

# EXECUTIVE FUNCTIONING AND DAILY FUNCTIONING IN OLDER ADULTS

by

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(Under the Direction of L. Stephen Miller)

## ABSTRACT

The purpose of this study was to investigate the predictive abilities of measures of executive functioning on observed and self-reported daily functioning in older adults. It was hypothesized that: 1) executive measures would be more strongly related to observed daily functioning than self-reported daily functioning, 2) executive measures would be significantly related to observed daily functioning, and 3) executive measures of planning and sequencing would be more predictive of observed daily functioning than executive measures of cognitive fluency. Findings revealed a stronger relationship between executive functioning and observed daily functioning than the relationship between executive functioning and self-reported daily functioning. Overall executive functioning and observed daily functioning were significantly related to one another. A single executive measure of planning and sequencing was the most predictive of observed daily functioning. These results provide support for the ecological validity of some measures of executive functioning.

**INDEX WORDS:** Executive functioning, older adults, ecological validity, Delis-Kaplan Executive Function System, D-KEFS

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## CHAPTER 1

### INTRODUCTION

#### Overview and Aims of Project

This study characterized executive functioning in older adults and determined how well executive functioning predicted functional ability. This was done by examining the predictive abilities of the executive functioning domains of planning and cognitive fluency on measures of both observed and self-reported functional ability. There were three specific aims: 1) to compare a direct assessment measure of functional ability to a self-report measure to determine which measure was more strongly associated with performance on measures of executive functioning, 2) to examine the relationship between executive functioning and observed functional ability in a community-based sample of older adults, and 3) to determine which components of executive functioning were most predictive of observed functional ability.

From these three aims, there were three hypotheses. First, it was hypothesized that, consistent with earlier work from our laboratory, direct observation of functional abilities would be more strongly correlated with performance on measures of executive functioning than a self-report measure of functional ability (Lewis, 2001). Second, it was hypothesized that there would be a positive correlation between scores on measures of executive functioning and an observed measure of functional ability, with greater impairment on executive measures predicting greater impairment on the functional measure. Third, it was hypothesized that the component of

executive functioning that would be most predictive of functional ability would be planning and sequencing ability.

### Background and Relevance

The population in America across age groups is currently undergoing a shift with an increasingly large portion of older adults. As medical technologies increase the average human lifespan, the elderly population (aged 65 and over) similarly increases at an unprecedented rate. For example, the national population of older adults increased by 3.6 million people from 1990 to 2000. It is projected that by the year 2050, the number of older adults in America will be 78.9 million people (United States Census Bureau, 2005). As the aging population and life expectancy increase, so does the population of older adults who experience difficulties in their functional ability (Inzarti & Basile, 2003).

Functional ability is a term used in gerontology literature to describe one's ability to carry out activities of daily living (ADLS; e.g. bathing, dressing, eating) and instrumental activities of daily living (IADLS; e.g. managing finances, preparing meals, grocery shopping). Impairment in ADLs and IADLs is one of a constellation of symptoms that are present in older adults who experience dementia (Diagnostic and Statistical Manual, 4<sup>th</sup> edition, American Psychiatric Association, 1994). In addition to these more impaired populations, many older adults with unimpaired or mildly impaired cognitive functioning also experience difficulties in their daily functioning (Tabert et al., 2002).

Detecting impairment in daily functioning is an area of research that is of great importance for the safety and welfare of older adults. With the loss of functional abilities, older adults are at an increased risk of experiencing detrimental outcomes such as malnutrition, falls, car accidents, and prescription medication noncompliance (Hall, 1997). For example, Edelberg,

Shallenberger, and Wei (1999) found a positive correlation between functional independence and medication compliance. Thus, older adults who experience functional impairment run the risk of not properly adhering to their regimen of medication which can lead to worsening of medical conditions or potential drug overdose.

In addition to the importance of ensuring older adults' safety when functional impairment becomes an issue, emotional well-being is also relevant. In a study of common perceptions regarding loss of independence among older adults, Salmoni, Viverais-Dressler, Porter, & Garg (1997) found that older adults commonly view a loss of independence as strongly linked to a loss of personal well-being. Similarly, a study of 2,523 older adults in the Netherlands found that older adults who live in assisted living facilities have smaller social networks and spend more time indoors when compared to independently living older adults (Broese van Groenou & Thomese, 1996). Thus, early detection of functional impairment is important to provide older adults with services necessary with the aim of maintaining their independence in the community.

#### Methods of Measuring Functional Abilities

In research and clinical settings, neuropsychologists typically assess functional abilities by directly asking patients or their family members how well the patient is able to carry out ADLs and IADLs. Typically, this is done by having the patient or the caregiver fill out a questionnaire that asks the person to rate the patient on a scale from most to least functionally independent. Self-report measures of functional ability have historically been used because they enable clinicians to easily obtain large amounts of information in a short amount of time. Although research has found significant relationships between self-report measures of functional ability and a variety of social, emotional, and cognitive variables, typically these relationships are only moderate (Loewenstein et al., 2001; Zanetti, Frisoni, Rozzini, Bianchetti, & Trabucchi,

1998). One proposed explanation for the discrepancy between self-reported measures of functional ability and various other variables is that individuals have the tendency to overestimate their level of competence on self-report measures (Kempen, Steverink, Ormel & Deeg, 1996). In addition, self-report measures are limited in their ability to indicate causes of functional deficits. For example, if an individual is unable to perform a task, their limitations could be due to any number of problems, such as sensory difficulties, memory problems, or inexperience with the task.

An alternative to self-report measures is the use of a collateral-report measure to supplement or replace the self-report measure. Collateral reports are often viewed as superior to self-report measures because self-reports are often inaccurate due to cognitive impairment of the individual being assessed (Magaziner, Zimmerman, GruberBaldini, Hebel, & Fox, 1997). In general, collateral reports have been found to report more impairment than self-report measures (Zanetti et al., 1998). This increased report of impairment has been speculated to be due to increased accuracy of the caregiver but may also be due to personal characteristics of the caregiver. For example, Zanetti et al. (1998) found that the perceived level of burden that the caregiver experienced was positively correlated with the level of functional impairment that they reported their family member experienced. Thus, collateral reports may also be influenced by factors (e.g., depression, stress) that decrease the objectivity of the assessment of the older adult's functional abilities.

A more objective way in which to assess functional ability is to use performance-based measures. Performance-based measures typically focus on complex functions associated with instrumental activities of daily living (IADLs). Functional abilities are typically divided into domains, which are assessed using several items, allowing for increased accuracy and reliability

within the observational methods (Sherman & Reuben, 1998). Performance-based measures have been found to possess high levels of face validity when used in older adult populations because they directly assess tasks that older adults typically perform on a daily basis (Myers, Holliday, Harvey, & Hutchinson, 1993). Previous work in our laboratory found an observational measure of functional ability to be strongly correlated with cognitive functioning, whereas the relationship between cognitive variables and a self-report measure of functional ability was nonsignificant (Lewis, 2001).

However, there are potential weaknesses of direct measures of functional ability. For example, the daily activities assessed by the test may not be representative of the most essential or critical tasks required for independent living. Additionally, proponents of self-report measures argue that tests of functional ability are impractical clinical tools, as they are lengthier than self-report measures to administer, and they require training of assessors (Kempen et al., 1996; Myers et al., 1993).

Self-report and observed functional measures are found in the literature to only moderately correlate with one another (Kempen et al., 1996; Loewenstein et al., 2001; Sager et al., 1992). The discrepancy that is generally found between the two types of measures is a higher level of self-reported functional ability than observed functional ability (Kempen et al., 1996). There are many possibilities for why self-report and observed functional measures show this discrepancy. A frequently argued reason in the literature is that performance-based measures are more accurate due to their objectivity (Zanetti, Geroldi, Frisoni, Bianchetti & Trabucchi, 1999). In contrast, on self-report measures, it is possible that older adults underreport their difficulties with ADLs and IADLs because of their desire to remain independent (i.e., to avoid nursing home placement), to appear competent to the examiner, or due to lack of insight (Zanetti et al., 1999).

Observational measures assess basic and specific functional limitations, as opposed to the broader range of ADLs and IADLs assessed by self-report measures. While there is no general consensus among neuropsychologists, it is possible that neither the performance-based nor self-report measures of functional ability should be viewed as more accurate in research with older adult participants, given the strengths and weaknesses of each type of measure (Zanetti et al., 1999). Instead, when possible, both assessment tools used in conjunction obtain the most accurate picture of older adults' functional abilities and functional impairments (Myers et al., 1993).

### The Relationship Between Cognition and Functional Ability

Empirical investigation of relationships between various cognitive variables and functional abilities in elderly populations suggest that there are many cognitive factors that contribute to functional decline (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002). Cognitive variables that have been found to be linked to functional status include global cognitive functioning (Farias, Harrell, Neumann & Houtz, 2003; Inzarti & Basile, 2003), memory (McCue, Rogers, & Goldstein, 1990) visuospatial abilities (Glosser et al., 2002), and executive functioning (Bell-McGinty, et al., 2002).

Glosser et al. (2002) found that a visuospatial task involving object form discrimination was correlated with performance on IADLs involving visuospatial skills, such as driving and recognizing familiar faces in patients with dementia. However, the authors note that other IADLs that do not involve visuospatial skills, such as making phone calls or managing finances, were not correlated with patients' performance on measures of visuospatial abilities. Such studies indicate that on some ADLs and IADLS, there are very specific sensory perceptual systems that must be intact for one to perform the activity.

Several studies have examined the predictive ability of a mixed battery of neuropsychological tests with the aim of determining which components of cognition are the most predictive of functional abilities. Loewenstein et al. (1992) found that in a sample of patients diagnosed with possible or probable Alzheimer's disease, the total amount of variance accounted for by the overall performance on a neuropsychological battery ranged from 21 to 46 percent across the seven functional domains assessed via a performance-based measure of daily functioning. While Loewenstein and colleagues note that functional domains were best predicted by multiple neuropsychological variables, the most predictive individual components of neuropsychological functioning included in the battery were a brief screen of cognitive status, a measure of verbal fluency, a measure of object memory, and a measure of visuospatial ability.

Loewenstein, Rubert, Arguelles, and Duara (1995) found that the total variance accounted for by a mixed neuropsychological battery across seven domains of daily functioning as assessed by a performance-based measure ranged from 9 to 35% in a sample of Spanish and English-speaking patients with Alzheimer's disease. This study found that the neuropsychological variables that were most predictive of functional status were a measure of visuospatial ability, a measure of verbal working memory, a brief screen of cognitive status, and a measure of verbal fluency.

Richardson, Nadler, and Malloy (1995) also took the approach of using a mixed battery of tests to determine the most predictive measures of functional ability among 108 older adults in an inpatient psychiatric unit and found that a measure of visuospatial ability was the most predictive neuropsychological variable of performance-based daily functioning, followed by measures of memory.

Farias, Harrell, Neumann, and Houtz (2003) examined the predictive ability of a mixed battery of neuropsychological functioning on a collateral-report measure of functional ability and a performance-based measure of functional ability and found that all combined neuropsychological variables accounted for 25% of the variance in the collateral-report measure of functional ability and 50% of the variance in the performance-based measure of functional ability. The individual neuropsychological variables that were found to be the most predictive of collateral-reported functional ability were measures of immediate memory, executive functioning, confrontation naming, and apraxia. The neuropsychological variables that were most predictive of performance-based functional ability were measures of apraxia, visuospatial ability, immediate memory, and executive functioning.

Farias et al. (2003) note that in some cases it is simple to see the relationship between a neuropsychological variable and an aspect of daily functioning. For example, they note that the ability to write a check and address an envelope was significantly associated with a neuropsychological task of copying a figure, as well as measures of executive functioning. The authors point to this relationship as evidence that the IADL of managing finances involves visuospatial and executive abilities, a relationship that makes intuitive sense. However, the logical connection between other neuropsychological variables and their functional correlates is less clear. For example, the ability to read time on a clock was significantly correlated with a neuropsychological measure of motoric functioning. Thus, it appears that while some neuropsychological tasks lend themselves well to directly mapping on to functional abilities, the relationship between neuropsychological measures and functional ability is not always intuitive.

Bell-McGinty, Podell, Franzen, Baird, & Williams (2002) found that a brief neuropsychological battery of executive functioning accounted for 54% of the variance in daily

living skills in a sample of community-dwelling and assisted-living older adults. More specifically, Bell-McGinty et al. (2002) found that the Trails B test, a test that requires the examinee to alternate between sequential numbers and letters with a pencil, was the single most predictive measure of both observed and self-reported functional impairment in their brief executive battery. The only other individual measure of executive functioning that was found to be a significant predictor of functional impairment was the Wisconsin Card Sorting Test, a measure that requires problem solving and shifting of cognitive set.

Cahn-Weiner, Malloy, Boyle, Marran, and Salloway, (2000) examined the predictive abilities neuropsychological variables derived from a comprehensive battery of neuropsychological tests on a performance-based measure of IADLs in a sample of 27 older adults. Findings revealed that a composite score of four measures of executive functioning was the only significant predictor of a measure of observed functional ability when entered into a stepwise multiple regression analysis with composite scores from all other domains of cognitive functioning assessed.

