

EXECUTIVE FUNCTION AS A PREDICTOR OF INSTRUMENTAL ACTIVITIES OF DAILY LIVING
(IADLs) IN COMMUNITY-DWELLING OLDER ADULTS

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Abstract

Objective. Executive functioning is a set of cognitive processes that support planning, initiation, and execution of purposeful behaviors, of mental flexibility, and of problem solving. Previous studies have demonstrated that executive dysfunction is a more sensitive and strong predictor of functional impairment than other cognitive abilities in elderly individuals. Currently, there is not sufficient evidence about the relation between specific executive function and functional abilities that can practically be applied among older adults for improvement of functional status. The purpose of this study is to identify which component of executive function (updating, shifting, and inhibition) is most closely related to functional abilities in older adults, as measured by the Direct Assessment of Functional Status-Extended version (DAFS-Extended version).

Method. 41 healthy community dwelling older adults aged from 66 to 90 years participated in this study. The Direct Assessment of Functional Status-Extended version (DAFS-Extended version) was used as a performance-based measure of instrumental activities of daily living (IADLs), including communication, financial, shopping, and medication tasks. A battery of cognitive tasks measuring executive function was administered, and this includes six tests: Antisaccade and Stroop tasks tapping “Inhibition”, Letter Memory and Keep Track tasks tapping “Updating”, and Category Switch and Color Shape tasks tapping “Shifting”.

Results. A multiple regression analysis was conducted to examine the relation between the three executive function factor scores and DAFS total scores. The results of the present study indicated that the measures of executive function, used in this study, predicted IADL functioning significantly. Measures of inhibition were the best predictors of ability to perform IADLs as measured by DAFS-Extended version.

Conclusion. This study suggests that inhibition (deliberately suppressing dominant, automatic, or prepotent responses) may be important to perform IADLs, and the measures of inhibition might serve as a

detector of initial functional decline among older adults. Also, occupational therapists can create interventions focusing on developing inhibition skills to improve or maintain functional abilities. This study will inform occupational therapists about which component of executive function they should target in treatment processes to promote and maintain functional abilities, independent living, and well-being among older adults.

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Introduction and Literature Review

Functional impairment frequently interferes with an individual's ability to live independently in the community, and to maintain a good quality of life among older people and their caregivers (Grigsby, Kaye, Baxter, Shetterly, & Hamman, 1998). Since older adults' physical and cognitive functions significantly affect the level of independence and participation in their necessary and desired activities, the importance of maintaining and improving functional status of the elderly has been a growing interest. Various cognitive factors affect functional decline in the elderly, such as global cognitive status, visuospatial ability, memory, and executive functioning (Mitchell & Miller, 2008). If executive functions are intact, a person can be independent and productive even after the loss of other cognitive abilities, such as memory, language, or visuospatial ability. (Lezak, Howieson, & Loring, 2004).

Executive functioning is a set of cognitive processes that support planning, initiation, and execution of purposeful behaviors, including mental flexibility and problem solving (Johnson, Lui, & Yaffe, 2007). Because many of these skills are required to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs), even mild executive dysfunction could have an impact on functional ability (Johnson et al., 2007). While ADLs are self-care activities including dressing, grooming, toileting, and bathing, IADLs are more complex and are essential for living within the home and community. For example, IADLs include shopping, using telephones, preparing meals, and managing medications.

Prior studies support that executive dysfunction is a more sensitive and stronger predictor of functional impairment than other cognitive abilities in elderly individuals. For example, Grigsby et al. (1998) found a significant association between executive functioning and seven functional status

measures (self-report and observed performance in ADLs and IADLs) among 1158 community-dwelling elderly people. By contrast, general mental status (MMSE score) was not a significant predictor of functional status in this study. Also, Royall, Palmer, Chiodo, and Polk (2004) demonstrated that executive function was strongly correlated with a decline in functional status over 3 years in the non-demented elderly, but the Mini-Mental State Examination (MMSE) was not, which is a widely used measure of global cognitive ability. Johnson et al. (2007) studied 7717 community-dwelling elderly women who completed cognitive and functional evaluations at baseline and at a 6-year follow-up. They found that women with executive function impairment, regardless of their scores on the 26-point modified MMSE, had much worse ADL and IADL function than women with no impairment at baseline and over 6 years. Johnson et al. (2007) stated that this finding is consistent with prior studies that found a strong relationship between executive function and functional dependence (Grigsby et al., 1998; Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Carlson et al., 1999). All these studies suggest executive dysfunction may be a strong predictor of functional decline in normal aging.

Improvements of executive function may bring about improved functional status (Ball et al., 2002; Levin et al., 2000; Willis et al., 2006). However, executive function has multiple components, and the studies described above generally assessed only one component of executive function. Before developing an intervention to improve functional status, we need to know what aspect of executive function is most closely related to functional status. One approach to solving the question of identifying the components of executive function is the factor analytic approach used by Miyake, Emerson, and Friedman (2000). They studied three frequently postulated executive functions (termed “shifting”, “updating”, and “inhibition”) to examine the extent to which these executive functions tap different, separable abilities. By performing confirmatory factor analysis, the authors concluded that, these three executive functions have a degree of underlying commonality, showing moderately high correlations among the three latent variables. At the same time, however, these executive functions are separable, producing a significantly better fit to the data in the full three-factor model than a one-factor or a two-factor model (Miyake et al., 2000). This approach is useful in understanding the subcomponents of executive function, and provides a

framework to identify which executive function component is most closely related to functional ability instead of relying only on broad conceptualizations of complex cognition.

Miyake et al. (2000) based their findings on studies of college students, but other studies have used a similar factor analysis approach with older adults. Like Miyake et al., Hull, Martin, Beier, Lane, & Hamilton (2008) identified robust shifting and updating factors in one hundred older adults (ages 51-74), but their measures of inhibition, including the Stroop verbal/nonverbal tasks and the Antisaccade task, had weak factor loadings. Although one of the two-factor models was not significantly different from the full, three factor model, Hull et al. (2008) argued that the full, three factor model still provided the best fit to the data. In other work, Vaughan and Giovanelli (2010) studied 95 older adults (ages 60-90) and reported that a three factor model paralleling Miyake et al.'s model provided the best fit. Fisk and Sharp (2004) found inhibition, updating, shifting, and an additional factor (access to long term memory), and age-related deficits in only three factors (inhibition, updating, and shifting). However, this study was conducted with individuals aged between 20 and 81, and it is not known whether this result would be the same in the separate age groups. Even so, overall, these studies suggest that Miyake et al.'s (2000) full, three factor model is applicable to older adults.

Earlier work attempting to identify the relevant component of executive function responsible for functional status has produced mixed results. Jefferson, Paul, Ozonoff, & Cohen (2006) assessed multiple elements of executive functioning to examine the association of these elements (i.e., working memory, generation, inhibition, planning, and sequencing) to IADLs among older adults at risk for future cognitive and functional decline. They determined that inhibition was most strongly related to IADL impairment among the participants. Bell-McGinty, Podell, Franzen, Baird, & Williams (2002) examined multiple clinical executive functioning measures to predict functional status among older adults (i.e., tests of novel problem solving and set shifting, mental flexibility, the ability to initiate and sustain production of words under restricting search conditions, and execution of bodily postures). The results indicated measures of

mental flexibility and novel problem solving were significant predictors of performance in IADLs, as measured by the Independent Living Scales (ILS; Loeb, 1996). The mental flexibility component of the Trail Making Test had a significant contribution to performance on IADLs (Carlson et al., 1999), and Vaughan and Giovanello (2010) found a strong relationship between task switching and performance-based IADLs. Grigsby et al. (1998) demonstrated that the autonomous regulation of behavior, measured by the Behavior Dyscontrol Scale (BDS), was a strong predictor of the ability to engage in ADLs and IADLs. As illustrated above, a number of studies have tried to find the executive function most associated with functional status (Bell-McGinty et al., 2002; Jefferson et al., 2006; Grigsby et al., 1998; Cahn-Weiner et al., 2000; Carlson et al., 1999; Vaughan & Giovanello, 2010). However, it is difficult to summarize this work because each study used different executive function and IADL measures.

To summarize, brief screening tests such as Mini-Mental State Examination (MMSE) are insufficient to detect and assess functional impairment in older adults. Executive function has been shown to be a significant predictor of functional impairment, but in order to translate this finding into a practical intervention, it is important to know which aspects of executive function are most closely related to functional status.

There is not sufficient evidence about the relation between specific executive function and functional abilities which can be practically applied for improvement of functional status among older adults. The purpose of this study is to identify which component of executive function among updating, shifting, inhibition is most closely related to functional abilities in older adults, as measured by the Direct Assessment of Functional Status-Extended version (DAFS-Extended version). Another focus in this study is to examine whether the three executive function factors predict different DAFS subscales.

It is difficult to predict which component of executive function is most related to functional ability, and there is relatively little existing data to help make predictions. The data that does exist is mixed. Some studies say than functional status is most related to inhibition (Jurado & Roselli, 2007; Jefferson et al., 2006), switching (Bell-McGinty et al., 2002; Carlson et al., 1999; Vaughan & Giovanello,

2010), or updating (Braver et al., 2001; Hull et al., 2008). Few studies have measured multiple executive function components in a single study. Based on age differences in inhibition (McCrae & Abrams, 2001; Chiappe, Hasher, & Siegel, 2000; Nieuwenhuis, Ridderinkhof, de Jong, Kok, & van der Molen, 2000; Hasher, Stoltzfus, Zacks, & Rypma, 1991), and the finding that inhibition is related to IADLs (Jurado & Rosselli, 2007), it is hypothesized that “inhibition” will be most related to performance on the DAFS-Extended version.

