turn may provide a better locus for interventions aimed at heading off functional decline. The conceptual model representing the hypothesized relationships between the constructs investigated in this study are illustrated in Figure 1-1. The present conceptual model is unidirectional. That is older adults' engagement in everyday activities is likely to influence their performance on both basic and everyday cognitive tasks. While a number of studies support the idea that activity engagement serves as a protective factor against cognitive decline (Hultsch, Hertzog, Small, Dixon, 1999; Allaire & Willis, 2006), the empirical examination of the reciprocal interrelationships between study constructs is outside the scope of the present work, which focuses exclusively on the contribution of cognitive precursors to self-reported everyday functioning.

As illustrated in Figure 1-1, the purpose of this study was to investigate the relative contributions of basic and everyday cognition to predicting older adults' everyday function. Embedded in this question was whether (a) everyday cognitive measures (which tend to brief, process-impure, and highly face valid) would be as effective at predicting everyday function as basic laboratory measures of cognition, and (b) everyday cognitive measures might be more closely related to everyday function than basic cognitive measures, because of their greater similarity to the target outcome (i.e., higher predictive/ecological validity). Superimposed on these questions is the issue of change over time. The current study asked not only what the nature of the association between everyday cognition, basic cognition, and everyday function might be, but it also addressed how these constructs "traveled together", i.e., whether they evinced coupled change over the 5 years of this longitudinal study.

The following sections will be organized as follows: First, the concepts of everyday function, everyday cognition, and basic cognition, as well as methods for their assessment will be defined and described. Second, the concept of ecological validity as it pertains to the assessment of older adults' everyday function will be discussed. Third, research examining the interrelationships among basic cognition, everyday cognition, and everyday function will be reviewed in both cross-sectional and longitudinal studies. This review will set the context for the questions examined in this study.

Older Adults' Everyday Function

Broadly defined, everyday function encompasses tasks of daily living that facilitate independence in this society (Willis, 1996). Katz, Ford, Moskowitz, Jackson, and Jafee (1963), as well as Lawton and Brody (1969) have distilled older adult's daily activities into discrete domains of everyday functioning. Specifically, Katz and colleagues identified a basic set of activities of daily living (ADL), such as bathing, toileting, dressing, and eating, which are related to self-care. On the other hand, Lawton & Brody (1969) described a set of activities such as food preparation, medication use, financial management, and transportation, which are related to the management of one's affairs. These are referred to as instrumental activities of daily living (IADL).

The percentage of people 65 years and older increased 12% since 1990 to 2000, and among the older population, those 85 years and over showed the highest percentage of increase (~37%) (Hetzel & Smith, 2000). Given that as a group, individuals over 65 years amount to 12.4% of the total U.S population (Hetzel & Smith, 2000), and those 85 and over constitute the group most at risk for health and functional impairments (Campion, 1994), older adults' functional independence is a concern not only for these individuals and their families, but also society as a whole (Willis, 1996). Specifically, impairment in older adults' everyday activities has been linked to reduced psychological well-being (Willis, 1991; Lawton, 1987), greater health care utilization, increased rates of institutionalization (Wolinsky, et al., 1983; Wolinsky, Callahan, Fitzgerald, & Johnson, 1993; Miller & Weissert, 2000) and higher mortality (Wolinsky et al., 1993; Ferrucci, et al., 1991; Miller & Weissert, 2000). Furthermore, loss of IADL functional competence has been shown to be predictive of dementia (Pérès et al., 2008; Barberger-Gateau, Fabrigoule, Rouch, Letenneur, & Dartigues 1999).

Given the numerous negative consequences of functional impairment, clinical and empirical assessments of older adults' everyday functioning aim to identify individuals who already have difficulty performing these everyday tasks, and those who might be at risk for functional decline. While the former helps clinicians identify individuals who are already in need of assistance, the latter leaves more room for intervention designed to prevent functional decline. In either case, thorough and accurate assessment may be the first step to improvements in the daily lives of older individuals as well as the reduction of the broader negative socio-economical impact of aging.

Assessment of Older Adults' Everyday Function

In general, researchers and clinicians are unable to obtain naturalistic samples of what older adults actually do in their everyday lives. First, older adults' "natural" task performance, even in the context of their home environment, is likely to be influenced by the presence of an observer, and second, "naturalistic" assessments are costly, time consuming, and are historically not carried out by professionals outside Occupational

Therapy. Consequently, most functional assessments pose the question “Can the individual perform an activity?” and as such, they likely capture the everyday functional competence of older adults, or their potential to perform ADL and IADL tasks (Willis, 1996; Salthouse, 1990), as opposed to what they do.

There are three main types of approaches to the assessment older adults’ everyday function. First, while there is no “gold standard” measure, one widely utilized approach involves self-report measures which typically consist of questions asking older individuals to rate their level of perceived functional independence, and/or level of experienced difficulty performing tasks in a number of ADL and IADL domains. While these questionnaire-based assessments are subject to bias due to their dependence on the subjective impressions of individuals, they continue to be widely utilized in both research and clinical practice (Diehl, 1998).

A second approach to the assessment of the everyday function of older adults involves proxy (i.e., spouse, family members, and caregivers) reports. Two measures commonly utilized to obtain proxy-ratings of older adults’ everyday functioning include the Clinical Dementia Rating Scale (CDR; Morris, 1993) and the Blessed Dementia Rating Scale (DS; Blessed, Tomlinson, & Roth, 1968). Proxy-based assessments are generally questionnaires that are similar in content to the self-assessment measures. While this approach benefits from being more objective, it is not without flaws and biases. Because proxies vary in their actual contact with the older adult, their capacity to provide valid information, they have been shown to misrepresent the functional competence of older adults (Royall et al., 2007; Diehl, 1998).

A third approach to the assessment of older adults’ everyday function involves the observation of performance of older adults on everyday tasks. Because the goal of this type of approach is to obtain “objective” ratings of performance, these assessments are designed for administration by clinicians, such as Occupational Therapists. While such approaches have the strength of being based on observations of performance, they are costly and time consuming to administer (Willis, 1996), and consequently utilized less-frequently. Furthermore, given their structured, non-individualized, clinical nature, they necessarily only gather a small sample of a person’s behavior. Thus, because of the brief and sheltered nature of the testing sessions, areas of strength or weakness may not be adequately assessed (Sbordone, 1997).

The issue of nomenclature is an important one, with respect to whether assessments indeed capture a person’s everyday functioning (to the extent a given approach permits), or whether they are instead capturing the cognitive components of everyday functioning (i.e. “everyday cognition”, to be discussed in more detail below).

Because studies frequently don’t draw a clear distinction between these two everyday concepts, for the purposes of this manuscript, “everyday function” will be concretized to represent the empirical outcomes (scores) of self- and/or proxy- reported ADL/IADL function, and performance-based assessments when actual task performance was observed and coded by a clinician, such as an Occupational Therapist. Such assessments, which are most frequently undertaken with patients recovering from injuries, are typically done in the home or a simulated setting.

Irrespective of the approach utilized, the assessments of everyday function described above are better suited for the detection of current functional impairment, and less well-suited to detect individuals at risk for functional decline (however see the review by Miller & Weissert, 2000, showing that across multiple longitudinal studies, current impairments in IADL predict more functional impairment over time). One reason for this has to do with how late in the lifespan functional decline typically occurs. That is, studies show that decline in IADL precedes ADL decline, and usually begins after age 80 in community samples (Fillenbaum, 1985). Furthermore, assessments of older adults everyday functioning provide little information with regard to the causes of impairment or decline (Willis, 1991). For these reasons, researchers have focused their efforts on understanding the physical and cognitive processes that might antecede older adults everyday functioning.

Antecedents of Everyday Functioning

The antecedents of older adults' everyday functioning include physical health, cognitive functioning, & psychological factors (Baltes, Mayr, Borchelt, Maas, & Wilms 1993). Other factors that influence and are influenced by everyday functioning are the social/interpersonal, community, & financial aspects of older adults' lives (Willis, 1996).

With respect to the effects of physical health, Diehl (1998), reviewing prior research, reported that older adults' everyday function is positively related to their general physical heath and sensory functioning, with relationships between ratings of physical health and ratings of everyday function ranging from .30 to.54. For example, Marsiske, Klumb, and Baltes (1997) reported latent-level correlations of .38 and .47 between older adults' everyday function and hearing and vision respectively. Overall, data from studies of the association between health/sensory functioning and everyday function suggest that deterioration of health increases the likelihood that assistance with activities of daily living becomes necessary.

With respect to psychological factors, researchers have looked at deficit awareness, mood (Caron, 1996; Barberger-Gateau et al., 1992), control and self-efficacy (e.g. Baltes & Baltes, 1986, Baltes et al., 1990; Duffy & MacDonald, 1990).

These studies have found that psychological factors influence the way older adults perceive their everyday abilities, which in turn influences their responses on questionnaires assessing their everyday function. For example, Caron (1996) reported that greater awareness of impairment was highly correlated (r =0.69) with functional scores. Baltes and colleagues (1990) found a significant positive relationship between self-efficacy beliefs and perceived level of everyday function. Finally, research has shown that subjective depression contributes to functional impairment independently of cognitive impairment (Barberger-Gateau et al., 1992).

With respect to cognitive function, there are two main approaches to quantifying older adults' cognitive fitness: measures of basic cognition and measures of everyday cognition. Before reviewing these two approaches in more detail, it is important to note that, as detailed above, cognition is one of a multitude of factors that influence older adults' everyday functioning. Therefore, its explanatory power is confined by its inability to capture the variance that might be attributed to other relevant human factors.

Basic Cognition

One widely-utilized approach to the assessment of older adults' cognitive functioning involves the assessment of "basic" cognitive abilities such as visual and verbal short- and long- term memory, speed of information processing, visual attention, verbal fluency, and "executive" abilities or reasoning. These aspects of cognition have been widely and extensively studied at the behavioral level, and researchers have created behavioral measures that, to some extent, isolate and quantify these skills. With increasing accessibility of electroencephalography and neuroimaging techniques, there is also a growing knowledge base with respect to the neural correlates of these abilities (e.g. the involvement of the hippocampus in memory). Importantly, these basic abilities appear to underlie other, “higher order” processes such as problem solving, decision making, and creativity, the output of which is reflected in everyday functioning (Willis & Schaie, 1993, Willis & Marsiske, 1991).

Assessment of Basic Cognition

To quantify basic cognitive abilities, researchers and clinicians utilize measures that were developed to assess intelligence, academic performance or neurological impairment. The measures used for these purposes are structured, paper and pencil tasks that elicit a “maximum” level of performance, often under timed conditions (Salthouse, 1990). Tests of intelligence (e.g. IQ tests) have a long history of being utilized to predict academic and vocational performance, while neuropsychological tests were created and historically utilized to detect neurologic insult (e.g. brain lesions) and to quantify the resulting cognitive impairment. There is a methodological drawback to the utilization of such measures in the assessment of unimpaired older adults. These measures were not designed with the intention of assessing everyday functioning, and consequently lack the sensitivity to do so (Spooner & Pachana, 2006). When administered cross-sectionally, these measures almost invariably show that younger adults outperform older adults, which contributes little to our understanding of the everyday functioning of older adults. As Salthouse (1990) pointed out, assessments of older adults’ cognitive fitness need to bridge the gap between these age-related discrepancies in basic cognitive abilities, and the often successful functioning of older adults in everyday life (Salthouse, 1990).

Everyday Cognition

Everyday cognition has been conceptualized as a “higher order” set of abilities, representing the cognitive components of everyday functioning (Willis & Marsiske, 1991;

Willis & Schaie, 1993). This type of cognition is thought to be goal-directed and involving the manipulation of data or objects in everyday life in order to attain self- and home-maintenance goals (Marsiske & Margrett, 2006). As such, these cognitive processes are contextualized, in that they resemble familiar, relevant, “everyday” challenges that rely on the individual’s experience for an effective solution (Marsiske & Margrett, 2006). What makes them “higher order” is that in addition their reliance on more basic cognitive abilities like memory, reasoning, and speed of processing, they also make use of accumulated experience, which represents domain specific knowledge (e.g. the person’s prior experience of having prepared a meal) (Marsiske & Margrett, 2006). Thus, everyday cognitive abilities are viewed as “compiled” skills (Salthouse, 1990).

Because everyday cognitive abilities draw upon this compiled, domain specific knowledge, some researchers have speculated that these abilities might be “preserved” against the age-related decline observed in the more basic cognitive abilities (Salthouse, 1990). In a meta-analysis of age differences in everyday cognition, Thornton and Dumke (2005) concluded that their results do not support theories of the preservation of these abilities. However most studies reviewed by these authors were cross-sectional, which confounds cohort and maturational factors (Schaie, 1965) and has been shown in statistical simulation studies to be misleading with respect to conclusions about change over time, particularly when results from correlations are used to draw these conclusions (Kraemer, Yesavage, Taylor, & Kupfer, 2000). For example, in their longitudinal study, Willis, Jay, Diehl, and Marsiske (1992) showed that 57% of their sample did not show a reliable decline in these abilities over a 7-year period. Therefore, the question of whether these abilities are, at least to an extent, “buffered” against age-related decline is still open.

The terminology utilized in reference to this type of cognition has been variable, encompassing terms such as “practical problem solving” (Denney, 1989), “everyday problem solving” (Marsiske & Margrett, 2006, Thornton & Dumke, 2005), and “practical intelligence” (Sternberg & Wagner, 1986). This preponderance of nomenclature stems in part from the variable theoretical orientations of the researchers in the field (Marsiske & Margrett, 2006). Another distinction exists between types of everyday cognitive assessment approaches. That is, everyday problems might be either “ill- structured”, or “well-structured”, with the former being more open ended-type problems, and the latter being problems that must be approached more systematically and having one target correct answer (Allaire & Marsiske, 2002). The present study focuses exclusively on the well-structured approach to the assessment of everyday cognition, which is grounded in cognitive and psychometric traditions, and employs the term “everyday cognition” (Poon, Rubin, & Wilson, 1989) to underscore this focus.

Assessments of Everyday Cognition

A number of measures have been developed to assess the everyday cognition of older adults. Marsiske and Margrett (2006) conducted a focused review of multiple measures of everyday cognition, in which they summarized the theoretical underpinnings, structural properties, and available evidence for validity, of multiple instruments designed to assess older adults’ performance of everyday-type tasks. According to this review, well-structured tasks share a substantial portion of their variance with basic cognitive tasks (50-80%), with provides support for the notion that well-structured assessments are a “bridge” between basic abilities and everyday outcomes. Furthermore, while multiple everyday instruments assess a single everyday domain, there is evidence to support the idea that everyday cognition is better viewed as a multifaceted construct (e.g. Marsiske & Willis, 1995). Therefore, the present study is specifically focused on the utility of multi-domain, well-structured measures of everyday cognition in predicting everyday function.

