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Evaluating elements of executive functioning as predictors of instrumental activities of daily living (IADLs)

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Abstract

OBJECTIVE: Executive functioning has been repeatedly linked to the integrity of instrumental activities of daily living (IADL). The present study examined the association of multiple executive functioning elements (i.e., working memory, generation, inhibition, planning, and sequencing) to IADLs among an older adult cohort at risk for future cognitive and functional decline.
METHODS: Seventy-two participants with prevalent but stable cardiovascular disease completed a neuropsychological protocol assessing multiple elements of executive functioning, including COWA, PASAT, DKEFS Color-Word Interference Test, DKEFS Trail-Making Test, DKEFS Tower Test, and Ruff Figural Fluency Test. Reliable informants completed a measure of IADLs.
RESULTS: Stepwise logistic regression selected a model involving a single significant predictor, a measure of inhibition (i.e., DKEFS Color-Word Interference Test), which had a significant regression coefficient. Subsequent correlation analyses confirmed an association between the inhibition measure and multiple IADL items. Inter-item comparisons among the IADLs revealed significant differences, such that telephone use and laundry were significantly more intact than most other IADLs while shopping and housekeeping were most compromised.
CONCLUSIONS: Our data suggest that inhibition, also known as susceptibility to interference, is most strongly related to IADL impairment among patients at risk for future cognitive and functional decline.
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Functional abilities include a number of activities of daily living (ADLs) that have traditionally been dichotomized into two categories, including instrumental activities of daily living (IADLs) and basic activities of daily living (BADLs (Lawton & Brody, 1969)). IADLs facilitate independent living and include telephone use, food preparation, medication management, driving or traveling, financial management, meal preparation, housekeeping, laundry, and shopping. BADLs are composed of basic, self-care, habituated behaviors that include feeding, toileting, bathing, grooming, ambulating, and dressing. Impairment in one or more of these functional capacities is an essential feature for the diagnosis of dementia according to multiple diagnostic criteria (American Psychiatric Association, 1994; McKhann

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et al., 1984; World Health Organization, 1992). Functional impairment is the defining feature separating individuals with mild cognitive impairment (MCI) from those categorized with dementia, as diagnostic criteria for MCI require minimal to no functional impairment (Petersen et al., 1999).

Functional impairment is associated with patient institutionalization (Spector, Katz, Murphy, & Fulton, 1987), decreased quality of life (DeBettignies, Mahurin, & Pirozzolo, 1990), and death (Jorm, 1994) as well as increased caregiver burden (DeBettignies et al., 1990) and health care costs (Cahn et al., 1998). Cognitive decline contributes to functional changes, so determination of the cognitive predictors and course of functional decline are important research endeavors with health care implications and clinical utility in differential diagnosis. Knowledge of the predictors of functional decline would allow clinicians to make determinations regarding patients' personal independence and safety. Such predictions would be extremely useful in clinical cases where patients lack direct care providers.

Efforts to link cognitive performances to functional decline have yielded mixed results. Though more recent research has emphasized elements of visuoperceptual abilities such as object recognition (Glosser et al., 2001, 2002; Jefferson et al., in press-a), most previous studies have emphasized executive functioning (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Boyle et al., 2003a, 2003b; Boyle, Paul, Moser, & Cohen, 2004; Cahn-Weiner, Boyle, & Malloy, 2002; Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Cahn-Weiner, Ready, & Malloy, 2003; Jefferson et al., in press-b).

One explanation for the recurrent finding underscoring executive functioning is that it reflects a complex domain encompassing multiple cognitive components, such as working memory, inhibition, sequencing, generation, and planning. The methodology of some previous studies has focused on heterogeneous measures of executive functioning beyond the expected heterogeneity of most clinical measures. For instance, the initiation/perseveration subscale of the Dementia Rating Scale (Mattis, 1973) includes multiple items assessing generation, motor sequencing, and perseveration. Such heterogeneous measures may inadvertently serve as proxy measures for cognitive impairment or dementia severity rather than a more specific cognitive process. Thus, it is important to parcel out specific elements of executive functioning with more precise measures to determine elements that are most salient to functional changes.

There has been limited direct examination of the relationship between multiple elements of executive functioning and instrumental functional abilities. The most comprehensive study to date was conducted by Bell-McGinty et al. (2002), who simultaneously compared a measure of independent living to multiple clinical executive functioning measures (i.e., tests of perseveration, sequencing, generation, execution of bodily postures, and initiation/perseveration). Results indicated that only measures of sequencing and perseveration were relevant to IADLs.

