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Journal
Archives of Psychiatric Nursing, 33(5)

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Publication Date
2019-10-01

DOI
10.1016/j.apnu.2019.08.006

Peer reviewed

Published in final edited form as:
Arch Psychiatr Nurs. 2019 October ; 33(5): 43–50. doi:10.1016/j.apnu.2019.08.006.

Predictors of instrumental activities of daily living in community-dwelling older adults

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Abstract

Psychiatric mental health clinicians often rely on proxy and self-report evaluations to determine the cognitive function of older adults however, performance measures have greater accuracy and predictive ability for everyday function. This study tested physical and cognitive predictors of functional abilities in fifty-one community residing older adults. We administered a computerized battery of executive function tasks, a performance-based measure of instrumental activities of daily living (IADL), and three physical function measures (grip strength, 30-second Chair Stand Test, and 8-foot Up and Go). Regression models assessed the associations of three components of executive function (updating, shifting, and inhibition) with IADLs and physical functions. Updating was a significant predictor of the Medications and Financial DAFS scores and of grip strength. Shifting also predicted grip strength. In conclusion, different executive functions predict different domains of IADL functioning. Working memory was a robust predictor of IADL functioning in older adults, especially medication management skills.

Keywords

Executive function; Instrumental activities of daily living; Mental flexibility; Physical fitness

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Living independently is regarded as an important component of healthy or successful aging among community-dwelling older adults (Depp & Jeste, 2006). Since older adults.' that is individuals > 60 years of age in developed countries, 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 (World Health Organization, 2010). Various cognitive factors affect

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functional decline and self-care in the elderly, such as global cognitive status, visuospatial ability, memory, and executive functioning (McDougall, Mackert, Becker, & Vaughan, 2012; McDowd & Shaw, 2000; Mitchell & Miller, 2008).

Executive function is a set of complex cognitive processes that support planning, initiation, and execution of purposeful behaviors, including mental flexibility and problem solving (Johnson, Lui, & Yaffe, 2007; Walters & Hines-Martin, 2018). On a practical level executive functions have been described as core functions such as mentally playing with ideas; taking the time to think before acting; meeting novel, anticipating challenges; resisting temptations; and staying focused on the most relevant information for a task (Diamond, 2013).

Executive function includes three separable components: *updating*–revising working memory contents; *inhibition*–suppressing responses; and *shifting*–switching attention between tasks (e.g., Jewsbury, Bowden, & Strauss, 2016; Miyake, Emerson, & Friedman, 2000).

Updating is defined as the continuous monitoring and quick addition or deletion of contents within one's working memory, depending on context and relevance to the individual's current goals or task (McCabe, Roediger, III, McDaniel, Balota & Hambrick, 2010). Inhibition is one's capacity to supersede or suppress responses that are influencing a given situation. For example, inhibitory processes may prevent a poor behavior choice, or avert a potentially dangerous action while driving in traffic. Set shifting is the cognitive ability or flexibility that involves shifting attention between one task and another (Miyake et al., 2000). This 3-component model of executive function has received empirical support in studies of both young (Miyake et al., 2000) and older adults (e.g., Fisk & Sharp, 2004; Hull, Martin, Beier, Lane, & Hamilton, 2008; Vaughan & Giovanello, 2010). Hull et al. (2008) administered a series of executive function tasks to one hundred older adults (ages 51–74 years) with the goal of identifying common abilities across tasks. Similar to Miyake, they identified robust shifting and updating factors, and a weaker inhibition factor. In other work, Vaughan and Giovanello (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) identified four separable components of executive function: inhibition, updating, shifting, and speed of access to long term memory, defined in terms of the number of words beginning with a certain letter that a person could name in 1 min. Interestingly, the authors reported age-related deficits in the first three factors (inhibition, updating, and shifting), but not the memory factor. Overall, these studies suggest that Miyake et al.'s (2000) full, three factor model is applicable to older adults.