As such, these measures resemble the tasks that older adults might do in their everyday life, such as food preparation, medication use, financial management, and transportation, where adults are given real-world stimuli and asked to solve novel everyday problems that have one correct answer. These measures are structured, laboratory-based tests that, much like neuropsychological and psychometric assessments, elicit a "maximum" level of performance, however on tasks that are familiar and relevant to everyday life.

Ecological Validity

The question of relevance is central to the concept of ecological validity. Heaton and Pendleton (1981), foreseeing the increased use of neuroimaging techniques for the assessments of brain injury, in many ways supplanting neuropsychological measures, called for more research into the ecological validity of these measures as predictors of everyday function. Ecological validity is the "functional and predictive relationship between the patient's performance on a set of neuropsychological tests and the patient's behavior in a variety of real world settings" (Sbordone, 1996, p. 16). Two approaches to establishing ecological validity have emerged: verisimilitude and veridicality (Frazen & Wilhelm, 1996).

Verisimilitude refers to the similarity between the task demands of the test and the demands of the everyday environment. Establishing verisimilitude requires tests that are comprised of everyday cognitive tasks, an approach taken by researchers who have developed measures of everyday cognition (Spooner & Pachana, 2006; Chaytor & Schmitter-Edgecombe, 2003). Therefore, such tests differ from traditional neuropsychological measures in their intended focus -- identifying individuals with functional limitations -- rather than diagnosing and describing the etiology of brain dysfunction (Chaytor & Schmitter-Edgecombe, 2003).

Veridicality on the other hand, refers to the extent to which results of an assessment are related to scores on other measures that predict everyday functioning (Spooner & Pachana, 2006; Chaytor & Schmitter-Edgecombe, 2003). In this formulation, the veridicality of basic and everyday cognitive assessments, particularly as it relates to change in function over time (i.e. predictive validity), is the central focus of the present study, and prior work in this domain is reviewed below.

The Predictive Validity of Measures of Basic Cognition

Research studies investigating the relationship between basic cognition and everyday function have attempted to answer the questions: what is the strength of the cross-sectional and longitudinal association between basic cognitive measures and measures of everyday function and what specific aspects of cognition might be related to everyday function? The following sections examine this body of work to date. First, the large body of cross-sectional work, suited to the identification of current functional limitations, and less well-suited to address predictive questions is examined. Second, longitudinal studies of the association between basic abilities and everyday function, better-suited to address questions of predictive utility/veridicality, are reviewed.

Cross-sectional Associations between Basic Cognition and Everyday Function

While this review is not exhaustive, it nevertheless captures the effects as they pertain to strengths of association, as well as specific cognitive domains that appear to be salient predictors of everyday function. Of the studies examined, three examined clinical populations (e.g. Farmer & Eakman, 1995; McCue, Rogers, & Goldstein, 1990; Baird, Podell, Lovell, & McGinty, 2001) and of these, two utilized performance-based assessments of everyday function (e.g. Farmer & Eakman, 1995; McCue, Rogers, & Goldstein, 1990). The rest examined healthy older adults' and utilized self- or informant-report measures of everyday function, particularly IADL. Despite some methodological differences, and different measures utilized, across studies memory and executive function emerged as significant cross-sectional predictors of function (e.g. Royall, Palmer, Chiodo, & Polk, 2005a; Farmer & Eakman, 1995; McCue et al., 1990; Jefferson, Paul, Ozonoff, & Cohen, 2006; Tan, Hultsch, & Strauss 2009). Processing speed also emerged as a significant predictor in a subset of the studies (e.g. Tan et al., 2009; Farmer & Eakman, 1995), however this relationship was smaller, and appeared to be associated with timeliness of IADL performance (Farmer & Eakman, 1995). Bivariate associations between specific basic abilities and function across studies were mostly in the moderate range (0.48 to 0.61).

With respect to global cognitive functioning and reviews of the literature in this domain, findings from large representative samples of older adults have shown that the relationship between everyday function and general cognition scores is in the order of .50-.60 (Fillenbaum, 1985), which appear to be at least as high and often higher than relationships with specific basic abilities. In a review of the cognitive correlates of functional status, Royall et al. (2007) concluded that the variance that can be specifically attributed to cognition is modest and that global measures are “surprisingly strong” correlates of functional status.

In summary, cross sectional studies typically show moderate relationships between basic cognitive measures and assessments of everyday function. With respect to specific abilities, memory, executive function, and to a lesser extent processing speed, appear to be the best and most consistent predictors of current levels of everyday function.

Longitudinal Relationships between Basic Cognition and Everyday Function

Longitudinal assessments have the advantage of being able to capture trajectories of change and concurrent relationships between constructs of interest. With respect to the longitudinal trajectory of functional decline, in a study examining the hierarchy of functional loss (i.e. which everyday skills became impaired first) associated with decline in basic cognitive abilities in older adults, Njegovan, Hing, Mitchell, and Molnar (2001) reported that dependency in IADLs tended to occur at higher cognitive scores compared with ADLs. These authors also reported that a greater number of persons in their sample became dependent in at least one IADL compared to ADLs over a 4 year period. This is consistent with prior findings that IADLs evince earlier age-related decline than ADLs (Willis, 1996).

Most of the studies reviewed examined longitudinal basic cognition and everyday function in healthy older adults, however some studies also included groups with mild cognitive impairment (MCI) and/or dementia (e.g. Tomaszewski Farias et al., 2008; Barberger-Gateau et al., 1999), and one study examined a geriatric sample with cardiovascular disease (Cahn-Weiner, Mallowy, Boyle, Marran & Salloway, 2007). Nearly all longitudinal studies employed self-reported ADL and/or IADL ratings as measures of longitudinal everyday functioning, with two studies employing informant reported IADL (Cahn-Weiner et al., 2007, Tomaszewski Farias et al., 2008). Across studies, changes in IADL were significantly related to changes in memory and executive function. Results of random effects regressions revealed a -0.69 correlation between changes in memory and IADL, and -0.72 between changes in executive function and IADL (Tomaszewski Farias et al., 2008). In their clinical sample, Cahn-Weiner et al. (2007) found that only executive function predicted changes in IADL. Barberger-Gateau et al. (1999) found that speed of processing was a significant longitudinal predictor of IADL (odds ratios 0.52 to 0.74). In their studies using growth curve analyses, Royall and colleagues (2004, 2005a, 2005b) found a moderate negative relationship between change in IDAL and executive function (-0.57), and that executive function mediated the effect of memory on IADL function.

In summary, there is evidence for significant, moderate to large relationships between changes in basic cognitive abilities, particularly executive function, memory and processing speed, and changes in perceived levels of everyday functioning in healthy older adults as well as in pre-clinical and clinical geriatric samples. Executive functioning in particular emerges as a salient longitudinal predictor of everyday function.

The Predictive Validity of Measures of Everyday Cognition

Given the strict definition of “everyday function” posited in this manuscript, to date relatively few studies have examined the predictive validity (relationship to everyday function) of measures of everyday cognition. That is, most studies that claim to study everyday function have utilized measures of everyday cognition as outcome variables, using these measures as a “proxy” for everyday functioning without adequate evidence of their veridicality. In their review of measure of everyday cognition, Moore, Palmer, Patterson, & Jeste (2007) similarly note that information on the predictive validity of these measures was largely unavailable.

Of the studies that examined the relationship between everyday cognition and everyday function, one study utilized a clinical geriatric sample of individuals diagnosed with Alzheimer's Disease (AD; e.g. Willis et al., 1998), while the remaining studies utilized samples of healthy older adults (e.g. Allaire & Marsiske, 2002; Diehl, Willis, & Schaie,1995) or mixed samples (e.g. Tan et al., 2009). While there was heterogeneity in the everyday cognitive measures used, in most studies, self- and caregiver- rated ADL/IADL was the selected measure of everyday function. Results of these cross-sectional analyses revealed significant moderate associations between function and everyday cognition in AD patients (r =0.36; e.g. Willis et al., 1998), higher associations in healthy older adults (r =0.50; e.g. Diehl et al., 1995) and still higher associations at the latent level (r = -0.69; e.g. Allaire & Marsiske, 2002). On the other hand, Tan and colleagues' (2009) correlations between everyday function and everyday cognition ranged from -0.037 (n.s) to 0.43, suggesting some variability in outcomes. However, the results from Tan et al. (2009) should be interpreted with caution as the extent to with their measure of everyday function is reflective of traditional ADL/IADL domains is unclear.

In summary, it appears that in healthy older adults, there is evidence for a moderate to high association between everyday cognition and everyday function, thus supporting the predictive validity of these measures. However, little is known about the strength of this relationship over time.

The Relationship between Basic Cognition and Everyday Cognition

If everyday cognition is to be conceptualized as the instantiation of basic abilities in everyday context, then it would be important to first examine the strength of the relationship between basic cognitive abilities and everyday cognition. As mentioned above, there has been a considerable amount of work done in this domain, as measures of everyday cognition have been utilized as “proxy” measures representing everyday function. The vast majority of the studies reviewed investigated samples of healthy older adults. At the same time, all but one study (i.e. Willis, Jay, Diehl, & Marsiske, 1992) in this domain have been at the cross-sectional level and this body of work has been very heterogeneous with respect to the everyday and basic measures utilized, as well as with respect to the types of basic abilities investigated (Marsiske & Margrett, 2006).

Cross-sectional relationship between basic and everyday cognition

Nevertheless, one relatively consistent finding from this literature is that of a moderate to large bivariate relationship between measures of basic and everyday cognition overall, with correlations from 0.31 to 0.86 (e.g. Thornton, Deria, Gelb, Shapiro, Hill, 2007; Diehl et al., 1995; Burton, Strauss, Hultsch, Hunter, 2006; Allaire & Marsiske, 1999; Wood et al., 2005; Weatherbee & Allaire, 2008). Results from regression analyses suggest that with demographic variables accounted for, basic cognitive variables together explained 32% to 55% of the variance in everyday cognition (e.g. Thornton et al., 2007; Wood et al., 2005; Mitchell & Miller, 2008). As with studies investigating the relationship between basic cognition and everyday function, executive/reasoning abilities and memory, and to a lesser extent processing speed emerged as the most consistent predictors of everyday cognitive abilities, however these abilities were also the most consistently studied. For example, Burton et al. (2006) reported that after controlling for demographic variables, executive abilities contributed 11% unique explanatory variance to the prediction of everyday cognition, followed by 3% unique variance contributed by speed. Wood et al. (2005) found that non-speed basic abilities uniquely explained 17% of the variance in timed IADL outcome, with 14% unique explained by speeded basic cognition.

Longitudinal relationship between basic and everyday cognition

Willis et al. (1992) examined the predictive relationship between basic measures of fluid and crystallized intelligence, speed, and memory and a measure of everyday IADL cognition - Educational Testing Service's Test of Basic Skills (ETS Basic Skills; ETS, 1977). Using data collected from two occasions of measurement, the authors reported that baseline level of fluid intelligence was predictive of later ETS Basic Skills performance explaining 52% of the variance, of the 70% total variance accounted for by all basic abilities and demographics.

In summary, there does appear to be evidence for a significant moderate to high cross-sectional association between basic cognition and everyday cognition in healthy older adults, with executive/reasoning/fluid intelligence emerging as the most salient predictor. Longitudinal results from Willis et al. (1992) appear to support these conclusions, further suggesting that basic fluid intelligence can be predictive of later everyday cognitive abilities.

The Relationship between Basic Cognition, Everyday Cognition and Everyday Function

Willis et al. (1998) examined all three constructs in a sample of individuals with AD. These authors reported that the everyday cognitive tasks accounted for significant additional variance in everyday function beyond that accounted for by global cognitive measures. These results were supported by Allaire and Marsiske (2002), who also showed that everyday cognition accounted for the basic cognitive variance in everyday function, and significant unique variance beyond that.

Summary

Prior work shows that both basic and everyday cognition have moderate cross-sectional relationships to everyday function, supporting the use of these measures to assess individuals who already have some functional impairment. At the cross-sectional level, everyday cognition has been shown to mediate the basic cognitive variance in everyday function, and to explain additional variance beyond that. This finding provides empirical support for the notion that basic abilities are a part of, or involved in everyday cognition, however findings of concurrent change in these abilities would provide considerably stronger support for this notion. Of the basic abilities, memory, executive/reasoning skills, and speed of processing appear to be consistently related to everyday function both cross-sectionally and over time. On the other hand, little is known about whether changes in everyday cognitive abilities are predictive of changes in everyday function. The examination of the longitudinal relationships between basic and everyday cognition and everyday function would permit more informed conclusions regarding the unique predictive utility of basic ability and everyday cognition measures, facilitating a better conceptualization of the parsimony and validity of the everyday cognition approach (as operationalized), to the assessment of everyday function.

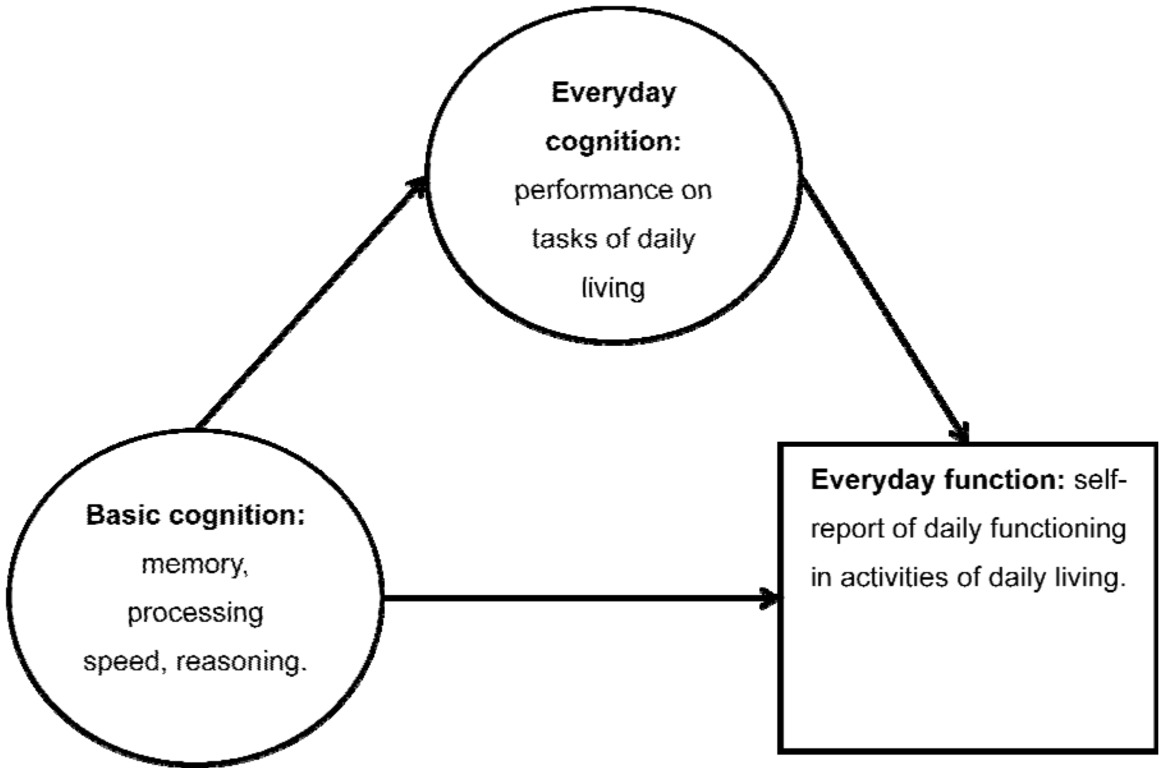

Figure 1-1. Conceptual model for the present study, showing the hypothesized predictive relationships between study constructs

CHAPTER 2
STATEMENT OF THE PROBLEM

Overview

A large body of research lends support to the predictive relationship between basic cognition (e.g., cognitive abilities such as memory, reasoning, and processing speed) and everyday function (e.g., older adults' self-reported levels of difficulty and/or independence in performing activities of daily living), between basic cognition and everyday cognition (e.g., cognitive tasks that simulate activities of daily living), and between everyday cognition and everyday function. Furthermore, there is some evidence that everyday cognition mediates the basic ability variance in everyday function (Allaire & Marsiske, 2002; Willis et al., 1998). That is, age-related changes in basic abilities are hypothesized to influence performance on tasks assessing contextualized cognition, which it turn contributes to changes in the ability to perform critical household and self-maintenance tasks. In previous research these relationships were examined predominantly at the cross-sectional level. Longitudinally, most research has examined only the direct relationship between basic cognition and everyday function, suggesting that baseline levels of basic cognition are predictive of longitudinal change in everyday function (Willis et al., 1992). Due to their face validity and reliance on contextualized, domain specific knowledge, measures of everyday cognition have been conceptualized as more direct measures of the cognitive processes involved in the successful execution of the tasks that comprise everyday functioning. Given the research findings that both basic and everyday cognition predict everyday function, the present study investigated whether everyday cognition variance might account for the basic ability variance in everyday function. The present analyses utilized longitudinal data collected at five occasions of measurement, at baseline, annually 1-3 years post-baseline and at 5 years post-baseline, from a large sample of healthy, community-dwelling older adults age 65 years and over. There were two aims of the study.