In a later investigation by the same research group, neuropsychological variables from three neuropsychological measures of executive functioning were used to predict collateral-report and performance-based measures of functional ability in 30 community-dwelling older adults (Cahn-Weiner, Boyle, & Malloy, 2002). The three measures of executive functioning used in this study were the Trails B test, the Wisconsin Card Sorting Test, and the Controlled Oral Word Association Test. As described previously, the Trails B test is a measure of sequencing and set shifting, and the Wisconsin Card Sorting Test is a measure of problem solving and maintaining cognitive set. The Controlled Oral Word Association Test is a measure

of verbal fluency. Findings were that the Trails B test was the only significant predictor of observed functional ability.

### Executive Functioning and Functional Ability

From the above review of the literature, it appears that there are many aspects of cognition that influence functioning in daily life. A weakness of the aforementioned literature on the ecological validity of neuropsychological measures is that the research findings were typically arrived at via an exploratory research design, meaning that a priori hypotheses based on a theory of cognition are rarely mentioned. Instead of collecting data on multiple domains of cognition, the present study was designed based on the hypothesis that executive functioning is the domain of cognition that best explains how people function in daily life. This hypothesis is based on the theory that executive functioning is the area of cognition that controls and regulates all other aspects of cognition and thus should be the best cognitive predictor of how people behave in their day-to-day lives.

Executive functioning is a theoretical construct that encompasses many different cognitive abilities that are all considered higher-order cognitive processes, such as the ability to initiate, monitor, and perform behavior (Lezak, Howieson, & Loring, 2004). Inherent in the concept of executive function is a complexity that lends itself to many different views on its definition and its characteristics.

One way to conceptualize the complexity of executive functioning is to examine the neuroanatomical regions of the brain associated with executive functioning. Neuroanatomically, executive functioning is a cognitive process that has been shown to occur in the frontal lobes of the brain (Luria, 1966). First observed in the patient Phineas Gage, individuals with frontal lobe lesions exhibit difficulties with inhibition, goal-directed behavior, and attention (Harlow, 1868).

In the last decade, neuroimaging studies have corroborated these observations, as performance on tasks of executive functioning has been shown to be associated with increased cortical activity in the frontal cortex (Bench et al., 1993; Royall et al., 2002). However, as executive functioning involves the integration of many aspects of brain function which are then translated into goal-directed thought and behavior, many subcortical neural circuits synapse in the frontal cortex and are differentially activated in various executive tasks (Royall et al., 2002).

While different areas of the frontal cortex have been associated with different aspects of executive functioning, there still remains a debate among scientists as to whether executive functioning is centralized (i.e., the “central executive” as proposed by Baddeley and Hitch, 1974) or fractionated into distinct neural circuits (Shallice, 2002). While this debate of localization versus unification of function is certainly not resolved, there is mounting evidence to suggest that there are at least two distinct neuroanatomical pathways that involve different areas of the frontal cortex that are associated with distinct aspects of executive function.

The first pathway includes the dorsolateral prefrontal cortex (DLPFC), which has been shown to be crucial for working memory, planning, and sequencing abilities (Mesulam, 2002). In non-human primates with lesions of the DLPFC, performance on tasks of working memory is severely impaired (Jacobsen, 1936; Goldman & Rosvold, 1970). Similarly, the DLPFC has been shown to be activated in numerous fMRI studies in humans when participants are engaged in tasks of working memory, planning, and sequencing (Frith, & Dolan, 1996; MacDonald, Cohen, Stenger, & Carter, 2000). The DLPFC has connecting neural pathways to other brain areas including the posterior parietal cortex, the head of the caudate nucleus, and the dorsomedial thalamic nucleus. This circuit has been proposed to be necessary for the executive functions of working memory, planning, and sequencing ability (Mesulam, 2002). Nonetheless, it is

recognized even by proponents of the fractionation of executive function that the brain is dynamic and that there is continual interaction between so-called “distinct” circuits within the frontal cortex (Stuss, 2002).

The second pathway includes the orbitofrontal cortex (OFC), which has been shown to be associated with the distinct executive functions of emotion regulation, motivation, and decision making (Mesulam, 2002). Thus, individuals with lesions of the OFC often demonstrate “avolition,” or an inability to initiate behaviors due to an absence of motivation. Individuals with OFC lesions also commonly have difficulties regulating their emotions and may display poor decision-making capabilities, as was the case with Phineas Gage. The OFC has connecting neural pathways to other areas in the paralimbic cortex including the temporal pole, insula, parahippocampal gyrus, and cingulate gyrus, as well as subcortical areas of the hypothalamus, amygdala, and hippocampus (Mesulam, 2002).

Other areas of the frontal cortex that have been associated with distinct executive functions include the medial prefrontal cortex, which has been shown to be active during inhibition tasks (Mesulam, 2002). The ventromedial prefrontal cortex has been shown to be involved in risky decision-making. Specifically, people with lesions to the ventromedial prefrontal cortex have been shown to have a lack of the visceral response that typically occurs in humans prior to making risky decisions (Mesulam, 2002).

Neuropsychologists typically conceptualize executive functions as divided into the non-emotional components of planning, sequencing, and working memory (i.e., the DLPFC network) and the emotional components of self-regulation, decision making, and motivation (i.e., the OFC network). In neuropsychological assessment, the non-emotional components of executive functioning are typically assessed with psychometric measures, and the emotional components

are assessed via behavioral observations and historical information obtained from the patient and family members. The focus of this thesis is on the non-emotional aspects of executive functioning, and the following review of neuropsychological conceptualizations of executive functioning is primarily centered on these aspects of executive functioning.

There are many different neuropsychological views of executive functioning. One of the predominant models describes executive functioning as being divided into four domains (Lezak, et al., 2004): volition, planning, purposive action, and effective performance. In this conceptualization, volition is defined as “the capacity for intentional behavior” (Lezak, Howieson, & Loring, 2004, p. 612). Planning is conceptualized as the ability to identify and organize the steps necessary to complete a task. Purposive action is conceptualized as the ability to initiate and adjust behavior when necessary and includes the ability to maintain a cognitive set and to shift cognitive set when necessary. In addition to maintaining and shifting cognitive set, purposive action is conceptualized by Lezak and colleagues as including self-regulation. Finally, effective performance is defined as the ability to monitor one’s performance and to self-correct and adjust to changes in cognitive tasks. Overall, Lezak and colleague’s (2004) four domains of executive functioning involve the filtering of sensory information into meaningful thoughts and subsequent meaningful behaviors.

Sbordone (2000) uses Lezak’s conceptual framework in his discussion of executive functioning to create a sequential model for how the brain processes information from start to finish. He theorizes that initially, the volitional component of executive functioning is elicited to initiate awareness of needs and determination of a desired goal. Next, Sbordone proposes that planning is elicited to identify the steps necessary to achieve a desired goal. The formulation of a goal involves evaluating many different plans and choosing a plan that is deemed effective.

Next, Sbordone proposes that Lezak's third domain of executive function, purposive action, is elicited. Purposive action is the component of executive function that allows for the initiation of the chosen plan. While the chosen plan is being enacted, purposive action also involves the ability to ignore interfering stimuli that could limit the successful completion of the plan. Within this framework, purposive action encompasses cognitive fluency, or the ability to generate response sets based on a cognitive set. Finally, effective performance is the domain of executive functioning that is elicited to provide monitoring of plans being carried out and the success or failure of the plan.

A large review paper by Royall et al. (2002) examined the literature on executive functioning since the introduction of the concept in 1966 by A.R. Luria. Royall et al. acknowledge that there is ambiguity inherent in the concept of executive functioning at the outset of their paper, as it is a concept that encompasses the integration of all lower-order cognitive processes. In their review, Royall et al. examine forty-six factor analytic studies to observe patterns across multiple studies depicting which neuropsychological tasks load on the same factors within executive functioning. Factor analytic studies ranged from studies in which all neuropsychological tasks were found to load on a single factor to studies in which each neuropsychological test was found to load on a separate factor. The overall methodological concept that these factor analytic studies share is that they examine shared variance of different neuropsychological tests, and infer that if this shared variance is significant in amount, it implies that the measures that share that variance are measuring the same underlying construct. The next logical step that most researchers make in these factor analytic studies of executive function is to conclude that the underlying construct is a domain of executive function.

In their discussion of the large amount of variability in the factor analyses of executive measures, Royall et al. (2002) do not propose their own model of various components of executive function. Rather, they point to the huge discrepancies among studies and the range in the number of factors on which executive measures load. Royall et al. conclude that more research is necessary in order to further delineate components of executive functioning.

Delis, Kaplan, and Kramer are leaders of a third group of researchers who have done extensive work in the area of executive function assessment. In the development of their nine-test neuropsychological assessment system of executive functioning, Delis et al. emphasize the importance of using a “process-oriented” approach to evaluating executive functioning (Delis et al., 2001). By this, they mean that instead of administering a large battery of executive functioning tasks and determining which tests load on the same factors as inferred from shared variance in factor analysis, they argue for a more cognitive-experimental approach of looking at one task and the component processes that are involved in performance on the task. The logic behind this approach is that executive function theory remains in its infancy, and to divide executive function into separate domains that are mutually exclusive and exhaustive of all of the aspects of executive functioning would be jumping ahead of theory-based research (Delis et al., 2001).

In one of the research group’s papers, Delis, Jacobson, Bondi, Hamilton, and Salmon, (2003) provide evidence for the view that the factor analytic approach to research on the assessment of vastly complex cognitive concepts, such as executive functioning and memory, is a flawed approach. They exemplify this by showing that in a sample of older adults with normal cognitive functioning and a sample of adults with Huntington’s Disease, the variables of total immediate recall and long delay free recall on the California Verbal Learning Test (CVLT;

Delis, Kramer, Kaplan, & Ober, 2000), were found to all load on a single factor. However, in a sample of Alzheimer's disease adults, these two measures did not share a significant amount of variance (Delis et al., 2003). Thus, the argument is made that in heterogeneous samples, factor analytic techniques to derive underlying constructs from two or more variables that share a significant amount of variance is a flawed approach, as these variables do not consistently share variance in the same characteristic way across different clinical groups (Delis et al., 2003).

The question is raised, then, as to what to do in neuropsychological assessment of the complex areas of cognition such as executive function. If we are not yet at a theoretical point at which we can say with confidence that there are specific and separate domains of executive functioning of which there are specific neuropsychological tests that assess those specific domains, then how do we talk about executive functioning? Delis, Kramer, Kaplan, & Holdnack (2004) suggest that we use measures that assess very specific aspects of cognition, in the tradition of cognitive experimental neuroscience. As such, the nine tests that make up the Delis-Kaplan Executive Function System (D-KEFS; Delis et al., 2001) are not presented as representative of domains of functioning. Rather, the nine tests are presented as cognitive tasks that are shown in experimental studies and clinical practice to be sensitive to impaired frontal lobe function. Thus, Delis et al. recognize the limitations in our current understanding of executive function, and the aim of the D-KEFS is not to summarize this complex area of cognition with factor-derived summary scores, but to characterize and deconstruct various executive processes into their component parts.

While Delis and colleagues' are accurate in their view that our current understanding of executive functioning is incomplete, current measures of executive functioning do provide important information about individuals' ability to carry out their daily tasks. Performance on

traditional neuropsychological measures of executive functioning has been found to be a good predictor of functional ability in older adults. Neuroanatomically, this can be explained by the loss of frontal lobe brain tissue that is associated with aging (Stuss & Knight, 2002). With the loss of frontal lobe functioning, tasks that require executive function thus become impaired.

Grigsby et al. (1998) explored the possibility that executive functioning measures predict older adults' everyday abilities in a community-based sample of 1,158 older adults. Their study compared the predictive ability of a general cognitive screen to a measure of executive functioning to determine which measure was more predictive of functional ability. Findings were that a neuropsychological measure of executive functioning, the Behavioral Dyscontrol Scale (Luria, 1980), a brief assessment involving inhibition and rule switching, was more predictive of level of impairment on a self-reported and observed measure of functional abilities. Thus, the authors conclude that while there is a positive correlation between level of general cognitive impairment and level of functional impairment, executive functioning measures are stronger predictors of daily functioning and are therefore important clinical tools in geriatric assessment.

Royall, Palmer, Chiodo, & Polk (2004) similarly found that in a sample of 547 non-institutionalized older adults, a brief screen of executive functioning was more predictive than a brief screen of general cognitive functioning at predicting self-reported IADLs. A strength of this study's findings was that participants were followed over the course of 3 years with yearly assessments, and the association between executive impairment and functional impairment was correlated cross-sectionally and longitudinally. A weakness of the study was that only a self-report measure of functional ability was used.