A variety of evidence supports the prediction of inhibition as most related to IADLs. Jefferson et al. (2006) found that the Color word task, inhibiting prepotent responses, had higher correlations with more IADLs among global cognitive ability, verbal generation, nonverbal generation, shifting and sequencing, working memory, planning and problem solving, and inhibition tasks. The authors suggested that previous studies emphasized sequencing as a closely associated executive function with IADLs because few studies included pure measures of inhibition, shifting, and working memory (Jefferson et al., 2006). Although MMSE and Trail-Making test showed significant correlations with some IADL items, these tests don’t tap pure aspect of executive function. On the other hand, the color-word test is a purer inhibition test, and more aspects of correlations with IADLs in this inhibition task indicate that inhibition is most closely related to IADLs (Jefferson et al.). Some studies found that age-related deficits in updating were significant suggesting reduction in working memory capacity in older adults, which seems to be the most representing capacity of updating skills (Braver et al., 2001; Hull et al., 2008). However, the Paced Auditory Serial Addition Task (PASAT), a measure of working memory, didn’t show significant correlation with any IADL items (Jefferson et al., 2006). These results are consistent with the hypothesis that inhibition will be most related to performance in IADLs, as measured by the DAFS-Extended version, among updating, inhibition, shifting.

Some studies have also supported an association between executive function and physical function (Ble et al., 2005; Carlson et al., 1999; Rosano et al., 2005). Older adults who engaged in more physical activity had significantly better performance on executive function tests (Eggermont, Milberg,

Lipsitz, Scherder, & Leveille, 2009). This might be because aerobic fitness protects older adults from age-related frontal atrophy and improves frontal metabolism (Kramer et al., 2002). The present study also will assess the relation between physical function and executive function.

Medication management skills are required for older adults' health and quality of life (Roth & Ivey, 2005). Since some age-related factors, such as reduced comprehension, memory, visual acuity, and strength, may interfere with managing medication properly (Kendrick & Bayne, 1982), the association between age and DAES medication scores will also be conducted.

Method

Participants/ Setting

The participants were 41 randomly selected older individuals chosen from among 200 participants who participated in a larger study of health and aging (HSC # 10454) at the University of Kansas Medical Center. Each participant came to the Grayhawk lab at the Landon Center on Aging at the University of Kansas Medical Center, Kansas City, KS. The participants were all healthy community dwelling older adults aged from 66 to 90 years, consisting of 20 males and 21 females. Among the participants, 56.1% had high-blood pressure, 43.9% had arthritis, 24.4% had heart disease, and 14.6% had diabetes. Participants were predominantly White (40 White, 1 Hispanic), and they were all native English-speaker with normal or corrected-to-normal hearing and vision.

Materials/Instrumentation

Functional Status Measure. The Direct Assessment of Functional Status-Extended version (DAFS-Extended version) is a performance-based measure of instrumental activities of daily living (IADLs). It was revised from a previous version (DAFS; Loewenstein et al., 1989) to remove items that were too simple such as time orientation and to add more difficult subscales (e.g., emphasizing

medication management skills) in order to be more appropriate for use with healthy community-dwelling older adults (McDougall, Becker, Vaughan, Acee, & Delville, 2009). McDougall et al. (2009) stated that the validity of the DAFS-Extended version was supported by correlations with the Mini-Mental State Examination (MMSE) and the Rivermead Behavioral Memory Test (RBMT), and suggested that the items in DAFS-Extended version requiring higher level daily living skills can be used for an initial screening tool of functional decline.

The four categories of test items are:

1. Communication Skills (10 points): assesses the ability to use a telephone and prepare a letter for mailing.
2. Financial Skills (13 points): assesses the ability to count currency, write a check, balance a checkbook, and make change for a purchase.
3. Shopping Skills (12 points): assesses the ability to recall and recognize six grocery items from a list after a brief delay.
4. Medication Skills (24 points): demonstrates the ability to identify medication, refill a prescription over the phone using an automated phone system, and manage a pillbox.

Executive Function Measures. A battery of cognitive tasks measuring executive function was administered (Friedman & Miyake, 2004). The computerized battery included six tests.

1. Antisaccade task (inhibition): Participants see a small black square presented on either the left or right side of the computer screen that acts as a cue to the location of a target number. The task was to say the number out loud as quickly as possible before the number was covered by a visual mask. In the first condition, the number appeared on the same side with the black square cue. In the second condition, the number was presented on the opposite side from the

- cue, and participants must inhibit the tendency to look at the cue, and look in the opposite direction to report the number. The measure of interest is accuracy in the two conditions.
2. Stroop task (inhibition): In the first condition, participants were instructed to name the color of a series of asterisk strings that appeared in the center of the screen as quickly as possible. In the second condition, color words were presented in different colored fonts. Participants were required to say the color of the words as quickly as possible while ignoring the word itself. The measure of interest is reaction time difference in the two conditions.
 3. Letter Memory task (updating): In this task, a series of 7-13 letters were presented one at a time for 3 seconds per letter. Participants were required to keep track of the most recent 3 letters, and to report the most recent 3 letters at the end of trial. The measure of interest is accuracy of participants' recall.
 4. Keep Track task (updating) – In the keep track task, 2 or 3 exemplars from each of six possible target categories (animals, colors, countries, distances, metals, and relatives) were shown serially and in random order for 1500 ms apiece. Participants were instructed to monitor the words from a subset of the categories, update working memory contents each time a word from one of these target categories is presented, and report the most recent word from each of the target categories at the end of each trial. The measure of interest is accuracy of participants' recalled words.
 5. Color-Shape task (shifting): In the color-shape task, the participants were presented with one colored shape at a time on the computer screen. Just above the colored shape, a letter 'C' or 'S' appeared acting as a cue. The participants were instructed to decide whether the colored shape was green or red when they saw the letter 'C', and to decide whether the colored shape was a circle or a triangle when they saw the letter 'S'. In the first condition, participants were required to do a set of color only or shape only trials. In the second condition, participants had to shift between color and shape in two blocks of mixed trials, depending on the cue letter 'C' or 'S'. The measure of interest is reaction time difference in the two conditions.

6. Category Switch task (shifting) – In the category switch task, participants were presented with a word on a computer screen. Just before the word, either a heart or intersecting arrows appeared as a cue. The participants were instructed to decide whether the word represents a living or nonliving thing when they saw a heart, and decide whether the word represents something that is smaller or larger than a soccer ball when they saw intersecting arrows. In the first condition, the computer only showed the heart symbol and the words, or intersecting arrows and the words, separately. In the second condition, participants had to switch between the two categories according to the symbol they saw on the screen on a trial by trial basis. The measure of interest is reaction time difference in the two conditions.

Physical Function Measures.

The Physical Function tasks included an evaluation of grip strength, the 30-second chair rise test, and the 8-foot up and go test. To measure grip strength, participants hold their dominant arm at their side, bend their elbow slightly, and squeeze a dynamometer as hard as they can three times. The 30-second chair rise test is a measure of leg strength. Participants were instructed to fold their arms across their chest and then stand up from and sit back down onto a straight-back desk chair as many times as they can over a 30 second period. The measure of interest is the number of full stands during the 30-second test period. The 8-foot up and go test assesses both walking speed and balance ability. Participants were instructed to get up from a straight-back desk chair, walk forward in a straight line for 8 feet, around a marker placed at the 8-foot point, return to the chair, and sit back down. They were asked to do this sequence as quickly as they can while still feeling comfortable.

Additional measures. A computerized Visual Acuity task required participants to decide which direction a letter “C” was pointing on the computer screen by pressing one of the 8 possible direction keys on the keyboard. The computer made the letter “C” smaller and smaller when participants responded

correctly until they could not see the letter, and the letter “C” got bigger when participants were wrong several times in a row. The dependent measure for this task is Snellen Fraction (ft).

In the Shipley Vocabulary task, participants were presented with one target word in capital letters and four other words below that target word. Participants were instructed to circle the word that is synonymous (or most similar) to the target word. There are 40 target words, with each correctly identified synonym scored as 1 point.

Procedure and design

Participants were scheduled via telephone, and they were required to come to the laboratory on two separate days. Informed consent was obtained prior to participation in the first session. Assessments in the first session included the demographic information form, the measure of visual acuity, the Shipley Vocabulary task, the DAFS-Extended version test, and other tests from the larger battery. The first session took 1.5-2 hours to complete.

In the second session, each participant returned to the laboratory on a separate day, not later than a month after the first session, and completed 9 executive function tasks and two speeds of processing tasks. Participants had three rest breaks scheduled during tests and they could ask for additional breaks at any time. The second session took 2.5 -3 hours to complete. Upon completing the study, participants received \$ 50 in compensation for their time. Separate subject numbers were assigned to identify each participant’s data in order to maintain confidentiality. No personally-identifying information was included in the dataset.

Results

Table 1 shows the demographic characteristics and physical function scores of participants. Mean age was 78.1 years, and the mean years of formal education were 16.7 years. Participants’ mean BMI was 27.6 ($25 \leq \text{BMI} < 30$: overweight). They got 35 correct answers among 40 questions in the Shipley

Vocabulary test. Mean visual acuity was 20/30, and mean grip strength was 25.4 kg. The participants could stand up and sit down from a chair almost twelve times for 30 seconds. It took almost 8 seconds in 8-foot Up and Go test. Table 3 compares the participants' physical function measure scores with norms in the same age group. The participants were representative of older adults in the same age group in all three physical function measures. Table 2 shows the characteristics of participants divided by age decades and sex.

Descriptive statistics for DAFS scores, including total score and subscale scores, are presented in Table 4. These data indicate that percent correct responses were highest in finance (92.3%) and lowest in shopping (79.2%). Percent correct in the other two items (communication= 86.0%, medication= 87.9%) and total (86.8%) are similar. To examine performance differences between items within each subscale more closely, the percent correct for each task was calculated (Figure 1). Participants performed more than 80% correct in all but three tasks, which were dialing number from phone book, dialing number orally presented, and recalling the six grocery items.