Mediation of Basic Cognition Variance in Everyday Function by Everyday Cognition

Aim 1

This aim addressed the extent to which everyday cognition measures might constitute the cognitive component of everyday function, as measured in this study. The purpose of the first aim was to replicate and extend prior cross-sectional mediation findings (e.g. Allaire & Marsiske, 2002; Willis et al., 1998), and to assess baseline mediation in the present sample with the current measures, as a precursor to the assessment of mediation at the longitudinal level in Aim 2. Specifically, the aim was to assess whether the relationship between basic cognitive abilities (memory, reasoning, speed) and everyday function (self ratings of IADL) is mediated by individual differences in everyday cognition (Everyday Problems Test, Observed Tasks of Daily Living, Timed IADL) at the baseline occasion of assessment.

Hypothesis 1

Everyday cognition measures will show significant direct associations with everyday function, and they will explain all or most of the basic memory/reasoning/speed related variance in everyday function. These findings would support the conceptualization of everyday cognition as a more proximal measure of everyday function.

Longitudinal Relationships between Basic Cognition and Everyday Function, and Mediation by Everyday Cognition

Aim 2

The purpose of the second aim was to examine the predictive interrelationships between longitudinal changes in basic cognition, everyday cognition and everyday function, extending the analyses from Aim 1 to longitudinal data. Thus, the second aim was to examine if (a) longitudinal changes in everyday function are associated with concurrent time-varying changes in basic cognition, (b) changes in everyday cognition will serve as time-varying mediators of the basic cognition/everyday function relationship. Embedded in this aim is the investigation of the trajectory of longitudinal change in all of our constructs (basic abilities, everyday cognition and everyday function).

Hypothesis 2

As basic cognition changes, (a) everyday function is expected to change in the same direction as basic cognition. With regard to mediation, (b) changes in basic cognition are expected to be associated with changes in everyday cognition, and changes in everyday cognition, in turn to be associated with changes in everyday function. Based on prior research, no residual relationship between basic cognition and everyday function is expected. Furthermore, it is expected that (c) the unique path between everyday cognition and everyday function will explain more variance in everyday function than the unique path between basic cognition and everyday function (from (a) above). If supported, these findings would provide strong evidence to support the conceptualization of everyday cognition as the instantiation of basic abilities in tasks that better predict older adults' everyday functioning.

CHAPTER 3
RESEARCH DESIGN AND METHODS

Overview

The present study represents cross-sectional and longitudinal analyses of data from control participants enrolled in the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study. The following sections describe the ACTIVE study, outlining procedure, participant recruitment, and eligibility. Next the present sample, and measures used are described.

The ACTIVE Study

ACTIVE is a longitudinal, randomized controlled single-blind clinical trial designed to determine whether the effects of cognitive training would transfer to everyday functioning, as assessed by laboratory measures. The study has a 4-group design, which includes 3 treatment groups and one no-contact control group. Participants in the treatment groups received cognitive training in memory or reasoning or speed of information processing, all of which have previously been shown to improve cognitive abilities. Assessment of cognitive skills was conducted at baseline, 0.23 years following the training (post-test), and annually at 1, 2, 3 and 5 years after post-testing. Data collection took place at six field sites. Standardization of data collection procedure was ensured through training and quality control procedures. The ACTIVE study design is detailed extensively by Jobe and colleagues (2001) and illustrated in Figure 3-1. The present study was focused on subset of 698 controls, which constituted a non-intervention longitudinal sub study from the larger ACTIVE trial.

Recruitment

The main goals of recruitment for the ACTIVE trial was to induct older adults who were at risk for loss independence due to functional decline, but who have yet to experience such declines, and to compile a representative sample of older adults, with particular emphasis on representation of African-American elders (Jobe et al., 2001). Recruitment ran from March 1998 through October 1999. Recruitment strategies and sources varied by site; strategies included on-site presentations, letters to interested persons, newspaper advertisements, introductory letters and follow-up telephone calls. (Jobe et al., 2001)

The University of Alabama recruited participants through the Alabama Department of Public Safety and through UAB eye clinics. The Hebrew Rehabilitation Center for Aged recruited from congregate and senior housing sites, senior centers, and a research volunteer registry. Indiana University recruited through a network of facilities providing activities and social services to seniors, as well as local churches and senior citizens' organizations. Johns Hopkins University recruited from senior community organizations and centers, churches, senior housing, and through programs offering or coordinating wellness or service programs for seniors. Pennsylvania State University recruited through a state-funded pharmaceutical assistance program for low-income elders. Wayne State University recruited from a large range of community organizations, churches, hospital-based senior assessment centers, senior-housing sites, and driver registration lists.

Eligibility

To produce a sample of individuals that is physically and cognitively healthy enough to remain in the study for at least 2 years (initial enrolment period), not planning to move away, not yet experiencing ADL impairment that would undermine potential intervention benefits, and not having a terminal condition that would make individuals unavailable for follow-up testing, the following exclusion criteria were implemented: a) less than 65 years of age at initial screening; b) substantial existing cognitive decline (score of 23 or less on the Mini-Mental State Examination (MMSE; Folstein et al., 1975); self-reported diagnosis of Alzheimer's Disease); c) substantial existing functional decline (self-report of ≥2 ADL disabilities) (Morris et al., 1997); d) medical conditions that are likely to lead to imminent functional decline or mortality before the 2 year assessment (e.g. certain cancers); e) severe sensory losses (self-report of extreme difficulty reading newspaper print or performance-based vision test scores exceeding 20/50) (Mangione et al., 1992); f) communicative difficulties substantial enough to prevent participation in study protocol (interviewer-rated); g) recent cognitive training; or h) unavailability during the phases of the study.

Participants

Full ACTIVE Sample

A total of 2802 cognitively healthy, community-dwelling older adults aged 65 to 94 years comprised the ACTIVE analytic sample. Table 3-1 presents the baseline socio-demographic characteristics of the full analytic ACTIVE sample. Following baseline assessment, participants were randomly assigned to one of 4 groups: memory training, reasoning training, speed training or no-contact control. Following random assignment, 703 individuals were randomized to memory training, 699 to reasoning training, 702 to speed training and 698 to the no-contact control group. In the absence of intervention, the control sample constituted a de facto longitudinal study that permitted us to examine natural rates of change in basic and everyday cognition, and everyday function functional. Thus, only data from the no-contact control participants was included in the present analyses.

Present Study Sample

The present study sample consisted of the 698 individuals randomized to the no-contact control group and who contributed data on at least one of the 14 measures selected for this study (see measures table, Table 3-4). Table 3-1 presents the baseline socio-demographic characteristics of the present sample. Relative to the rest of the ACTIVE analytic sample at baseline (i.e. those randomized to intervention groups), the present study sample was .45 years older, with no significant differences in years of education, MMSE scores, gender, race, or marital status (Table 3-2). Thus, it was quite representative of the parent sample.

Aggregate Longitudinal Retention Pattern of the Present Study Sample

The present study assessed data collected at baseline, Year 1, Year 2, Year 3 and Year 5 of the ACTIVE clinical trial. The longitudinal retention pattern of the sub-sample selected for this study is presented in Figure 3-2, which depicts sample size and the percentage of baseline sample assessed at each occasion. It is important to emphasize that these numbers are aggregate numbers. At each wave, participants could exit and re-enter the study.

Characterization of Attrition Effects

To characterize the selectivity of longitudinal attrition to facilitate interpretation of the generalizability of results, study participants from the original baseline sample (N-698) who were assessed at Year 5 (N=452) were compared to those who were not assessed at this occasion (N=246). Results from these analyses are presented in Table 3-3. Relative to those not assessed, those assessed at Year 5 were younger, had more years of education, higher MMSE scores and had a higher percentage of females. White participants were more likely to be re-assessed at Year 5 than participants in other racial groups. There were no significant differences in marital status. These results suggest that attrition was selective, leading to the retention of younger, healthier individuals over time.

Measures

Table 3-4 outlines the measures employed in the present analyses, organized by domain. The choice of measures to include in the present analyses stemmed from prior ACTIVE studies, which showed that these measures yielded sufficient variance for the present analyses (e.g. Ball et al., 2002).

Basic Cognition Measures

Basic memory. Memory ability, the ability to encode and recall word lists and paragraphs, was included as a consequence of prior work illustrating its relationships to everyday cognition and function (Diehl et al., 1995; Willis et al., 1992; Willis, 1996). Furthermore, memory ability has been shown to be vulnerable to age-related decline (Schaie, 1996). Basic memory was assessed using the Hopkins Verbal Learning Test, Related Word Lists (HVLT; Brandt, 1991); Rey Auditory-Verbal Learning Test, Unrelated Word Lists (AVLT; Rey, 1941); and the Rivermead Behavioral Memory Test, Paragraph Recall task (RBMT-PR; Wilson et al., 1985).

The HVLT required participants to recall a list of 12 words, which could be grouped into semantically related categories (e.g. precious stones, animals). The list was repeated and recalled for 3 trials and included a recognition task in which participants heard the list of words from the original list, new words from the same semantic categories as the target list, and new semantically unrelated words. Participants were asked to identify whether or not they recognized each word from the original list. Responses to each trial were provided in written form. The test-retest reliability of the HVLT was 0.73 (Ball et al., 2002).

The AVLT measure used in this study consisted of five learning and recall trials. Participants heard a 15-item word list that was read aloud by the tester with an 8-second pause between each word. They were then asked to write down in any order as many words as they could remember, including any words recalled correctly on previous trials. Two minutes were allowed for writing down the words they recalled. This was repeated five times. The participants' responses were then scored for total number of words correctly recalled for each of the five trials (0–15 for each trial), with total scores potentially ranging from 0 to 75. The test-retest reliability of the AVLT was 0.78 (Ball et al., 2002).

The RBMT-PR assessed story memory. Alternate passages were administered at each occasion. Participants listened to the story on an audiotape, and were asked to write down everything they could remember immediately after the story was finished. The story is divided into idea units, or individual lexical items, which were used for scoring story recall. Each story consisted of 21 idea units. Participants received scores for the quality of their recall of each idea unit (0 = not recalled; 0.5 = approximately accurate; 1 = completely accurate). The sum of these for each person at each occasion provided the RBMT-PR raw score, which represented total recall. The test-retest reliability of the RBMT-PR was 0.60 (Ball et al., 2002).

Basic reasoning. Inductive reasoning skills were targeted due to prior work showing their vulnerability to age-related decline, and illustrating a relationship between these abilities and everyday cognition and function (Schaie, 1996; Allaire & Marsiske, 2002; Royall et al., 2007). Basic reasoning was assessed using the Letter Sets, Letter Series, and Word Series tasks (Gonda & Schaie, 1985; Thurstone & Thurstone, 1949; Ekstrom et al., 1976, respectively). These measures are standardized, timed, paper-and-pencil assessments.

Letter Sets items consist of five sets of letter with four letters in each set. Four of the five sets are alike in some way and the participant was asked to determine which letter set did not belong with the rest. After working through several examples, the participant was given 7 minutes to work through 15 problems. The total number of items completed correctly in the time allowed (possible scores of 0-15) was the score. The test-retest reliability of the Letter Sets was 0.69 (Ball et al., 2002).

Letter Series items consist of series of letter of varying lengths, and the participant was asked to determine the letter that should go next in the series, selected from among five choices. After working through several examples, the participant was presented with a total of 30 word series and told he/she had a 6-minute time limit. The total number of items completed correctly in the time allowed (possible scores of 0-30) was the score. The test-retest reliability of the Letter Series was 0.86 (Ball et al., 2002)

Word Series items resembled those of the Letter Series task, but consisted of a series of days of the week or months of the year, and the participant determined how the series progressed, in order to select the next day/month in the series from among five choices. After working through several examples the participant was presented with a total of 30 word series and told he/she had a 6-minute time limit. The total number of items completed correctly in the time allowed (possible scores of 0–30) was the score. The test-retest reliability of the Word Series is 0.84

Basic speed. This domain targeted visual-spatial perceptual speed, and was selected due to prior studies illustrating its relationship to everyday outcomes, such as driving (Ball, Owsley, Sloane, Roenker, & Bruni, 1993), and everyday function (Barberger-Gateau, 1999). Thus, basic speed was assessed via the Useful Field of View (UFOV; Ball, et al., 1993) tasks 2 and 3. Tasks 1 and 3 were also assessed; however they were excluded from analyses due to floor and ceiling effects that limited their variance (Ball et al., 2002).

UFOV Task 2, or Divided Attention, was comprised of central and peripheral stimuli presented on a computer screen. The stimuli were dichromatic, two-dimensional drawings of either a car or a truck. During the task, one of two stimuli was presented centrally and at the same time, a car was presented to one of 8 locations around the periphery of this central stimulus. Participants were required to judge the identity of the centrally presented stimulus and to identify the location of the peripheral stimulus, at decreasing latencies. The minimum stimulus duration needed to perform both aspects of this task at 75% correct was the score.