While the aforementioned studies have examined relationships between measures of executive functioning and functional ability, little work has been done to establish a concrete link between the theoretical concept of executive functioning and the more practical concept of how cognition guides people through their day-to-day lives. As people age, whether they are experiencing normal aging or a neurodegenerative disease such as Alzheimer's disease, there is a decline in overall cognitive abilities, as well as a more marked decline in executive functioning (Royall et al., 2002). For example, Daigneault, Braun, and Whitaker (1992) found impairment in executive functioning in a group of adults aged 45 to 65 years old when compared to a demographically-matched group of 20 to 35 year-old adults. Given the evidence that many older adults experience a decline in executive functioning, coupled with the relationship between executive functioning and functional ability, measures of executive functioning have the potential to be helpful tools in clinical settings to detect impairment in daily functioning, which is not readily evident in a clinical setting.

Previous work in our neuropsychology laboratory has explored the relationship between neuropsychological measures of executive functioning and measures of self-reported and observed functional ability (Lewis & Miller, in press). This study divided executive functioning into four domains: attention, planning, cognitive fluency, and cognitive flexibility, which were broadly based on the theorized domains of executive functioning proposed by Lezak (2004). Each domain was assessed by creating composite scores from a number of neuropsychological variables. Next, each composite score was entered into a step-wise multiple regression to determine which domain of executive functioning was most predictive of functional ability. Findings were that planning and cognitive fluency were the best predictors of observed functional ability. Interestingly, there was not a significant relationship between executive

functioning and self-reported functional ability. Because this is the only study to examine specific domains of executive functioning and their impact on functional ability, more research is necessary to further understand the component processes involved in the loss of functional ability.

The purpose of the present study was to characterize executive functioning in older adults, and to see how strongly executive functioning predicted functional ability. The model that was used to conceptualize executive functioning is that proposed by Lezak et al. (2004) and elaborated by Sbordone (2000). This model appears to be the only model that comprehensively categorizes neuropsychological tasks according to the underlying constructs that they assess. There appears to be a disconnect in the literature between measures of executive functioning and the underlying construct that is being assessed. Based on the findings in our laboratory that planning and cognitive fluency (a component of what Lezak terms “purposive action”) were the most predictive domains of functional impairment, and also due to limitations in the ability to assess what Lezak conceptualizes as volition and effective performance (Lezak et al., 2004), the domains of executive functioning that were assessed in the current study were planning and cognitive fluency. These two domains were hypothesized to be the most critical in the maintenance of older adult’s functional abilities.

While there is little evidence in the literature outside of our laboratory that demonstrates that any one specific domain of executive functioning is the most essential to the maintenance of functional abilities, the tasks that appear to be the most predictive involve planning and cognitive fluency. For example, as stated previously, the Trails B test, a measure of sequencing that involves planning, has been found in two separate studies to be predictive of functional ability (Cahn-Weiner et al., 2002; Bell-McGinty et al., 2002). Similarly, the Wisconsin Card Sort, a

measure of cognitive fluency and cognitive flexibility that involves problem solving and cognitive set switching, is a task that has been shown to be predictive of functional ability (Bell-McGinty, 2002). Given this evidence, coupled with the results from our laboratory, the domains of planning and cognitive fluency have the most promise as being predictive of functional ability.

There were three specific aims in the present study. The first aim was to compare an observation-based assessment of functional ability with a self-report measure to determine which measure was most strongly correlated with performance on measures of executive functioning. It is important to compare self-report measures to observation-based measures in order to determine whether or not self-report measures are sensitive to early decline in functional ability. The second aim was to examine the relationship between executive functioning and observed functional ability. This relationship is important in order to establish the ecological validity of tests of executive functioning. The third aim was to assess which aspect of executive functioning --planning and sequencing or cognitive fluency-- was most predictive of functional ability. Determining which aspect of executive functioning is most crucial to the maintenance of daily functioning is important in order to identify tests that are useful clinical tools for the detection of early functional decline.

From these aims, there were three hypotheses. First, it was hypothesized that an observed measure of functional ability would be more strongly correlated with performance on measures of executive functioning than a self-report measure of functional ability. Second, it was hypothesized that there would be a positive correlation between scores on measures of executive functioning and scores on an observed measure of functional ability with more impairment on executive measures predicting more impairment on the functional measure.

Third, it was hypothesized that the aspect of executive functioning that would be most predictive of functional ability would be planning and sequencing.

## CHAPTER 2

### METHOD

#### Participants

##### *Recruitment*

Participants were recruited from assisted living homes in Athens, GA by visiting three retirement communities. Fliers were placed under every resident's door, and fliers were also posted and placed in common areas. Enrollment was thus initiated by residents' interest upon receiving information about the study. Potential participants contacted the University of Georgia Neuropsychology and Memory Assessment laboratory via telephone, and a two-hour appointment time was scheduled with each interested participant.

“Older adult” was defined as 65 or older. Given the demographic makeup of older adults in the Athens area, as well as the limited access to populations of lower socioeconomic status (SES) due to a lack of representation of low SES individuals in retirement communities, this sample was admittedly a convenience sample of community-dwelling older adults. Participants were predominantly Caucasian (44 Caucasian, 1 Hispanic), moderate SES (mean monthly income = \$1,748), and the majority were women (80% women).

Participants were interviewed and assessed in one session that took place at the participants' residence. The sessions lasted approximately two hours each, and breaks were offered to participants whenever requested. The sessions involved the following sequence of administration procedures: Participants were told that they were participating in a research study investigating the effects of aging on daily living. Participants were also told that they would

receive \$10 upon completion of their testing session for their participation. Consent was obtained, followed by the completion of a demographic form, a measure of self-reported depression (Center for Epidemiologic Studies Depression Scale; CES-D, Radloff, 1977), a measure of self-reported functional ability (Older American Resources and Services Instrumental Activities of Daily Living and Activities of Daily Living Scale; OARS, Duke University, 1978), four tests from the Delis-Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan, & Kramer, 2001): D-KEFS Trail Making Test, D-KEFS Verbal Fluency Test, D-KEFS Design Fluency Test, and D-KEFS Tower Test, and an observed measure of functional ability (Direct Assessment of Functional Status; DAFS, Loewentstein & Bates, 1989).

#### *Exclusionary Criteria*

The following exclusionary criteria were used in the initial telephone contact: self-reported illiteracy, visual impairment, or motor impairment that was significant enough to preclude the completion of paper and pencil tasks. These exclusionary criteria were chosen to control for two reasons. Illiterate participants were excluded because illiteracy has been shown in neuropsychological literature to attenuate performance on traditional measures of neuropsychological functioning due to the obvious reason that people who are unfamiliar with paper and pencil tests tend to perform worse than their literate counterparts and thus appear more impaired on neuropsychological measures than they are likely to be (Manly et al., 1999). In addition, many of the tasks used in the present study required familiarity with the alphabet and general word knowledge. No participants interested in participating in the study were illiterate, and thus no participants were excluded for this reason.

One set of confounding variables that attenuate performance on neuropsychological measures is visual or motor impairment. If an individual cannot see or use his or her hands to

manipulate test stimuli, these sensorimotor deficits will make his or her test performance appear unduly impaired. In clinical neuropsychology, these impairments are seen as obstacles to the process of determining brain-behavior relationships. For example, if an individual is blind, a clinical neuropsychologist will attempt to assess as many domains of cognitive functioning as possible given this limitation. Thus, the blind patient could be given measures that only require verbal response (e.g., vocabulary, similarities, word list learning and memory, verbal fluency). However, because the present study sought to compare some measures that require only verbal responses to other measures that require only visuomotor responses, participants who were blind or motorically impaired were excluded. There were two participants who were excluded for visual impairment. No participants were excluded for motor impairment.

Another common set of exclusionary criteria employed in aging research is medical diagnoses that impact cognitive functioning (e.g., stroke, heart attack, hypertension, diabetes, Alzheimer's disease, Parkinson's disease). These exclusionary criteria were not used in the present study for two reasons. One, the aim of the present study was to recruit a sample of participants that was as accurate as possible at representing the general population of community-dwelling older adults in the region. Two, the older adults recruited for the present study were living independently and it can thus be inferred from this fact that their medical diagnoses did not impair their daily functioning enough to impact their level of independence.

To ensure that a certain subset of individuals who had cognitive impairments that could be attributable to their medical conditions was not systematically driving the statistical effect of our measured relationships between dependent and independent variables, an analysis of outliers was employed, yielding no outliers. In addition, the demographic form in the study included a list of all medical diagnoses and medications. These diagnoses and medications were used as

continuous variables (i.e., number of medications, number of medical conditions) to determine if number of medications or number of medical conditions accounted for a significant amount of the variance in our dependent measures. Number of medications did not account for a significant amount of the variance in observed or self-reported functional ability, nor did number of medical conditions.

### Power Analyses

Forty-five participants were recruited. The number of participants in this study was arrived at by two separate approaches. First, the effect size found in similar research from our laboratory was used to compute the amount of participants required to find a similar effect size. This power analysis used the overall effect size reported in the study ( $R^2 = .463$ ; Lewis, 2002) to compute the number of participants necessary to find a meaningful effect in the present study. The power analysis used followed the guidelines set forth by Cohen, Cohen, West, and Aiken's (2003) on conducting power analyses for study designs using a multiple regression analysis with seven independent variables (age, education, monthly income, D-KEFS Letter Fluency, Design Fluency, Tower Test, and Trails 4) and one dependent variable (observed functional ability). This analysis yielded an approximate  $n$  of 22 participants. However, this number of participants was arrived at with a caveat. Specifically, the regression analysis used for Lewis's (2002) study was a stepwise regression. This type of regression analysis is somewhat liberal in taking advantage of chance and, thus, the  $R^2$  reported in this study may be viewed as an overestimate of effect size.

Thus, to take a more conservative approach, a second, more generic, power analysis was also conducted. Again using Cohen, Cohen, West, and Aiken's (2003) guidelines, a generic power analysis was conducted to determine the number of participants needed if the effect size

was a large effect size ( $R^2 = .26$ ) with an alpha of .05 and a power of .80 between the seven independent variables and the dependent variable. This analysis yielded an  $n$  of approximately 45 participants. Taking these two power analyses together, the investigator sought to take a conservative approach by recruiting 45 participants. This number of participants was deemed sufficient, given the evidence from Lewis's (2002) study that the anticipated effect size would be large, while still taking into account the possibility that the effect size was unduly influenced by chance.

## Stimuli

### *Independent Measures*

#### *Planning and Sequencing*

As defined by Sbordone (2000), planning involves the ability to generate a set of plans to achieve a goal and to choose the most effective plan after evaluating a number of plans. To assess the executive functioning domain of planning, two neuropsychological measures of planning ability were used, the D-KEFS Trail Making Test and the D-KEFS Tower Test (Delis, Kaplan, & Kramer, 2001).

The D-KEFS Trail Making Test is a test that involves sequencing of responses in five levels of complexity, labeled conditions 1 through 5. For all conditions of the task, the examinee is given a shorter practice version of each task before they are given the test version. Condition 1 is a simple visual scanning task in which the examinee is given a page with numbers and letters on it and is instructed to draw a line through all of the 3s on the page. Condition 2 is a number sequencing task in which the examinee is given a page with numbers and letters on it and is instructed to connect all of the numbers in numerical order. Condition 3 is a letter sequencing

task in which the examinee is given a page with numbers and letters on it and is instructed to connect all of the letters in alphabetical order. Condition 4 is a number-letter sequencing task in which the examinee is given a page with numbers and letters on it and is instructed to alternate between connecting numbers in numerical order and letters in alphabetical order (e.g., 1-A-2-B, and so on). Finally, Condition 5 is a motor speed task in which the examinee is instructed to simply connect circles on a page by following a dotted line.

The main measure of the D-KEFS Trail Making Test is Condition 4, a measure similar to the Trails B Test first developed by Partington (Brown & Partington, 1942; Partington & Leiter, 1949, as cited in Delis, Kaplan & Kramer, 2001). The other four conditions on the D-KEFS Trail Making Test involve component processes of condition 4 with the aim of examining each component process individually. The variable of interest for the current study was the performance on Condition 4, which mimics the planning ability of sequencing of behaviors in a pre-determined manner to attain a desired goal. The other conditions of the Trail Making Test were collected for exploratory purposes that are beyond the scope of this thesis proposal. Test-retest reliability for the D-KEFS Trail Making Test for adults aged 50 to 89 ranges from .37 to .74 (Delis, Kaplan, & Kramer, 2001). Trail making tests have been shown in the literature to load onto the same factor as other measures of planning as well as measures of functional ability (Bell-McGinty et al., 2002). The variable used in all analyses was the D-KEFS Trail Making Test 4 scale score.

The second measure of planning was the D-KEFS Tower Test. This test is similar to the Tower of Hanoi and the Tower of London tests, which have both been shown to be sensitive to age-related decline in planning ability (Owen, Downes, Sahakian, Polkey, & Robbins, 1990; Robbins et al., 1998). The D-KEFS Tower Test is a task in which the examinee is presented

with a wooden fixture with three vertical pegs. The pegs have disks of varying sizes that have holes in their centers which allow them to be placed and removed from each of the pegs. The examinee is presented with an arrangement of the disks on the three wooden pegs, and he or she is instructed to rearrange the pegs to match an arrangement portrayed in a picture. The examinee is instructed to only move one disk at a time from each peg and s/he is informed that s/he is not allowed to place a larger disk on top of a smaller disk. The examinee is also informed to attempt to rearrange the pegs in as few moves as possible. Thus, the D-KEFS Tower Test mimics the ability to formulate a plan and carry out the steps necessary to attain a desired goal.