Executive function and managing medications

Because executive function abilities are often required to perform everyday tasks, even mild executive dysfunction could have an impact on functional ability (Johnson et al., 2007). Instrumental activities of daily living (IADLs) such as shopping, preparing meals, managing medications, using transportation, and managing finances, are cognitively complex and critical for independent living at home and in the community (Gold, 2012). Indeed, executive function is found to be a stronger predictor of IADLs than is global cognition among older adults (Ball et al., 2002; Johnson et al., 2007; Royall, Palmer, Chiodo, & Polk, 2004).

Optimal medication management skill is suggested as one of the keys to successful aging (Advinha, Lopes, & de Oliveira-Martins, 2017), and one most vulnerable to decline. Medicare expenditures for 8125 Nurses were higher by $1488 for individuals with impairment in executive function (Bender, Austin, Grodstein, & Bynum, 2017). A large prospective study of 10,263 Canadian adults over the age of 65 (Njegovan, Hing, Mitchell, & Molnar, 2001) revealed that across 5 years, participants increasingly needed assistance with their medications, even though they remained able to manage their finances, prepare meals, shop, and do basic home-making tasks. Insel, Morrow, Brewew, and Figueredo (2006) found that a composite of executive function (switching, updating) tasks predicted which community-dwelling older adults might be at risk for failure to take prescribed medicines. Anderson and Birge (2016) reported that among older adults, low scores on a composite measure of switching and updating was a risk factor for hospital readmission for those older adults self-managing their medications, and that those individuals at the greatest risk were managing seven or more medications. Clearly, the optimal management of a complex set of prescribed medications is an important IADL task for older adults, and medication management may be the IADL task most sensitive to cognitive decline.

Physical function and instrumental activities

In addition to predicting IADL performance, some studies also have identified an association between executive function and physical function (Clouston et al., 2013; Eggermont, Milberg, Lipsitz, Scherder, & Leveille, 2009; Gross et al., 2016; Huh et al., 2011; Muir et al., 2013; Rosano et al., 2005). The Trail-making Test is a “connect the dots” task where participants are asked to draw lines to connect dots printed with numbers and letters that are scattered randomly on a page. More recently, Gross et al. (2016) reported that both impairment in executive function and declines in executive function over 9 years were associated with transitions to physical frailty in a sample of older women, who at baseline were high-functioning between the ages of 70–79. Physical frailty is manifested as a comprehensive medical syndrome that may include slowness, weakness, reduced activity, weight loss, and exhaustion, hospitalization, falls, delirium, future disability, and mortality. Because physical mobility can also be critical to independence in aging, we were interested in further examining the specific components of executive function related to physical function.

Interest in the relationship between executive function and IADL performance has been spurred by the possibility that improvements in executive function may bring about improved functional status, thus supporting independent living among older adults (Rebok et al., 2014; Wang, Chang, & Su, 2011; Willis et al., 2006). Indeed, if improvements of executive function bring about improved functional status, then executive function training would be a major positive intervention for cognitive aging (Ball et al., 2002; Levine et al., 2000; Willis et al., 2006).

Before developing an intervention to improve functional status, it is important to identify the executive function components most closely related to functional status. To date, however, findings were mixed regarding the component of executive function most related to functional ability. In some studies, functional status is most related to inhibition (e.g., Jefferson, Paul, Ozonoff, & Cohen, 2006), whereas others indicate shifting (e.g., Ball et al., 2002; Vaughan & Giovanello, 2010) or updating (Lewis & Miller, 2007). It is difficult to synthesize this research because each study used different measures of executive function and of IADL ability, and often do not take a comprehensive approach to either executive function or IADL abilities.

The purpose of this study was 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 (DAFS-E) version (McDougall, Becker, Vaughan, Acee, & Delville, 2010). The DAFS-E is performance-based measure which assesses the functional domains of communication, finances, shopping, and medication management. A secondary aim in this study was to determine which component of executive function best predicts physical performance as an additional marker of independence among older adults.

Methods

Participants

Participants were 51 older individuals (25 males and 26 females) who participated in a larger study of health and aging at the University of Kansas Medical Center. Participants were all community-dwelling older adults aged from 66 to 90 years. Participants were predominantly White (50 White, 1 Hispanic), and they were all native English-speakers with normal or corrected-to-normal hearing and vision. Self-reported health conditions included high-blood pressure (56.9%), arthritis (41.2%), heart disease (23.5%), diabetes (15.6%), asthma (5.88%), COPD (5.88%), and high cholesterol (4.0%). Characteristics of participants are included in Table 1.