UFOV task 3, or Selective Attention, was identical to UFOV Task 2, with the exception of the addition of visual clutter around between the central and peripheral stimuli, in the form of an array of triangles. Again, the minimum stimulus duration needed to perform both aspects of this task, which now included speeded visual search, at 75% correct was the score.

For both measures, higher scores represented longer latencies required for a correct response; therefore higher scores were indicative of worse performance, while lower scores were indicative of better performance on this task. The test-retest reliability of a UFOV composite of the two tasks used in this study, plus a third, was 0.80 (Ball et al., 2002).

Everyday Cognition Measures

Everyday cognition, the ability to solve well-structured, everyday problems, was selected due to prior findings illustrating a relationship with self-reported everyday function (Allaire & Marsiske, 2002), as well as age-related decline in this domain (Willis et al., 1992) assessed with the Everyday Problems Test (EPT; Willis & Marsiske, 1993), the Observed Tasks of Daily Living (OTDL; Diehl, et al., 2005), and the Timed Instrumental Activities of Daily Living (tIADL; Owsley, Sloane, McGwin, & Ball 2002).

The EPT is a pencil-and-paper measure designed to assess adults' ability to solve problems of daily living using printed materials. Participants were presented with 14 everyday stimuli (e.g. medication labels, transportation schedules, telephone rate charts, Medicare benefits charts) and were asked to answer two questions about each stimulus (e.g. to calculate the number of days the supply of medication will last). The EPT has items representing 7 domains of daily living: meal preparation and nutrition, medication use and health behaviors, telephone use, shopping, financial management, household management, and transportation. Scores represented the number of correct answers generated (possible scores of 0 - 28). The standardized alpha for the EPT was 0.94 and that the 1-year Spearman-Brown test-retest stability was 0.91 (Marsiske &Willis, 1994). Ball and colleagues (2002) reported a test-retest reliability of 0.87 for this measure. See Appendix A for sample items.

The OTDL is conceptually similar to the EPT, in that participants are required to use printed materials (e.g. cake mix ingredients, medicine bottles, telephone book) to solve everyday problems. The OTDL consisted of nine tasks, with a total of 13 questions addressing three IADL domains (medications, phone usage, and financial management). An example task is allowing the subject to examine three medication containers with pharmacy labels attached and then asking him/her how many days will a refill of a given medication last or which medications might cause drowsiness. Testers were required to indicate the correctness of each response by circling ‘yes’ or ‘no’ and then writing verbatim responses in the space allowed. Furthermore, testers indicated whether or not it was necessary to prompt the participant. Performance on the OTDL measure was scored by a certified scorer (possible scores 0 - 28). Diehl et al. (2005) reported that the Kuder-Richardson’s corrected alpha for the total measure was 0.71 and the internal consistency of the total measure was 0.81. Ball et al. (2002) report an internal consistency of 0.75. See Appendix B for sample items.

In the tIADL, participants were asked to perform 5 everyday tasks (finding a phone number in the phonebook, counting out change, reading food can ingredients, finding items on a shelf, and reading directions on medicine containers) using everyday stimuli (e.g. a phonebook, coins, cans of food). Accuracy of task performance and time to complete each task was recorded with a stopwatch. For each task there was a completion time and an error code, which were combined as follows. Subjects with a major error code on a given item were assigned the maximum time allotted on that item. For those with a minor error code, a time penalty was added to their completion time; this penalty was defined as 1 SD based on the data from all participants who had completed that item without error (range of scores 46 – 806). Owsley et al. (2002) reported that the 7-8 week test-retest reliability for the tIADL was 0.85. Ball et al. (2002) reported a test-retest reliability of 0.64. See Appendix C for sample items.

Everyday Function Measure

Everyday Function, which focused on instrumental activities of daily living (IADL) capacity, was selected due to its role as a key outcome in most aging research (Diehl, 1998). This domain was assessed with a self-report measure, drawn from the Minimum Data Set methodology (Morris et al., 1997). Instrumental activities of daily living questions elicited self reported capacity in areas such as preparing meals, housework, managing finances, managing health care, shopping, telephone use and travel. Participants were asked, 'in the last 7 days, how much of the activity did you do on your own?' and then asked 'how difficult was it (or would it have been) to do on your own?' Responses ranged from 'not difficult,' to 'great difficulty', on a 5-point Likert-type scale (possible scores 19 to 57; the measure is included in Appendix D). According to the coding of this scale, higher scores represented more difficulty with IADL, and lower scores represented less difficulty, thus a lower score on this measure would be indicative of gain or improvement, while a higher score would be indicative of loss or deterioration in everyday functioning. The reliability analysis of a precursor measure using a similar assessment approach yielded a weighted Kappa of 0.76, which is indicative of excellent reliability (Morris et al., 1997). In ACTIVE, Ball et al. (2002) reported an internal consistency alpha of 0.75 for the IADL Difficulty scale.

Statistical Analyses

The study addressed two main experimental hypotheses. First we aimed to replicate prior cross-sectional data and show that everyday cognition mediates the basic cognition variance (both assessed at the latent level) in everyday function at the baseline occasion of measurement (Aim 1). To address these questions, analyses examined the relationships between all observed measures of basic and everyday cognition and everyday function, followed by analyses of latent-level mediation using nested models via Structural Equation Modeling (SEM).

Second, we aimed to confirm that basic cognitive abilities would be longitudinal (occasion to occasion) predictors of everyday function, and that everyday cognition would mediate this relationship. We employed the Multilevel modeling (MLM; Bryk & Raudenbush, 1992) approach to assess the question of longitudinal mediation of the basic cognition variance in everyday function by everyday cognition. To do so we first assessed the nature of longitudinal change in the data (Aim 2.1) followed by analyses of mediation using nested models (Aim 2.2).

Data Preparation and Reduction

To be conformal with the assumptions of multivariate statistics (especially normality), and to produce correct effect codings for some models, data were first prepared for the analyses, as described in the next sections.

Aim 1: Structural Equation Models. All data were Blom transformed (Blom, 1958) by ACTIVE statisticians prior to analyses. The Blom transformation converts each value of the item distribution to its Z-score equivalent at the same percentile on the standard normal distribution, under the assumption that the underlying true score is normally distributed, resulting in improved normality of the data.

Aim 2.1 and 2.2: Multilevel models. For basic memory, reasoning and speed, and for everyday cognition, composite variables were computed by averaging across constituent measures (basic memory: RBMT-PR, HVTL, AVLT; basic reasoning: Letter

Series, Letter Sets, Word Series; basic speed: UFOV 2 & 3; everyday cognition: EPT, tIADL, OTDL). These composite variables were utilized in the MLM analyses of change over time. Visual inspection of the longitudinal data suggested both linear and quadratic time trends. Furthermore, prior longitudinal work in aging suggests that quadratic decline in abilities is a common trajectory of change (Schaie, 1994), which is likely related to similar patterns of change observed in brain anatomy (e.g. Raz et al., 1995). Two time variables, one representing linear time (coded as 0.23, 1.23, 2.23, 3.23, 5.23, to reflect occasions of measurement and their spacing) and another representing quadratic time, computed by squaring the linear time variable and taking the residual, were computed to fit to the longitudinal data. All variables were then converted to Z-scores, which were utilized in analyses to facilitate comparisons.

Aim 2.2: Multilevel mediation models. In addition to the linear and quadratic time variables used in analyses of change over time (Aim 2.1), 8 additional variables were created, to be examined as predictors of everyday function. For each cognitive variable: basic memory, reasoning, speed, and everyday cognition, two variables were computed, one to represent the mean performance in each domain across occasions, and the second to capture deviation from this mean value at each occasion. This latter variable is therefore “centered” on the mean level, and represents the slope of longitudinal change in performance relative to the mean (Singer &Willett, 2003).

Criteria for Evaluation of Models

Prior to considering the specific models, this section outlines the criteria used to evaluation models for the two main study aims.

Aim 1: Structural Equation Models. Structural equation models were estimated as a planned series of nested models, in which each subsequent model added or removed paths from the preceding model. For these nested models, model adequacy was evaluated using a number of criteria (e.g. Martens 2005, Weston & Gore, 2006), including the root mean square error of approximation (RMSEA), a fit index indicating the discrepancy between the original and reproduced covariance matrix divided by the degrees of freedom and for which values of .05 or lower were indicative of adequate fit; pCLOSE, or the probability of close fit assessed the null hypothesis that the population RMSEA was no greater than .05; the Comparative Fit Index (CFI), for which values close to 1.0 indicate a good fit; the Normed Fit Index (NFI), which compared the improvement in the minimum discrepancy for the specified model to the discrepancy for the independence model, where a value below 0.90 indicated that the model can be improved; the Relative Fit Index (RFI), which takes the degrees of freedom of the model into account, values close to 1.0 indicated good fit; the Incremental Fit Index (IFI), for which values close to 1.0 indicated good fit (Bentler & Chou, 1987; Hu & Bentler, 1997; Marsh, Balla & McDonald, 1988; Schumaker & Lomax, 2004). Furthermore, change in Chi-Square ($\Delta\chi^2$), where significance was indicative of a notable change in relative model fit, and the Akaike's Information Criterion (AIC), where improvement in fit signaled lower relative values, were also examined.

Aims 2.1 and 2.2: Multilevel models. MLM allows for the examination of fixed and random effects. Fixed effects refer to the "average" effects, or effects that hold true across all individuals. Random effects test whether there are significant individual differences in the obtained fixed effects. For example, with respect to the effects of time, fixed effects would illustrate whether the longitudinal data across individuals can be characterized by growth, decline or a combination of the two. A random effect of time would illustrate whether this slope of change varies significantly between individuals (i.e. some individuals improve or decline faster or slower than others). Furthermore, MLM analyses permit the examination of predictors that interact with the dependent variable on separate levels. When data is clustered within persons, meaning that the same people are observed at multiple occasions of measurement (as in this study), Level 2 predictors answer the question: to what extent does a person’s level on the predictor influence their outcome at each occasion. For example, what is the effect of a person’s mean level of memory on their self-reported everyday functioning (IADL Difficulty)? On the other hand, a Level 1 predictor varies with the dependent variable at each occasion and permits the examination of how change in the predictor is related to change in the dependent variable. For example, what might participants endorse on everyday function, on those occasions when their basic memory performance is higher or lower than their mean value of basic memory?

All longitudinal analyses were conducted via series of nested models. These models were estimated using the Maximum likelihood (ML) method, which was selected to facilitate the examination of both fixed and stochastic model components making it better suited for conducting nested model tests. The fit of each subsequent modeling step was compared to that of the prior step. Furthermore, the within- and between-person variance explained by subsequent modeling steps was also compared to that of the initial, worst-fitting model, which defined the within- and between- person variance to be explained (i.e. model 1 in Aim 2.1 and 2.2). For each model, relative goodness of fit was assessed via an examination of the reduction in -2LL (denoted $\Delta\chi^2$), as well as via changes in AIC, & the Schwartz Bayesian Information Criterion (BIC). Improvements in the predictive value of a modeling step were evaluated by the extent to which the modeling step explained the within- and between- person variance, relative to the criterion model (Bryk & Raudenbush, 1992). Decreases in the intercept related and residual variance, represent a proportional reduction of the prediction error, which is analogous to R^2, and used as an estimate of effect size.

Analytical Framework for Aim 1: Cross-sectional Mediation

Structural Equation Modeling (SEM) with Amos 17 software (Arbuckle, 2008) was used to assess the relationships among basic cognition, everyday cognition, and everyday function. Multiple steps were used to evaluate whether particular paths were essential to model fit, or whether they could be eliminated. The broad goal of this section was to evaluate whether everyday cognition might account for some or all of the basic cognitive variance in everyday function, although formal mediation analyses were not conducted because of the failure to meet certain preconditions for establishing mediation (Baron & Kenny, 1986).

Explication of modeling steps. Modeling steps were as follows:

1. **Measurement model:** this was the best-fitting model consisting of all possible correlations between the four hypothesized latent-level factors: basic memory, basic reasoning, basic speed, everyday cognition, and observed (non-latent) everyday function (IADL difficulty). Given that the Measurement model was the best-fitting model, its fit was used as the criterion against which subsequent models' fit was assessed.

2. **Fully-recursive model*:*** this model estimated all possible regression paths between the four cognitive latent factors, the predictors, and everyday function, the outcome variable. This step was mathematically equivalent to the Measurement model; however it yielded standardized estimates that represent the unique relationships between each predictor and the outcome. Changes in these values in subsequent nested models were evaluated in addition to changes in model fit.

3. **Basic cognitive factors predict everyday function**: in this step, the path from everyday cognition to everyday function is removed, with the resulting model

assessing the unique relationships between latent-level basic memory, reasoning and speed, and everyday function without everyday cognition as a predictor.

4. **Basic memory predicts everyday function:** in this model the paths from basic reasoning and speed to everyday function are removed to assess whether basic memory is a significant predictor of everyday function. This step was based off the results from step 3, which established that Basic reasoning and speed were not significant unique predictors of Everyday function.

5. **Basic memory and everyday cognition predict everyday function:** in this model the path from everyday cognition to everyday function is added to model 4, to evaluate whether the addition of everyday cognition as a predictor would diminish the unique relationship between basic memory and everyday function, which would suggest mediation of this variance by everyday cognition;

6. **Direct path from basic memory to everyday function is removed***:* the purpose of this step is to assess the extent of the mediation of the basic memory variance in everyday function by everyday cognition. By removing the direct path from basic memory to everyday function, this model allows for an assessment of the indirect path from basic memory via everyday cognition to everyday function.

Analytical Framework for Aim 2.1: Change over Time in Study Constructs

Prior to conducting analyses investigating whether changes in basic and everyday cognition varied systematically with changes in everyday function, a first set of analyses sought to describe the functional form of 5-year cognitive change in each of the study constructs.

Explication of modeling steps. The nested models to assess change over time were estimated in a series of five steps for each study construct (basic memory, reasoning, speed, everyday cognition and everyday function). The five steps estimated were as follows:

1. **Unconditional means** (no predictors): this was the worst fitting model, which defined the within- and between- person variance to be explained. This model served as the criterion model for evaluations of the predictive value of subsequent models.

2. **Fixed linear time**: in this model the fixed effects of the linear time variable were assessed.

3. **Random linear time**: in this model the random effects of the linear time variable were added to model 2.

4. **Fixed quadratic time**: in this model the fixed effects of the quadratic time variable were assessed in addition to the predictors in model 3.

5. **Random quadratic time**: this model adds an estimate of the random effects of the Quadratic time variable to the predictors in model 4.

Analytical Framework for Aim 2.1: Longitudinal Mediation of Basic Cognitive Variance in Everyday Function by Everyday Cognition

The longitudinal mediation of the basic cognition variance in everyday function was also examined using the MLM approach, building on the models in Aim 2.1, with Everyday function as the dependent variable.