The variable of interest from the D-KEFS Tower test was the Total Achievement scale score, which is a measure of performance across all test trials. Test-retest reliability among adults ages 50 to 89 for the D-KEFS Tower Test is .38 (Delis, Kaplan, & Kramer, 2001). While this is a low-moderate level of test-retest reliability, the authors attribute this finding to a large practice effect. Across all age groups, average performance was found to improve from first testing to second testing. The D-KEFS Tower Test has been found to have high internal consistency in an older adult sample, with intercorrelations between test trials ranging from .61 to .72 (Delis, Kaplan, & Kramer, 2001).

All of the D-KEFS tests have been normed and validated on a wide range of normal and clinical populations of older adults, including controls (Wecher et al., 2000), patients with frontal-temporal dementia (Hallam et al., in press, as cited in Delis, Kramer, Kaplan, & Hodnack, 2004), and Mild Cognitive Impairment (Grant et al., in press, as cited in Delis et al., 2004).

### *Cognitive Fluency*

Cognitive fluency, or purposive action, as defined by Sbordone (2000) involves the ability to initiate and generate responses according to a predetermined plan and to ignore stimuli that compete with the planned response set. Thus, measures that require the generation of responses according to a predetermined objective are good measures of cognitive fluency (Sbordone, 2000). Two D-KEFS subtests that require the generation of responses according to a predetermined response set are the Verbal Fluency subtest, and the Design Fluency subtest.

The Verbal Fluency Test of the D-KEFS has three conditions. The first condition was used in the current study. In condition 1, the examinee is required to state as many words as he or she can think of that begin with a particular letter in one minute. The examinee is instructed to not repeat the same word with a different ending (e.g., eat and eating), and to not include proper nouns. This procedure is repeated across three different letters (F, A, and S), and a total score is generated from the total number of words generated across three letters after errors have been subtracted. Condition 1 is termed phonemic fluency or letter fluency because it involves the generation of words that begin with a specific letter. Test-retest reliability among adults aged 50 to 89 for condition 1 of the Verbal Fluency Test of the D-KEFS ranges from .82 to .88 (Delis, Kaplan, & Kramer, 2001). The variable of interest from the Verbal Fluency subtest was the scale score derived from the letter fluency condition. The letter fluency condition of the D-KEFS Verbal Fluency test is similar to the Controlled Oral Word Association Test (COWAT; Benton & Hamsher, 1976), which has been shown to be sensitive to age-related decline in prefrontal functioning of the language dominant hemisphere (Demakis & Harrison, 1997).

The second measure of cognitive fluency was the Design Fluency Test of the D-KEFS, which has three conditions of increasing levels of difficulty. In condition 1, the examinee is

presented with a grid of identical arrangements of dots. The examinee is instructed to generate as many unique designs as possible by connecting four or more dots with straight lines in each grid. In condition 2, the examinee is given another page with a grid containing identical arrangements of dots. However, in condition 2, some of the dots are filled, and some of the dots are empty. The examinee is instructed to make as many unique designs as possible by connecting four or more of the empty dots with straight lines. Thus, the examinee must ignore the competing stimuli of the filled dots to maintain cognitive set according to the instructions. Finally, in condition 3 the examinee is presented with a grid containing identical arrangements of empty and filled dots. The examinee is instructed to make as many unique designs as possible by connecting four or more empty and filled dots in an alternating sequence. Thus, condition 3 involves the generation of responses according to a response set.

Overall, the Design Fluency Test of the D-KEFS is a measure of one's ability to generate unique responses within the framework of a set of rules, thus mimicking the cognitive fluency that is required in daily life to generate novel responses while maintaining focus on a desired goal. The D-KEFS Design Fluency Test is similar to the Ruff Figural Fluency Test (RFFT; Ruff, 1998), which has been shown to be sensitive to age-related decline in prefrontal functioning of the non-dominant hemisphere (Ruff, 1988). Test-retest reliability among adults aged 50 to 89 for the Design Fluency Test of the D-KEFS ranges from .43 to .58 (Delis, Kaplan, & Kramer, 2001). The variable of interest from the Design Fluency subtest was the scale score derived from the summation of all unique designs completed across all three conditions.

### *Dependent Measures*

The dependent measures in the present study were two measures that assess functional ability: one direct measure and one self-report measure. To assess patients using a direct measure of functional ability, the Direct Assessment of Functional Status, Revised edition (DAFS-R) was used (Loewenstein & Bates, 1989). The DAFS-R is a clinician-rated scale based on patient's performance on observed functional domains: 1) time orientation, 2) communication, 3) financial skills, 4) grocery shopping, 5) dressing and grooming, 6) eating, 7) driving, 8) meal preparation, 9) providing demographic information, and 10) taking a telephone message. The DAFS takes approximately 30 minutes to administer, and is shown to be a reliable and valid measure of observed functional ability (Loewenstein, et al., 1989). The DAFS-R is made up of ten clinical rating scales, which combine to create a total score across domains of functioning. The DAFS is validated in older adults with memory impairment, as well as older adult controls (Loewenstein et al., 1989). The DAFS Scale has been found to have test-retest reliability of at least 85% agreement on each item of the scale. Test-retest reliability has been found to range from .55 to .91 across subscales (Loewenstein et al., 1989).

Self-report of functional ability was assessed using the Older American Resources and Services Instrumental Activities of Daily Living and Activities of Daily Living Scale (OARS; Duke University, 1978). The OARS consists of 15 items assessing participants' capacity to perform daily activities necessary for personal care and independent living, including managing telephone calls, transportation, grocery shopping, meal preparation, eating, household chores, medications, grooming, walking, and bathing. Each question will be rated by the participant with a score of 2 (without any help), 1 (with some help), or 0 (completely unable to do so alone). The sum of all 15 items generates a composite measure of the participant's self-reported

functional ability. Inter-rater reliability of the OARS scale has been shown to be at .87 ( $p < .001$ ), and test-retest reliability over a time period of three months was found to be .71 ( $p < .001$ ) for the IADL items, and .82 ( $p < .001$ ) for the ADL scale items (Duke University, 1978).

### Data Analysis

The domains of executive functioning, planning and sequencing and cognitive fluency, were measured by using scores derived from the D-KEFS. Each score generated from the D-KEFS measures is on the metric of scale scores, meaning that the mean score for each test is 10 with a standard deviation of 3. These scores are derived from a normative sample in which individuals are compared to the sample of people their age.

To test the first hypothesis that executive measures are more predictive of observed functional ability than self-reported functional ability, the variance accounted for by all executive measures in observed functional ability was compared to the variance accounted for by all executive measures in self-reported functional ability using a t-test for comparing dependent correlations.

To test the second hypothesis that there was a positive relationship between executive functioning and observed functional ability, a composite score of all measures of executive functioning was correlated with the dependent measures of observed functional ability.

To test the third hypothesis that planning and sequencing was the domain of executive functioning that was most predictive of observed functional status, a multiple regression equation was used to determine if measures of planning and sequencing accounted for a significant amount of the variance in functional ability above and beyond the variance accounted for by demographic variables and measures of cognitive fluency. Thus, the first predictors entered into the regression equation were the demographic variables of age, education, and monthly income.

In this first step, the only demographic variable that was found to significantly predict performance on the dependent variable was years of education. The demographic variables of age and monthly income were dropped from the model. In the second step, the D-KEFS scores of verbal fluency and design fluency were entered, and in the third step the scores on the D-KEFS Trail Making Test 4 and Tower Test were entered.

CHAPTER 3  
EXECUTIVE FUNCTIONING AND OBSERVED VERSUS SELF-REPORTED MEASURES  
OF FUNCTIONAL ABILITY<sup>1</sup>

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<sup>1</sup> Mitchell, M.B., & Miller, L.S. To be submitted to The Clinical Neuropsychologist

### Abstract

This study investigated the relationship between measures of executive functioning and both observed and self-reported functional ability. It was hypothesized that performance on a direct assessment of functional ability would have a stronger correlation with performance on measures of executive functioning than a self-report measure of functional ability. Results supported the hypothesis, indicating that self-report measures may not be sensitive to early decline in functional ability. Results also provide evidence to support the use of measures of executive functioning to detect early decline in functional ability that otherwise may not be detected by the typical self-report measures used in clinical settings.

## Introduction

Self-report measures of functional ability are commonly used in the neuropsychological assessment of older adults to assess their ability to carry out activities of daily living (ADLs) and instrumental activities of daily living (IADLs). When available, neuropsychologists also obtain caregiver-report measures of ADLs and IADLs. These measures are used because of their ease of administration; they are self-explanatory questionnaires that can be completed in the waiting room prior to an assessment. However, the relationship between self-report measures of functional ability and a variety of cognitive and functional measures have been inconsistent (Loewenstein et al., 2001; Zanetti, Frisoni, Rozzini, Bianchetti, & Trabucchi, 1998).

A more objective way in which to assess functional ability is to use performance-based measures. Performance-based measures have been found to possess high levels of face validity when used in older adult populations because they directly assess tasks that older adults typically perform on a daily basis (Myers, Holliday, Harvey, & Hutchinson, 1993). However, there are potential weaknesses of direct measures of functional ability. For example, the daily activities assessed by the test may not be representative of the most essential or critical tasks required for independent living. Additionally, proponents of self-report measures argue that tests of functional ability are impractical clinical tools, as they are lengthier than self-report measures in administration, and they require training of assessors (Kempen et al., 1996; Myers et al., 1993).

Self-report and observed functional measures are found in the literature to only moderately correlate with one another (Kempen et al., 1996; Loewenstein et al., 2001; Sager et al., 1992). The discrepancy that is generally found between the two types of measures is a higher level of self-reported functional ability than observed functional ability (Kempen et al., 1996). There are many possibilities for why self-report and observed functional measures show this

discrepancy. A frequently argued reason in the literature is that performance-based measures are more accurate due to their objectivity (Zanetti, Geroldi, Frisoni, Bianchetti & Trabucchi, 1999). In contrast, on self-report measures, it is possible that older adults underreport their difficulties with ADLs and IADLs because of their desire to remain independent (i.e., to avoid nursing home placement), to appear competent to the examiner, or due to lack of insight (Zanetti et al., 1999).

While there is no general consensus among neuropsychologists, it is possible that neither the performance-based nor self-report measures of functional ability should be viewed as more accurate in research with older adult participants, given the strengths and weaknesses of each type of measure (Zanetti et al., 1999). Instead, when possible, both assessment tools used in conjunction obtain the most accurate picture of older adults' functional abilities and functional impairments (Myers et al., 1993).

Nonetheless, observed measures of functional ability are rarely used in clinical practice. Thus, the purpose of this study was to compare a self-report measure of functional ability to an observed measure of functional ability to determine which measure had a stronger relationship with performance on multiple measures of executive functioning. The reason for using measures of executive functioning as a reference for comparison of the two functional measures was that measures of executive functioning have been shown in the literature to correlate highly with performance on observed measures of ADLs and IADLs (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Cahn-Weiner, Boyle, & Malloy, 2002). It was hypothesized that the relationship between performance on an observed measure of daily functioning and executive functioning would be stronger than the relationship between self-reported functional ability and executive functioning.

## Method

Forty-five participants, ranging in age from 65 to 92, were recruited from three Northeast Georgia retirement communities. Enrollment was initiated by residents' interest upon receiving information about the study through the use of fliers. Potential participants contacted the investigator via telephone, and a two-hour appointment time was scheduled with each interested participant. Given the demographic makeup of older adults in Northeast Georgia, as well as the limited access to populations of lower socioeconomic status (SES) due to a lack of representation of low SES individuals in retirement communities, this sample was admittedly a convenience sample of community-dwelling older adults. Participants were predominantly Caucasian (44 Caucasian, 1 Hispanic), moderate SES (mean monthly income = \$1,748), and the majority were women (80% women).

Participants were interviewed and assessed in one two-hour session that took place at the participants' residence. The sessions involved the following sequence of administration procedures: Participants were told that they were participating in a research study investigating the effects of aging on daily living. Participants were also told that they would receive \$10 upon completion of their testing session for their participation. Consent was obtained, followed by the completion of a demographic form, a measure of self-reported depression (Center for Epidemiologic Studies Depression Scale; CES-D, Radloff, 1977), a measure of self-reported functional ability (Older American Resources and Services Instrumental Activities of Daily Living and Activities of Daily Living Scale; OARS, Duke University, 1978), four tests from the Delis-Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan, & Kramer, 2001): D-KEFS Trail Making Test, D-KEFS Verbal Fluency Test, D-KEFS Design Fluency Test, and D-

KEFS Tower Test, and an observed measure of functional ability (Direct Assessment of Functional Status, Revised; DAFS-R, Loewentstein & Bates, 1989).