Measure

Performance-based IADL assessment

The Direct Assessment of Functional Status-Extended version (DAFS-E) is a performance-based measure of IADLs that can be used as an initial screening tool of functional abilities in community-dwelling older adults (McDougall et al., 2010, 2012). The domains measured from the DAFS extended version were time orientation, communication abilities, transportation, financial skills, and shopping skills. A fifth domain, medication skills, with three sections (identifying, refilling, and managing medications). There are 55 items in the DAFS-Extended, 20 of which are in the Medication Skills domain. Scoring the measure is being developed as more normative data is collected. Higher scores imply greater success with completing the test.

In the Identifying Medications section of the Medication Skills domain, participants were presented with a medication bottle and asked to identify the prescription or OTC medication, the patient's name, medication name, the prescribing doctor, and any special instructions. Therefore, there were five items in this section and scores could range from 0 to 5. The Prescription Refill Task made up the second section of the Medication Skills domain. Participants were presented with a phone and a bottle of medication and were told that the activity was designed to give them practice in refilling prescriptions using an automated phone system. As in a real automated phone system, the instructor read instructions from a script and asked the participants to respon by pushing numbers on the phone. The phone had a small screen where the instructor could read the numbers that the participant pushed. The first item asked participants to select from a list of options the purpose of their call, which was to refill a prescription. The second item asked them to key in the prescription number. The third item asked them to enter the last four digits of their home phone number. The fourth item asked if they wanted to pick up the prescription or wanted it mailed to them. Previously participants had been told that they were to pick up the prescription from the pharmacy tomorrow at 10 am. Therefore, the correct answer was to indicate that they wanted to pick it up from the pharmacy. The fifth item asked participants to choose whether they wanted to pick up the prescription today or tomorrow (the latter being the correct answer). The sixth item asked them if they wanted to pick up the prescription before noon or after noon (the former being the correct answer). Finally, the seventh item asked them to key into the phone the exact time they wanted to pick up the prescription (the correct answer was "1000"). Scores could range from 0 to 7.

The Managing Medications Task section of the Medication Skills domain was composed of eight items. Participants were presented with a pillbox and eight bottles of medications commonly used by older adults that had labels and candy pills inside. Participants were instructed to fill the pillbox according to the labels on the different bottles. For example, they were instructed to take two Lipitor tablets every evening with dinner and one Levaquin tablet every morning for 3 more days. If any mistake was made on an item, it was scored as incorrect; otherwise the participants got one point. Scores could range from 0 to 8.

The reliability and validity of the DAFS-E was supported for the sample of elders living independently in the community. The internal consistency reliability (Cronbach alpha) of the 10 sub-scales was 0.68 when removing the writing a check sub-scale, which had no variation. We note that Cronbach alpha is sensitive to the average inter-item correlation as well as the number of items. While the alpha coefficient is slightly lower than traditional standards, it should be noted that the DAFS tests skills from a variety of areas of functioning. Consequently, we might not expect to see high inter-item agreement. Future studies with a larger sample should be undertaken to test the temporal stability of scores on this measure.

The validity of the DAFS-E was supported by the moderate correlations of the total score as well as most of the sub-scales with the concurrently administered MMSE, which screens for cognitive impairment. The DAFS-E total score also discriminated between those previously identified as having normal versus impaired functioning, as measured by the previously administered Rivermead (McDougall et al., 2010).

The administration of the DAFS-E may have required up to thirty minutes to administer, primarily because the pillbox exercise was somewhat time-consuming. Future studies should conduct a head-to-head comparison between the two versions to determine if the DAFS-E is markedly longer than the DAFS, because the decision of which version of the tool to utilize would be informed by the relative differences in administration time.