Explication of modeling steps. The seven nested models were as follows:

1. **Fixed quadratic time**: this model was the final estimable model from Aim 2.1, which explored the nature of the longitudinal change in everyday function by fitting linear and quadratic time variables to the data (model 4 from Aim 2.1; Table 4-10). For the series of the following nested models, this model serves as the baseline, "worst-fitting" model, which defines the within- and between-person variance to be explained. Furthermore, this model establishes the fixed effects of linear and quadratic time as well as the to-be-explained variance attributable to the random effects of linear time. Thus, in subsequent models, in addition to testing mediation of the basic cognition variance in everyday function by everyday cognition, the goal is to determine whether additional predictors a) account for the fixed effects of linear and quadratic time, and b) account for the significant variance in individual positive linear slopes.

2. **Fixed mean basic cognition**: in this model, the fixed effects of mean basic memory, reasoning and speed are added to the model.

3. **Fixed centered basic cognition**: in this model, the fixed effects of the centered Basic memory, reasoning and speed are added to the model.

4. **Random centered basic cognition**: in this model, the random effects of the centered Basic memory, reasoning and speed are added to the model.

5. **Fixed mean everyday cognition**: in this model, the fixed effects of mean Everyday cognition are added to the model.

6. **Fixed effects of centered everyday cognition**: in this model, the fixed effects of centered Everyday cognition are added to the model.

7. **Random effects of centered everyday cognition**: in this model, the random effects of centered everyday cognition are added to the model.

Table 3-1. Sociodemographic characteristics of the present study sample and the full ACTIVE sample

	Present study sample (N=698)			Full ACTIVE sample (N=2802)		
	Mean	S.D.	Range	Mean	S.D.	Range
Age	74.05	6.05	65-94	73.63	5.91	65-94
Years of Education	13.37	2.71	6-20	13.53	2.7	4-20
MMSE	27.27	2.00	23-30	27.31	2	23-30
Gender	%			%		
Women	73.6			75		
Men	26.4			25		
Race						
White	71.1			72		
African American	26.8			26		
Other/Unknown	2.1			2		
Married	37.1			36		

MMSE: Mini-Mental State Exam

Table 3-2. Sociodemographic comparison of the present study sample to the rest of the ACTIVE sample at baseline

Characteristic	ACTIVE Trained Sample (N=2,104)	Present Study Sample (N=698)	t	df	d	χ^2	p
Age, years	73.50	74.05	2.15	2800	0.09		0.032
Years of Education	13.58	13.37	1.75	2798	0.07		0.080
MMSE	27.33	27.27	0.61	2800	0.02		0.543
Sex, %Female	76.60	73.60				2.54	0.111
Race, %White	72.80	71.10				1.91	0.384
Marital Status, %Married	35.00	37.10				0.55	0.458

MMSE: Mini-Mental State Exam

Table 3-3. Sample attrition, comparing participants assessed at Year 5 to those not assessed at Year 5

Characteristic	Assessed at Year 5 (N=452)	Not Assessed at Year 5 (N=246)	*t*	df	*d*	χ^2	*p*
Age, years	73.58	74.91	2.78	696	0.22		0.006
Years of Education	13.58	13.00	-2.71	696	0.21		0.007
MMSE	27.52	26.83	-4.41	696	0.35		0.000
Sex, %Female	68.30	66.30				10.66	0.001
Race, %White	75.70	63.00				17.66	0.000
Marital Status, %Married	36.30	38.60				0.37	0.542

MMSE: Mini-Mental State Exam

Table 3-4. Measures used

Cognitive Domain	Test	Published Source
Basic Memory	Hopkins Verbal Learning Test, Related words (HVLT); Rey Auditory Verbal Learning Test, Unrelated words (AVLT); Rivermead Behavioral Memory Test, Paragraph recall (RBMT-PR)	Brandt, 1991; Rey, 1941; Wilson et al., 1985
Basic Reasoning	Letter Sets; Letter Series; Word Series	Gonda & Schaie, 1985; Thurstone & Thurstone, 1949; Ekstrom et al., 1976
Basic Speed	Useful Field of View (UFOV), Tasks 2 & 3	Ball & Owsley, 1993
Everyday Cognition	Everyday Problems Test (EPT); Observed Tasks of Daily Living (OTDL); Timed IADL (tIADL)	Willis & Marsiske, 1993; Diehl et al., 2005; Owsley et al., 2002
Everyday Function	Activities of Daily Living and IADL functioning Minimum Data Set -IADL perceived degree of difficulty	Morris et al., 1997

Figure 3-1. ACTIVE study design. Note: booster training occurred prior to the first and third follow-up assessments.

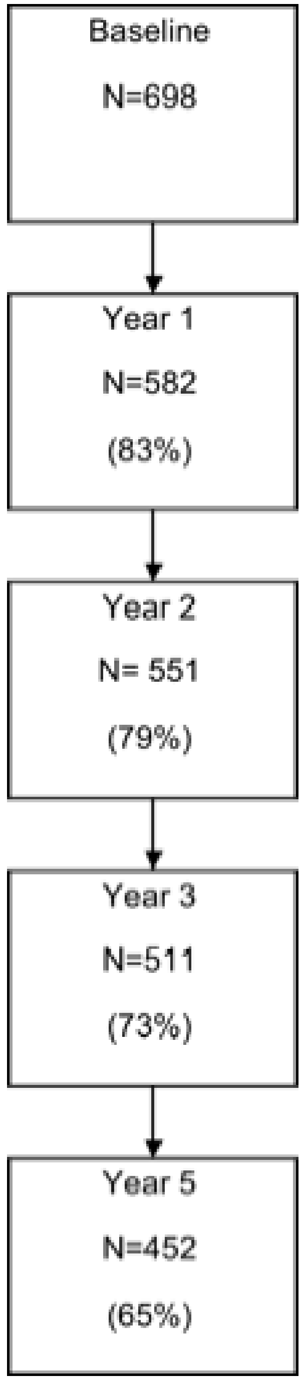

Figure 3-2. Aggregate longitudinal retention pattern of the current study sample. Note: the chart doesn't describe participants' entrances and exits

CHAPTER 4
RESULTS

Overview

This study investigated the relationship between basic cognition, everyday cognition and everyday function in a sample of healthy, community-dwelling older adults age 65 and over who were tested at five occasions of measurement (baseline, Year 1, Year 2, Year 3 and Year 5 post baseline). Specifically, the study addressed the question of whether everyday cognition accounts for the basic ability variance in everyday function cross-sectionally, or at a specific point in time, as well as longitudinally over time.

Aim 1: Baseline Mediation of Basic Cognition Variance in Everyday Function by Everyday Cognition

Preliminary Analyses

Initial analyses examined the interrelationships between all observed measures of Basic and Everyday cognition, and Everyday function (see Table 3-4 in the Measures section) at baseline. Table 4-1 displays the bivariate correlations between measures of basic memory, reasoning, and speed, everyday cognition and everyday function. As can be seen in the table, all measures were significantly correlated, with the exception of the correlations between Everyday function (IADL difficulty) and the RBMT-PR, and everyday function and Letter Sets. Correlations between measures of basic and everyday cognition were medium to large (-0.27 to 0.83), while all correlations with everyday function were small (.03 to 0.19) (Cohen, 1992).

Nested Model Findings

The following models assessed the baseline relationship between basic cognition, everyday cognition and everyday function. A comprehensive explication of these modeling steps is presented in the Statistical Analyses section of Methods, above. This portion of the analyses was intended to replicate and extend prior findings (e.g. Allaire & Marsiske, 2002), and is the modal approach in the literature to date.

(1) Measurement model. The standardized four-factor solution for the Measurement model is displayed in Table 4-2. All measures loaded highly and significantly on their respective factors, confirming the hypothesized four-factor structure (basic memory, basic reasoning, basic speed, everyday cognition). Model fit indices for this and all subsequent baseline models are displayed in Table 4-3. As Table 4-3 illustrates, the fit of the Measurement model was good. Standardized factor intercorrelations are presented in Table 4-4. The correlations between all basic cognitive factors and everyday cognition were high (-0.57 to 0.85), while the correlations with everyday function were low (-0.10 to -0.15). Results from the measurement model reflect these from the bivariate intercorrelations between observed measures of basic and everyday cognition and everyday function, and suggest that measures of cognition have stronger relationships with each other than they do with everyday function.

(2) Fully-recursive model. This model estimated all possible regression paths between the four cognitive latent factors and Everyday function. As illustrated in Table 7, the fit of this model was good, with no decrement in fit from the Measurement model. The standardized loadings, and variance explained is presented in Figure 4-1. As Figure 4-1, panel A illustrates, only the unique relationships between basic memory and everyday cognition (0.33), and basic reasoning and everyday cognition (0.58) were significant ($p < .05$), suggesting that when added to the predictive value of memory and reasoning, speed of processing is not a significant predictor of everyday cognition. None of the paths from basic or everyday cognitive variables to everyday function reached significance, suggesting that when all cognitive latent variables were simultaneously included as predictors of everyday function, their unique predictive variance, above and beyond the variance shared with one another, was trivial. The basic cognitive factors together accounted for 80% of the variance in everyday cognition, while all the cognitive factors together accounted for only 3% of the variance in everyday function.

(3) Basic cognitive factors predict everyday function. In this model, the path from everyday cognition to everyday function was removed, to allow only the basic cognitive factors to predict everyday function. The fit of this model was good, with non-significant decrement in fit from the previous, Fully recursive model (Table 4-3, panel A). The standardized loadings and variance explained in the dependent variable is presented in Figure 4-1, panel B. As illustrated by Figure 4-1, panel B, with basic reasoning and speed controlled for, only basic memory significantly predicted everyday function ($p < .05$). Without everyday cognition in the model, the basic cognitive factors still accounted for 3% of the variance in everyday function.

(4) Basic memory predicts everyday function. Given results from the previous model, the paths from both basic reasoning and speed were removed, leaving only basic memory as a predictor of everyday function. This model exhibited good fit and no decrement in fit from the previous model (Table 4-3). Figure 4-1, panel C illustrates the standardized loadings and variance explained by this model. Basic memory alone was a significant predictor of everyday function ($p < .05$), accounting for 2% of its variance.

(5) Basic memory and everyday cognition predict everyday function. In this model, everyday cognition was included as an additional direct predictor of everyday function, in addition to basic memory. The fit of this model was good, and resulted in improvement in fit over the previous model where basic memory alone predicted everyday function (Table 4-3). The standardized loadings and variances explained are presented in Figure 4-1, panel D. As Figure 4-1, panel D illustrates, basic memory was a significant predictor of everyday cognition ($p < .05$), accounting for 80% of its variance. With everyday cognition in the model, neither basic memory nor everyday cognition was a significant unique predictor of everyday function. The change in the predictive status of basic memory, from a β-weight of 0.15 ($p < .05$) to 0.08, ($p > .05$), suggests that everyday cognition accounted for its variance in everyday function.

(6) Direct path from basic memory to everyday function is removed. To examine the extent of the mediation of the basic memory variance in everyday function by everyday cognition, the direct path from basic memory to everyday function was removed. This fit of this model was good, and resulted in no decrement in fit from the previous model (Table 4-3). The standardized loadings, presented in Figure 4-1, panel E, show that everyday cognition became a significant predictor of everyday function, thus fully accounting for the basic memory variance in everyday function.

Aim 2.1: Change over Time in Study Constructs

The following set of analyses was carried out in order to describe the trajectory of change over time in the study constructs. A comprehensive explication of these modeling steps is presented in the Statistical Analyses section in Methods. These descriptive analyses allowed us to characterize longitudinal change in the study constructs, the nature of which must be established prior to investigations of coupled change, which were carried out in Aim 2.2, building on these results.

Table 4-4 displays the fit indices and variances explained by the series of nested models that examined the fixed (across individuals) and random (interindividual differences) effects of linear and quadratic time for each study construct (basic memory, reasoning, and speed, everyday cognition and everyday function). Of the five constructs under investigation, four failed to achieve convergence when Random quadratic time was estimated. Subsequently, step 4, Fixed quadratic time, was the last estimable model. Table 4-5 displays the fixed and random estimates for modeling step 4, Fixed quadratic time, for each of the five variables. As illustrated in Table 4-5, each modeling step represented significant improvements in fit over the preceding modeling step, which was evidenced by a reduction in the -2LL ($\Delta\chi^2$). All variables evidenced significant linear positive trends, indicative of gain or improvement over time, that were modified by significant negative quadratic trends, indicative of loss or decline, that were true across participants (fixed effects). Furthermore, all variables evidenced significant individual differences (random effects) in linear gain (Figure 4-2). These findings indicate that in general, participants evidenced (linear) improvement, and there were individual differences in this gain. Across participants, this positive linear trajectory was modified by a quadratic trend, which suggested that the overall longitudinal trend in the study constructs was initial increase followed by a decline, which did not appear to vary between participants.

Aim 2.2: Longitudinal Mediation of Basic Cognitive Variance in Everyday Function by Everyday Cognition

Nested models were used to examine the longitudinal interrelationships between basic cognition, everyday cognition, and everyday function as well as to determine the extent to which the cognitive predictors accounted for the effects of time. Table 4-6 displays the model fit characteristics as well as the between-person (Level 2) within-person (Level 1), and linear time-related (Level 1) variance explained by the predictors in each of the seven nested models. Table 4-7 displays the estimates for the final model 7, Random effects of centered everyday cognition.

As illustrated by Table 4-6, each modeling step represented a significant improvement in fit relative to the previous model, with the exception of the final model, which failed to achieve a significant improvement in fit ($\Delta\chi^2$ (1) = 0.08, p >.05). As Table 4-7 (right side) illustrates, the mean and centered basic and everyday predictors together accounted for about 29% of the between-person and 14% of the within-person variance in everyday function, above and beyond that accounted for by the effects of time. Furthermore, these predictors accounted for about 42% of the individual differences in linear gain observed in everyday function. As illustrated by Table 4-7, the fixed effects of both linear and quadratic time, and the random effects of linear time remained significant with all the cognitive predictors in the model, suggesting that the cognitive predictors failed to fully explain the linear gain and quadratic decline in everyday function that was observed across participants, as well as for the individual differences in linear gain.

With respect to the longitudinal interrelationships between basic abilities, everyday cognition and everyday function, results from models 2 – 5 will first be summarized, and subsequently compared to those of model 6, illustrated in Table 4-7.

In model 2, the fixed effects of all the mean cognitive variables were estimated. Mean memory and speed emerged as significant predictors (p < .001), suggesting that older adults whose average, cross-occasion level of memory is higher, report fewer functional difficulties Older adults whose level of speed was slower (indicative of poorer performance) reported more functional IADL difficulty.

In model 3, the fixed effects of centered memory, reasoning and speed were included to the predictors in model 2. These predictors, which were coded to capture change over time in these constructs, allowed us to examine whether change in basic abilities was predictive of change in everyday function. None of these centered basic cognitive variables emerged as significant predictors of everyday function, which suggested that across individuals, occasion-to-occasion changes in basic cognitive abilities (relative to their mean performance across occasions) were not associated with functional scores.