Given that functional impairment is first expressed among instrumental activities (Jefferson et al., in press-b; Kempen & Suurmeijer, 1990; Spector et al., 1987), the present study examines IADLs among a cohort of outpatients with prevalent but stable cardiovascular disease at risk for future cognitive and functional decline secondary to vascular risk factors (Wang, van Belle, Kukull, & Larson, 2002). The primary purpose of the present study is to further explore the relationship between executive functioning and IADLs among patients who are at risk for dementia by concentrating on multiple cognitive functions sensitive to frontal-subcortical circuit disruption. The present study augments past research in this area (Bell-McGinty et al., 2002) by focusing on previously unconsidered elements of executive functioning (i.e., planning, inhibition, and working memory) among individuals who are not yet demented. The aims of the present study are two-fold:

(1) *To parcel out multiple elements of executive functioning and study their individual relationship to an informant-based functional measure assessing IADLs*. In light of the complexity of instrumental functional skills such as balancing a checkbook and preparing meals, executive functioning is hypothesized to be associated with IADLs. The previous literature in this area has predominantly emphasized sequencing (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2002; Carlson et al., 1999). Thus, when comparing multiple components of executive functioning concurrently, we hypothesized that a measure of sequencing would be most important because IADLs require mental flexibility and sequencing of actions.
(2) *To qualitatively identify those specific IADL items most susceptible to impairment*. Given our previous findings among vascular dementia patients (Jefferson et al., in press-b), we hypothesized that meal preparation, laundry, and financial management would be most susceptible to impairment, while telephone use and transportation would be less impaired.

1. Methods

1.1. Participants

Participants were 72 community-dwelling individuals participating in an NIH-supported study (*F32 AG022773*) examining the effects of reduced systemic perfusion (i.e., cardiac output) on cognitive and functional abilities in the elderly. Participants were recruited from local medical centers, rehabilitation programs, private practices, and general advertisements in the greater Providence, Rhode Island area. Inclusion criteria required a documented history of cardiovascular disease, such as prior myocardial infarction, heart failure, coronary artery disease, cardiac surgery, or hypertension. Participants were English-speaking with normal or corrected hearing and vision at the time of testing. Exclusion criteria included any history of traumatic brain injury with loss of consciousness greater than 10 min, neurological disease (e.g., Parkinson's disease), major psychiatric illness (e.g., schizophrenia), and/or drug or alcohol use requiring hospitalization.

Participants consisted of 38 males and 34 females, with a mean age of 69.24 years (S.D. = 7.48) and a mean education of 14.17 years (S.D. = 2.85). The sample was comprised of 86.8% non-Hispanic Caucasian participants. The sample's mean Mini-Mental State Examination score (MMSE (Folstein, Folstein, & McHugh, 1975)) was 28.74 (S.D. = 1.34).

Informants consisted of 52 males and 20 females, with a mean age of 58.77 years (S.D. = 14.77) and a mean education of 14.68 years (S.D. = 2.65). The majority of informants (i.e., 62.5%) were spouses or domestic partners of the participants.

1.2. Neuropsychological assessment

Neuropsychological measures were selected to emphasize tasks sensitive to executive functioning mediated by frontal-subcortical systems. The measures were carefully selected so that a range of performance was documented, precluding floor or ceiling effects.

Controlled Oral Word Association (*COWA* (Spreen & Strauss, 1991)) is a test of rapid word generation. Raw scores reflect the total number of words generated across three letters ('F', 'A', 'S') during three separate 60 s trials. Lower scores indicate greater impairment.

Trail Making Test (*DKEFS subtest* (Delis, Kaplan, & Kramer, 2001)) is sensitive to difficulties with cognitive flexibility and sequencing. Raw scores reflect time to completion with greater scores indicating worse performance.

Paced Auditory Serial Addition Task (*PASAT* (Gronwall, 1977)) is a task of working memory. Raw scores reflect the average number of items correct across four separate trials involving different presentation paces. Lower scores denote more compromised performance.

Color-Word Interference Test (*DKEFS subtest* (Delis et al., 2001)) is a modified version of a task of inhibition involving suppression of an automatic response (word reading) in favor of a novel response (color naming) that was first developed by Stroop (1935). Raw scores reflect the speed at which participants complete the task. Higher scores denoting worse performance.