Descriptive statistics for six measures of executive function are presented in Table 5. Because one participant was not able to complete the executive function tasks, 40 participants' data were used. Based on Miyake et al.'s (2000) work, factor scores representing composite measures of the three executive function components were created for use in the regression analysis described below. The keep track and letter memory tasks were found to tap "updating" in Miyake's work; we entered these variables into a factor analysis to create "updating" factor scores. These variables were found to load strongly on a single factor; 75.13% of variance was accounted for by the single factor; factor loadings for each task were .867. The Antisaccade and Stroop tasks were found to tap "inhibition" in Miyake's work; we entered these variables into a factor analysis to create "inhibition" factor scores. These variables were found to load strongly on a single factor; 63.76% of variance was accounted for by the single factor; factor loadings for

each task were .798 and -.798, respectively. The category switch and color shape tasks were found to tap “shifting” in Miyake’s work; we entered these variables into a factor analysis to create “shifting” factor scores. These variables were found to load strongly on a single factor; 65% of variance was accounted for by the single factor; factor loadings for each task were .806. Table 6 shows the Pearson product-moment correlation coefficients between the three EF factor scores and DAFS total scores. All three executive function factors were correlated with DAFS total. Correlation coefficients for inhibition, updating, and shifting factors with DAFS total were .581, .510, and .500, respectively.

A multiple regression analysis was conducted to examine the relation between the three executive function factor scores and DAFS total scores. In this model, the dependent variable was DAFS total scores, and the independent variables were inhibition factor scores, updating factor scores, and shifting factor scores. The overall analysis was significant (adjusted $R^2=0.420$, $F (3, 36) = 10.417$, $p=0.000$). 42.0% of the variance in DAFS total scores can be accounted for by its linear relationship with the independent variables. The results of the multiple regression analysis for prediction of DAFS-total are presented in Table 7. The standardized regression coefficients showed that the inhibition factor scores were most highly related to the DAFS total scores among the three EF factors (standardized coefficient= .344, $p=.026$).

To examine how well each EF factor can predict the four DAFS subscales (Communication, Financial, Shopping, and Medication tasks), multiple regression analyses were conducted among the three EF factors and each DAFS subscale (Table 8). Of the three executive function factors, the shifting factor accounted for the most variance in the shopping task (adjusted $R^2=.218$, $F (3, 36) = 4.624$, $\beta =.327$, $p=.044$), and the updating factor accounted for the most variance in the medication task (adjusted $R^2=.261$, $F (3, 36) = 5.597$, $\beta =.393$, $p=.021$). However, none of the individual executive function factors accounted for significant variances in the communication and financial tasks. Medication management skills are required for older adults’ health and quality of life (Roth & Ivey, 2005). Since some age-related factors, such as reduced comprehension, memory, visual acuity, and strength, may interfere with managing

medication properly (Kendrick & Bayne, 1982), the association between age and DAFS medication scores will also be conducted.

Factor scores for the two physical function measures, including number of stands and 8 foot up and go, were created for use in the regression analysis described below. Grip strength was eliminated because of its low correlation with cognitive ability. We entered these variables into a factor analysis to create “physical function” factor scores. These variables were found to load strongly on a single factor; 84.1% of variance was accounted for by the single factor; factor loadings in number of stands and 8 foot up and go were .917 and -.917, respectively. A multiple regression analysis was conducted using the three executive function factors and the physical function factor (Table 9). The dependent variable was the physical function factor, and independent variables were updating factor scores, inhibition factor scores, and shifting factor scores. The overall analysis was significant ($p=.002$), and 28.1% of the variance in physical function factor scores was accounted for by executive function variables. The standardized regression coefficients showed that the inhibition factor scores and shifting factor scores were highly related to the physical function factor scores among the three EF factors (Standardized coefficients= .555 and -.516, respectively).

Significant correlations were found between age and DAFS medication scores and between age and DAFS total scores (Table 10). The correlation coefficients were -.485 between age and DAFS medication scores and -.438 between age and DAFS total scores.

Discussion

The results of the present study indicate that the measures of executive function used in this study predicted IADL functioning significantly. The composite measure of inhibition was the best predictor of ability to perform IADLs as measured by DAFS-Extended version. Therefore, the ability to deliberately inhibit dominant, automatic, or prepotent responses was most important to IADLs among the variables we

measured in generally healthy, community-dwelling older adults. Attention and memory-related abilities were required to do daily activities, and inhibition may affect memory and attention. Also, inhibition may be important to perform IADLs and the measures of inhibition might serve as a detector of initial functional decline among older adults.

Another important finding is that individual IADL subscales (communication, finance, shopping, and medication) were not significantly predicted by the measures of inhibition. In other words, inhibition may be more important to the integrity of IADLs than updating and shifting, but not to the specific IADLs. In other work, Jefferson et al. (2006) also found that a measure of inhibition (Stroop task) was the best predictor of the ability to perform IADLs. However, significant correlations were found between the inhibition measure and individual IADL items (shopping, laundry, transportation, and finances) in Jefferson et al. The different results between Jefferson et al. and the present study may be because Jefferson et al. used only one inhibition measure (Stroop task) and five complex executive function measures such as the Tower Test and the Trail-Making Test. Except for the Stroop task, which is a relatively purer measure of executive function, the other complex executive function measures are not suitable to isolate individual executive processes, and only one inhibition measure could be less accurate than two or three measures of inhibition. The present study used a performance-based IADL measure, but a caregiver-reported IADL measure was used in Jefferson's study. Because of informant bias, the real abilities could be over- or under-estimated in Jefferson's study. Also, participants in Jefferson et al. had a documented history of cardiovascular disease. This might cause different results of the relationships between inhibition measure and individual IADL items because these relationships might vary with disability.

Most participants performed well on most of the DAFS items. However, a few items appeared to be particularly difficult. Among communication tasks, the lowest performance was for the item requiring the participant to dial a telephone number presented orally (Figure 1). This is the lowest percent correct among the entire tasks as well as communication tasks. This result can be because of diminished auditory

focused attention or my accent when I read the number to the participants. Compared to high performance in the other communication tasks, participants also performed relatively poorly in dialing a telephone number from a phone book. This can be because of selective visual attention problem, small letters of the phone book, or fine motor control problem. Many participants pressed the same number on the phone twice, or they tried to press the number, but it was not pressed indeed. However, the percent correct was high in the task of dialing a number written down in bigger letters, so the reason why the score in dialing number from phone book was relatively low may be due to visual problems. The scores in the letter mailing tasks were high in which the instruction was to “prepare this letter and envelope to be mailed as you would normally do.” Participants had to think about several steps of mailing, and the instruction was not as definite as the ones like “write the address, put the letter in the envelope, and seal and stamp the envelope.” Some participants forgot to seal envelop or put the letter in the envelope even though they have mailed a letter many times in their entire lives. This may be because of an age-related decrease in attention, simply low concentration on the task, fatigue, or decreased abilities in planning and sequencing. Most of the older adults performed well on communication tasks, and this indicates that communication is not significantly affected by the aging process in normal older adults.

The participants showed the highest performance in financial tasks (Table 4). Since mathematical calculation is related to intelligence or education, the participants with high education performed well on finance. The correlation between education and DAFS financial scores was significant (Pearson correlation= .420, p<.001). This suggests that financial management skills may not be affected by age and they are more related to intelligence or education.

The results of the shopping tasks have the greatest variability and lowest percent correct among the four IADL subscales (Table 4). In the shopping tasks, memory and visual attention /scanning were required to recall the six grocery items which the participants had memorized 10 minutes previously and point out the items on the grocery shelf with many grocery items. The grocery shopping list was repeated until the participant could correctly learn all six items. Average repetitions required to learn all the six

grocery items was two, though some participants needed more repetitions to learn all six items. I wondered if more repetitions helped participants to recall or recognize the six grocery items 10 minutes later because more repetitions could help some items be more deeply encoded. For example, some participants could say four or five items, and they listened to the list of the six grocery items several times until they could say the entire list. The items encoded the first time were repeated again and again while learning the other items which were not encoded well. This might help deeper encoding of the list. However, the number of repetition had no statistically significant correlation with recalling or recognizing the six items. The percent correct in recall and in recognition are presented in Figure 1. Participants remembered more items when they saw the grocery shelf than trying to recall the items without any cues. These results support that recall is more difficult than recognition because recall requires retrieval of candidate items from memory along with a familiarity decision, but recognition only needs a familiarity decision (Haist, Shimamura, & Squire, 1992).

The medication task requires many cognitive skills such as memory, problem solving, reasoning, auditory attention, and visual attention skills. Among the medication tasks, participants performed poorly on the prescription refill task (Figure 1). Some participants could not remember the day and time to pick up the prescription from the pharmacy, or pressed the wrong number on the phone. This can be because of inattention, a working memory problem, or fine motor control by pressing the same number twice or failing to press the number on the phone. In the pillbox task, participants had 86.3% correct in the entire task and poor performances in specific medication instructions. For example, the instruction for Marinol was to take 1 tablet before lunch and dinner, and participants had lowest percent correct on this item (Figure 2). Participants seemed confused with this ambiguous instruction. Some participants eat lunch between noon and evening, and they were not sure about where they should put the pills thinking that there is no perfectly fit space for this instruction. However, because the instruction is to take the pill before lunch, the participants can put the pill in the space for noon if they eat lunch after noon. On the other hand, they performed much better with concrete and definite instructions such as taking 1 pill at

bedtime for sleep (Figure 2). As people age, it might be getting more difficult to manage their medication. The present study found age-related decrease in medication management skills (Table 10). Since optimal medication management skill is one key to successful aging (Edelberg, Shallenberger, & Wei, 1999), performance-based medication management skill tasks should be regarded as a sensitive indicator of age-related cognitive and functional declines.

Inhibition factor scores were most related to DAFS total scores, and attention and memory-related abilities were required in DAFS-Extended version. This suggests that inhibition may affect memory and attention. Because age-related deficits in inhibition have been found in studies, inhibition might be an important ability for successful aging.

Some changes might be made to increase the DAFS-Extended version's sensitivity to the early decrements in IADLs and initial cognitive impairments among older adults in the normal aging process. First, this IADL instrument can be revised to serve better as an early detector of decreased functional and cognitive abilities by omitting easy items and adding more challenging subscales. Although this revised version omitted easy items from the previous version, there are still some easy items, such as dialing the operator, counting currency, and identifying medication, in this version (Figure 1).