In model 4, random effects of these centered basic cognitive variables were estimated, and were found not to be significant, suggesting that change in basic cognition was not a predictor of change in everyday function. The estimates for model 4 are presented in Table 4-8. Therefore, models 2-4 illustrated that over time, individual differences in memory and speed are predictive of individual differences in everyday function.

In model 5, the fixed effects of mean everyday cognition were added to the predictors in model 4. The estimates for model 5 are presented in Table 4-8. These effects were highly significant ($p < .001$), suggesting that higher mean levels of everyday cognition were associated with less self-reported difficulty in everyday function.

With everyday cognition in the model, mean memory was no longer significant. Table 4-8, right side illustrates an inferential test for the mediation of the fixed effects of mean basic memory by mean everyday cognition. According to this analysis, mediation would be supported if the estimates from model 5 fell outside of the confidence intervals of the corresponding estimates from model 4. As illustrated by Table 4-8, mean everyday cognition mediated the memory–related variance in everyday function, mirroring the cross-sectional findings from Aim 1. Interestingly, with mean everyday cognition in the model, mean reasoning emerged as a significant predictor (p = .025), which is indicative of the presence of a suppressor effect.

In model 6, the fixed effects of centered everyday cognition were assessed. These effects were significant (p = .003), suggesting an overall occasion-to-occasion association between everyday cognition and everyday function. In model 7, the random effects of centered everyday cognition were estimated. These effects were not significant, suggesting that the occasion-to-occasion association between everyday cognition and everyday function did not vary in magnitude between participants, or at least that this study was not sensitive to individual differences in the strength of this relationship. As illustrated in Table 4-7, across participants a point increase in the level of basic reasoning was associated with .11 standard deviation units increase in self-reported functional difficulty; a point increase in mean level of speed was associated with a .09 unit increase in functional difficulty, and a point increase in mean level of everyday cognition was associated with 0.23 unit decrease in functional difficulty. Furthermore, on average, on occasions when scores on everyday cognition went up, self-reported functional difficulty decreased by 0.05 units.

Table 4-1.Bivariate correlations between measures of basic and everyday cognition and everyday function

Measure	1	2	3	4	5	6	7	8	9	10	11	12
1. HVLT	1.00											
2. AVLT	0.69**	1.00										
3. RBMT-PR	0.49**	0.49**	1.00									
4. Letter Sets	0.43**	0.39**	0.40**	1.00								
5. Letter series	0.49**	0.42**	0.46**	0.67**	1.00							
6. Word series	0.50**	0.45**	0.45**	0.63**	0.83**	1.00						
7. UFOV2	-0.40**	-0.33**	-0.32**	-0.39**	-0.48**	-0.47**	1.00					
8. UFOV3	-0.38**	-0.32**	-0.27**	-0.40**	-0.45**	-0.44**	0.62**	1.00				
9. Timed IADL	-0.45**	-0.42**	-0.34**	-0.43**	-0.52**	-0.51**	0.36**	0.39**	1.00			
10. OTDL	0.47**	0.42**	0.43**	0.46**	0.56**	0.55**	-0.39**	-0.39**	-0.49**	1.00		
11. EPT	0.52**	0.45**	0.52**	0.56**	0.68**	0.66**	-0.44**	-0.39**	-0.54**	0.65**	1.00	
12. IADL Difficulty	-0.11**	-0.16**	-0.04	-0.03	-0.10*	-0.08*	0.09*	0.10*	0.19**	-0.10**	-0.10*	1.00

* p<.05

**p<.001

HVLT: Hopkins Verbal Learning Test, Related Words; AVLT: Auditory Verbal Learning Test, Unrelated Words; RBMT-PR: Rivermead Behavioral Memory Test - Paragraph Recall Task; UFOV: Useful Field of View; IADL: Instrumental Activities of Daily Living; OTDL: Observed Tasks of Daily Living; EPT: Everyday Problems Test

Table 4-2. Factor loadings for the basic and everyday cognition factors

Measure	Factors Basic Memory	Basic Reasoning	Basic Speed	Everyday Cognition	Communalities
1. HVLT	0.85				0.72
2. AVLT	0.80				0.64
3. RBMT-PR	0.65				0.42
4. Letter Sets		0.73			0.53
5. Letter series		0.92			0.85
6. Word series		0.89			0.80
7. UFOV2			0.80		0.65
8. UFOV3			0.77		0.59
9. Timed IADL				-0.67	0.44
10. OTDL				0.74	0.55
11. EPT				0.85	0.73

All factor loadings were significant
HVLT: Hopkins Verbal Learning Test, Related Words; AVLT: Auditory Verbal Learning Test, Unrelated Words; RBMT-PR: Rivermead Behavioral Memory Test - Paragraph Recall Task; UFOV: Useful Field of View; IADL: Instrumental Activities of Daily Living; OTDL: Observed Tasks of Daily Living; EPT: Everyday Problems Test

Table 4-3. Baseline mediation nested model fit indices

Model	Model fit characteristics								Model fit comparisons		
	χ^2	df	RMSEA	pCLOSE	CFI	NFI	RFI	IFI	$\Delta\chi^2$	Δdf	AIC
1. Measurement model	108.38	45.00	0.05	0.77	0.98	0.97	0.96	0.99	0.00	0.00	198.39
2. Fully recursive model	108.38	45.00	0.05	0.77	0.98	0.97	0.96	0.99	0.00	0.00	198.39
3. Basic cognitive factors	110.68	46.00	0.05	0.77	0.98	0.97	0.96	0.98	-2.30	1.00	198.68
4. Basic memory	111.68	48.00	0.04	0.83	0.98	0.97	0.96	0.99	-1.00	2.00	195.68
5. Basic memory and everyday cognition	110.70	47.00	0.04	0.81	0.98	0.97	0.96	0.99	0.98	1.00	196.68
6. Direct path from basic memory is removed	111.80	48.00	0.04	0.83	0.98	0.97	0.96	0.98	-1.10	1.00	195.80

Dependent variable: Everyday function (IADL difficulty)
df: degrees of freedom; RMSEA: Root Mean Square Error of Approximation; pCLOSE: probability of Close Fit; CFI: Comparative Fit Index; NFI: Normed Fit Index; RFI: Relative Fit Index; IFI: Incremental Fit Index; AIC: Akaike Information Criterion

Table 4-4. Intercorrelations between basic cognition factors and everyday cognition factor and observed everyday function

Factor	1	2	3	4	5
1. Basic Memory	1.00				
2. Basic Reasoning	0.66^{**}	1.00			
3. Basic Speed	-0.57^{**}	-0.65^{**}	1.00		
4. Everyday Cognition	0.76^{**}	0.85^{**}	-0.65^{**}	1.00	
5. Everyday Function (IADL Difficulty)	-0.14^{**}	-0.10^{*}	0.12^{*}	-0.15^{**}	1.00

$^{*}p<.05$
$^{**}p<.001$

Table 4-5. Model fit indices and variance explained for models examining the effects of time in study constructs

Dependent Variable	Model	-2LL	df	Δ2LL	Δdf	AIC	BIC	Intercept	Residual	R^2 Between	R^2 Within
Basic memory	1. Unconditional means	4985.75	3.00			4991.75	5009.20	0.79	0.22		
	2. Fixed linear time	4936.79	4.00	48.96	1.00	4944.79	4968.05	0.81	0.21	-0.02	0.03
	3. Random linear time	4929.11	5.00	7.68	1.00	4939.11	4968.18	0.81	0.20	-0.02	0.09
	4. Fixed quadratic time	4767.11	6.00	162.00	1.00	4779.11	4814.00	0.81	0.18	-0.03	0.19
	Model	-2LL	df	Δ2LL	Δdf	AIC	BIC	Intercept	Residual	R^2 Between	R^2 Within
Basic Reasoning	1. Unconditional means	4034.10	3.00			4040.10	4057.63	0.91	0.12		
	2. Fixed linear time	3996.54	4.00	37.56	1.00	4004.54	4027.91	0.90	0.12	0.01	0.01
	3. Random linear time	3983.88	5.00	12.66	1.00	3993.88	4023.09	0.90	0.11	0.02	0.08
	4. Fixed quadratic time	3820.36	6.00	163.52	1.00	3832.36	3867.42	0.89	0.10	0.02	0.18
	Model	-2LL	df	Δ2LL	Δdf	AIC	BIC	Intercept	Residual	R^2 Between	R^2 Within
Basic Speed	1. Unconditional means	5297.89	3.00			5303.89	5321.38	0.76	0.25		
	2. Fixed linear time	5265.55	4.00	32.34	1.00	5273.55	5296.87	0.75	0.25	0.02	0.01
	3. Random linear time	5261.97	5.00	3.59	1.00	5271.97	5301.11	0.75	0.24	0.02	0.05
	4. Fixed quadratic time	5130.04	6.00	131.93	1.00	5142.04	5177.01	0.75	0.22	0.02	0.12
	Model	-2LL	df	Δ2LL	Δdf	AIC	BIC	Intercept	Residual	R^2 Between	R^2 Within
Everyday cognition	1. Unconditional means	5337.44	3.00			5343.44	5361.16	0.82	0.21		
	2. Fixed linear time	5334.65	4.00	2.79	1.00	5342.65	5366.28	0.82	0.21	0.00	0.00
	3. Random linear time	5326.39	5.00	8.26	1.00	5336.39	5365.92	0.82	0.20	0.00	0.05
	4. Fixed quadratic time	5277.02	6.00	49.37	1.00	5289.02	5324.46	0.82	0.19	0.01	0.08
	Model	-2LL	df	Δ2LL	Δdf	AIC	BIC	Intercept	Residual	R^2 Between	R^2 Within
Everyday function	1. Unconditional means	7201.96	3.00			7207.96	7225.73	0.44	0.56		
	2. Fixed linear time	7163.14	4.00	38.81	1.00	7171.14	7194.84	0.45	0.55	-0.02	0.02
	3. Random linear time	7124.24	5.00	38.90	1.00	7134.24	7163.87	0.46	0.48	-0.05	0.14
	4. Fixed quadratic time	7089.21	6.00	35.03	1.00	7101.21	7136.76	0.47	0.47	-0.06	0.16

AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion

Table 4-6. Estimates of fixed and random effects for the fixed quadratic time model for each variable

Dependent Variable	Fixed Effect	Estimate	S.E	df	*t*	*p*	Random Effect	Estimate	S.E	Wald *Z*	*p*
Basic memory	Intercept	-0.10	0.04	696.01	-2.89	0.004	Residual	0.18	0.01	25.69	0.00
	Linear time	0.28	0.03	1752.08	9.76	0.000	Intercept	0.81	0.05	17.06	0.00
	Quadratic time	-0.39	0.03	1571.62	-13.11	0.000	Linear time	0.02	0.00	3.77	0.00
Basic reasoning	Intercept	-0.10	0.04	702.18	-2.63	0.009	Residual	0.10	0.00	26.03	0.000
	Linear time	0.30	0.02	1749.87	14.43	0.000	Intercept	0.89	0.05	17.83	0.000
	Quadratic time	-0.28	0.02	1570.57	-13.12	0.000	Linear time	0.01	0.00	4.17	0.000
Basic speed	Intercept	0.07	0.03	707.71	1.90	0.058	Residual	0.22	0.01	26.22	0.000
	Linear time	-0.40	0.03	1734.02	-12.98	0.000	Intercept	0.75	0.04	16.76	0.000
	Quadratic time	0.38	0.03	1597.31	11.72	0.000	Linear time	0.01	0.00	2.61	0.009
Everyday cognition	Intercept	-0.07	0.04	698.96	-2.06	0.040	Residual	0.19	0.01	27.33	0.000
	Linear time	0.20	0.03	1892.35	7.23	0.000	Intercept	0.82	0.05	17.20	0.000
	Quadratic time	-0.20	0.03	1695.47	-7.07	0.000	Linear time	0.01	0.00	2.94	0.003
Everyday function	Intercept	0.03	0.03	685.39	1.11	0.266	Residual	0.47	0.02	27.61	0.000
(IADL Difficulty)	Linear time	-0.15	0.04	2027.47	-3.41	0.001	Intercept	0.47	0.03	14.15	0.000
	Quadratic time	0.26	0.04	1746.24	5.95	0.000	Linear time	0.06	0.01	5.49	0.000

Table 4-7. Fit indices and variance explained for the longitudinal mediation nested models

Model	2LL	Δ2LL	df	Δdf	AIC	BIC	intercept	residual	linear time	R^2 between	R^2 within	R^2 linear time
1. Fixed quadratic time	7089.21		6.00		7101.21	7136.76	0.47	0.47	0.06			
2. Fixed mean basic cognition	7003.26	85.95	9.00	3.00	7021.26	7074.52	0.39	0.48	0.06	0.16	-0.02	-0.05
3. Fixed centered basic cognition	5890.96	1112.30	12.00	3.00	5914.96	5984.45	0.35	0.44	0.04	0.25	0.07	0.34
4. Random centered basic cognition	5817.43	73.53	15.00	3.00	5847.43	5934.29	0.35	0.41	0.03	0.26	0.13	0.41
5. Fixed mean everyday cognition	5799.25	18.18	16.00	1.00	5831.25	5923.90	0.33	0.41	0.03	0.29	0.13	0.41
6. Fixed centered everyday cognition	5790.24	9.02	17.00	1.00	5824.24	5922.68	0.33	0.41	0.03	0.29	0.13	0.42
7. Random centered everyday cognition	5790.15	0.08	18.00	1.00	5826.15	5930.38	0.33	0.41	0.03	0.29	0.14	0.42

AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion.