Tower Test (*DKEFS subtest* (Delis et al., 2001)) is a test of planning and problem solving abilities. Participants are asked to construct towers of discs on a set of pegs corresponding to a model. Raw scores are reported as an achievement score reflecting the participant's ability to use the fewest possible moves to achieve the tower depicted in the model. Lower scores denote worse performance.

Ruff Figural Fluency Test (*Figural Fluency* (Ruff, Light, & Evans, 1987) is a test of nonverbal generation in which participants are asked to draw lines connecting a series of dots. To control for the complexity of designs generated across participants, modified instructions were provided directing individuals to always use four lines in their generation of patterns. Raw scores reflect the total number of designs generated across three trials, each of which lasts 60 s. Lower scores indicate greater impairment.

1.3. Functional assessment

Activities of Daily Living Questionnaire (Lawton & Brody, 1969): A modified version of the Instrumental Activities of Daily Living & Physical Self-Maintenance Scale (IADL-PSMS (Lawton & Brody, 1969)) was administered to

primary caregivers who judged participants' performance of basic self-care activities (i.e., BADLs including feeding, dressing, grooming, bathing, toileting, ambulating) and more complex instrumental activities that facilitate independence (i.e., IADLs including traveling, management of finances, telephone use, meal preparation, housekeeping, laundry, shopping, and medication maintenance). The IADL-PSMS version used in the present study allows for performance gradations across each item, including *complete dependence* (0), *requires assistance* (1) and *complete independence* (2). Summary scores are calculated based on basic-self care functions (i.e., BADL subscale, 6 items, range 0–12), instrumental activities (i.e., IADL subscale, 8 items, range 0–16), and a combination of both reflecting global functional status (ADL total, range 0–28). Higher scores denote more intact functional abilities. The present study focused only on the IADL subscale. In those cases where a particular item did not apply to a participant, a pro-rated score was calculated to exclude impertinent items, while preserving the overall estimate of functional status. However, for the inter-item comparisons (i.e., the second aim of this study), missing data were not replaced with pro-rated scores.

1.4. Procedure

Informed consent was obtained from all participants prior to testing. Participants were compensated 25 dollars for their cognitive assessment. Evaluations were conducted in a single session for all participants except one, who required two testing sessions secondary to the participant's time constraints. With respect to the cognitive protocol, three participants were unable to complete a single trial of the PASAT due to time constraints or difficulty comprehending the instructions. Six participants were able to complete the early PASAT trials but unable to sustain the task in its entirety secondary to increasing difficulty, fatigue, or frustration. Data analyses including the PASAT consist of only 63 participants. Reliable informants completed the functional measure at the time of cognitive testing.

1.5. Data analysis plan

Pearson correlational analyses were conducted among all of the executive functioning measures (i.e., *Tower Test*, *Trail-Making Test*, *COWA*, *Ruff Figural Fluency Test*, *PASAT*, and *Color-Word Interference Test*). To account for multiple comparisons, significance was set at $\alpha = 0.01$. The first aim of the study was tested utilizing a logistic regression to examine the relative contribution of several predictor variables assessing executive functioning (i.e., planning as assessed by the *Tower Test*, sequencing as assessed by the *Trail-Making Test*, verbal generation as assessed by *COWA*, nonverbal generation as assessed by the *Ruff Figural Fluency Test*, working memory as assessed by the *PASAT*, and inhibition as assessed by the *Color-Word Interference Test*) to a binary outcome (i.e., independent versus requires some assistance) based on a criterion variable reflecting IADLs. The *MMSE* was not entered as a predictor variable for this analysis. Next, a Spearman correlation matrix was generated between the eight IADL items and the six measures of executive functioning. The purpose of this post hoc analysis was to examine the cognitive correlates of the individual IADL items to determine if the relationship identified by the regression was driven by one IADL or if the relationship was diffuse across multiple IADLs. Because of the confirmatory nature of this analysis, statistical significance was fixed at $\alpha = 0.05$. The second aim of the study was assessed via the Friedman test to assess inter-item differences among the eight IADL items, followed-up by a nonparametric procedure for post hoc comparisons (i.e., Wilcoxon test). To account for multiple comparisons, a more stringent level of significance was used (i.e., $\alpha = 0.01$).