Self-report of functional ability was assessed using the Older American Resources and Services Instrumental Activities of Daily Living and Activities of Daily Living Scale (OARS; Duke University, 1978). The OARS consists of 15 items assessing participants' capacity to perform daily activities necessary for personal care and independent living, including managing telephone calls, transportation, grocery shopping, meal preparation, eating, household chores, medications, grooming, walking, and bathing. Each question was rated by the participant with a score of 2 (without any help), 1 (with some help), or 0 (completely unable to do so alone). The sum of all 15 items generates a composite measure of the participant's self-reported functional ability. Inter-rater reliability of the OARS scale has been shown to be at .87 ( $p < .001$ ), and test-retest reliability over a time period of three months was found to be .71 ( $p < .001$ ) for the IADL items, and .82 ( $p < .001$ ) for the ADL scale items (Duke University, 1978).

The DAFS-R is a clinician-rated scale based on patient's performance on observed functional domains: 1) time orientation, 2) communication, 3) financial skills, 4) grocery shopping, 5) dressing and grooming, 6) eating, 7) driving, 8) meal preparation, 9) providing demographic information, and 10) taking a telephone message (Table 3.1). The DAFS-R is made up of ten clinical rating scales, which combine to create a total score across domains of functioning. The DAFS-R is validated in older adults with memory impairment, as well as older adult controls (Loewentstein et al., 1989). The DAFS-R has been found to have test-retest reliability of at least 85% agreement on each item of the scale. Test-retest reliability has been found to range from .55 to .91 across subscales (Loewentstein et al., 1989).

To obtain a measure of executive functioning, participants were administered four tests from the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001): D-KEFS Trail Making Test 4, the D-KEFS Tower Test, the D-KEFS Verbal Fluency Test: Letter Fluency, and the D-KEFS Design Fluency Test.

## Results

Demographic information and descriptive statistics for the D-KEFS measures and the DAFS-R are summarized in Table 3.2. The variables from the D-KEFS measures were: D-KEFS Letter Fluency scale score, D-KEFS Design Fluency scale score, D-KEFS Trail Making Test 4 scale score, and D-KEFS Tower Test Total Achievement scale score. To create a composite score of executive function, these four scale scores were averaged. This composite score was found to be internally consistent (Cronbach's  $\alpha = .753$ ). The outcome measures used to measure daily functioning were the total raw scores on the OARS and the DAFS-R. A summary of the distribution of scores on both measures of daily function are summarized in Figure 3.1.

Because the distribution of scores for the OARS was highly positively skewed, Spearman's rank-order correlations were used. To test the hypothesis that the correlation between executive functioning and observed daily functioning was stronger than the correlation between executive functioning and self-reported daily functioning, a *t*-test for dependent correlations was used. The correlation between executive functioning and observed daily functioning (Spearman's  $\rho = .639, p < .001$ ) was found to be significantly greater than the correlation between executive functioning and self-reported daily functioning (Spearman's  $\rho = .266, p > .05; t = 2.656, p < .05$ ).

## Discussion

As can be seen clearly in Figure 3.1, while performance on the DAFS-R was quite variable, participants' self-report of ADLs and IADLs on the OARS was positively skewed. This graphical representation depicts one of two possibilities. One possibility is that this sample of community dwelling older adults are having little difficulty in their day-to-day lives. If this is the case, one would conclude that the OARS scores are an accurate representation of older adults' daily functioning, and the DAFS-R scores are an inaccurate representation of daily functioning. A second possibility is that the DAFS-R scores are representative of daily functioning, while participants' self-report of daily functioning is not. This second possibility is supported by the evidence that the DAFS-R scores were more strongly correlated with measures of executive functioning.

While it has been previously noted that demented older adults tend to underestimate their difficulties in daily living (DeBettignies, Mahurin, & Pirozzolo, 1990), it has not been established in the literature that community-dwelling older adults demonstrate a similar lack of insight into their functional limitations. In fact, several studies have suggested that self-report measures of daily living are accurate indicators of daily functioning for older adults (Alexander et al., 2000; Whittle & Goldenberg, 1996). Our results suggest that even among older adults without diagnoses of dementia, there is a wide range of executive ability as well as functional ability that is not accurately represented by self-report measures. Nonetheless, direct assessment of ADLs and IADLs are rarely routine in geriatric assessment. This is most likely due to the length of time involved in administering measures such as the DAFS-R, and possibly due to lack of proliferation of such measures. Instead, clinicians commonly rely on self-report and caregiver report to obtain information on skills of daily living. We recommend the continued use of such

measures, but suggest that in addition to these, direct assessment should be obtained. In the absence of direct assessment of ADLs and IADLs, our results suggest that impairment across multiple measures of executive functioning may be useful in detecting decline in functional ability, and may serve as a “red flag” to clinicians.

The limitations of our study include lack of diversity in our sample due to the demographic makeup of the area as well as an over-representation of women. However, given that the mean age of our sample was 81 years, our results were clearly influenced by the steady decrease in the ratio of men to women as age increases (U.S. Census Bureau, 2000).

Another limitation of our study was that we did not obtain a collateral report on ADLs and IADLs, which may have been a more accurate measure of daily functioning than self-report. Collateral reports were not obtained because our sample consisted of older adults who were living independently and typically alone and thus did not have a caregiver capable of reporting on the participants’ day-to-day functioning. Despite such limitations, this study offers important new information to the practicing neuropsychologist as well as researchers interested in the validity of self-report measures.

#### References

- Alexander, N.B., Guire, K.E., Thelen, D.G., Ashton-Miller, J.A., Schultz, A.B., Grunwald, J.C., & Giordani, B. (2000). Self-reported walking ability predicts functional mobility performance in frail older adults. *Journal of American Geriatrics Society, 48*, 1408-1413.
- Bell-McGinty, S., Podell, K., Franzen, M., Baird, A.D., Williams, M.J. (2002). Standard measures of executive function in predicting instrumental activities of daily living in older adults. *International Journal of Geriatric Psychiatry, 17*, 828-834.

- Cahn-Weiner, D.A., Boyle, P.A., & Malloy, P.F. (2002). Tests of executive function predict instrumental activities of daily living in community-dwelling older individuals. *Applied Neuropsychology, 9*, 187-191.
- De Bettignies, B.H., Mahurin, R.K., & Pirozzolo, F.J. (1990). Insight for impairment in independent living skills in Alzheimer's disease and multi-infarct dementia. *Journal of Clinical and Experimental Neuropsychology, 12*, 355-363.
- Delis, D.C., Kaplan, E., & Kramer, J.H. (2001). *Delis-Kaplan Executive Function System Technical Manual*. San Antonio, TX: The Psychological Corporation.
- Duke University. Center for the Study of Aging and Human Development (1978). *Multidimensional functional assessment: The OARS methodology*. Durham, NC: Duke University Press.
- Kempen, G., Steverink, N., Ormel, J., & Deeg, D. (1996). The assessment of ADL among frail elderly in an interview survey: self-report versus performance-based tests and determinants of discrepancies. *Journal of Gerontology, 51B*, 254-260.
- Loewenstein, D.A., Arguelles, S., Bravo, M., Freeman, R., Arguelles, T., Acevedo, A., & Eisdorfer, C. (2001). Caregivers' judgments of the functional abilities of the Alzheimer's disease patient: a comparison of proxy reports and objective measures. *Journal of Gerontology: Psychological Sciences, 56B*, 78-84.
- Loewenstein, D.A., & Bates, B.C. (1989). *The direct assessment of functional status (DAFS): Manual for administration and scoring*. Unpublished manuscript.
- Myers, A.M., Holliday, P.J., Harvey, K.A., & Hutchinson, K.S. (1993). Functional performance measures: Are they superior to self-assessments? *Journal of Gerontology, 48*, M196-M206.

- Radloff, L.S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*, 385-401.
- Sager, M.A., Dunham, N.C., Schwantes, A., Mecum, L., Halverson, K., & Harlowe, D. (1992). Measurement of activities of daily living in hospitalized elderly: A comparison of self-report and performance-based methods. *Journal of the American Geriatric Society, 40*, 457-462.
- Whittle, H. & Goldenberg, D. (1996). Functional health status and instrumental activities of daily living performance in noninstitutionalized elderly people. *Journal of Advanced Nursing, 23*, 220-227.
- Zanetti, O., Frisoni, G.B., Rozzini, L., Bianchetti, A., & Trabucchi, M. (1998). Validity of Direct Assessment of Functional Status as a tool for measuring Alzheimer's disease severity. *Age and Ageing, 27*, 615-622.
- Zanetti, O., Geroldi, C., Frisoni, G.B., Bianchetti, A., & Trabucchi, M. (1999). Contrasting results between caregiver's report and direct assessment of activities of daily living in patients affected by mild and very mild dementia: The contribution of the caregiver's personal characteristics. *Journal of the American Geriatrics Society, 47* (2), 196-202.

Table 3.1.

## DAFS Domains and Skill Requirements

Domain	Skill Requirements
Time Orientation	Telling Time Orientation to Date
Communication	Using the Telephone Preparing a letter for mailing
Transportation	Correct identification of road signs
Financial ability	Identifying currency Counting Change Writing a Check Balancing a Checkbook
Shopping	Memory for grocery items Selecting grocery items with a list Making correct change
Grooming	Performing basic grooming skills
Eating	Using eating utensils correctly

Table 3.2.

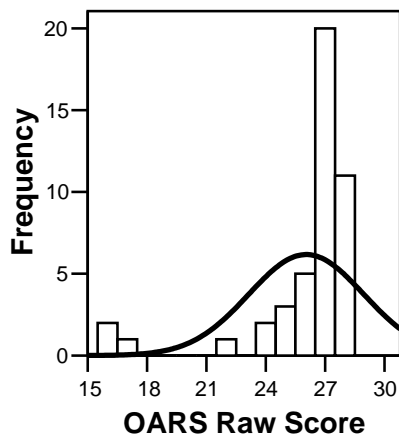
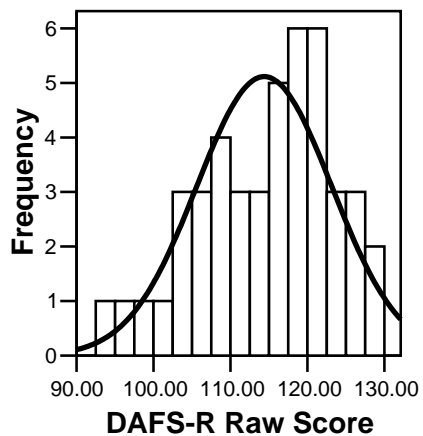
Descriptive Statistics: Demographics, D-KEFS Scale Scores, OARS and DAFS-R Raw Scores (N = 45)

Variable	Minimum	Maximum	Mean	SD
Age	65	92	81.2	6.09
Years Education	9	18	13.2	2.33
Monthly Income	300.00	5833.33	1747.77	1239.46
D-KEFS Design Fluency	4	17	10.5	3.07
D-KEFS Letter Fluency	3	19	8.7	3.43
D-KEFS Tower Test	5	16	9.9	2.70
D-KEFS Trail Making 4	2	15	7.7	4.08
OARS Raw Score Total	16	28	26.0	2.91
DAFS-R Raw Score Total	94	128	114.4	8.77

*Note: D-KEFS scale scores based on mean of 10, s.d. of 3. DAFS-R raw scores have a minimum value of 0, maximum value of 133. OARS raw scores have a minimum value of 0, maximum value of 28.*

Figure 3.1.

Distribution of Raw Scores on the Direct Assessment of Functional Status (DAFS-R; minimum possible score of 0, maximum of 133) and the Older Adults and the Older American Resources and Services Instrumental Activities of Daily Living and Activities of Daily Living Scale (OARS; minimum possible score of 0, maximum of 28).



## CHAPTER 4

## THE ECOLOGICAL VALIDITY OF DELIS-KAPLAN EXECUTIVE FUNCTION SYSTEM

(D-KEFS) TESTS: PREDICTION OF FUNCTIONAL STATUS IN OLDER ADULTS<sup>1</sup>

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<sup>1</sup> Mitchell, M.B., & Miller, L.S. To be submitted to Archives of Clinical Neuropsychology

### Abstract

The present study sought to test the ecological validity of four Delis-Kaplan Executive Function System (D-KEFS) tests by examining how well performance on D-KEFS measures predicted performance on an observed measure of daily functioning in older adults. In this study, 45 older adults, 65 to 92 years old, completed four D-KEFS tests requiring verbal and nonverbal cognitive fluency and planning and sequencing abilities. In a multiple regression analysis, the D-KEFS Trail Making Test 4 was the only significant predictor of observed daily functioning. The results are discussed in terms of theories of executive functioning and the real-world implications of decline in executive functioning.

## Introduction

The Delis-Kaplan Executive Function System (D-KEFS) is a relatively new assessment tool that consists of nine stand-alone tests of executive functioning. A recent test review by Homack, Lee, and Riccio (2005) indicates that strengths of the D-KEFS include that it allows clinicians and researchers to compare performance on multiple executive functioning measures to the same normative sample, provides lower floors and higher ceilings than many other executive functioning measures, and it uses the process approach to examine the component processes of complex cognitive tasks. As the D-KEFS is a new clinical and research tool, it is necessary to establish the ecological validity of the D-KEFS, or the implications that impairment of D-KEFS measures has on daily functioning.