Table 4-8. Fixed and random estimates for the final longitudinal mediation model

Fixed Effect	Estimate	S.E	df	t	p	Random Effect	Estimate	S.E	Wald Z	p
Level 2 (Between Subject Effects)										
Memory mean	-0.07	0.04	679.81	-1.69	0.092					
Reasoning mean	0.11	0.05	689.07	2.28	0.023					
Speed mean	0.09	0.04	658.81	2.50	0.013					
Everyday cognition mean	-0.23	0.05	708.71	-4.36	0.000					
Intercept	-0.04	0.03	671.89	-1.30	0.194	Between-subject residual	0.33	0.03	12.61	0.00
Level 1 (Within Subject Effects)										
Linear time	-0.15	0.05	1868.39	-3.16	0.002	Linear time	0.03	0.01	3.43	0.00
Quadratic time	0.20	0.05	1753.36	4.01	0.000					
Memory change	-0.01	0.02	344.02	-0.97	0.332	Memory change	0.00	0.01	0.78	0.44
Reasoning change	0.00	0.02	430.69	-0.31	0.756	Reasoning change	0.01	0.01	0.98	0.33
Speed change	0.01	0.01	427.59	0.63	0.527	Speed change	0.00	0.00	0.40	0.69
Everyday cognition change	-0.05	0.02	376.85	-2.97	0.003	Everyday cognition change	0.00	0.01	0.28	0.78
						Within subject residual	0.41	0.02	21.40	0.00

Memory/Reasoning/Speed/Everyday cognition change: centered variables

Table 4-9. Inferential test for the mediation of basic cognitive variance in everyday function by everyday cognition

Fixed Effects			95% Confidence Interval			
	Estimate	*p*	Lower Bound	Upper Bound	Estimate model 5	Estimate model 6
Intercept	-0.034	0.212	-0.088	0.020		
Linear	-0.169	0.001	-0.264	-0.073	-0.170	-0.155
Quadratic	0.222	0.000	0.123	0.321	0.222	0.205
Memory mean	-0.149	0.000	-0.225	-0.074	-0.072	-0.071
Reasoning mean	0.001	0.974	-0.078	0.081	0.105	0.106
Speed mean	0.121	0.001	0.051	0.191	0.091	0.089
Memory change	-0.018	0.256	-0.048	0.013	-0.018	-0.015
Reasoning change	-0.009	0.575	-0.039	0.021	-0.009	-0.005
Speed change	0.012	0.433	-0.017	0.040	0.011	0.009

Memory/Reasoning/Speed/Everyday cognition change: centered variables
Estimate model 5: fixed estimates from model 5, Fixed mean everyday cognition; Estimate model 6: fixed estimates from model 6, Fixed centered everyday cognition

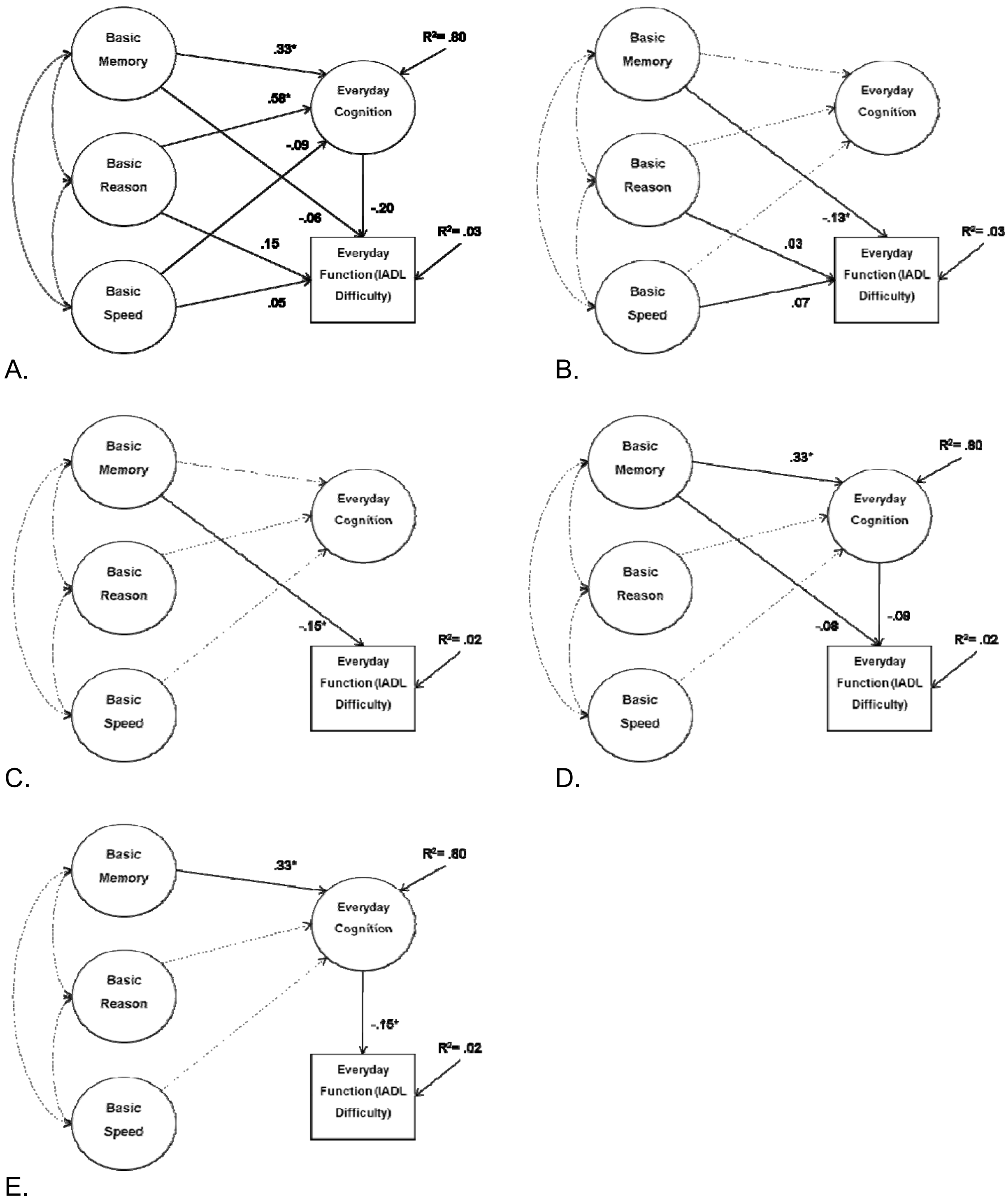

Figure 4-1. Baseline SEM models investigating the mediation of Basic cognition variance in Everyday function by Everyday cognition

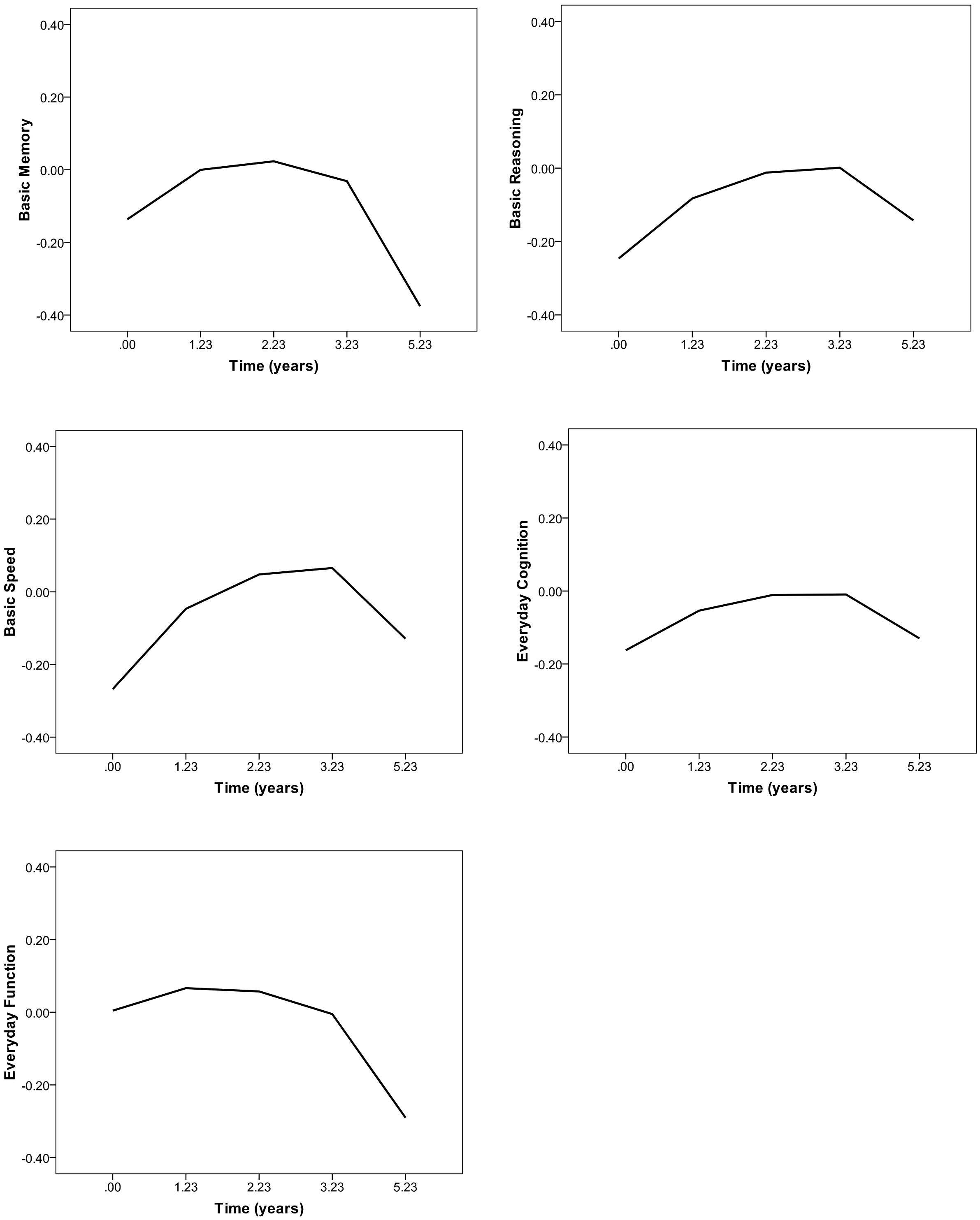

Figure 4-2. Longitudinal trajectories for all study constructs. Note, negative values of basic speed and everyday function were plotted to facilitate visual comparisons.

CHAPTER 5
DISCUSSION

Overview of Findings

The present study investigated the extent to which basic and everyday cognitive abilities uniquely predicted older adults' everyday function (self-reported difficulty carrying out IADL), at a specific point in time (cross-sectionally) and over the course of five years (longitudinally). More specifically, however, the present study assessed to what extent everyday cognition would account for the basic cognitive variance in everyday function, thus allowing for the evaluation of the claim that everyday cognition is a more proximal, ecologically valid and parsimonious measure of everyday function.

Cross-sectional analyses were conducted on data from the baseline occasion of measurement. This provided us with preliminary estimates based on the largest possible sample size, and it replicates the conventional cross-sectional approach used in the extant literature in this domain. With variables assessed at the latent level, the bivariate correlation results from the Measurement model suggested that the relationship between the cognitive factors and everyday function was small (Table 4-2). This was likely due to the fact that at baseline, when the mean age of the sample was around 74 years, few individuals endorsed having many IADL difficulties, which is consistent with findings from previous studies citing 80 years as the modal onset of self-reported functional difficulties (Fillenbaum, 1985). Therefore, the restriction in range of the everyday function variable further restricted its potential covariance with other variables under investigation. Nevertheless, with basic memory, reasoning and speed alone predicting everyday function, basic memory emerged as a significant unique predictor, and as hypothesized, its variance in everyday function was fully mediated by everyday cognition. At baseline, cognitive predictors accounted for only 2% of the variance in everyday function, which alludes to the likely importance of numerous other determinants of self-reported functional difficulty, including health, emotional, and social factors in addition to the restriction of range already mentioned. Overall, these findings replicated those of prior studies, albeit with a much lower predictive effect size (Willis et al., 1995, Allaire & Marsiske, 2002).

The main focus of the present study were the analyses of the covariance of study constructs over time, which if supported, would facilitate more informed conclusions regarding meaningful interrelationships. Over time, across participants all study constructs evidenced significant linear positive trends, indicative of gain. As the plots in Figure 4-2 suggest, this trend was evidenced over the first three-to-four occasions of measurement, and likely represents practice effects in the cognitive measured constructs. The positive linear trend was considerably smaller for everyday cognition, suggesting that these measures were less susceptible to practice effects. In the case of everyday function, the small initial gain observed might have reflected a response bias related to study involvement. For example, since everyday cognitive skills were tested at each occasion, it is possible that having the opportunity to perform these tasks favorably biased responses regarding difficulty of performing them in everyday life. Furthermore, the significant random effects of this linear trend suggested that these effects varied in magnitude between participants. In contrast, the quadratic trend, which was evident beginning around year 3 post baseline and was indicative of decline in study constructs, did not differ in magnitude between individuals. In sum, these findings suggested that practice effects were in evidence as long as 3 to 4 years post study onset, thus decline, if present during this time, might have been overshadowed until participants reached an age where decrement in performance was substantial enough to “outweigh” these practice effects.

With respect to the relationship between study constructs over time, the present analyses assessed the extent to which basic and everyday cognition might account for the linear gain and quadratic decline in everyday function, and conjointly the extent to which everyday cognition might account for the effects of basic abilities on function over time. These analyses, which examined coupled change over five occasions of assessment, were conducted to answer the question: does decline in cognitive abilities relate to (i.e. translate to) loss in function? To date, no study has investigated whether change across cognitive systems was coupled with change in function, a pattern that was thus far implied by cross-sectional findings. Results from these analyses suggest that the linear gain, quadratic decline and individual differences in linear gain in everyday function can only in part be attributed to cognitive factors. Specifically, about 42% of the individual differences in the initial gain can be attributed to cognition.

A number of other interesting findings emerged from these longitudinal analyses. First, basic processing speed emerged as a significant unique predictor of everyday function, in contrast to findings at the cross-sectional level. These results augment the findings from existing longitudinal studies, many of which did not examine speed as a separate predictor of function (e.g. Royall et al., 2004, 2005a, 2005b; Barberger-Gateau et al., 1999; Tomaszewski Farias et al., 2008).

Second, everyday cognition accounted for the effects of basic memory in everyday function, suggesting that memory abilities are utilized in solving everyday problems, such as looking up a phone number or balancing the checkbook (indeed they explained 80% of the variance in everyday cognition at baseline), which in turn affects the way older adults perceive their ability to solve such problems in their everyday life.

Third, basic reasoning showed evidence of a suppressor effect when in a model with everyday cognition, and emerged as a significant negative predictor of function when everyday cognition was included as a predictor in the model. This was in contrast to the bivariate relationship between reasoning and function, which was positive (better reasoning associated with better function). This outcome suggests that everyday cognition was able to isolate and “remove” a specific type of shared variance in reasoning, thus “purifying” a small, residual effect of reasoning that was associated with an increase in functional difficulty. While purely speculative, this residual variance in reasoning, not accounted for by memory, speed, or everyday cognition, might be attributed to the cost-tradeoff of what it takes to be disproportionately “good at” reasoning, such as lack of physical pursuits, which would negatively affect daily functioning. Since reasoning abilities are frequently correlated with levels of education and intellectual pursuits, it might be concluded that individuals who are high on these factors and therefore high on reasoning, might be less likely to engage in physical activity, which would independently predispose them to functional difficulties over time.

Finally, results suggest that everyday cognition independently contributed to the prediction of both individual differences in level as well as change in everyday function, which was not the case for the basic cognitive abilities. These results strongly support the predictive validity of everyday cognition as a predictor of everyday function.

Limitations

The present study has a number of limitations. The sample under investigation was specifically and meticulously selected for participation in a larger longitudinal cognitive intervention study. The exclusion criteria, which are detailed in the methods section, were implemented to ensure participants' capability to comply with training regimens, and as much as possible, retention of participants throughout the course of the study. Therefore, participants in the current study sample were likely to have less health-related, cognitive, and functional problems than older adults in the general population, and very possibly, participants in most other studies. This selection bias was likely the major reason behind the unusually small proportion of variance in everyday function that could be attributed to cognition (basic and everyday) at baseline, which was 2%, relative to the 20% that is typically reported (Royall et al., 2007).