Second, the DAFS-Extended version can be updated according to the current trends and a pattern of loss of functional tasks in the elderly. Some participants responded that they no longer use an automated phone system to refill a prescription and use a computer system instead. They said that they do not have to call the pharmacy to refill the prescription any more. To reflect this trend, it will be useful to include all possible choices such as automated phone system and computer refilling system. A specific pattern of loss of functional tasks was suggested in a large prospective study of 10,263 elderly Canadians for 5 years (Njegovan, Hing, Mitchell, & Molnar, 2001). The participants lost independence in medication use at first, and then finances, use, meal preparation, shopping, and homemaking. This result is similar but not identical to other studies suggesting the earlier dependency in activities outside

(shopping) than those within the home (telephone use). This might be because tasks can be so different according to the abilities the task requires. For example, the shopping task in the DAFS- Extended version includes remembering the six grocery items and recalling and pointing out the items in ten minutes. Thus this task more focuses on memory, and not the real shopping situation.

Third, IADL subscales can be revised by including more various physical functions. This DAFS- Extended version mostly requires minimal physical function, but some IADL tasks simultaneously require more various physical functions in the real environments. We will bend our body to find the pot in a bottom cabinet, or lift shoulder to take down a stored vegetable can on the top shelf. Because there is a relationship between physical function and cognition, it will be better to include more various physical functions in the IADL tasks in order to serve as a better predictor of independence in a real life rather than requiring only arm and hand function in a seated position.

Fourth, tasks can be revised to be as similar as possible to the real tasks to assess the same abilities in real life situation, especially the shopping task. It takes more time and effort to do shopping tasks in naturalized settings such as a supermarket and shopping mall. This shopping task we use here only tests the ability to recall the six grocery items which the participant was asked to remember 10 minutes ago and point out the items from 30 items, arranged on a shelf. However, the real grocery shopping situation is more complex and it requires more than memory. Most people take a shopping list and they don't have to memorize the items. For successful and independent shopping, people should find the shopping items effectively from the correct section without being distracted by other items, people, or noises. This requires various cognition-related abilities to find the needed items effectively, such as visual selective attention, spatial relation, figure-ground, and visual motor coordination. It would be optimal to do the shopping task in a real supermarket but if it is impossible, the task should be done in a similar setting at the lab or hospital. The Test of Grocery Shopping Skills (TOGSS) was assessed in the natural context of a grocery store and participants were required to select the correct size and lowest price for each item from a list of ten grocery store items (Hamera & Brown, 2000). To make the unnatural task

environment in the present study more similar to a real life shopping situation like TOGSS, for example, a participant is given a list of grocery items with more detailed descriptions like 300 ml tomato ketchup of the specific brand, arranged on a shelf with three or four ketchups of different brands, and do the same thing for the different items on a list. The participant will be tested about how accurately and quickly he or she finishes the grocery shopping. It requires higher level of attention. Memory capacity of the elderly has been found to be decreased as they age. However, if older people use some strategies to make up for their diminished memory for independent participation in their everyday lives, it is no big deal. Also, the shopping task we used here depends highly on memory capacity, and it might hinder measuring actual abilities for shopping.

Fifth, these findings suggest that the instruction for Tramadol (take every 6 hours as needed for pain) should be revised in pillbox task. Because the instruction is to take a pill every 6 hours as needed for pain, when participants encountered this instruction, many of them chose not to put Tramadol in the pillbox. The scores of Tramadol were removed in this present study because of the insufficient instruction. To use this instruction in the task, more information can be added, such as asking “if you had the pain all day long today, how would you take this medication?” Because people have the different time schedules to get up and to go to sleep, this variable could be added by asking participants about it. Also, several versions should be developed for follow-up. If the exact same task is used for follow-up, the results of the second or third test may be better than the first one due to practice alone. Developing several versions of the test will provide better validity of retest.

Last, performance time can be included in each IADL task. In addition to accuracy in performing IADL tasks, the time taken to complete the tasks is also important criterion for successful aging. Older adults with poor cognitive status are more likely to take more time to complete IADL tasks such as locating an item on a crowded shelf, reading the instructions on a medication bottle, and reading the ingredients on a can of food (Owsley, Sloane, McGwin, & Ball, 2002).

Executive function was found to be a significant predictor of physical performance in this present study (Table 9). A physically active lifestyle may contribute to the maintenance of executive function and thus independent functioning. In this present study, grip strength was not included in calculating the physical function factor scores. Grip strength does not require high level cognitive abilities and executive function processes, but lower extremity function, such as balance and gait, may (Nieto, Albert, Morrow, & Saxton, 2008). Some studies have found the association of poor balance and gait in older adults with atrophy of the frontal and temporal lobes (Whitman, Tang, Lin, & Baloh, 2001). Including lower extremity function tasks like Short Physical Performance Battery (Guralnik et al., 1994) might help to better measure physical function and predict functional ability in further studies.

The present study found different results from a similar study by Vaughan and Giovanello (2010). “Inhibition” was found to be the best predictor of the ability to perform IADLs in the present study, but “shifting” was the best predictor in Vaughan and Giovanello (2010). The present study only analyzed partial data including only two measures of each factor among three (inhibition, updating, and shifting). This might bring about different results because the Miyake’s full three factor model includes three measures for each factor. Also, the executive function tasks were different from that of Vaughan’s study. Although our study and Vaughan’s study used purer measures of executive function, and both used factor analysis, different measures may bring about different results. However, both study used similar performance-based IADL tasks such as medication management, telephone use, financial management, and recalling a shopping list. To find the best EF factor to predict IADLs, the present study should analyze full data by including three measures for each factor.

The results of the present study have practical implications. Measures of executive function, especially inhibition, can be used to predict functional ability and identify initial functional decline in older adults when performance-based IADL tasks are not available. Also, occupational therapists can create interventions focusing on inhibition skills to improve or maintain functional abilities. Occupational therapists should be aware that even minimal losses of cognition can affect participation and quality of

life significantly (Baum, Perlmutter, & Edwards, 2000). This study provides occupational therapists with which aspect of executive function they should target in treatment processes to promote and maintain functional abilities, independent living, and well-being among older adults.

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Table 1

Characteristics of Participants (n=41)

Variable	Mean	SD	Range
Age (years)	78.1	7.4	66.0-90.0
Education (years)	16.7	2.6	8.0-22.0
BMI (kg/m ²)	27.6	4.6	20.0-40.6
Vocabulary (40)	35.4	3.1	25.0-40.0
Snellen Fraction	20/30	-	20/44-20/27
Grip Strength (kg)	25.4	9.5	9.0-47.3
Number of Stands (for 30 sec.)	11.6	5.1	0.0-27.0
8-foot Up & Go (sec)	7.8	2.5	4.0-15.0

Table 2

Characteristics of Participants Divided by Age Decades and Sex (n=41)

	Sex (n)	Age (years)	Education (years)	BMI	Vocab (40)	Snellen Fraction	Grip Strength (kg)	Number of Stands (for 30sec)	8-foot Up&Go (sec)
60's	M(3)	67.0	17.3	30.0	35.7	20/27	38.3	16.3	5.3
	F(4)	67.5	14.0	27.8	32.5	20/27	22.2	16.3	5.8
70's	M(7)	74.1	17.3	26.8	36.0	20/31	33.7	15.0	6.3
	F(8)	74.5	16.5	29.1	36.3	20/29	20.1	9.3	8.6
80+	M(10)	84.8	18.5	28.0	36.3	20/31	28.0	9.0	8.7
	F(9)	85.2	15.4	25.5	34.2	20/33	17.9	10.2	9.0

Table 3

Physical Function Measure Scores

Measure		Mean	SD	Norm
Grip Strength (kg)	Male	31.53	8.94	33.0
	Female	19.52	5.36	21.6
Number of Stands (for 30 sec.)	Male	12.20	5.58	13.0
	Female	11.00	4.74	12.0
8-foot Up & Go (sec)	Male	7.35	2.32	7.2-4.6
	Female	8.24	2.63	7.4-5.2

Table 4

Scores on DAFS-Extended Version (n=41)

DAFS	Mean	SD	Range	Percent Correct (%)
Communication (10)	8.6	1.4	4.0-10.0	86.0
Shopping (12)	9.5	2.4	1.0-12.0	79.2
Financial (13)	12.0	1.0	9.0-13.0	92.3
Medication (24)	21.1	2.2	15.0-24.0	87.9
Total (59)	51.2	4.7	37.0-59.0	86.8

Table 5

Descriptive Statistics for the Executive Function Measures (n=40)

Variable	Mean	SD	Definition
Category Switch RT Cost (ms)	-152.11	240.23	Difference between the average RTs of the trials requiring a mental shift and no shift
Color Shape RT Cost (ms)	-141.99	222.12	Difference between the average RTs of the trials requiring a mental shift and no shift
Antisaccade (items)	75.86	13.29	Percent of target trials answered correctly
Stroop (ms)	362.60	187.87	RT difference between incongruent trials and congruent trials
Keep Track (items)	50.26	14.70	Percent of words recalled correctly
Letter Memory (items)	78.03	17.52	Percent of letters recalled correctly

Table 6

Correlations between the three EF factor scores and DAFS total scores

Correlations					
		UpdateFacSc	InhibFacSc	ShiftFacSc	DAFS-T
UpdateFacSc	Pearson Correlation	1	.509 **	.340 *	.510 **
	Sig. (2-tailed)		.001	.032	.001
	N	41	40	40	41
InhibFacSc	Pearson Correlation	.509 **	1	.405 **	.581 **
	Sig. (2-tailed)	.001		.010	.000
	N	40	40	40	40
ShiftFacSc	Pearson Correlation	.340 *	.405 **	1	.500 **
	Sig. (2-tailed)	.032	.010		.001
	N	40	40	40	40
DAFS-T	Pearson Correlation	.510 **	.581 **	.500 **	1
	Sig. (2-tailed)	.001	.000	.001	
	N	41	40	40	41