2. Results

2.1. Demographic characteristics

Descriptive statistics, including means, standard deviations, or frequencies, were calculated for all participant and informant demographic variables (e.g., age, education level; see Table 1). Descriptive statistics, including means and standard deviations, were generated for all participant cognitive performances, IADL total score, and individual IADL items (see Table 2). Cognitive test performances were converted to T-scores based on available

Table 1
Participant demographic statistics

Demographic variable	CVD patient participants M (S.D.)	Informant participants M (S.D.)
Age (years)	69.21 (7.50) Range = 56–85	58.77 (14.77) Range = 22–85
Education level (years)	14.26 (2.90) Range = 8–22	14.68 (2.65) Range = 8–11
Gender (% female)	47.4	52.0

CVD, cardiovascular disease; M, mean; S.D., standard deviation.

normative data (see Table 2; Delis et al., 2001; Diehr, Heaton, Miller, & Grant, 1998; Tombaugh, Kozak, & Rees, 1999).

2.2. Cardiovascular medical history

Vascular medical history data was collected from participants and confirmed using available medical records. Frequency of condition is summarized as follows: angina (29.3%), atrial fibrillation (13.5%), coronary artery bypass (28.9%), diabetes (17.1%), heart failure (23.0%), hypercholesterolemia (60.0%), hypertension (69.7%), myocardial infarction (34.2%), stent insertion (20.0%), valve repair (2.7%), or valve replacement (5.3%).

2.3. Correlations between executive functioning measures

Statistically significant correlations emerged among several of the executive functioning variables, though the strength of relationships was modest (see Table 3).

Table 2
Means and standard deviations for cognitive and functional performances

Measure	Participants M (S.D.)	Mean T-score
Cognitive measures		
COWA[a]	39.79 (10.73)	57
Trail-Making[b]	80.68 (32.10)	53
PASAT[c]	59.37 (15.43)	53
Color-Word[b]	66.72 (18.35)	54
Tower Test[b]	17.24 (4.25)	57
Figural Fluency	29.43 (8.58)	*
Measure	**Participants M (S.D.)**	**Range**
Functional measure		
IADL subscale	15.37 (1.23)	10–16
Telephone use	2.00 (0.00)	2
Laundry	1.97 (0.18)	1–2
Medication management	1.96 (0.20)	1–2
Transportation	1.94 (0.23)	1–2
Financial management	1.92 (0.28)	1–2
Food preparation	1.89 (0.32)	1–2
Shopping	1.86 (0.35)	1–2
Housekeeping	1.77 (0.43)	1–2

M, mean; S.D., standard deviation; COWA, Controlled Oral Word Association; Trail-Making, DKEFS Trail-Making Test; Color-Word, Color-Word Interference Test; PASAT, Paced Auditory Serial Addition Task; IADL, instrumental activities of daily living.

[a] Standardized scores based on Tombaugh et al. (1999).

[b] Standardized scores based on Delis et al. (2001).

[c] Standardized scores based on Diehr et al. (1998).

[*] Conversion to normative data is not possible because of modified test administration.

Table 3
Correlations among executive functioning measures

	COWA (*r*=)	Trail-Making (*r*=)	PASAT (*r*=)	Tower Test (*r*=)	Figural Fluency (*r*=)	Color-Word (*r*=)
MMSE	**0.39**[a,b]	**−0.52**[a,b]	0.34[a]	0.31[a]	0.27	**−0.39**[a,b]
COWA	–	**−0.47**[a,b]	**0.40**[a,b]	0.14	**0.34**[a,b]	**−0.40**[a,b]
Trail-Making		–	**−0.68**[a,b]	**−0.48**[a,b]	**−0.46**[a,b]	**0.45**[a,b]
PASAT			–	0.36[a]	**0.43**[a,b]	**−0.64**[a,b]
Tower Test				–	0.23	**−0.43**[a,b]
Figural Fluency					–	−0.34[a]
Color-Word						–

MMSE, Mini-Mental State Examination; COWA, Controlled Oral Word Association; Trail-Making, DKEFS Trail-Making Test; Color-Word, Color-Word Interference Test; PASAT, Paced Auditory Serial Addition Task.
[a] Significance at 0.01 level.
[b] Significance at the 0.002 level (Bonferroni correction factor).