The four categories of test items are: a) Communication Skills (10 points) assessing the ability to use a telephone and prepare a letter for mailing; b) Financial Skills (13 points) assessing the ability to count currency, write a check, balance a checkbook, and make change for a purchase; c) Shopping Skills (12 points) assessing the ability to recall and recognize six grocery items from a grocery shelf 10 min after grocery items were told; and d) Medication Skills (24 points) assessing 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 (Miyake et al., 2000). The computerized battery included 10 tests.

1. Antisaccade task (inhibition): This task assesses the ability to inhibit eye-movements to certain spatial locations. A single digit (0–9) was presented to participants very briefly on a computer screen; the task was simply to name the number as quickly as possible. On each trial a small black square would appear first, on either the left or right side of the computer screen, immediately before the number appeared. In the control condition, the number appeared on the same side with the black square cue. In the inhibition condition, the number was presented on the opposite side from the square, requiring participants to inhibit the tendency to look at the square, and look in the opposite direction to report the number. If a person's inhibitory ability was weak, the number would disappear from the screen before they had a chance to name it. In this case the measure of inhibition was the difference in accuracy between the two conditions.

2. Stroop task (inhibition): In the control condition of this task (not requiring inhibitory processes), participants were instructed to name the color (red, yellow, blue, green) of a series of asterisk strings that appeared in the center of the screen as quickly as possible. In the inhibition condition, color words were presented in one the four different colored fonts, different from the color word itself. Participants were required to name the printed color of the words as quickly as possible while ignoring the word itself. Inhibitory ability was indexed by the relative slowing of color naming from the baseline to inhibition conditions.

3. Spatial Stroop task (inhibition): Similar to the Stroop task just described, the spatial stroop task compares two conditions, one requiring inhibitory processes, and one not. On each trial of this task, participants were presented with a set of left-or right-pointing arrows, located on either left or right side of the computer screen. Participants were asked to press the left or right button according to the direction that the arrows were pointing as quickly and accurately as possible, while ignoring the location of the arrows on the screen. In the control condition,

the direction of the arrows matched the location of the arrows on the screen. In the inhibition condition, the direction of the arrows was randomly associated with the location of the arrows. Inhibitory ability was indexed by the relative slowing of button presses from the baseline to inhibition conditions.

4. Stop-signal task (inhibition): In the first condition, participants were instructed to press the right arrow button on the keyboard as soon as they see green arrows pointing to the left or the right. In the second condition, participants were instructed to do the same thing but try not to respond when an arrow turned red. The measure of interest is reaction time difference in the two conditions.

5. Letter Memory task (updating): In this task, a series of 7–13 letters were presented one at a time for 3 s 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. This required that the contents of memory be continually updated across the trial, as the identity of the “3 most recent” letters was continually changing. The measure of interest was accuracy of participants’ recall.

6. 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 1.5 s each. Participants were instructed to monitor the words from a subset of the categories, updating memory each time a word from one of these target categories was presented, and then 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’ recall.

7. 2-back task (updating): Participants were presented with a fixed set of rectangles arranged in a visual display. On each trial, the rectangles were sequentially filled in with black for a brief time. Participants were asked to keep track of the order in which the boxes were filled in, and to make a yes/no response to each box as it was filled in based on whether the current box was the same as the one that was filled 2-back. The measure of interest was response accuracy.

8. Color-Shape task (shifting): In the color-shape task, 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. Participants were instructed to decide whether the colored shape was green or red when they saw the letter ‘C’ (for color), and to decide whether the colored shape was a circle or a triangle when they saw the letter ‘S’ (for shape). In the control condition, all trials were either color or shape, so no response shifting was necessary. In the shifting condition, participants had to shift between color and shape mixed trial sequences, and respond based on the presented cue letter ‘C’ or ‘S’. The measure of interest was reaction time difference in the two conditions.

9. 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. 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. For example, if they saw a heart followed by the word “cow” the response would be “living”. If they saw the arrows followed by the word “cow” the response would be “larger”. In the control condition, only the heart symbol or intersection arrows symbol were shown, so no task switching was necessary. In the switching condition, participants had to switch between the two categories according to the symbol they saw on the screen on a trial by trial basis. Efficiency of switching was indexed by calculating reaction time differences between the two conditions.