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7

Results of the multiple linear regression analysis for prediction of DAFS total

Model	Coefficients ^a										
	Unstandardized Coefficients		Standardized Coefficients		t	Sig.	95.0% Confidence Interval for B		Correlations		
	Beta	Beta					Lower Bound	Upper Bound	Zero-order	Partial	Part
1 (Constant)	51.439		.245	94.325	.000	50.333	52.545				
UpdateFacSc	1.096		.344	1.701	.098	-.211	2.403	.514	.273	.207	
InhibFacSc	1.559		.344	2.328	.026	.201	2.918	.581	.362	.284	
ShiftFacSc	1.257		.278	2.051	.048	.014	2.500	.500	.323	.250	

a. Dependent Variable: DAFS-T

Table 8

Regression among the Three EF Factors and Each DAFS Subscale

Dependent variable	Adjusted R square ^a	ANOVA				Coefficients		
		Model	df	F	Sig.	Model	Beta	Sig.
DAFS-C	-.005	Regression	3	.935	.434	(constant)		.000
		Residual	36			UpdateFacSc	-.173	.366
		Total	39			InhibFacSc	.294	.139
						ShiftFacSc	.045	.800
DAFS-F	.210	Regression	3	4.461	.009	(constant)		.000
		Residual	36			UpdateFacSc	.306	.076
		Total	39			InhibFacSc	.182	.298
						ShiftFacSc	.166	.299
DAFS-S	.218	Regression	3	4.624	.008	(constant)		.000
		Residual	36			UpdateFacSc	.067	.689
		Total	39			InhibFacSc	.257	.144
						ShiftFacSc	.327	.044
DAFS-M	.261	Regression	3	5.597	.003	(constant)		.000
		Residual	36			UpdateFacSc	.393	.021
		Total	39			InhibFacSc	.172	.310
						ShiftFacSc	.123	.424

a. Predictors: (Constant), UpdateFacSc, InhibFacSc, ShiftFacSc

Table 9

Regression among the Three EF Factors and physical function factor

Dependent variable	Adjusted R square ^a	ANOVA				Coefficients		
		Model	df	F	Sig.	Model	Beta	Sig.
Physical Function Factor Score	.281	Regression	3	4.459	.002	(constant)		.939
		Residual	36			UpdateFacSc	-.035	.829
		Total	39			InhibFacSc	.555	.002
						ShiftFacSc	-.516	.002

a. Predictors: (Constant), UpdateFacSc, InhibFacSc, ShiftFacSc

Table 10

Correlations between Age and IADLs

	DAFS-C	DAFS-F	DAFS-S	DAFS-M	DAFS-T
Age	Pearson Correlation	-.305	-.255	-.117	-.485**
	Sig.(2-tailed)	.052	.107	.467	.001
					.004

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 1

Percent Correct for Individual Tasks in the DAFS-Extended Version

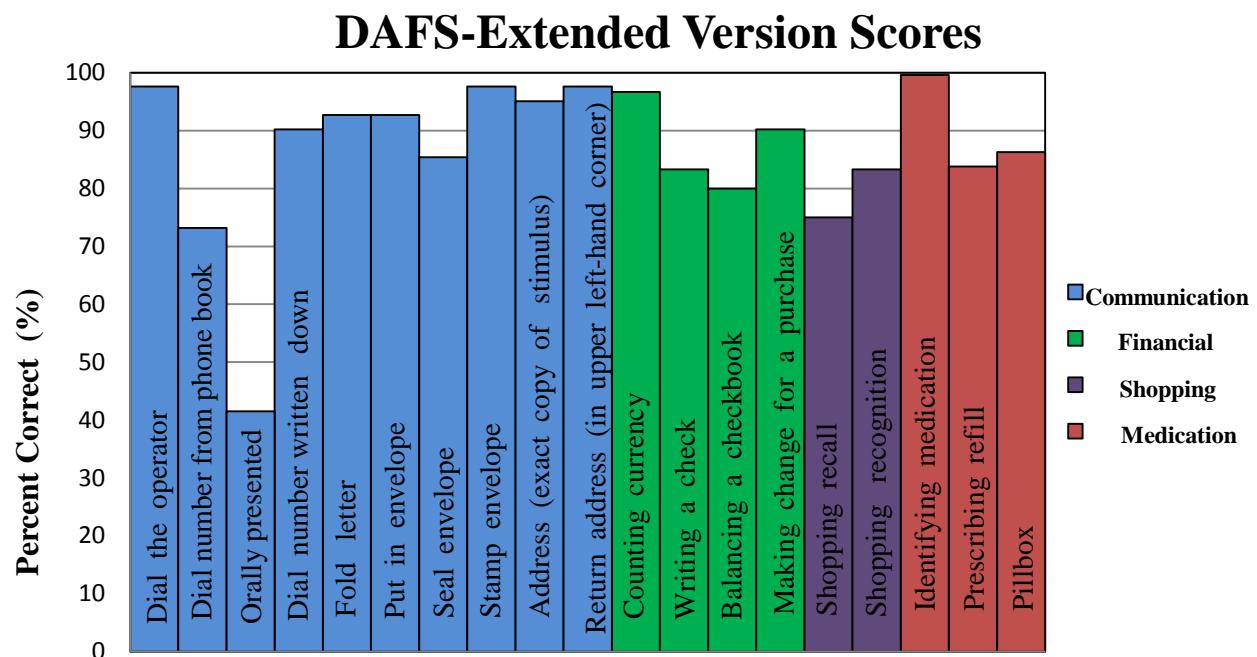
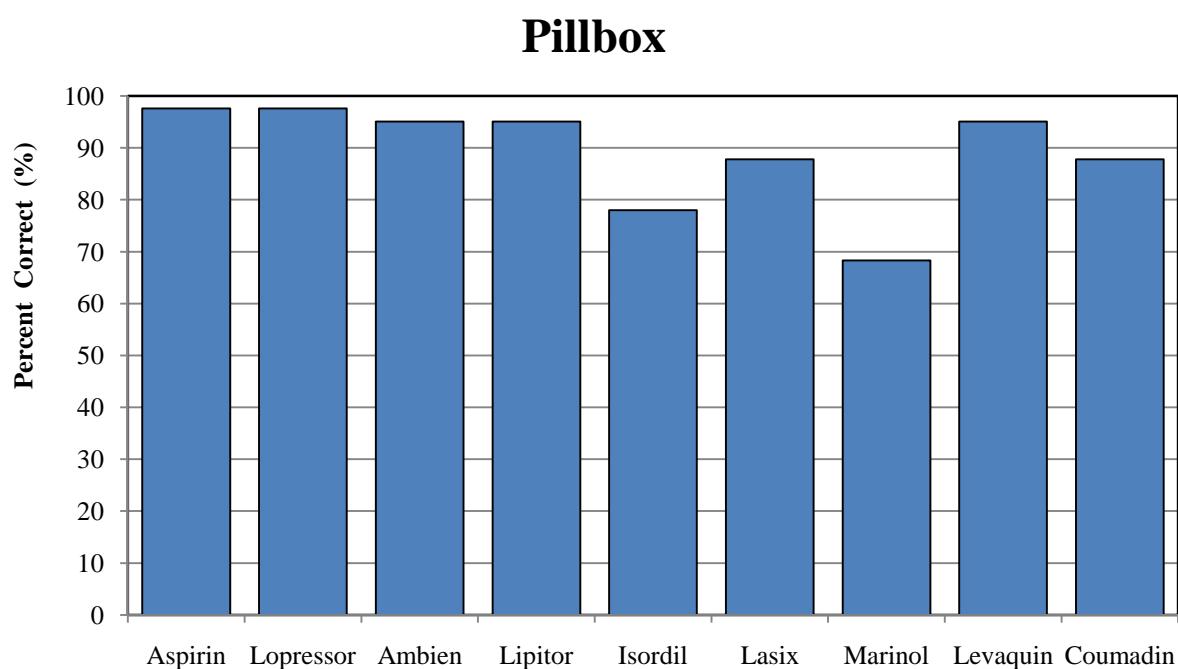


Figure 2

Percent Correct for each Medication in the Pillbox task



Appendix A

Informed Consent

Measuring Cognitive Executive Function

INTRODUCTION

As an older adult who has completed the “Many Dimensions of Aging” questionnaire, you are being invited to participate in a research study. This study is designed to measure the thinking and attention abilities known as cognitive executive function. This research study will be conducted in the Landon Center on Aging at the University of Kansas Medical Center with Joan McDowd, PhD as the principal investigator, in collaboration with David Johnson, PhD from the Gerontology Program at the University of Kansas-Lawrence. Participants will be recruited from Dr. McDowd’s Grayhawk subject panel. We will recruit up to 250 people to complete the survey part of the study, and a subset of 50 people will be recruited to participate in this computerized portion of the study.

BACKGROUND

There are many aspects of attention and cognition that are relevant for everyday tasks like reading or driving. We are interested in how to best design tests that can measure these abilities. In the future, this information will help researchers and health professionals make better decisions about the capabilities of a given person.

PURPOSE

The purpose of this study is to see how different types of computer tasks can be used to measure different types of thinking abilities, such as switching attention between tasks, or focusing on some information and ignoring other information. We are also interested in how performance on these computer tasks may be related to the information you provided on the Many Dimensions of Aging questionnaires.

PROCEDURE

There are four activities that you will be asked to do in this study: (1) thinking tasks, (2) daily life tasks, (3) physical function tasks, and (4) saliva collection. These activities are described in the following paragraphs.

- (1) You will be asked to perform several thinking tasks here in the Grayhawk Laboratory in the Landon Center on Aging. All tests will be performed in a private room. The tests will include tasks like reading words on a computer screen, naming colors, sorting words into categories, learning lists of words, and recalling whether you have seen a particular word or shape before. Each task will be carefully explained before beginning, and you will be given the opportunity to practice each task so you will know exactly what to do.

- (2) You will also be asked to perform a series of daily life tasks such as answering a telephone, taking a message, writing a check, and so forth. As for the computer tasks, each of these daily life tasks will be carefully explained to you before beginning, so you will know exactly what to do.
- (3) You will be asked to perform some physical function tests, and we will measure your height and weight. The physical function tests include gripping a handle as hard as you can to measure hand strength, standing up from a chair several times to measure your leg strength, and walking a short course (16 ft) as quickly as possible to measure walking speed.
- (4) You will be asked to provide a sample of your saliva for genetic testing. The saliva collection procedure requires that you spit saliva into a container that we will provide. This should only take a few minutes to complete. Your saliva will be analyzed for the presence of some specific genes that are associated with particular personality characteristics and with variations in thinking abilities. These genes are not used for any sort of diagnosis of illness.