2.4. Logistic regression

For the logistic regression, the IADL total score was recoded as a dichotomous variable (i.e., completely independent across all items versus requiring some assistance on one or more IADL items). In order to balance predictive capability with model parsimony and to account for the multicollinearity of several of the potential predictor variables, a stepwise logistic regression procedure was used for model selection. Both forward and backward stepwise procedures, using a likelihood ratio criterion for variable addition/deletion, selected a model with the DKEFS Color-Word Interference Test as the single significant predictor (beta = −0.40, $p = 0.02$). Post hoc Spearman correlation analyses yielded statistically significant correlations between the Color-Word Interference Test and several IADL items (see Table 4), including shopping ($r = -0.23$, $p = 0.05$), laundry ($r = -0.27$, $p = 0.03$), transportation ($r = -0.33$, $p = 0.004$), and finances ($r = -0.23$, $p = 0.05$).

2.5. Friedman test for IADL inter-item comparisons

IADL inter-item comparisons were made for all eight IADL items using the Friedman test, yielding a significant main effect ($x^2 = 28.94$, $p = 0.001$). Post hoc comparisons using the Wilcoxon test yielded multiple statistically significant between-item differences. Specifically, telephone use was significantly more intact than transportation ($Z = -2.00$, $p = 0.046$), finances ($Z = -2.45$, $p = 0.014$), meal preparation ($Z = -2.65$, $p = 0.008$), shopping ($Z = -3.16$, $p = 0.002$), and housekeeping ($Z = -3.87$, $p = 0.001$). Laundry was significantly more intact than shopping ($Z = -2.24$, $p = 0.03$). Medication was significantly more intact than meal preparation ($Z = -2.24$, $p = 0.025$), shopping ($Z = -2.65$, $p = 0.008$),

Table 4
Correlations among all cognitive measures and IADL items

	MMSE	COWA	Figural Fluency	Trail-Making	PASAT	Tower Test	Color-Word
Telephone use	–	–	–	–	–	–	–
Shopping	**0.270**[a]	0.202	0.074	−0.139	0.171	0.036	**−0.232**[a]
Food preparation	**0.394**[a,b]	**0.311**[a]	0.179	−0.213	0.244	0.200	−0.230
Housekeeping	0.140	0.135	−0.025	−0.033	0.092	0.174	−0.057
Laundry	0.216	0.162	0.047	**−0.264**[a]	0.232	0.168	**−0.272**[a]
Transportation	0.172	0.188	0.126	**−0.255**[a]	0.156	**0.249**[a]	**−0.334**[a]
Medication	−0.015	0.179	0.009	0.100	−0.008	0.003	−0.048
Finances	−0.058	0.051	−0.037	−0.062	0.184	0.056	**−0.233**[a]

Telephone use was excluded from the analysis because there was no variability in informant responses; MMSE, Mini-Mental State Examination; COWA, Controlled Oral Word Association; Trail-Making, DKEFS Trail-Making Test; Color-Word, Color-Word Interference Test; PASAT, Paced Auditory Serial Addition Task.
[a] Significance at 0.05 level.
[b] Significance at the 0.001 level (Bonferroni correction factor).

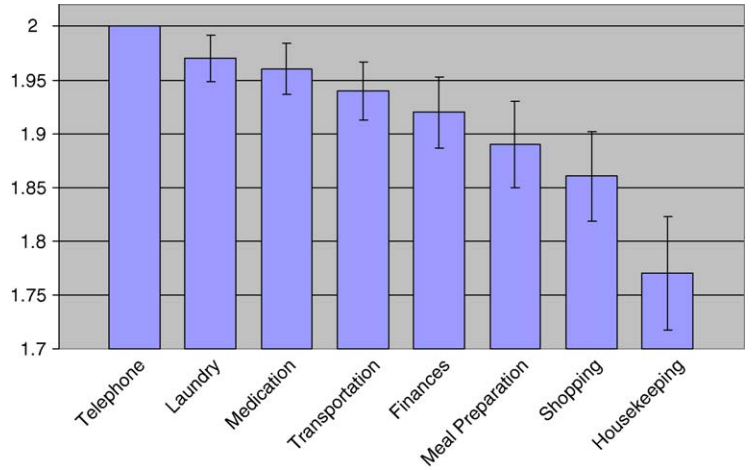

Fig. 1. Mean score with standard error of the mean for each IADL item.

and housekeeping ($Z = -3.61$, $p = 0.001$). Transportation was significantly more intact than housekeeping ($Z = -2.84$, $p = 0.005$). Meal preparation was significantly more intact than housekeeping ($Z = -2.33$, $p = 0.02$), as was shopping ($Z = -2.53$, $p = 0.005$). Housekeeping was significantly more intact than laundry ($Z = -3.16$, $p = 0.005$) and finances ($Z = -2.50$, $p = 0.01$). Means and standard deviations for all IADL items can be found in Table 2 with a graphical depiction of these differences in Fig. 1.