10. Number Letter task (shifting): Participants were presented with a number and a letter paired together (e.g., 7R) in one of four quadrants of a square on the computer screen. Participants were required to press left button if the number was odd or press right button if the number was even If the number/letter pair was in one of the top two quadrants, participants were to respond whether it was odd or even number. If the pair was in one of the bottom quadrants, participants were required to respond whether the letter was a vowel or consant. In the control condition the stimuli appeared in only the top or only the bottom quadrants; in the shifting condition the stimuli appeared randomly among the four quadrants. The measure of interest was reaction time difference in the two conditions.

To obtain a single inhibition, shifting, and updating score for each subject, we standardized the scores on each of the 10 executive function tasks, centering each variable at zero (by subtracting the sample mean from each raw score) and scaling each variable to have a standard deviation of one (by dividing each centered score by the sample standard deviation of the raw scores for the task). We then averaged each subject’s standardized scores across the 3–4 tasks for each executive function, yielding one inhibition score, one shifting score, and one updating score for each subject. Standardization in this manner is a common method used to put different variables (BMI, height, accuracy) on a common scale (see Staggs, 2017). When variables with very different variances are averaged without standardization, those with larger variances can dominate the average; standardizing is a way of giving each variable equal weight.

Physical performance measures

We measured grip strength with a dynamometer (Mathiowetz et al., 1985), lower body strength using the 30-s Chair Stand test (Rikli & Jones, 1999), and walking speed while moving using the 8-ft Up and Go test (Rose, Jones, & Lucchese, 2002). To measure grip strength, participants were asked hold their dominant arm at their side, bend their elbow slightly, and squeeze a dynamometer as hard as they could. This test was repeated three times; the mean of the three trials was calculated for analysis. To measure lower body strength, participants were instructed to fold their arms across their chest and then stand up from and sit back down onto a straight-back chair as many times as they could over a 30-s period. The measure of interest was the number of full stands during the 30-s test period. To measure walking speed, participants were instructed to get up from a straight-back chair, walk forward in a straight line for 8 ft, around a marker placed at the 8- ft point, return to the chair, and sit back down. They were asked to do this sequence as quickly as they could, while maintaining a safe pace. Time taken to complete the test was recorded.

Procedure

Study tasks were performed in two sessions on 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 DAFS-Extended version test, and other tests from the larger battery. The first session took 1.5–2 h 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 10 executive function 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 h to complete. Upon completing the study, participants received a $50 honorarium.

Statistical Analyses

Analyses were carried out using SAS 9.4 and R 3.2.3. For descriptive purposes we computed the Spearman correlation between each pair of variables in the study. The Spearman correlation is a measure of monotonic association between variables and serves as a non-parametric alternative to the more familiar Pearson correlation when data are non-Gaussian.

We assessed the relative importance of the three executive functions on the four DAFS domains as follows. For each of the four DAFS tasks, we used linear regression to model the percentage of DAFS items correct as a function of inhibition, shifting, and updating. Because percentage variables generally violate assumptions of linear regression we used the R *boot* package to compute bootstrap *p*-values and 95% bootstrap confidence limits for the regression coefficients. We then regressed each of the three physical function measures on the three executive function variables with age included as a covariate, using bootstrapping to compute *p*-values and confidence limits.

Results

Demographic characteristics and means and standard deviations for outcome measures are shown in Table 1. Mean BMI of participants (27.5) was in the range of overweight ($25 \leq BMI < 30$: overweight). Scores on Chair Stand test (see Rikli & Jones, 1999 for normative data) and 8-foot Up and Go test (see Pondal & de Ser, 2008 for normative data) were in the normal range in both female and male participants. Scores on grip strength in all female participants except one person were above normal, and scores of all male participants were below normal (see Mathiowetz et al., 1985 for normative data). On the DAFS task, percent correct responses were highest in finance (92.2%) and lowest in shopping task (79.9%). Percent correct in the other two tasks (communication: 85.5%, medication: 88.6%) and total (87.1%) were similar. Table 2 shows Spearman correlations between outcome measures.