The cells in your body, including your saliva, contain deoxyribonucleic acid, or DNA for short. DNA is passed down from your parents. It carries the genes that determine how you look and how your body works. Differences in genes may help explain why some people are affected more or less by various health conditions or life experiences. The study of DNA is called genetic research.

Your DNA will only be used for research to understand how certain personality traits, health status, stress and coping, relationship styles, thinking ability and genes are related. This type of testing is still experimental, and the results would not be useful to a physician. For this reason, the results will not be shared with you or your doctor.

Your entire genetic makeup will not be determined from this testing. The information we gain from these analyses will never be associated with your identity or any personal information. All genetic samples from this study will be destroyed after the initial project is complete (about 1 year from now).

The entire study requires approximately 5 hours of your time. We will schedule two sessions for you. The first session will take about 2 hours, and the second session will take 2 ½ - 3 hours of your time. These will be scheduled for you on separate days.

RISKS

You may become tired or feel uncomfortable completing the computer tasks. There will be rest breaks between tasks, and if some tasks are particularly difficult you may skip it and move on to the next one. Also, if at any point you are too tired or uncomfortable to continue you may stop participating all together at any time.

There is a small risk that if people other than the researchers were given your genetic facts, they could misuse them. In order to minimize these risks, your genetic information will be kept confidential.

BENEFITS

There are no benefits to you personally for participating in this study. The main benefit to society of participation is that it will likely increase knowledge about executive function in older adults.

COSTS AND PAYMENTS

There is no cost for participating in this study. You will receive \$50 after completing the study. Your name and other identifying information, as well as the title of this study will be used by offices at KUMC that process payments to research subjects.

ALTERNATIVES

Participation in this study is voluntary. Deciding not to participate will have no effect on the care or services you receive at University of Kansas Medical Center.

INSTITUTIONAL DISCLAIMER STATEMENT

If you believe you have been harmed as a result of participating in research at Kansas University Medical Center (KUMC), you should contact the Director, Human Research Protection Program, Mail Stop #1032, University of Kansas Medical Center, 3901 Rainbow Blvd., Kansas City, KS 66160. Compensation to persons who are injured as a result of participating in research at KUMC may be available, under certain conditions, as determined by state law or the Kansas Tort Claims Act.

CONFIDENTIALITY AND PRIVACY AUTHORIZATION

In an effort to maintain confidentiality, the study staff will use a study number and/or your initials rather than your name as an identifier on study records. In addition, if the results of this study are published or presented in public, information that identifies you will be removed.

Use and Disclosure of Protected Health Information

The privacy of your health information is protected by a federal law known as the Health Insurance Portability and Accountability Act (HIPAA). If you choose to participate in this study, you will be asked to give permission for uses and disclosures of your health information.

To perform this study, researchers at KU Medical Center will collect health information about you from the study activities that are listed in the Procedures section of this consent form. Your study-related health information will be used at KU Medical Center by Dr. McDowd, members of the research team, and officials at KUMC that oversee research, including committees and offices that review and monitor research studies, and federal officials who oversee research, if a regulatory review takes place. All study information that is sent outside KU Medical Center will have your name and other identifying characteristics removed, so that your identity will not be known. Because identifiers will be removed, your health information will not be re-disclosed by outside persons or groups and will not lose its federal privacy protection.

Permission granted on this date to use and disclose your health information remains in effect indefinitely. By signing this form you give permission for the use and disclosure of your information for purposes of the study at any time in the future.

If you change your mind during the study, and decide that you want to cancel permission to use your health information, you will tell the person who is giving you the tests. The investigators will not use or disclose any of your health information.

If you want to cancel permission to use your health information after your participation is finished, you should send a written request to Joan McDowd, PhD. The mailing address is Joan McDowd, Mail Stop 1005, University of Kansas Medical Center, 3901 Rainbow Boulevard, Kansas City, KS 66160-7602. If you cancel permission to use your health information, the research team will stop collecting any additional information about you. You are aware that the research team may use and disclose information that was gathered before they received your cancellation.

By signing this form, you give your permission for your health information to be used and disclosed for the purposes of this research study. If you choose not to sign this form, you will not be able to participate in the study.

SUBJECT RIGHTS AND WITHDRAWAL FROM THE STUDY

You understand that your participation in this study is voluntary and that the choice not to participate or to quit at any time can be made without penalty or loss of benefits. You understand that not participating or quitting will have no effect upon the medical care or treatment received now or in the future at the University of Kansas Medical Center. The entire study may be discontinued for any reason without your consent by the investigator conducting the study. Your participation can be discontinued by the investigator if it is felt to be in your best interest or if you do not follow the study requirements.

QUESTIONS

You have read the information on this form. The researcher has answered your questions to your satisfaction. You know if you have any more questions about the study after signing this form that you may contact Joan McDowd, PhD, who can be reached by phone at (913) 588-0646, in writing at Mail Stop 1005, University of Kansas Medical Center, 3901 Rainbow Boulevard, Kansas City, KS 66160-7602, or email at jmcgowd@kumc.edu. If you have questions about your rights as a research subject you may call or write the Human Subjects Committee, University of Kansas Medical Center, 3901 Rainbow Boulevard, Kansas City, KS 66160-7700, (913) 588-1240.

CONSENT

The researcher has given you information about what you are being asked to do. You have been told how it will be done, what you will have to do, and how long it will take. You were told of any inconveniences, discomforts, or risks you may experience by participating in this research. You agree to take part in this study as a research participant. If you decide to participate in this study, you will receive a copy of the signed consent form.

Print name of participant

Participant's signature

Date

Print name of person obtaining consent

Signature of person obtaining consent

Date

Appendix B
DEMOGRAPHIC INFORMATION

ID# _____ Date: _____

Date of birth: _____

Race (circle one): Black White Hispanic Asian Pacific Islander

Sex: Male Female

Years of formal education: _____ (grade school = 8, high school = 12, college = 16)

Primary occupation: _____

Do you have any chronic health conditions?

- Diabetes
 - Stroke
 - Heart disease
 - High blood pressure
 - Arthritis
 - Other
-
-
-
-

Appendix C

Direct Assessment of Functional Status – Extended Version

I. **Communication** (10 points)

a. Using the Telephone

To begin, we'll do some tasks using the telephone. You will use this telephone to dial numbers according to the task I give you.

1. Dial the operator - *Using the telephone, please dial the operator like you would normally do.*

Correct (1 point) _____ **Incorrect** (0 points) _____

2. Dial number from book – *Next, I will ask you to look up a number in the phone book and dial it. Please look up the name (give name from chart) and dial their number.*

Name	Number	Page number in book
Carolyn Clark	913-856-8349	19
Leslie Hayes	785-242-7667	45
David Milner	620-852-3451	73
Bret Oswald	913-856-5246	80
Jill Valentine	913-757-2471	110

Name given _____

Correct (1 point) _____ **Incorrect** (0 points) _____

3. Dial number presented orally – *Now I am going to say a telephone number out loud. Please use the telephone to dial the numbers that I say to you. You'll have to remember it as I say it to you. Ready? Say 913-236-8314*

Correct (1 point) _____ **Incorrect** (0 points) _____

4. Dial a number written down – *Next I am going to show you a telephone number written on a sheet of paper. Please use the telephone to dial the number that I show to you. Show the participant the page with the number.*

Correct (1 point) _____ **Incorrect** (0 points) _____

b. Preparing a Letter for Mailing

Next, we will do a letter mailing task. I will give you a sheet of paper, an envelope and some stamps. Please prepare this letter and envelope to be mailed as you would normally. Address the envelope using this address (Show subject mailing address stimulus) and include your return address. Give the participant the paper, envelope, pen, and stamps.

	Correct (1 point)	Incorrect (0 points)
Fold letter in half		
Put in envelope		
Seal envelope		
Stamp envelope		
Address (<u>exact</u> copy of stimulus)		
Return Address (in upper left-hand corner)		

COMMUNICATION TOTAL _____

II. Pre-shopping Instructions

Now we will prepare to do a grocery shopping task. In about 10 minutes, I will show you a grocery shelf where you will be asked to pick out 6 grocery items from a list you have memorized.

Here are the items you will need to pick out: Read the list slowly, about 1 word every 2 seconds. 1. Orange juice 2. Soup 3. Cereal 4. Tuna fish 5. Rice 6. Jelly

Please repeat those items to me. Have the participant repeat the list until they can recall all 6 items.

Current time: _____ # repetitions required: _____

GO TO THE GROCERY STORE AFTER 10 MINUTES HAVE ELAPSED

III. Financial

a. Counting currency

Next, we are going to do some financial tasks. During the first task, I will place some money in front of you and ask you to show me different amounts.

Please show me:	Correct (1 point)	Incorrect (0 points)
Place all coins in front of the subject:		
Show me 1 dollar and 2 cents (in coins)		
Place dollars and coins in front of subject:		
Show me 6 dollars and 73 cents		
Place collars and coins in front of subject:		
Show me 12 dollars and 17 cents		

b. Writing a check

Now I will ask you to write a check. Please write a check to yourself for \$400. Include all of the information that you normally would when writing a check.

	Correct (1 point)	Incorrect (0 points)
Signature		
Pay to the order of		
Written amount		
Numeric amount		
Date (location – date does not have to be correct)		

c. Balancing a checkbook

Now I will ask you to do a checkbook balance task.

Using the check register form, please calculate the balance remaining for these 4 transactions: Give the participant the check register and a pencil and have them do the 4 subtractions.