3. Discussion

The purpose of the present study was to concurrently assess the relevance of multiple elements of executive functioning to instrumental functional abilities. Results were contrary to expectation, as a measure of inhibition was most strongly related to IADL integrity. The literature documenting the relationship between executive functioning and IADLs has primarily emphasized sequencing (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2002; Carlson et al., 1999) over other components of executive functioning, though few studies have simultaneously compared multiple elements of executive functioning (Bell-McGinty et al., 2002) or included measures of inhibition, planning, and working memory. Therefore, our findings augment the existing literature by simultaneously considering multiple elements of executive functioning and by illustrating that inhibitory control (often reported as susceptibility to interference) is most important to IADLs among non-demented individuals at risk for future cognitive and functional changes.

Follow-up correlations suggest that the relationship between inhibition and IADLs is not driven by one IADL in particular, but rather the relationship is consistent across multiple instrumental activities, including shopping, laundry, financial management, and transportation. These findings suggest that susceptibility to interference while performing instrumental functional activities is more important to the integrity of IADLs than other executive functioning elements, including planning, sequencing, generation, or working memory.

The inhibition task implemented in the present study (i.e., Color-Word Interference Test from the DKEFS) is a variant of the Stroop paradigm, which requires inhibition of an automatic response (i.e., word reading) in favor of a novel response (i.e., color naming (Stroop, 1935)). The neuroanatomical correlates of this effect have been localized to the frontal lobes, as neuroimaging data indicate that cerebral blood flow activation is greatest in the left inferior frontal gyrus when engaging in a task similar to that utilized in the current study (Willis et al., 1998). A more recent neuroimaging study employing a similar paradigm among healthy elderly documented that the cognitive process of inhibitory control is associated with functional magnetic resonance imaging activation in multiple frontal areas, including the left inferior frontal gyrus (Langenecker, Nielson, & Rao, 2004). Thus, the neuroimaging correlates of cognitive inhibitory control suggest that the integrity of specific areas of the frontal lobe may be particularly relevant when performing instrumental functional abilities.

Though the present study is unique in its consideration of multiple elements of executive functioning, our findings are not the first to report an association between inhibition and IADLs. Recently, Boyle et al. (2004) reported that baseline performances on measures of inhibition and a heterogeneous measure of executive functioning (i.e., Initiation/Perseveration subscale of the Dementia Rating Scale (Mattis, 1973)) were predictive of IADLs at 1-year follow-up among patients with vascular dementia. Our findings extend those of Boyle et al. (2004) by illustrating that the relationship between inhibition and IADLs is observable before the onset of a dementia syndrome. Furthermore, our findings demonstrate that inhibition has a unique relationship with IADLs when multiple elements of executive functioning are simultaneously considered, extending the work of Bell-McGinty et al. (2002).

A possible criticism of the present methodology is that the inhibition measure utilized reflects a timed task that may inadvertently masquerade as speed of processing rather than inhibitory control. Though time to completion served as the dependent variable for the inhibition measure, it is worthwhile to mention that additional measures included in our methodology utilize a similar dependent variable (i.e., measures of sequencing and generation). Therefore, we believe that the significance of the inhibition measure contrasted with the null findings for the remaining speed-based tasks emphasizes something unique about inhibitory control in relation to IADLs.

Specific analyses of inter-task differences revealed that finances, meal preparation, housekeeping, and shopping are the earliest IADLs to deteriorate, suggesting increased vulnerability to cognitive decline. In contrast, telephone use appears resistant to impairment, as there were no reported difficulties for any participant's ability to use the telephone. These findings are somewhat consistent with our predictions as we hypothesized that meal preparation and financial management would be most susceptible to impairment while telephone use would be less susceptible. Furthermore, though preliminary, the inter-item differences noted in the current study are consistent with our previous findings among patients with vascular dementia (Jefferson et al., in press-b).