Regression model results for the DAFS variables and physical function variables are shown in Table 3. We checked for multi-collinearity problems using the COLLIN and VIF options in the SAS Regression Procedure and found none. In interpreting the significance test results the usual caveat about multiple testing and Type I error rate inflation applies; at the $\alpha = 0.05$ level one would expect one significant *p*-value in a set of 21 tests due to chance alone.

Updating was a significant predictor of the Medications and Financial DAFS scores and of grip strength. Holding other predictors constant, a 1 SD higher score on updating was associated with a 4.8 higher percentage correct score on Medications, a 3.1 higher percentage correct score on Financial, and a 0.3 SD higher score on grip strength, on average. A 1 SD higher score on shifting was also associated with a 0.3 SD higher score on grip strength. We did not find any statistically significant associations between inhibition and the dependent variables.

Discussion

The present study evaluated the contribution of executive function components of shifting, updating, and inhibition to the performance of IADLs among healthy, community-dwelling older adults. Of the three executive functions assessed, updating was most relevant to IADLs, and significantly predicted medication management skills, everyday financial skills, and grip strength. Shifting also predicted grip strength. These executive function measures may be useful in predicting initial functional decline in older adults and may form the basis of intervention approaches to support IADL abilities among older adults.

We found that updating predicted performance on two of the four IADL tasks we assessed, whereas shifting and inhibition did not predict performance on any of the four IADL tasks. In contrast to our findings, Vaughan and Giovanello (2010) found shifting as the only significant predictor of a composite score of performance-based IADL tasks. They included nine tasks of executive function, five of which were the same as ours. The performance-based IADL measure used in Vaughan and Giovanello was very similar to that used in our study. However, they calculated a composite IADL score and we assessed individual IADL domains. Thus, it may be that different patterns of associations are present depending on whether IADLs are considered separately or in aggregate.

In our study, updating was the only significant predictor of the Medications DAFS-E scores. This finding is consistent with a previous nursing study that found a measure of updating as a significant predictor of taking medications as prescribed in community-dwelling older adults (Insel et al., 2006). One of the medication management tasks in the present study was to manage a one-week pillbox, and participants were asked to fill the pillbox according to the labels on each of the 10 different bottles of pills. Our participants self-reported that their average number of medicines taken each week was about eight, suggesting that this task is very similar to their actual medication management at home. When considering the importance and needs of medication self-management in older adults, our finding suggests that an updating assessment be considered for use in screening older adults who may be vulnerable to losing the ability to manage medications and further IADL functioning.

Updating was also the only executive function ability related to the Finances subtest of the DAFS-E. This subtest required the participant to count currency and make change and write a check and balance a checkbook. Although not extremely complex, these tasks do require that information (e.g., check amount or total cost) be held in mind while other information is manipulated (in this case through subtraction, to make change or balance a checkbook). Thus, the ability to recall and update information is key to these tasks.

The significant findings from our study demonstrate the importance of updating of working memory in relationship to cognitive tasks. Updating predicted medication management and financial management functions. Updating is the continuous monitoring and quick addition or deletion of contents within one's working memory. The updating of this information in working memory (WM) is a critical executive function responsible both for continuously replacing outdated information with new relevant data and to suppress or inhibit content that is no longer relevant according to task demands (McCabe, Roediger, III, McDaniel, Balota, & Hambrick, 2010).

We did not find any significant predictors of the Communication subtest or the Shopping subtest. The tasks comprising the Communications subtest included looking up and dialing a phone number using a phone book, remembering and dialing a phone number presented orally, and preparing a letter for mailing, including all the steps from folding a letter to addressing and stamping an envelope. Although these tasks require attention, memory, and sequencing abilities, performance was near perfect on all components except remembering and dialing a phone number presented orally, a task which primarily requires short-term memory and not executive function.

There were no significant predictors of Shopping DAFS-E scores. In earlier work, Jefferson et al. (2006) found that a measure of inhibition (Stroop task) was correlated with shopping ability. However, their participants were older adults with significant cardiovascular disease, and IADL performance was assessed by informant report whereas we used the performance-based DAFS-E. In addition, Jefferson et al. did not assess any of the other executive function components that were assessed in the present study. Thus, additional studies are needed to sort out these differing findings.