Recent attention has been given to the real-world implications of impairment on neuropsychological tests in older adults. While clinicians can judge with a good deal of certainty that frank impairment on multiple neuropsychological tests tapping multiple cognitive domains suggests impairment in daily functioning, as is the case in older adults with dementia, it is less clear whether subtle impairment on neuropsychological tests has any bearing on older adults' daily functioning.

Empirical investigation of relationships between various cognitive variables and functional abilities in elderly populations suggest that there are many cognitive factors that contribute to functional decline (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002). Cognitive variables that have been found to be linked to functional status include global cognitive functioning (Farias, Harrell, Neumann & Houtz, 2002; Inzarti & Basile, 2003), memorial abilities (McCue, Rogers, & Goldstein, 1990) visuospatial abilities (Glosser et al., 2002), and executive functioning (Bell-McGinty, et al., 2002).

Several studies have examined the predictive ability of a mixed battery of neuropsychological tests with the aim of determining which components of cognition are the most predictive of functional abilities. For example, Loewenstein et al. (1992) found tests of cognitive status, verbal fluency, object memory, and visuospatial ability to be the most predictive of observed functional ability. Loewenstein, Rubert, Arguelles, and Duara (1995) found tests of visuospatial ability, verbal working memory, cognitive status, and verbal fluency to be the best predictors of functional status in their test battery. Richardson, Nadler, and Malloy (1995) found that a test of visuospatial ability was the most predictive of performance-based daily functioning, followed by tests of memorial ability in their sample of 108 older adults in an inpatient psychiatric unit. Farias, Harrell, Neumann, and Houtz (2003) found tests of apraxia, visuospatial ability, immediate memory, and executive functioning to be the best predictors of observed daily functioning.

From the above review of the literature, it appears that there are many aspects of cognition that influence functioning in daily life. However, a weakness of the aforementioned literature on the ecological validity of neuropsychological measures is that the research findings are typically arrived at via an exploratory research design, meaning that a priori hypotheses based on a theory of cognition are rarely mentioned. Instead of collecting data on multiple domains of cognition, several studies have chosen to examine how well measures of executive functioning predict daily functioning, based on the theory that executive functioning is the area of cognition that controls most aspects of cognition and thus controls how people behave. Evidence to support this hypothesis is that Cahn-Weiner, Malloy, Boyle, Marran, and Salloway, (2000) found that a composite score of four measures of executive functioning was the only significant predictor of a measure of observed functional ability when entered into a stepwise

multiple regression analysis with composite scores from all other domains of cognitive functioning assessed. Previous results from our laboratory indicated that executive measures of planning are significant predictors of observed daily functioning, over and above the variance accounted for by age, education, gender, and executive measures of working memory, cognitive fluency, and cognitive flexibility (Lewis & Miller, in press).

Bell-McGinty, Podell, Franzen, Baird, and Williams (2002) examined the predictive abilities of multiple measures of executive functioning on daily functioning and found that the Trails B test was the single most predictive measure of both observed and self-reported functional impairment. Similarly, Cahn-Weiner, Boyle, and Malloy (2002) used three measures of executive functioning and found that the Trails B test was the only significant predictor of observed functional ability. Grigsby et al. (1998) compared the predictive ability of a general cognitive screen to a measure of executive functioning to determine which measure was more predictive of functional ability and found that the measure of executive functioning was more predictive of level of impairment on a self-reported and observed measure of functional abilities. Thus, the authors conclude that while there is a positive correlation between level of general cognitive impairment and level of functional impairment, executive functioning measures are stronger predictors of daily functioning and are therefore important clinical tools in geriatric assessment. Royall, Palmer, Chiodo, and Polk (2004) similarly found that in a sample of 547 non-institutionalized older adults, a brief screen of executive functioning was more predictive than a brief screen of general cognitive functioning at predicting self-reported IADLs.

While the aforementioned studies have examined relationships between measures of executive functioning and functional ability, little work has been done to establish a concrete link between the theoretical concept of executive functioning and the more practical concept of how

goal-directed cognition guides people through their day-to-day lives. As people age, whether they are experiencing normal aging or a neurodegenerative disease such as Alzheimer's disease, there is a decline in overall cognitive abilities, as well as a more marked decline in executive functioning (Daigneault, Braun, & Whitaker, 1992; Royall et al., 2002). Given the evidence that many older adults experience a decline in executive functioning, coupled with the relationship between executive functioning and functional ability, measures of executive functioning have the potential to be helpful tools in clinical settings to detect impairment in daily functioning, which is not readily evident in a clinical setting. While there is little evidence in the literature that any one specific component of executive functioning is the most essential to the maintenance of functional abilities, the tasks that appear to be the most predictive involve planning and cognitive fluency.

The purpose of this study was to examine the predictive abilities of four D-KEFS test to determine which aspect of executive functioning is the most predictive of functional ability. It was hypothesized that D-KEFS measures of planning and sequencing (i.e., the D-KEFS Trails and Tower Tests) would be more predictive of daily functioning than D-KEFS measures of cognitive fluency (i.e., the D-KEFS Design Fluency and Letter Fluency Tests). We hypothesized that measures of planning and sequencing would be the most ecologically valid of the D-KEFS measures used based on previous findings that tests similar to the D-KEFS Trail Making Test 4 (i.e., Trails B) and the D-KEFS Tower Test (i.e., Tower of London) are good predictors of observed ADLs and IADLs (Cahn-Weiner et al., 2002; Lewis & Miller, in press).

### Method

Forty-five participants, ranging in age from 65 to 92, were recruited from three retirement communities in Northeast Georgia. This number of participants was found to be appropriate by a

power analysis to detect a large effect size ( $R^2 = .26$ ) using Cohen, Cohen, West, and Aiken's (2003) guidelines with an alpha of .05 and a power of .80 between seven independent variables and one dependent variable. Enrollment was initiated by residents' interest upon receiving information about the study via placement of fliers. Potential participants contacted the investigator via telephone, and a two-hour appointment time was scheduled with each interested participant. Given the demographic makeup of older adults in Northeast Georgia, as well as the limited access to populations of lower socioeconomic status (SES) due to a lack of representation of low SES individuals in retirement communities, this sample was admittedly a convenience sample of community-dwelling older adults. Participants were predominantly Caucasian (44 Caucasian, 1 Hispanic), moderate SES (mean monthly income = \$1,748), and the majority were women (80% women).

Participants were interviewed and assessed in one two-hour session that took place at the participants' residence. The sessions involved the following sequence of administration procedures: Participants were told they were participating in a research study investigating the effects of aging on daily living. Participants were also told they would receive \$10 upon completion of their testing session for their participation. Consent was obtained, followed by the completion of a demographic form, a measure of self-reported depression (Center for Epidemiologic Studies Depression Scale; CES-D, Radloff, 1977), a measure of self-reported functional ability (Older American Resources and Services Instrumental Activities of Daily Living and Activities of Daily Living Scale; OARS, Duke University, 1978), four tests from the Delis-Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan, & Kramer, 2001): D-KEFS Trail Making Test, D-KEFS Verbal Fluency Test, D-KEFS Design Fluency Test, and D-

KEFS Tower Test, and an observed measure of functional ability (Direct Assessment of Functional Status-Revised; DAFS-R, Loewenstein & Bates, 1989).

Test-retest reliability for the D-KEFS Trail Making Test for adults aged 50 to 89 ranges from .37 to .74 (Delis, Kaplan, & Kramer, 2001). Test-retest reliability among adults ages 50 to 89 for the D-KEFS Tower Test is .38 (Delis, Kaplan, & Kramer, 2001). While this is a low-moderate level of test-retest reliability, the authors attribute this finding to a large practice effect. Across all age groups, average performance was found to improve from first testing to second testing. The D-KEFS Tower Test has been found to have high internal consistency in an older adult sample, with intercorrelations between test trials ranging from .61 to .72 (Delis, Kaplan, & Kramer, 2001). Test-retest reliability among adults aged 50 to 89 for the D-KEFS Verbal Fluency: Letter Fluency ranges from .82 to .88 (Delis, Kaplan, & Kramer, 2001). Test-retest reliability among adults aged 50 to 89 for the Design Fluency Test of the D-KEFS ranges from .43 to .58 (Delis, Kaplan, & Kramer, 2001). The independent variables from the D-KEFS measures were: D-KEFS Letter Fluency scale score, D-KEFS Design Fluency scale score, D-KEFS Trail Making Test 4 scale score, and D-KEFS Tower Test scale score.

The outcome measure used to measure daily functioning was the Direct Assessment of Functional Status-Revised Edition (DAFS-R; Loewenstein & Bates, 1989), a laboratory assessment of activities of daily living (ADLs) and instrumental activities of daily living (IADLs). The DAFS-R is made up of ten clinical rating scales, which combine to create a total score across domains of functioning. The DAFS is validated in older adults with memory impairment, as well as older adult controls (Loewenstein et al., 1989). The DAFS Scale has been found to have test-retest reliability of at least 85% agreement on each item of the scale. Test-retest reliability has been found to range from .55 to .91 across subscales (Loewenstein et al.,

1989). The domains of daily functioning assessed using this measure are summarized in Table 4.1. The outcome variable used in the current study was the total raw score on the DAFS-R.

To test the first hypothesis that overall executive functioning would be positively correlated with daily functioning, a composite of all executive measures was made by averaging all D-KEFS scale scores of interest: D-KEFS Letter Fluency scale score, D-KEFS Design Fluency scale score, D-KEFS Trail Making Test 4 scale score, and D-KEFS Tower Test scale score. This composite measure of executive functioning was found to be internally consistent (Cronbach's  $\alpha = .75$ ). A bivariate correlation was computed with this composite executive score and the DAFS-R score to determine if overall executive functioning predicted daily functioning. To test the second hypothesis that D-KEFS measures of planning and sequencing would be more predictive of daily functioning than D-KEFS measures of fluency, a hierarchical linear regression was performed to determine if D-KEFS measures of planning and sequencing ability were predictive of daily functioning above and beyond the variance accounted for by the demographic variable of education and the D-KEFS measures of cognitive fluency.

## Results

Demographic information and descriptive statistics for the D-KEFS measures and the DAFS-R are summarized in Table 4.2. The Pearson product correlation between the composite score of executive functioning and the DAFS-R score was found to be significant (Pearson  $r = .66, p < .01$ ), confirming our first hypothesis that overall level of executive functioning is positively correlated with observed functional ability, with more impairment on executive measures predicting more impairment in daily functioning.

To test our hypothesis that D-KEFS measures of planning and sequencing (i.e., D-KEFS Trail Making Test 4 and D-KEFS Tower Test) would be more predictive of performance on the

DAFS-R than D-KEFS measures of cognitive fluency (i.e., D-KEFS Verbal Fluency: Letter Fluency and D-KEFS Design Fluency), multiple regression analyses were conducted. In order to determine which demographic variables to include in our regression model, we first entered the three demographic variables of age, years education, and monthly income in a regression equation to predict DAFS-R total score. The only demographic variable to account for a significant ( $p < .05$ ) amount of the variance in DAFS-R performance was years education. Thus, we dropped the demographic variables of age and monthly income from our model. Next, we conducted a multiple regression analysis entering education and the four D-KEFS variables as our predictors of DAFS-R performance. The model accounted for a significant amount of the variance in daily functioning as measured by the DAFS-R (adjusted  $R^2 = 0.392$ ,  $F(5,39) = 6.671$ ,  $p < .001$ ). A regression model summary, including beta values,  $t$  values, and correlation coefficients are presented in Table 4.3. The only variable that accounted for a significant amount of the variance above and beyond the variance accounted for by education and the other executive measures was the D-KEFS Trail Making Test 4 ( $\beta = .302$ ,  $t = 2.072$ ,  $p < .05$ ).

### Discussion

The relationship between executive functioning and daily functioning was clearly supported by this study. Our hypothesis that planning and sequencing abilities would be more predictive of daily functioning than cognitive fluency was partially supported by our findings that the D-KEFS Trail Making Test 4 was the best single predictor of daily functioning. However, our other measure of planning and sequencing ability—the D-KEFS Tower Test—was not found to account for a significant amount of the variance in our functional measure. As is depicted in Table 4.3, the “next best” predictor of functional ability behind the D-KEFS Trail

Making Test 4 was the D-KEFS Design Fluency Test. Although this only approached significance ( $p = .12$ ), it appeared to be a better predictor than the D-KEFS Tower Test.

Results of our study suggest that the D-KEFS Trail Making Test 4 may have ecological validity as a stand alone measure of sequencing abilities. This finding indicates that impairment on the D-KEFS Trail Making Test 4 may suggest difficulties carrying out basic and instrumental activities of daily living. However, the aim of this investigation was not to support the idea that single neuropsychological measures should be used to make decisions regarding an older adult's ability to live independently. Rather, the aim was to determine which components of executive functioning are necessary to maintain daily functioning.