The correlation analyses among the executive functioning measures suggest that some of the predictor variables are interrelated. Multicollinearity is a legitimate criticism of some neuropsychological studies utilizing multiple, overlapping cognitive predictors for regression analyses, as implementing this type of statistical approach may yield invalid conclusions because of arbitrary partialing of variance between predictor and criterion variables. Implementation of a stepwise regression procedure is intended to avoid the problems associated with multicollinearity. Also, it is notable that the inter-cognitive variable correlations in this study yielded moderately strong relationships at best, suggesting that multicollinearity is not a threat to the validity of the findings since the variables are not highly correlated. Furthermore, our efforts to detect multicollinearity (i.e., through the computation of multiple regression equations predicting each predictor variable using all of the remaining predictor variables) suggest that no predicted variable was multicollinear with any of the remaining variables (data not shown (Wetherill, 1986)).

Additional research is needed to further develop a hierarchical conceptualization of functional decline across the various instrumental activities. In light of recent studies linking elements of visuoperceptual functions to IADLs (Glosser et al., 2001, 2002; Jefferson et al., in press-a), future research should also compare visuoperceptual and executive functioning variables to determine the most salient predictors of functional impairment as this remains elusive.

The sample utilized in this study is comprised of older individuals with medically stable cardiovascular disease and no documented neurological history. A cohort such as this provides a unique opportunity to study the cognitive correlates of functional decline, as these participants are at risk for future cognitive and functional change secondary to their numerous vascular risk factors. Future studies may wish to follow *at risk* patients to determine the cognitive functions that are most strongly related to longitudinal functional decline.

The present study highlights the importance of conducting detailed cognitive analyses to relate to everyday functional abilities, as inhibitory control is a significant correlate of instrumental functional abilities. The present results underscore the importance of very specific elements of executive functioning among IADLs in this cohort, and information gathered from neuropsychological assessments may be useful in the clinical prediction of instrumental abilities, such as food shopping or organizing finances, among these participants.

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References

American Psychiatric Association. (1994). *Diagnostic & statistical manual: Vol. IV*, Washington, DC: American Psychiatric Association.

Bell-McGinty, S., Podell, K., Franzen, M., Baird, A. D., & Williams, M. J. (2002). Standard measures of executive function in predicting instrumental activities of daily living in older adults. *International Journal of Geriatric Psychiatry*, *17*(9), 828–834.

Boyle, P. A., Malloy, P. F., Salloway, S., Cahn-Weiner, D. A., Cohen, R., & Cummings, J. L. (2003). Executive dysfunction and apathy predict functional impairment in Alzheimer disease. *The American Journal of Geriatric Psychiatry*, *11*(2), 214–221.

Boyle, P. A., Paul, R. H., Moser, D. J., & Cohen, R. A. (2004). Executive impairments predict functional declines in vascular dementia. *The Clinical Neuropsychologist*, *18*(1), 75–82.

Boyle, P. A., Paul, R., Moser, D., Zawacki, T., Gordon, N., & Cohen, R. (2003). Cognitive and neurologic predictors of functional impairment in vascular dementia. *The American Journal of Geriatric Psychiatry*, *11*(1), 103–106.

Cahn, D. A., Sullivan, E. V., Shear, P. K., Marsh, L., Fama, R., Lim, K. O., et al. (1998). Structural MRI correlates of recognition memory in Alzheimer's disease. *Journal of the International Neuropsychological Society*, *4*(2), 106–114.

Cahn-Weiner, D. A., Boyle, P. A., & Malloy, P. F. (2002). Tests of executive function predict instrumental activities of daily living in community-dwelling older individuals. *Applied Neuropsychology*, *9*(3), 187–191.

Cahn-Weiner, D. A., Malloy, P. F., Boyle, P. A., Marran, M., & Salloway, S. (2000). Prediction of functional status from neuropsychological tests in community-dwelling elderly individuals. *The Clinical Neuropsychologist*, *14*(2), 187–195.

Cahn-Weiner, D. A., Ready, R. E., & Malloy, P. F. (2003). Neuropsychological predictors of everyday memory and everyday functioning in patients with mild Alzheimer's disease. *Journal of Geriatric Psychiatry & Neurology*, *16*(2), 84–89.

Carlson, M. C., Fried, L. P., Xue, Q. L., Bandeen-Roche, K., Zeger, S. L., & Brandt, J. (1999). Association between executive attention and physical functional performance in community-dwelling older women. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *54*(5), S262–S270.