Regarding the physical function tasks, Updating and Shifting significantly predicted grip strength. There is relatively little evidence on the association between executive function and muscle strength, but growing interest in the relation between cognitive function and physical function. Some studies have reported that poorer performance on executive function tests was associated with slower walking speed and longitudinal declines in walking speed (Atkinson et al., 2007, 2010; Donoghue et al., 2012; Mielke et al., 2013; Watson et al., 2010). These studies, however, did not measure which component of executive function was more related to walking speed. Further studies may assess whether updating and shifting are significant predictors of walking speed and physical mobility.

It is important to acknowledge potential limitations of the present study. For example, participants had multiple health conditions. Individual differences in executive function may be affected by different health conditions. For example, older adults with high blood pressure have shown significantly poorer executive function than older adults with normal blood pressure (Bucur & Madden, 2010). Since we did not control for health conditions in our analysis due to the limited sample size, our findings, the relationships between IADL performance and executive function might be affected by the varied health conditions in our participants. Further work should consider the potential role of vascular diseases (e.g., stroke, heart disease) and their risk factors (e.g., hypertension) in the associations described in this study. Future studies might include a measure of anxiety and/or depressive symptoms.

Future work might also be done to improve the validity and sensitivity of the DAFS-Extended version assessment of IADLs. Although this version omitted easy items identified from the previous version, there are still some easy items, such as dialing the operator and counting currency in this version. The DAFS-Extended version can also be updated to reflect current trends in technology and its use among older adults. Some participants indicated that they no longer use an automated phone system to refill a prescription and use a computer system instead. To reflect this trend with the technology, it will be useful to include all possible choices such as automated phone system and computer refilling system.

Implications for nursing practice and research

Nursing is interested in managing the multiple complex tasks of older adults to evaluate whether the individual can live independently. This study illustrated the complexity of measuring executive function and instrumental activities of daily living. However, few nurse researchers have investigated these aspects of cognitive and executive function. Future studies of executive function may want to include Trails A and B. The Trail-making Test is a known measure of executive function. In Part A, the dots are only printed with numbers, and are to be connected in numerical order. In Part B, the dots are printed with either a number or a letter, and are to be connected by alternating between numerical and alphabetical order (1 – A – 2 – B – 3 – C…), thus requiring switching and updating executive function ability. These measures are evaluated by psychologists who are specifically trained to use these neuropsychological measures (Llinàs-Reglà et al., 2017).

This study demonstrated that of the three executive functions assessed, updating was the only one relevant to the IADLs we assessed, and it was a significant predictor only of medication management skills and financial skills. Managing a complex medication regime is a cognitively demanding everyday task that confronts many older adults and can quickly escalate into a crisis requiring hospitalization. The adequacy of cognitive abilities underlying tasks such as medication management may be important indicators of success in independent living.

Understanding executive function and its components may be critical to predicting the abilities of older adults. Clearly more research is needed to fully understand the role of executive functions in the tasks of everyday living. Still, our findings suggest that updating measures may be useful in predicting initial functional decline in older adults and may form the basis of intervention approaches to support IADL abilities among older adults. It is possible that cognitive training focusing on improving updating skills may help community dwelling older adults improve or maintain functional abilities and live independently in the community.

The shopping task in the DAFS primarily assesses memory capacity. The real grocery shopping situation is more complex, and adults are likely to bring a shopping list with them, compensating for any memory loss. 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. It would be optimal to do the shopping task in a real supermarket, such as with the Test of Grocery Shopping Skills (TOGSS) (Hamera & Brown, 2000), but if it is impossible, the task could be simulated in the lab or hospital setting. To make the unnatural task environment in the present study more similar to a real life shopping situation like TOGSS, for example, a participant can be 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. Tasks such as these are more likely to challenge, and to reflect, an individual's executive function abilities.

Clinicians often rely on proxy and self-report evaluations to determine the cognitive function of older adults. However, performance testing is more reliable for the cognitive task being evaluated. Nursing is interested in managing the multiple complex tasks of older adults to evaluate whether the individual can live independently. This study illustrated the complexity of measuring executive function and instrumental activities of daily living. However, few nurse researchers have investigated these aspects of cognitive and executive function.