In contrast to the significant amount of variance accounted for by the D-KEFS Trail Making Test 4, the D-KEFS Tower Test was not a good predictor of daily functioning as a stand-alone measure. It appears that multiple measures of executive functioning—measures of cognitive fluency and measures of sequencing ability—account for unique amounts of variance in daily functioning. Findings support the D-KEFS Design Fluency Test and D-KEFS Trail Making Test 4 as ecologically valid measures of executive functioning that are good predictors of daily functioning in older adults. These findings are consistent with previous findings that similar tests of executive functioning (e.g., the Trails B test) predict functional ability in clinical samples of older adults.

In the context of executive functioning theory, these findings suggest that the ability to sequence behaviors in an orderly fashion and to switch between tasks is an essential component of executive functioning for the maintenance of daily functioning. Additionally, design fluency, or the ability to generate behavioral outputs based on a nonverbal cognitive set, also may be important in the maintenance of daily functioning.

In terms of implications for clinical utility, findings suggest that the D-KEFS Trail Making Test 4 is a good stand alone measure of ability to sequence and set shift. Impairment on this measure, along with information gathered in the interview (e.g., collateral report of functional ability) may be helpful in detecting difficulties in daily functioning that warrant safety interventions. Impairment on multiple measures of cognitive fluency may also serve as “red flags” for older adults who are having difficulty carrying out their daily activities.

#### References

- Bell-McGinty, S., Podell, K., Franzen, M., Baird, A.D., Williams, M.J. (2002). Standard measures of executive function in predicting instrumental activities of daily living in older adults. *International Journal of Geriatric Psychiatry, 17*, 828-834.
- Burgess, P.W., Alderman, N., Evans, J., Emslie, H., & Wilson, B.A. (1998). The ecological validity of tests of executive function. *Journal of the International Neuropsychological Society, 4*, 547-558.
- Cahn-Weiner, D.A., Boyle, P.A., & Malloy, P.F. (2002). Tests of executive function predict instrumental activities of daily living in community-dwelling older individuals. *Applied Neuropsychology, 9*, 187-191.
- Cahn-Weiner, D.A., Malloy, P.F., Boyle, P.A., Marran, M., & Salloway, S. (2000). Prediction of functional status from neuropsychological tests in community-dwelling elderly individuals. *The Clinical Neuropsychologist, 14*, 187-195.
- Cohen, J., Cohen, P., West, S.G., & Aiken, L.S. (2003). *Applied Multiple Regression / Correlation Analysis for the Behavioral Sciences* (3<sup>rd</sup> edition). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Daigneault, S., Braun, C.M.J., & Whitaker, H.A. (1992). Early effects of normal aging on

- perseverative and non-perserverative prefrontal measures. *Developmental Neuropsychology*, 8, 99-114.
- Delis, D.C., Kaplan, E., & Kramer, J.H. (2001). *Delis-Kaplan Executive Function System Technical Manual*. San Antonio, TX: The Psychological Corporation.
- Duke University. Center for the Study of Aging and Human Development (1978). *Multidimensional functional assessment: The OARS methodology*. Durham, NC: Duke University Press.
- Farias, S.T., Harrell, E., Neumann, C., & Houtz, A. (2002). The relationship between neuropsychological performance and daily functioning in individuals with Alzheimer's disease: ecological validity of neuropsychological tests. *Archives of Clinical Neuropsychology*, 18, 655-672.
- Glosser, G., Gallo, J., Duda, N., de Vries, J.J., Clark, C.M., & Grossman, M. (2002). Visual perceptual functions predict instrumental activities of daily living in patients with dementia. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, 3, 198-206.
- Grigsby, J., Kaye, K., Baxter, J., Shetterly, S.M., & Hamman, R.F. (1998). Executive cognitive abilities and functional status among community-dwelling older persons in the San Luis Valley Health and Aging Study. *Journal of the American Geriatrics Society*, 46, 590-596.
- Homack, S., Lee, D., & Riccio, C.A. (2005). Test review: Delis-Kaplan Executive Function System. *Journal of Clinical and Experimental Neuropsychology*, 27: 599-609.
- Inzarti, D., & Basile, A.M. (2003). Activities of daily living and global functioning. *International Psychogeriatrics*, 15, 225-229.
- Loewenstein, D.A., Amigo, E., Duara, R., Guterman, R., Hurwitz, D., Berkowitz, N, Wilkie, F.,

- Weinberg, G., Black, B., Gittleman, B., & Eisdorfer, C. (1989). A new scale for the assessment of functional status in Alzheimer's disease and related disorders. *Journal of Gerontology, 44*, 114-121.
- Loewenstein, D.A., & Bates, B.C. (1989). *The direct assessment of functional status (DAFS): Manual for administration and scoring*. Unpublished manuscript.
- Loewenstein, D.A., Rubert, M.P., Arguelles, T., & Duara, R. (1995). Neuropsychological test performance and prediction of functional capacities among Spanish-speaking and English-speaking patients with dementia. *Archives of Clinical Neuropsychology, 10*, 75-88.
- Loewenstein, D.A., Rubert, M.P., Berkowitz-Zimmer, N., Guterman, A., Morgan, R., Hayden, S. (1992). Neuropsychological test performance and prediction of functional capacities in dementia. *Behavior, Health, and Aging, 2*, 149-158.
- McCue, M., Rogers, J.C., & Goldstein, G. (1990). Relationship between neuropsychological and functional assessment in elderly neuropsychiatric patients. *Rehabilitation Psychology, 35*, 91-99.
- Owen, A., Downes, J.J., Sahakian, B.J., Polkey, C.E., & Robbins, T.W. (1990). Planning and spatial working memory following frontal lobe lesions in man. *Neuropsychologia, 28*, 1021-1034.
- Radloff, L.S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*, 385-401.
- Richardson, E.D., Nadler, J.D., & Malloy, P.F. (1995). Neuropsychologic predictors of performance measures of daily living skills in geriatric patients. *Neuropsychology, 9*, 565-572.

Royall, D.R., Palmer, R., Chiodo, L.K., & Polk, M.J. (2004). Declining executive control in normal aging predicts change in functional status: The Freedom House Study. *Journal of the American Geriatrics Society*, 52, 346-352.

Table 4.1.

## DAFS Domains and Skill Requirements

Domain	Skill Requirements
Time Orientation	Telling Time Orientation to Date
Communication	Using the Telephone Preparing a letter for mailing
Transportation	Correct identification of road signs
Financial ability	Identifying currency Counting Change Writing a Check Balancing a Checkbook
Shopping	Memory for grocery items Selecting grocery items with a list Making correct change
Grooming	Performing basic grooming skills
Eating	Using eating utensils correctly

Table 4.2.

Descriptive Statistics: Demographics, D-KEFS Scale Scores, and DAFS-R Raw Scores (N = 45)

Variable	Minimum	Maximum	Mean	SD
Age	65	92	81.2	6.09
Years Education	9	18	13.2	2.33
Monthly Income	300.00	5833.33	1747.77	1239.46
D-KEFS Design Fluency	4	17	10.5	3.07
D-KEFS Letter Fluency	3	19	8.7	3.43
D-KEFS Tower Test	5	16	9.9	2.70
D-KEFS Trail Making 4	2	15	7.7	4.08
DAFS-R Raw Score	94	128	114.4	8.77
Total				

*Note: D-KEFS scale scores based on mean of 10, s.d. of 3. DAFS-R raw scores have a minimum value of 0, maximum value of 133*

Table 4.3.

Multiple regression analysis for prediction of DAFS-R performance by D-KEFS tests (all variables entered)

Model:  $R = .679$ <sub>a</sub>;  $R^2 = .461$  Adj  $R^2 = .392$  Std. Err. of Est. = 6.842  $F = 6.671 (5, 39), p < .001$

Variable	Beta	<i>t</i>	Significance of <i>t</i>	Zero-order Correlation	Partial Correlation	Semi-Partial Correlation
Years Education	.090	.639	NS	.431	.102	.075
D-KEFS Letter Fluency	.171	1.300	NS	.410	.204	.153
D-KEFS Design Fluency	.240	1.608	NS	.545	.249	.189
D-KEFS Tower Test	.128	.952	NS	.409	.151	.112
D-KEFS Trail Making Test 4	.302	2.072	<.05	.560	.315	.244

a. Dependent variable: DAFS-R total raw score

## CHAPTER 5

### DISCUSSION

This thesis tested three hypotheses: 1) To determine whether an observed measure of daily functioning was more strongly related to measures of executive functioning than a self-report measure, 2) To demonstrate a relationship between performance on executive functioning measures and an observed measure of daily functioning, and 3) To determine whether executive measures of planning and sequencing abilities were better predictors of observed daily functioning than executive measures of cognitive fluency.

As has been discussed in Chapter 3, the hypothesis that the relationship between observed daily functioning and executive functioning would be stronger than the relationship between self-reported daily functioning and executive functioning was supported. The distribution of scores on the self-report measure further indicate that there appears to be a ceiling effect on self-report of ADLs and IADLs in this population of older adults. This finding could be due to the fact that the sample used in this study was a group of older adults who were living independently and typically alone. In the communities that this sample was taken from, community directors are often concerned that residents are not competent to care for themselves. Thus, residents in these communities may have over-reported their ability to complete ADLs and IADLs without assistance. This finding suggests that it is ideal to seek information from multiple sources (e.g., self-report, collateral report, observed daily functioning, and executive functioning).

However, it is important to note that the intention of this hypothesis was not to “prove” that older adults should not be trusted in their self-report. Rather, it is intended to demonstrate

the importance of maintaining older adults' safety by obtaining the most accurate information about their daily functioning. Thus, self-report measures can continue to be used in conjunction with other measures. Large discrepancies between self-report and collateral report are cause for concern and likely indicate underreporting of difficulty on the self-report measure and possible over-reporting of difficulty on the collateral report measure. In the absence of a measure of observed functional ability, performance on executive functioning measures can add further information to the clinician about the older adults' ability to carry out daily tasks.

As discussed in Chapter 4, the hypothesis that there would be a positive correlation between overall performance on executive measures and observed daily functioning was supported by the results. This finding is consistent with previous findings that executive measures relate to day-to-day functioning (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Cahn-Weiner, Boyle, & Malloy, 2002, Lewis & Miller, in press). The hypothesis that tests of planning and sequencing ability would be better predictors of observed daily functioning than measures of cognitive fluency was partially supported by the results in that one of the measures of planning and sequencing (D-KEFS Trail Making Test 4) was the best single predictor of daily functioning. This finding provides evidence for the ecological validity of the D-KEFS Trail Making Test 4.

There were two main limitations of this study. The first was that the sample used was homogeneous in terms of race (predominantly Caucasian) and gender (predominantly female). This limitation indicates that these results may only be relevant to older adults of similar demographics. However, it is important to note that the range of performance on measures used in this study was similar to that found in studies with more diverse samples (e.g., Loewenstein, Rubert, Arguelles, & Duara, 1995). The second limitation of this study was the lack of a

collateral-report of ADLs and IADLs. Having a caregiver or family member report on the study participants' ADLs and IADLs using the OARS would likely have yielded a wider range of scores on this measure. However, obtaining collateral reports was not possible in this study, because most of the study participants lived alone and did not have a caregiver to report on their daily functioning. Despite such limitations, this study offers new insight into the relationship between components of executive functioning and day-to-day functioning.

An important question for future research studies to answer is whether or not executive measures can predict future decline in daily functioning. A longitudinal study testing older adults' executive functioning and daily functioning at several time points over a time period of years would be the ideal study design to answer this question. Another avenue for future research is to explore the possibility of cognitive training in executive functioning skills as an intervention to prevent decline in daily functioning.

## REFERENCES

- Alexander, N.B., Guire, K.E., Thelen, D.G., Ashton-Miller, J.A., Schultz, A.B., Grunwalt, J.C., & Giordani, B. (2000). Self-reported walking ability predicts functional mobility performance in frail older adults. *Journal of American Geriatrics Society, 48*, 1408-1413.
- American Psychiatric Association. (2000). *Diagnostic and Statistical Manual of Mental Disorders, 4<sup>th</sup> edition, Text Revision*. Washington, D.C.: American Psychiatric Association.
- Baddeley, A.D., & Hitch, G.J. (1974). Working Memory. In G.A. Bower (Ed.) *Recent Advances in Learning and Motivation, 8* (pp. 47-90). New York: Academic Press.
- Bell-McGinty, S., Podell, K., Franzen, M., Baird, A.D., Williams, M.J. (2002). Standard measures of executive function in predicting instrumental activities of daily living in older adults. *International Journal of Geriatric Psychiatry, 17*, 828-834.
- Benton, A.L., & Hamsher, K. (1976). *Multilingual Aphasia Examination*. Iowa City, IA: University of Iowa.
- Broese van Groenou, M. & Thomese, F. (1996). The relative importance of independent living for the social functioning of the elderly. *Journal of Gerontology and Geriatrics (Dutch), 27* (4), 150-158.
- Burgess, P.W., Alderman, N., Evans, J., Emslie, H., & Wilson, B.A. (1998). The ecological validity of tests of executive function. *Journal of the International Neuropsychological Society, 4*, 547-558.