	Correct (1 point)	Incorrect (0 points)
\$500.00-\$350.00= \$150.00		
\$323.00-\$23.50= \$299.50		
\$21.75-\$3.92= \$17.83		
\$673.16-\$79.23= \$593.93		

d. Making change for a purchase (in shopping section)

FINANCIAL TOTAL (including making change task) _____

IV. Shopping Skills (10 minutes after items were given; note current time: _____)

We will now start the grocery shopping task that I told you about earlier. I will take you to the grocery shelf and you will pick out the 6 items that I asked you to remember a few minutes ago.

a. Shopping Recall

Before we do that, can you tell me what the 6 items were please?

	Correct (1 point)	Incorrect (0 points)
Orange juice		
Soup		
Cereal		
Tuna Fish		
Rice		
Jelly		

Ok now we will go to the grocery shelf to see if you can find the six items.

b. Shopping recognition (Subject is taken to the grocery shelves and asked to pick out the items)

	Correct (1 point)	Incorrect (0 points)
Orange juice		
Soup		
Cereal		
Tuna Fish		
Rice		
Jelly		

SHOPPING TOTAL _____

c. Making change for a purchase

For this next task, I will ask you to make change for a purchase. I will place some money in front of you, please make change for a \$2.49 purchase from \$5.00. Place money on the table...

	Correct (1 point)	Incorrect (0 points)
\$5.00-\$2.49= \$2.51		

add points to Financial Total

V. Medication Skills

Now we will move on to our medication skills tasks.

a. Identifying Medication

The first medication task that we will do involves identifying medication. I will ask you some questions about this medication. Hand the subject the pill bottle.

Questions:	Correct (1 point)	Incorrect (0 points)
<i>Is this a prescription or over-the-counter drug?</i>		
<i>What is the patient's name?</i>		
<i>What is the name of the medication?</i>		
<i>What is the prescribing doctor's name?</i>		
<i>What are the medication's instructions?</i>		

b. Prescription Refill Task

The next medication task that we will do has to do with refilling prescriptions over the phone, using an automated phone system. Before we do that, I will ask you some questions about your experience with automated phone systems.

1. *Have you ever refilled a prescription over the phone using an automated phone system? Yes _____ No _____ Don't know _____*
(If no, skip item 2 and 3)
2. *How often do you refill prescriptions using an automated phone system?*

3. *When is the last time you refilled a prescription using an automated phone system?* _____

Your goal for this activity is to refill this prescription.

(Present participant with the medication bottle)

4. *In order to refill the prescription you will need to know the prescription number. Can you find the prescription number on this bottle of medication and tell me what it is please?*
Correct _____ Incorrect _____
(If incorrect, show the participant the prescription number)

*For the purposes of this activity, we want you to **pick up** the prescription **tomorrow at 10AM** from the pharmacy. Please take a moment now to remember that because I won't be able to tell you again during the activity. So please remember, **tomorrow at 10AM** is when you want to pick up your prescription from the pharmacy.*

You will also need to know your home phone number.

- 5. What is your home phone number? (Write below. If participant does not have a phone number or cannot remember, leave blank and mark one of the options below.)**

Phone number: _____

No phone number _____ From memory _____ Can't remember _____

Because you can't actually order this prescription over the phone, I am going to have you listen to a pretend automated phone system on the computer. Like a real automated phone system, you will hear instructions and you will respond by pushing the numbers on this phone. After you make a response I will have to clear the phone to reset it, please try not to let this distract you. (Present the participant with the phone.)

The pretend automated phone system will continue to go until you press your response on the phone. Just like a real automated phone system, I will not be able to talk with you or answer any of your questions once we begin. If you get stuck, please do the best you can without my help. Let's do a practice run before we start so you can get used to the recorded voice and the phone.

Practice 1:

Please pick up the phone and do what the automated voice instructs you to do. Click on the Practice 1 segment on the computer to play the following:

Hello and welcome to the SeniorWise Pharmacy.

If you live in Kansas City, MO - press 1

If you live in Overland Park, KS – press 2

If you live somewhere else in the US – press 3

To repeat this message - press 8

(If they press 8, repeat this section on the computer.)

To end this call, press 9.

Write down everything the participant presses on the phone:

Practice 2:

Good, now we'll do a second task.

Click on the Practice 2 segment on the computer to play the following:

Now, I need to know your zip code. Please key in your zip code on the phone.

Write down everything the participant presses on the phone:

****Begin Test****

Do you have any questions before we start?

6. If no questions, play the pharmacy activity on the computer.

Pharmacy activity script:

Click on the Item 06 segment on the computer to play the following:

Thank you for calling the SeniorWise Pharmacy

If you are a physician or medical office, press 1.

To refill a prescription, press 2.

To check on the status of a prescription order that was already placed, press 3.

For Pharmacy information, press 4.

To repeat this message, press 8.

To end this call, press 9.

Write down everything the participant presses on the phone: (**If they push 8, repeat this section on the computer**)

7. Click on the Item 07 segment on the computer to play the following:

Now, please key in the prescription number.

Write down everything the participant presses on the phone:

8. Click on the Item 08 segment on the computer to play the following:

Please enter the last 4 digits of your home phone number.

Write down everything the participant presses on the phone:

9. Click on the Item 09 segment on the computer to play the following:

If you want your prescription to be mailed to you, press 1.

If you want to pick up your prescription from the pharmacy, press 2.

To repeat this message, press 8.

(If they push 8, repeat this section on computer)

To end this call, press 9.

Write down everything the participant presses on the phone:

**If participant chooses 1, play the “Due to high volume...” message on the computer.

10. Click on the Item 10 segment on the computer to play the following:

If you would like to pick up your prescription today, press 1.

If you would like to pick up your prescription tomorrow, press 2

To repeat this message, press 8.

(If they push 8, repeat this section on computer)

To end this call, press 9.

Write down everything the participant presses on the phone:

11. Click on the Item 11 segment on the computer to play the following:

If you would like to pick up your prescription before noon, press 1.

If you would like to pick up your prescription after noon, press 2.

To repeat this message, press 8.

(If they push 8, repeat this section on computer)

To end this call, press 9.

Write down everything the participant presses on the phone:

12. Click on the Item 12 segment on the computer to play the following:

Using the numbers on your phone, punch in the time you would like to pick up your prescription using a 4-digit number. For example, if you want to pick up your prescription at 8 AM, you would key in 0800.

Write down everything the participant presses on the phone:

13. Click on the Item 13 segment on the computer to play the following:

*Your prescription will be ready to be picked up tomorrow at 10 AM.
Press 1 if this is correct, press 2 if this is incorrect.*

Write down everything the participant presses on the phone:

Scoring Prescription Refill Task	Correct (1 point)	Incorrect (0 points)
Refill prescription		
Prescription number		
Phone number		
Pick up prescription		
Pick up date		
Pick up time A		
Pick up time B		

c. Pillbox task

(Prepare the pillbox and the 10 medication bottles)

The last medication activity involves preparing a pillbox. Here is a one-week pill box and 10 different bottles of pills - the pills are actually beads. A pillbox is useful because it helps you sort your pills so that you remember when to take them. Please fill the box according to the labels on each of the bottles, as you would do if you were taking these medications.

	Bottle	Label
1	Aspirin	Take 1 pill everyday
2	Lopressor	Take 1 pill twice a day
3	Ambien	Take 1 pill at bedtime for sleep
4	Lipitor	Take 2 tablets every evening with dinner
5	Isordil	Take 2 tablets in AM and 1 tablet in the PM
6	Lasix	Take 1 tablet twice a day before 3 PM
7	Marinol	Take 1 tablet before lunch and dinner
8	Levaquin	Take 1 tablet every morning for 3 more days
9	Coumadin	Take 1 tablet Monday, Wednesday and Friday AND 2 tablets Sunday, Tuesday and Saturday
10	Tramadol	Take every 6 hours as needed for pain

Scoring Pillbox Task	Correct (1 point)	Incorrect (0 points)
Aspirin		
Lopressor		
Ambien		
Lipitor		
Isordil		
Lasix		
Marinol		
Levaquin		
Coumadin		
Tramadol		

MEDICATION TOTAL _____

COMMUNICATION TOTAL _____

FINANCIAL TOTAL _____

SHOPPING TOTAL _____

GRAND TOTAL _____

Appendix D

PHYSICAL FUNCTION ASSESSMENTS

ID #: _____

Grip Strength (Dominant)

Hold your dominant arm at your side and then bend your elbow 90° so your hand extends in front of you. Then I'll ask you to squeeze the dynamometer as hard as you can. We'll do this three times. Ready?

1. _____. ____ kg
2. _____. ____ kg
3. _____. ____ kg.

30-second Chair Rise

Number of full stands that can be completed in 30 seconds with arms folded across chest.

Next we'll measure your leg strength. With your arms crossed over your chest while sitting in this chair, I'll ask you to move from a sitting position to a standing position and back as many times as you can until I say stop. You'll go up and down for 30 seconds. Any questions? Ok, begin...

of full stands _____

8-Foot Up-and-Go

Number of seconds required to get up from a seated position, walk 8 feet, turn, and return to seated position. Timing begins when the participant's bottom leaves the chair and ends when the bottom contacts the chair again. Record the best time of two trials.

The next task will assess your walking speed and balance ability. I'll ask you to get up from the chair, walk about 8 feet down and around the marker and then return to the chair and sit back down, as quickly as you feel comfortable. Any questions? Ok, begin...

TRIAL 1 _____. ____ s TRIAL 2 _____. ____ s BEST _____. ____ s

Height and Weight

Height _____. ____ cm Weight _____. ____ kg

Appendix E

Literature Review on the Relationship between Executive Function and Functional Status

Ah-reum Han

University of Kansas Medical Center

Introduction

There is an increasing interest in the role of cognition in functional disability, particularly the case in older adults. Older adults experience cognitive decline, and decreased cognitive function is related to loss of independence in elderly people. Increasing age has been known to associate with decline in the performance of executive function (Crawford, Bryan, Luszcz, Obonsawin, & Stewart, 2000). What is the role of executive decline in increasing disability or decreasing independence among older adults? This review focuses on definitions and measures of executive function, inhibition in executive function and aging, and the relation between executive function and functional status in aging.