Acknowledgment

This project was supported by National Institute on Aging (1 R01 AG15384) awarded to Dr. McDougall. We also thank the Landon Center on Aging at the University of Kansas Medical Center for their funding. We gratefully acknowledge the assistance of Akira Miyake for his help in adapting the executive function tasks for use with an older population. We thank Valorie Coffland for assistance with data collection, and Sara Kurtz for recruiting and scheduling participants. We also thank members of the Grayhawk Participant Pool for their time and good will in volunteering for this project.

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Table 1

Characteristics of Participants (*n* = 51).

Variable	Mean	SD	Range
Age (years)	78.2	7.5	66.0–90.0
Education (years)	16.7	2.5	8.0–22.0
BMI (kg/m^2)	27.5	4.6	20.0–40.6
Grip Strength (kg), Male	19.5	5.4	9.0–32.0
Grip Strength (kg), Female	31.2	8.4	16.3–47.3
Chair Stand (number), Male	11.2	5.7	0.0–23.0
Chair Stand (number), Female	12.2	5.0	0.0–27.0
8-foot Up & Go (sec), Male	8.3	3.0	4.0–17.0
8-foot Up & Go (*sec*), Female	7.1	2.2	5.0–15.0
DAFS-Communication (10)	8.5	1.4	4.0–10.0
DAFS-Finance (13)	12.0	1.0	9.0–13.0
DAFS-Shopping (12)	9.6	2.3	1.0–12.0
DAFS-Medication (24)	21.3	2.3	15.0–24.0
DAFS-Total (59)	51.4	4.7	37.0–59.0

Table 2

Spearman correlations.

	1	2	3	4	5	6	7	8	9
1. Inhibition									
2. Shifting	0.110								
3. Updating	0.458	0.251							
4. DAFS-C	0.214	0.166	0.349						
5. DAFS-F	0.302	0.133	0.510	0.320					
6. DAFS-S	0.168	0.172	0.278	0.053	0.204				
7. DAFS-M	0.336	0.079	0.591	0.296	0.400	0.136			
8. Grip	0.114	0.291	0.459	0.351	0.453	−0.080	0.319		
9. Stands	0.381	0.271	0.313	0.202	0.195	0.096	0.278	0.301	
10. Up & Go	−0.309	−0.210	−0.480	−0.226	−0.362	−0.114	−0.393	−0.485	−0.709

DAFS-C: DAFS-Communication; DAFS-F: DAFS-Financial; DAFS-S: DAFS-Shopping; DAFS-M: DAFS-Medications.

Table 3

Regression results.

	Inhibition		Shifting		Updating	
	***B* (95% CI)**	**p-Value**	***B* (95% CI)**	**p-Value**	***B* (95% CI)**	**p-Value**
Communication	3.9 (−0.8, 10.2)	0.147	1.5 (−2.9, 5.6)	0.459	0.9 (−3.7, 6.9)	0.709
Financial	1.8 (−0.6, 3.9)	0.148	0.0 (−1.7, 1.8)	0.958	3.1 (0.6, 5.6)	0.005
Shopping	2.1 (−3.5, 8.6)	0.511	1.2 (−4.9, 5.6)	0.617	7.0 (−0.6, 17.0)	0.157
Medication	1.0 (−2.2, 3.5)	0.451	0.2 (−2.1, 4.1)	0.899	4.8 (2.1, 6.5)	< 0.001
Grip strength	−0.1 (−0.4, 0.3)	0.575	0.3 (0.0, 0.5)	0.031	0.3 (−0.1, 0.7)	0.034
Up and go	−0.6 (−1.8, 0.3)	0.251	−0.2 (−1.1, 0.2)	0.405	−0.5 (−1.1, 0.2)	0.086
Stands	1.0 (−0.4, 2.5)	0.164	0.5 (−0.8, 2.0)	0.398	0.3 (−0.9, 1.3)	0.518

Notes. CI = confidence interval. Executive function variables and grip strength were standardized for modeling.