- Cahn-Weiner, D.A., Boyle, P.A., & Malloy, P.F. (2002). Tests of executive function predict instrumental activities of daily living in community-dwelling older individuals. *Applied Neuropsychology, 9*, 187-191.
- Cahn-Weiner, D.A., Malloy, P.F., Boyle, P.A., Marran, M., & Salloway, S. (2000). Prediction of functional status from neuropsychological tests in community-dwelling elderly individuals. *The Clinical Neuropsychologist, 14*, 187-195.
- Cohen, J., Cohen, P., West, S.G., & Aiken, L.S. (2003). *Applied Multiple Regression / Correlation Analysis for the Behavioral Sciences* (3<sup>rd</sup> edition). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Daigneault, S., Braun, C.M.J., & Whitaker, H.A. (1992). Early effects of normal aging on perseverative and non-perseverative prefrontal measures. *Developmental Neuropsychology, 8*, 99-114.
- De Bettignies, B.H., Mahurin, R.K., & Pirozzolo, F.J. (1990). Insight for impairment in independent living skills in Alzheimer's disease and multi-infarct dementia. *Journal of Clinical and Experimental Neuropsychology, 12*, 355-363.
- Delis, D.C., Jacobson, M., Bondi, M.W., Hamilton, J.M., & Salmon, D.P. (2003). The myth of testing construct validity using factor analysis or correlations with normal or mixed clinical populations: Lessons from memory assessment. *Journal of the International Neuropsychological Society, 9*, 936-946.
- Delis, D.C., Kaplan, E., & Kramer, J.H. (2001). *Delis-Kaplan Executive Function System Technical Manual*. San Antonio, TX: The Psychological Corporation.
- Delis, D.C., Kramer, J.H., Kaplan, E., & Hodnack, J. (2004). Reliability and validity of the

- Delis-Kaplan Executive Function System: An update. *Journal of the International Neuropsychological Society*, 10, 301-303.
- Delis, D.C., Kramer, J.H., Kaplan, E., & Ober, B.A. (2000). *The California Verbal Learning Test-Second Edition*. San Antonio, TX: The Psychological Corporation.
- Demakis, G.J., & Harrison, D.W. (1997). Relationships between verbal and nonverbal fluency measures: Implications for assessment of executive functioning. *Psychological Reports*, 81, 443-448.
- Duke University. Center for the Study of Aging and Human Development (1978). *Multidimensional functional assessment: The OARS methodology*. Durham, NC: Duke University Press.
- Edelberg, H.K., Shallenberger, E., & Wei, J.Y. (1999). Medication management capacity in highly functioning community-living older adults: detection of early deficits. *Journal of the American Geriatrics Society*, 47 (5), 592-596.
- Farias, S.T., Harrell, E., Neumann, C., & Houtz, A. (2002). The relationship between neuropsychological performance and daily functioning in individuals with Alzheimer's disease: ecological validity of neuropsychological tests. *Archives of Clinical Neuropsychology*, 18, 655-672.
- Frith, C., & Dolan, R. (1996). The role of the prefrontal cortex in higher cognitive functions. *Cognitive Brain Research*, 5, 175-181.
- Glosser, G., Gallo, J., Duda, N., de Vries, J.J., Clark, C.M., & Grossman, M. (2002). Visual perceptual functions predict instrumental activities of daily living in patients with dementia. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, 3, 198-206.
- Goldman, P.S., & Rosvold, H.E. (1970). Localization of function within the dorsolateral

- prefrontal cortex of the rhesus monkey. *Experimental Neurology*, 27, 291-304.
- Grant, D., Kramer, J.H., Rosen, H., Schauer, G., Pace-Savitsky, K., Rankin, K., Johnson, J., Weiner, M., & Miller, B.L. (in press). Neuroanatomy of semantic and phonemic fluency. *Journal of the International Neuropsychological Society*.
- Grigsby, J., Kaye, K., Baxter, J., Shetterly, S.M., & Hamman, R.F. (1998). Executive cognitive abilities and functional status among community-dwelling older persons in the San Luis Valley Health and Aging Study. *Journal of the American Geriatrics Society*, 46, 590-596.
- Hall, W.J. (1997). Update in geriatrics. *Annals of Internal Medicine*, 127, 557-564.
- Hallam, B.J., Kramer, J.H., Rosen, H.J., Schauer, G., Pace-Savitsky, C., Delis, D.C., Weiner, M., & Miller, B.L. (in press). Frontal lobe volumes specifically predict the capacity for set shifting on executive tasks. *Journal of the International Neuropsychological Society*.
- Harlow, J.M. (1868). Recovery from the passage of an iron bar through the head. *Publications of the Massachusetts Medical Society* 2, 327-347.
- Homack, S., Lee, D., & Riccio, C.A. (2005). Test review: Delis-Kaplan Executive Function System. *Journal of Clinical and Experimental Neuropsychology*, 27, 599-609.
- Inzarti, D., & Basile, A.M. (2003). Activities of daily living and global functioning. *International Psychogeriatrics*, 15, 225-229.
- Jacobson, C. (1936). Studies of cerebral function in primates. I. The functions of the frontal association areas in monkeys. *Comparative Psychology Monographs*, 13, 3-60.
- Kempen, G., Steverink, N., Ormel, J., & Deeg, D. (1996). The assessment of ADL among frail elderly in an interview survey: self-report versus performance-based tests and determinants of discrepancies. *Journal of Gerontology*, 51B, 254-260.

- Lewis, M., & Miller, L.S. (in press). Executive control functioning and functional ability in older adults. *The Clinical Neuropsychologist*.
- Lezak, M.D., Howieson, D.B., & Loring, D.W. (2004). *Neuropsychological Assessment* (4<sup>th</sup> ed.). New York, NY: Oxford University Press.
- Loewenstein, D.A., Amigo, E., Duara, R., Guterman, R., Hurwitz, D., Berkowitz, N, Wilkie, F., Weinberg, G., Black, B., Gittleman, B., & Eisdorfer, C. (1989). A new scale for the assessment of functional status in Alzheimer's disease and related disorders. *Journal of Gerontology*, 44, 114-121.
- Loewenstein, D.A., Arguelles, S., Bravo, M., Freeman, R., Arguelles, T., Acevedo, A., & Eisdorfer, C. (2001). Caregivers' judgments of the functional abilities of the Alzheimer's disease patient: a comparison of proxy reports and objective measures. *Journal of Gerontology: Psychological Sciences*, 56B, 78-84.
- Loewenstein, D.A., & Bates, B.C. (1989). *The direct assessment of functional status (DAFS): Manual for administration and scoring*. Unpublished manuscript.
- Loewenstein, D.A., Rubert, M.P., Arguelles, T., & Duara, R. (1995). Neuropsychological test performance and prediction of functional capacities among Spanish-speaking and English-speaking patients with dementia. *Archives of Clinical Neuropsychology*, 10, 75-88.
- Loewenstein, D.A., Rubert, M.P., Berkowitz-Zimmer, N., Guterman, A., Morgan, R., Hayden, S. (1992). Neuropsychological test performance and prediction of functional capacities in dementia. *Behavior, Health, and Aging*, 2, 149-158.
- Luria, A.R. (1966). *Higher cortical functions in man*. New York: Basic Books.
- MacDonald, A.W. III, Cohen, J.D., Stenger, V.A., & Carter, C.S. (2000). Dissociating the role

- of the dorsolateral prefrontal and anterior cingulated cortex in cognitive control. *Science*, 288, 1835-1838.
- Mack, J.L., Patterson, M.B. (1995). Executive dysfunction and Alzheimer's disease: Performance on a test of planning ability, the Porteus Maze Test. *Neuropsychology*, 9 (4), 556-564.
- Magaziner, J., Zimmerman, S.I., GruberBaldini, A.L., Hebel, J.R., & Fox, K.M. (1997). Proxy reporting in five areas of functional status- Comparison with self-reports and observations of performance. *American Journal of Epidemiology*, 146 (5), 418-428.
- Manly, J.J., Jacobs, D.M., Sano, M., Merchant, C.A., Small, S.A., & Stern, Y. (1999). Effect of literacy on neuropsychological test performance in nondemented, education-matched elders. *Journal of the International Neuropsychological Society*, 5, 191-202.
- McCue, M., Rogers, J.C., & Goldstein, G. (1990). Relationship between neuropsychological and functional assessment in elderly neuropsychiatric patients. *Rehabilitation Psychology*, 35, 91-99.
- Mesulam, M.M. (2002). The human frontal lobes: Transcending the default mode through contingent encoding. In D.T. Stuss & R.T. Knight (Ed.), *Principles of Frontal Lobe Function* (pp. 8-30). New York, NY: Oxford University Press.
- Myers, A.M., Holliday, P.J., Harvey, K.A., & Hutchinson, K.S. (1993). Functional performance measures: Are they superior to self-assessments? *Journal of Gerontology*, 48, M196-M206.
- Owen, A., Downes, J.J., Sahakian, B.J., Polkey, C.E., & Robbins, T.W. (1990). Planning and spatial working memory following frontal lobe lesions in man. *Neuropsychologia*, 28, 1021-1034.

- Radloff, L.S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*, 385-401.
- Richardson, E.D., Nadler, J.D., & Malloy, P.F. (1995). Neuropsychologic predictors of performance measures of daily living skills in geriatric patients. *Neuropsychology, 9*, 565-572.
- Robbins, T.W., Merle, J., Adrian, M.O., Sahakian, B.J., Lawrence, A.D., McInnes, L., & Rabbitt, P.M.A. (1998). A study of performance on tests from the CANTAB battery sensitive to frontal lobe dysfunction in a large sample of normal volunteers: Implications for theories of executive functioning and cognitive aging. *Journal of the International Neuropsychological Society, 4*, 474-490.
- Royall, D.R., Lauterbach, E.C., Cummings, J.L., Reeve, A., Rummans, T.A., Kaufer, D.I., LaFrance, W.C., & Coffey, C.E. (2002). Executive control function: a review of its promise and challenges for clinical research. *Journal of Neuropsychiatry and Clinical Neuroscience, 14*, 377-405.
- Royall, D.R., Palmer, R., Chiodo, L.K., & Polk, M.J. (2004). Declining executive control in normal aging predicts change in functional status: The Freedom House Study. *Journal of the American Geriatrics Society, 52*, 346-352.
- Ruff, R.M. (1988). *Ruff Figural Fluency Test, Professional Manual*. Odessa, FL: Psychological Assessment Resources.
- Sager, M.A., Dunham, N.C., Schwantes, A., Mecum, L., Halverson, K., & Harlowe, D. (1992). Measurement of activities of daily living in hospitalized elderly: A comparison of self-report and performance-based methods. *Journal of the American Geriatric Society, 40*, 457-462.

- Salmoni, M. R., Viverais-Dressler, G., Porter, E., & Garg, R. (1997). Perceived risks to independent living: the views of older, community-dwelling adults. *Gerontologist*, 37 (6), 729-736.
- Sbordone, R.J. (2000). The executive functions of the brain. In G. Groth-Marnat (Ed.), *Neuropsychological Assessment in Clinical Practice* (pp. 437-456). New York: John Wiley and Sons, Inc.
- Shallice, T. (2002). Fractionation of the supervisory system. In D.T. Stuss & R.T. Knight (Ed.), *Principles of Frontal Lobe Function* (pp. 261-277). New York: Oxford University Press.
- Sherman, S.E., Reuben, D. (1998). Measures of functional status in community-dwelling elders. *Journal of General Internal Medicine*, 13 (12), 817-823.
- Stuss, D.T., & Knight, R.T. (2002). *Principles of Frontal Lobe Function*. New York: Oxford University Press.
- Tabert, M.H., Albert, S.M., Borukhova-Milov, L., Camacho, Y., Pelton, G., Liu, X., Stern Y., & Devanand, D.P. (2002). Functional deficits in patients with mild cognitive impairment: Prediction of AD. *Neurology*, 58, 758-764.
- United States Census Bureau (2005). URL address: <http://www.census.gov>
- Wecker, N.S., Kramer, J.H., Wisniewski, A., Delis, D.C., & Kaplan, E. (2000). Age effects on executive ability. *Neuropsychology*, 14, 409-414.
- Whittle, H. & Goldenberg, D. (1996). Functional health status and instrumental activities of daily living performance in noninstitutionalized elderly people. *Journal of Advanced Nursing*, 23, 220-227.
- Zanetti, O., Frisoni, G.B., Rozzini, L., Bianchetti, A., & Trabucchi, M. (1998). Validity of

Direct Assessment of Functional Status as a tool for measuring Alzheimer's disease severity. *Age and Ageing*, 27, 615-622.

Zanetti, O., Geroldi, C., Frisoni, G.B., Bianchetti, A., & Trabucchi, M. (1999). Contrasting results between caregiver's report and direct assessment of activities of daily living in patients affected by mild and very mild dementia: The contribution of the caregiver's personal characteristics. *Journal of the American Geriatrics Society*, 47 (2), 196-202.