DeBettignies, B. H., Mahurin, R. K., & Pirozzolo, F. J. (1990). Insight for impairment in independent living skills in Alzheimer's disease and multi-infarct dementia. *Journal of Clinical and Experimental Neuropsychology*, *12*(2), 355–363.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan Executive Function System (D-KEFS): Examiner's manual*. San Antonio, TX: The Psychological Corporation.

Diehr, M. C., Heaton, R. K., Miller, W., & Grant, I. (1998). The Paced Auditory Serial Addition Task (PASAT): Norms for age, education, and ethnicity. *Assessment*, *5*(4), 375–387.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-mental state. A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189–198.

Glosser, G., Baker, K. M., deVries, J. J., Alavi, A., Grossman, M., & Clark, C. M. (2001). Disturbed visual processing contributes to impaired reading in Alzheimer's disease. *Neuropsychologia*, *40*, 902–909.

Glosser, G., Gallo, J., Duda, N., de Vries, J. J., Clark, C. M., & Grossman, M. (2002). Visual perceptual functions predict instrumental activities of daily living in patients with dementia. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, *15*(3), 198–206.

Gronwall, D. M. A. (1977). Paced Auditory Serial Addition Task: A measure of recovery from concussion. *Perceptual & Motor Skills*, *44*, 367–373.

Jefferson, A. L., Barakat, L. P., Giovannetti, T., Paul, R. H., & Glosser, G. (in press-a). Object perception predicts IADL impairment in Alzheimer's disease. *Journal of Clinical & Experimental Neuropsychology*.

Jefferson, A. L., Cahn-Weiner, D. A., Boyle, P. A., Paul, R. H., Moser, D. J., Gordon, N., et al. (in press-b). Longitudinal changes in activities of daily living (ADLs) among patients with vascular dementia (VaD). *International Journal of Geriatric Psychiatry*.

Jorm, A. F. (1994). Disability in dementia: Assessment, prevention, and rehabilitation. *Disability and Rehabilitation*, *16*(3), 98–109.

Kempen, G. I., & Suurmeijer, T. P. (1990). The development of a hierarchical polychotomous ADL-IADL scale for noninstitutionalized elders. *The Gerontologist*, *30*(4), 497–502.

Langenecker, S. A., Nielson, K. A., & Rao, S. M. (2004). fMRI of healthy older adults during Stroop interference. *Neuroimage*, *21*(1), 192–200.

Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*, *9*(3), 179–186.

Mattis, S. (1973). *Dementia rating scale professional manual*. Odessa, FL: Psychological Assessment Resources.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology*, *34*(7), 939–944.

Petersen, R. C., Smith, G. E., Waring, S. C., Ivnik, R. J., Tangalos, E. G., & Kokmen, E. (1999). Mild cognitive impairment. *Archives of Neurology*, *56*, 303–308.

Ruff, R.M., Light, R. H. & Evans, R.W. (1987). The Ruff figural fluency test: A normative study with adults. *Developmental Neuropsychology*, *3*, 37–52.

Spector, W. D., Katz, S., Murphy, J. B., & Fulton, J. P. (1987). The hierarchical relationship between activities of daily living and instrumental activities of daily living. *Journal of Chronic Diseases*, *40*(6), 481–489.

Spreen, O., & Strauss, E. (1991). *A compendium of neuropsychological tests*. New York: Oxford University Press.

Stroop, J. R. (1935). Studies of interference in serial verbal reaction. *Journal of Experimental Psychology*, *18*, 643–662.

Tombaugh, T. N., Kozak, J., & Rees, L. (1999). Normative data stratified by age and education for two measures of verbal fluency: FAS and animal naming. *Archives of Clinical Neuropsychology*, *14*(2), 167–177.

Wang, L., van Belle, G., Kukull, W. B., & Larson, E. B. (2002). Predictors of functional change: A longitudinal study of nondemented people aged 65 and older. *Journal of the American Geriatrics Society*, *50*, 1525–1534.

Wetherill, G. B. (1986). *Regression analysis with applications*. New York, NY: Chapman & Hall.

Willis, S. L., Allen-Burge, R., Dolan, M. M., Bertrand, R. M., Yesavage, J., & Taylor, J. L. (1998). Everyday problem solving among individuals with Alzheimer's disease. *The Gerontologist*, *38*(5), 569–577.

World Health Organization (1992). *The ICD-10 Classification of Mental and Behavioral Disorders*. Geneva.