Furthermore, selection biases extend to the effects of attrition. That is, the characterization of attrition effect suggested that attrition was selective, for younger, more educated individuals with higher baseline global cognitive scores (MMSE-based). These biases have not yet been explored in the analyses. Instead, the present analyses treated missing data as though it were missing at random (MAR), however this was not directly investigated. Future research with this sample will explore two alternative strategies: (a) covariate dependent attrition (i.e., are there changes in parameter estimates and standard errors when covariates predictive of attrition are controlled for?) and (b) pattern mixture models (i.e., where separate estimates are derived for groups with different missing data patterns, and then the final estimates are pooled across these missing data subgroups) (Little, 1993; Hedeker & Gibbons, 1997), Due to the magnitude of the data-collection venture (i.e. 2802 participants retested 5 times at different sites), some of the testing occurred in a study-optimzied format (e.g. in groups, written versus verbal responding in memory tests). While this has been the normative approach for testing in this literature, from a neuropsychological perspective it is difficult to speculate on the effects of these testing approaches to the pattern of individual differences observed. If, for example, non-optimal testing introduced “noise” to our ability to reliably capture individual differences in basic skills, this would have attenuated some of the relationships observed.

The psychometrics of the individual estimates revealed that for some of the basic cognition measures (especially memory) reliability tended to be fairly low (as low as 0.60 for some measures). The everyday cognition measures tended to have higher reliabilities (between 0.75 and 0.80). This is relevant to the current findings, because it is not clear that the better predictive performance of everyday cognition with regard to everyday function is not, at least in part, due to the superior reliability of these everyday cognition measures. From a different perspective, the higher reliability of these everyday cognition measures suggests that (a) despite their relative novelty to the field, they provide good measurement of individual differences, and (b) their superior psychometric properties may more strongly argue for their inclusion in clinical assessment batteries.

A large sample size (N=698), as well as the (unprecedented) five occasions of measurement might be regarded as a strength in this study. However, it appears that even with a sample this large the analyses nonetheless lacked the power to detect certain types of individual differences, particularly person-to-person variability in the rate of quadratic decline. Furthermore, it appears that 5 years post baseline in a sample of healthy older adults with a mean age of 74 years may not be sufficient to detect real decline. Therefore, analyses of data collected 10 years after baseline may be more illuminating as to the effects of interest.

Moreover, on theoretical grounds, even with 10 predictors the longitudinal MLM presented in Table 4-7 represents an under-specified model. That is, to adequately explain the variance in everyday function, covariates such as age, health status, sensory functioning, mood, and others should be included to help distill the unique effects of cognition.

Conclusions

The present findings have a number of important implications. First, results from this study highlight the importance of longitudinal assessments with multiple occasions of measurement. As findings from Aim 2.1 illustrate, the first 3 years post initial assessment were characterized by practice effects in the cognitive tasks and response biases in the self-reported measure. Cross-sectional analyses using different cohorts and studies with only fewer occasions of measurement likely fail to capture these effects, which might lead to misinterpretations of the trajectory of age-related cognitive and functional decline.

Second, the present study illustrates the differing effects of when in the lifespan older adults are assessed, which was highlighted by the shift from growth to decline around the 3rd year post baseline. What basic abilities might fail to capture, are the effects of more crystallized aspects of knowledge, such as previous domain-specific experience with everyday tasks. This experience may render everyday abilities less susceptible to decline earlier in the lifespan (i.e. prior to 78-80 years of age in healthy older adults).

Fourth, this study illustrates that everyday cognition contributes something unique to the prediction of everyday function, above and beyond what might be captured by measures of basic abilities, and appears to be a more proximal measure of everyday function thus supporting its predictive validity. This finding suggests that everyday cognitive measures might represent a better, more ecologically valid approach to the clinical assessment of older adults' everyday function than traditional neuropsychological measures. Given the present findings of coupled change over time between everyday cognition and everyday function, everyday cognition may also be a promising locus for intervention efforts aimed at preventing functional decline.

Finally, the present findings of coupled change over time between everyday cognition and everyday function, as well as the significant associations between mean level of everyday cognition and everyday function over time, support the clinical utility of everyday cognitive measures. Specifically, evidence of coupled change over time supports the use of these measures as clinical assessments in which change in performance on these everyday problem solving measures might signal concurrent changes in everyday functioning. Thus, a clinician might administer everyday cognitive measures at each annual appointment as a means of monitoring the older patient for signs that changes in everyday functioning are imminent. Thus, the everyday cognition measures serve as proxies for *in situ* observations of the older adult.

According to the present findings, everyday cognitive measures might be less suitable as proxies of current functioning in cases where little functional impairment exists. Our baseline data found little association between individual differences in everyday cognition and rated functional difficulty. Notably, as the sample aged and individual differences in level of everyday functioning widened, everyday cognitive measures also showed promise as single-occasion clinical assessments of current functioning, as suggested by significant associations between mean levels of everyday cognition and everyday function over time.

Future Directions

Being the first of its kind (i.e., to examine five-year concurrent change in basic and everyday cognition, as well as everyday function), this study serves as a good foundation for future studies aimed at optimizing the assessment of older adults, and creating and delivering interventions to improve older adults' everyday functioning. Future studies would greatly enhance our understanding of the trajectory of cognitive and functional decline, as well as of the relationships between basic and everyday cognitive and functional domains through replication and extension of these findings with longer longitudinal sequences, broader assessments of basic cognition via larger theoretically derived batteries, and measures of function less prone to ceiling effects in samples of healthy older adults.

The five year longitudinal period in this study is useful (in part because it seems to have captured a normative transition from young-old to old-old age, an attendant accelerated decline in cognition during the later period of study. As Schaie's (1994) and others' work has shown, however, the time course for late life cognitive decline is much more protracted, and appears to become manifest in late midlife and then extend for the next three-to-four decades. Thus, introduction of everyday cognition measures into longer-term sequences would provide a fuller picture of whether everyday cognition declines at a slower rate than basic cognition, and whether it serves as a useful sentinel measure for functional decline.

With regard to broader assessments of basic function, the current study was limited to memory, reasoning and speed because these were the clinical endpoints of the ACTIVE intervention. A broader neuropsychological battery aimed at assessing functional changes in cognition would also measure aspects of executive function, subtypes of memory (including verbal and nonverbal, attention, episodic and semantic, working memory versus secondary memory, etc.). In addition, following conventional approaches in cognitive aging research, most of the measures were speeded (confounding ability variance with speed variance). Ideally, tests would be given under power/untimed conditions, to provide purer estimates of individual abilities. So too, following neuropsychological assessment practice, individualized testing in a one-on-one situation may have provided purer estimates of individuals' actual ability, unconfounded by environmental distraction and insufficient monitoring of testing performance.

Lastly, it is vexing that the chief outcome in this study is a self-reported measure of functional limitation, prone to both ceiling effects and self-perception biases. As the main outcome of interest in most gerontological research, a more fully-rounded functional assessment (including multiple measures of self-report with a broader range of outcomes; proxy-assessment where possible, and possibly even behavioral observation) would be ideal. This would yield a functional composite score of maximal reliability and sensitivity to individual differences.

APPENDIX A
EVERYDAY PROBLEMS TEST

EPT 3

Chart: Choosing Furniture Polishing Products

FURNITURE POLISHING PRODUCTS

Product	Application	Results
Liquid polish	Apply with a soft cloth; buff lightly with a clean, soft cloth while wet	High luster; little protection
Paste wax	Apply sparingly with a soft cloth; buff vigorously with a clean, soft cloth when dry	High luster; moderate protection; slight yellowing
Spray wax	Spray on; buff with a clean, soft cloth while wet	Moderate luster; little protection
Dusting spray	Spray on; wipe off with a clean, soft cloth	Prevents dust from scattering; no protection
Scratch-cover liquid polish	Apply with a soft cloth; wipe off with a clean, soft cloth	Conceals blemishes; no protection
Oil finish	Apply with a soft cloth; dry with a clean, soft cloth	High luster; no protection

1. What product should you use to hide imperfections in the finish?

____

____

2. What product should you use if you want the most protection available for your furniture?

____

____

APPENDIX B
OBSERVED TASKS OF DAILY LIVING

Good Health Pharmacy 1200 Main Street, Grand City, USA Phone: (100) 458-8746
Rx: 402200 MFG **Date:** 4/17/97
Bill Reese Take 1 tablet twice a day
Tagamet 400 mg Qty: 60 Refills: 3 Dr.: Henry Jones

This prescription drug label is accompanied by the following auxiliary label which is attached to the medicine bottle:

OBTAIN MEDICAL ADVICE before taking non-prescription drugs as some may effect the action of the medication

Drug #2:

Good Health Pharmacy 1200 Main Street, Grand City, USA Phone: (100) 458-8746
Rx: 280804 JHG **Date:** 4/17/97
Bill Reese Take 1 capsule 3 times a day
Indocin 25 mg Qty: 45 Refills: 2 Dr.: Henry Jones

SECTION B. TAKING MEDICATIONS

TASK 1: PRESENT 2.5" X 2.0" MEDICINE BOTTLES FOR THREE PRESCRIPTIONS WITH PHARMACY LABELS FACING THE SUBJECT AND SAY:

Here are the three medicine bottles for an elderly man. His name is Bill Reese. Please look at the labels on these medicine bottles for a moment and then answer the questions that you see here on this index card.

B1. HOW MANY DAYS WILL A REFILL OF TAGAMET LAST FOR BILL? (Card 1)

SUBJECT BEHAVIOR	CODING
SUBJECT FINDS/POINTS TO/ EXAMINES TAGAMET BOTTLE.	YES…1 NO…2 IF NO, EXPLAIN BELOW (E.G., POINTED TO ANOTHER BOTTLE.):

IF SUBJECT DOES NOT GIVE ANY RESPONSE FOR AT LEAST 15 SECONDS, OR SUBJECT SAYS "I DON'T KNOW", YOU MAY GIVE THE FOLLOWING PROMPT: **Please look at the medicine bottles. Which of the medicines is Tagamet?**
B1a. PROMPT GIVEN? YES……….1 NO……….2

APPENDIX C
TIMED INSTRUMENTAL ACTIVITES OF DAILY LIVING

TASK A	**FINDING A TELEPHONE NUMBER**

For the first task, I will give you the name of a person I want you to look up in the phone book. When you find the number I want you to say it out loud so I can hear you. The name of the person I want you to look up is **Steven N. Nelson. That's, s-t-e-v-e-n n. n-e-l-s-o-n.** Will you repeat that name back to me?

IF CORRECT, PROCEED.

IF INCORRECT, REPEAT THE NAME TO THE SUBJECT.

MAKE SURE YOUR STOPWATCH IS READY.

Here is the phone book. Go ahead and look up the number for Steven N. Nelson for me. Remember, when you find the number, call it out loud so I can hear you.

START THE TIMER WHEN THE PERSON OPENS THE PHONE BOOK.

ALLOWABLE PROMPTS: TARGET NAME ONLY, SPELLED OUT AGAIN IF NECESSARY.

STOP THE TIMER WHEN THE SUBJECT IS FINISHED CALLING OUT THE NUMBER.

RECORD THE TIME, AND CHECK THE APPROPRIATE ACCURACY CATEGORY.

TASK A: FINDING A TELEPHONE NUMBER

CORRECT NUMBER = 408-9888

C1. TIME |__| : |__|__| : |__|__| TIME LIMIT IS 3 MINUTES

C2. ACCURACY CATEGORY:

COMPLETED CORRECTLY 1

COMPLETED INCORRECTLY 2

NOT COMPLETED WITHIN THE TIME LIMIT (3 MINUTES) 3

APPENDIX D
MINIMUM DATA SET

(1) In the last 7 days, how much of the activity did you do on your own? *(CIRCLE ONE)*

(2) How difficult was it (or would it have been) to do on your own? *(CIRCLE ONE)*

1. SELF PERFORMANCE OF IADLs

	Did all on own	**Some help some of time**	**Help all of time**	**Fully performed by others**	**Activity not performed by you or others**	**Not difficult**	**Some help needed or I am slow, or I became tired**	**Great difficulty**
Preparing Meals								
a. Planning meals, reading recipes, assembling ingredients	1	2	3	4	5	1	2	3
b. Setting out food and utensils	1	2	3	4	5	1	2	3
c. Cooking	1	2	3	4	5	1	2	3
Housework								
d. Doing dishes, dusting, making beds, tidying up	1	2	3	4	5	1	2	3
e. Laundry	1	2	3	4	5	1	2	3
Managing Finances								
f. Handling money, writing checks	1	2	3	4	5	1	2	3
g. Ensuring that all bills are paid on time	1	2	3	4	5	1	2	3
h. Balancing checkbooks	1	2	3	4	5	1	2	3
i. Keeping household expenses balanced	1	2	3	4	5	1	2	3
Managing Health Care								
j. Keeping track of doctor appointments	1	2	3	4	5	1	2	3

(1) **In the last 7 days, how much of the activity did you do on your own?**

(2) **How difficult was it (or would it have been) to do on your own?**

(CIRCLE ONE) *(CIRCLE ONE)*

	Did all On own	**Some help some of time**	**Help all of time**	**Fully performed by others**	**Activity not performed by you or others**	**Not difficult**	**Some help needed or I am slow, or I became tired**	**Great difficulty**
k. Remembering to take medications on time and as prescribed by doctor	1	2	3	4	5	1	2	3
l. Opening medicine bottles, taking own medications	1	2	3	4	5	1	2	3
m. Giving self injections, applying ointments, changing bandages	1	2	3	4	5	1	2	3
Phone Use								
n. Looking up phone numbers - either in phone books or by calling "information"	1	2	3	4	5	1	2	3
o. Remembering often called numbers without having to look them up	1	2	3	4	5	1	2	3
p. Answering phone when someone calls	1	2	3	4	5	1	2	3
q. Hanging up at end of call	1	2	3	4	5	1	2	3
Shopping								
r. Shopping for food and household items	1	2	3	4	5	1	2	3
Travel								
s. Travel by vehicle to go to places beyond walking distances	1	2	3	4	5	1	2	3

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BIOGRAPHICAL SKETCH

Anna Yam graduated Cum Laude from the University of California, San Diego (UCSD) with bachelor's degrees in Human Development and Linguistics. After graduating from UCSD and until her acceptance into the doctoral program in Clinical and Health Psychology at the University of Florida in 2008, Ms. Yam has worked as a Research Assistant at the Laboratory for Cognitive Neuroscience, at the Salk Institute for Biological Studies, studying the genetic underpinnings, brain structure and function, cognition, and behavior of individuals with Williams syndrome. At the University of Florida, Ms. Yam is currently pursuing her doctorate in clinical psychology, with a specialization in neuropsychology. Her research interests and focus is in cognitive aging and interventions to improve the everyday lives of older adults.