Concept and measure of Executive Function

Executive functioning is a cognitive skill which supports planning, initiation, and execution of purposeful behaviors, mental flexibility, and problem solving (Johnson, Lui, & Yaffe, 2007). However, executive function does not have clear and precise definition. In addition, executive function consists of different subcategories depending on the researchers who have studied. For example, executive functions are attentional control, cognitive flexibility, and goal setting (Anderson, 2001). Executive function can be defined as a set of cognitive skills that are responsible for the planning, initiation, preservation and alteration of goal-directed behavior (Hobson and Leeds, 2001). The same term can be used for conceptually different functions and different terms for the same function (Miyake et al., 2000). For instance, shifting is also called attention switching, task switching, or cognitive flexibility (Miyake et al.). In this way, executive functioning has been differently addressed in different studies, leading confusion about the meaning.

The broad definitions of executive function make it difficult to measure, and there is not yet in agreement on how to best measure executive function. The problem is that no pure measure exists that taps executive functioning exclusively because executive function involves a variety of different cognitive

processes (Burgess, Alderman, Evans, Emslie, & Wilson, 1997; Miyake et al., 2000; Hughes and Graham, 2002). For example, the Wisconsin Card Sorting Test (WCST), one of well-known executive function tests sorting cards according to one of three categories- color (red, green, blue, or yellow), number (1, 2, 3, or 4), or shape (circle, cross, star, or square), has been criticized because of its complexity and lack of specificity (Manchester, Priestley, & Jackson, 2004). Miyake et al. (2000) stated that although the WCST is often conceptualized as a set shifting task, this test may involve several cognitive processes such as set shifting, set maintenance, inhibition, rule detection, or concept formation.

There are various definitions about executive function presented in many studies, and there is no agreement on how to best measure executive function. In other words, what executive functions are and what components they have are not yet definite, and it is also difficult to specify what executive tasks really measure. One approach to solving the question of identifying the components of executive function is the factor analytic approach of Miyake et al. (2000). They studied three frequently postulated executive functions (shifting, updating, and inhibition) to know whether the three executive functions could be regarded as the same ability or they are distinguishable. Miyake et al. chose these three executive functions: (1) switching between multiple tasks or mental sets (“shifting”), (2) monitoring of working memory contents and replacing old, no longer relevant information with newer, more relevant information (“updating”), and (3) deliberately suppressing dominant, automatic, or prepotent responses (“inhibition”) (Miyake et al., 2000). By performing confirmatory factor analysis, Miyake et al. (2000) concluded that, these three executive functions have some underlying commonality, showing moderately high correlations among the three latent variables. In addition, they are clearly separable, indicating a significantly better fit to the data in the full three-factor model than one-factor or two factor model (Miyake et al.). This sort of approach is useful in understanding the subcomponents of executive function, and provides a framework for understanding executive function instead of relying only on broad conceptualizations of complex cognition.

Inhibition in Executive Function and Aging

Some authors stated that executive function declines earlier than other cognitive abilities, and increasing age correlates with declining executive function (Robbins et al., 1998; Crawford et al., 2000). Studies have been conducted to see age-related changes in executive functions in older adults, such as planning (Brennan, Welsh, & Fisher, 1997; Phillips, Kliegel, & Martin, 2006), working memory (Reuter-Lorenz & Lustig, 2005), and verbal fluency (Crawford et al. 2000; Brickman et al., 2005). However, while some studies indicated age difference between a senior and a young sample in each task, others found no significant difference.

Among executive functions, many studies found age-related deficits in inhibition (McCrae & Abrams, 2001; Chiappe, Hasher, & Siegel, 2000; Nieuwenhuis, Ridderinkhof, de JONG, Kok, & van der Molen, 2000; Hasher, Stoltzfus, Zacks, & Rypma, 1991). For example, the Hasher and Zacks (1988) theory proposed the existence of age differences in inhibition and suggested inhibition as a central mechanism influencing various cognitive functions (Hasher et al., 1991). In this study, older adults showed slower reaction time and more errors in a letter-naming task, which requires the ability to suppress irrelevant information in the context of a selection procedure, compared to young adults. Also, Nieuwenhuis et al. (2000) found older adults' slower antisaccades and increased proportion of saccades toward the cue by using an antisaccade task, a spatial inhibition task suppressing the reflexive eye movements toward abrupt flashing cues and looking in the opposite direction to identify target. That is, older adults' ability to inhibit a reflexive saccade toward the cue was worse than young adults (Nieuwenhuis et al.).

Age-related deficits in inhibition have been more often studied than other executive functions due to its consistency in studies and a strong relationship with instrumental activities of daily lives (IADLs). Jurado and Rosselli (2007) stated that age-related declines in inhibition seem to be supported independently of the task. However, planning and category fluency depend on tasks and set shifting seem to be affected by age (Jurado & Rosselli). Jefferson, Paul, Ozonoff, and Cohen (2006) found that a measure of inhibition was most strongly related to IADLs among verbal fluency, cognitive flexibility and

sequencing, working memory, inhibition, planning and problem solving abilities, and nonverbal generation. Jefferson et al. (2006) stated that previous studies emphasized sequencing as a closely associated executive function with IADLs, and they suggested that it was because few studies included measures of inhibition, planning, and working memory. In order to solve the confusion, studies are needed to directly compare subcomponents of executive function.

Increasing age is a significant factor of executive dysfunction, but the magnitude of this dysfunction seems to vary with particular subcomponent (Brennan et al., 1997; Phillips et al., 2006; Reuter-Lorenz & Lustig, 2005; Crawford et al., 2000; Brickman et al., 2005; McCrae & Abrams, 2001; Chiappe et al., 2000; Nieuwenhuis et al., 2000; Hasher et al., 1991). Although some components of executive function may or may not be affected by age, age-associated decline in inhibition has been most clearly supported. In addition, inhibition has been found to be most closely related to functional status.

Executive Function and Functional Status in Older Adults

Some studies have supported that executive dysfunction is a more sensitive and stronger predictor of functional impairment than other cognitive abilities in elderly individuals. For example, Grigsby, Kaye, Baxter, Shetterly, & Hamman (1998) found a significant association between executive functioning and seven functional status measures (self-report ADLs and IADLs and observed performance in dressing, eating, fine motor, money handling, and medications) among 1158 community-dwelling elderly people. General mental status (MMSE score) was not a significant predictor of functional status in this study. Also, executive function was strongly correlated with a decline in functional status over 3 years in the non-demented elderly, but the Mini-Mental State Examination (MMSE) was not, which is a widely used measure of global cognitive ability (Royall, Palmer, Chiodo, & Polk, 2004). In this study, executive function was measured by the Executive Interview (EXIT25), a standardized clinical executive control function assessment including items such as verbal fluency, design fluency, frontal release signs,

motor/impulse control, and imitation behavior. These studies suggest that executive dysfunction can serve as a better indicator of functional impairment than other cognitive abilities in older adults.

In addition, studies have been conducted to determine which functional impairments are associated with executive function tests. Among functional impairment in daily activities, many studies supported that IADLs are more strongly associated with executive function tests than activities of daily living (e.g., Jefferson et al., 2006; Royall et al., 2004; Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; McGuire, Ford, & Ajani, 2006). However, some higher levels of ADLs are also strongly related to executive function (Johnson et al., 2007). All these studies suggest executive dysfunction may be the best predictor of functional decline in normal aging.

Functional ability is critical for independent living and quality of life among older adults, and improvements of executive function may bring about improved functional status. It is important to know which aspects of executive functions are most closely related to functional status to use executive function as a predictor of functional impairment. Jefferson et al. (2006) assessed multiple elements of executive functioning to examine the association of multiple executive functioning elements (i.e., working memory, generation, inhibition, planning, and sequencing) to IADLs among older adults at risk for future cognitive and functional decline. They found out that inhibition was most strongly related to IADL impairment among the participants. Also, Bell-McGinty et al. (2002) examined multiple clinical executive functioning measures (i.e., tests of novel problem solving and set shifting, mental flexibility, the ability to initiate and sustain production of words under restricting search conditions, and execution of bodily postures) to predict functional status among older adults. Results indicated that measures of mental flexibility and novel problem solving were significant predictors of performance in IADLs, as measured by the Independent Living Scales (ILS; Loeb, 1996). The importance of executive function has been emphasized as a strong predictor of functional ability for older adults' independent living in studies. Studies have tried to find the most associated executive function with functional status, but the results seem to be difficult to compare because they used different executive function and IADL measures.

Just as different studies of executive function and functional status have used different measures of executive function, studies have also used different measures of functional status. To identify a relationship between executive functions and functional status, it is important to use reliable and valid measures of IADLs .While some studies measured IADLs by self-reported questionnaires to indicate relation between executive functions and functional status (Royall et al., 2004; Jefferson et al., 2006, McGuire et al., 2006), relatively fewer studies used performance-based measures of IADLs (Carlson et al., 1999; Bell-McGinty et al., 2002; Mitchell and Miller, 2008). Using performance-based assessment can remove informant bias through direct observation (Bell-McGinty et al., 2002). Also, performance-based measures of IADLs showed higher correlation between executive function and IADLs than self-reported measures of IADLs. For instance, a correlation ($r = -.872$) between the Direct Assessment of Functional Status test (DAFS-R) and the 25-item Executive Interview (EXIT25) scores in Pereira et al. (2008) is higher than a correlation ($r = -.57$) between the Older Adults Resources Scale (OARS), a self-reported interview, and the 25-item Executive Interview (EXIT25) scores in Royall et al.(2004). In terms of accuracy and strength of relation to executive function, performance-based measures of IADLs are mostly better than self-reported measures.

Conclusions

Functional ability is critical for independent living and quality of life among older adults, and executive dysfunction in older adults can predict functional status. Because of conceptual and measuring problems of studying executive functions, studying executive functions has been difficult, and there is no measure accepted as the best standard. In spite of this, it is important to understand that executive functions are closely related to functional status and they allow older adults to maintain independent and meaningful activities. Determining which aspects of executive functions are most closely related to functional status deserves attention. We can use executive function as a predictor of functional impairment to identify those who might need intervention.

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