Published in final edited form as:
Appl Neuropsychol. 2007 ; 14(3): 208–214.

The Relationship Between Executive Functioning and Activities of Daily Living in Patients With Relatively Mild Dementia

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Abstract

There is very little research regarding the relationship between tests of executive functioning and actual functional ability in patients with dementia. Thirty-three patients diagnosed with dementia and 35 age- and education-matched healthy controls were administered tests of executing functioning and an observation- and informant-based activities of daily living (ADL). As expected, the results revealed that the controls outperformed the dementia patients on the executive and ADL tests. Additionally, executive functioning correlated significantly with aspects of functional ability in patients with dementia. This relationship was strongest for tests of verbal fluency (i.e., FAS) and a complex test of cognitive flexibility and reasoning ability (i.e., WCST). These findings suggest that some executive function tests are more sensitive than others for predicting specific functional abilities and that they may be most useful to healthcare professionals for treatment planning.

Keywords

activities of daily living; functional ability; executive functioning; dementia; Alzheimer's disease

It has been well established that tests of executive functioning are useful in characterizing frontal lobe brain lesions and various forms of dementia (Kramer et al., 2005; Kennedy, 2004; Razani, Boone, Miller, Lee, & Sherman, 2001; Walker, Meares, Sachdev, & Bodaty,

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2005). Poor performance on executive tests is thought to represent a variety of cognitive inabilities including poor planning, organization, initiation, and "set shifting" ability (Lezak, Howieson, & Loring, 2004). However, there are currently very few empirical studies examining the relationship between executive dysfunction and everyday functional ability. In fact, there is sparse research on the relationship between neuropsychological performance and activities of daily living (ADLs) in general. Of the available studies, very few include a wide range of executive functioning measures, observation-based ADL tasks, and/or varied types of dementia patients. For the purposes of treatment planning and clinical management, a clear understanding of the relationship between test performance and functional ability would make results of executive function tests far more useful.

Most available studies have examined the relationship between ADLs and brief cognitive screening measures (e.g., MMSE) and ADLs (Vitaliano et al, 1984; Winograd, 1984) and have generally found strong correlations (Ford, Haley, Thrower, West, & Harrell, 1996; Reed, Jagust, & Seab, 1989; Warren et al., 1989). Similarly, few studies have examined the relationship between ADLs and larger neuropsychological test batteries. Cahn-Weiner et al. (2000) found that executive measures accounted for more variance in ADL performance than demographic variables such as age, health status, and education level in a community-dwelling group of elderly. The authors suggest that of the cognitive domains assessed, decline in executive abilities associated with normal aging may be the best predictor of functional deterioration. Boyle et al. (2003) found that that executive dysfunction on the Dementia Rating Scale alone explained 17% of the variance in instrumental ADLs (e.g., handling finances, managing medications) in patient with Alzheimer's disease. However, the executive measures used in this study were brief and the ADL test was informant rated, which is less reliable than observation-based measures (Pearson, 2000). Back-Madruga et al. (2002) found that a group of frontal-variant Alzheimer's disease patients performed worse on ADL tasks than the typical Alzheimer's patients.

In the most comprehensive study to date assessing cognitive functioning and ADLs, Farias, Harrell, Neumann, and Houtz (2003) found that the domain of executive functioning displayed one of the strongest correlations with ADLs. However, this domain contained only two tests: a letter fluency test and verbal reasoning. It is important to assess the relationship between functional ability and a wider range of traditional executive measures, particularly those that do not require as much verbal mediation (e.g., sorting tasks).

In recent years, a number of tests and test batteries have been developed with the sole purpose of assessing various aspects of executive functions (Delis, Kaplan, & Kramer, 2001). It is important to determine whether these tests, along with other gold standard executive measures (e.g., the Wisconsin Card Sorting Test) used in the clinical assessment of frontal-executive skills predict ADL skills in patients with dementia.

The purpose of the present study was to examine the relationship between traditional tests of executive skills and functional ability in a group of patients with varied forms of early-stage dementia.

Methods

Participants

A total of 68 participants, 33 patients diagnosed with cognitive impairment/dementia and 35 age- and education-matched healthy controls, participated in the present study. The patients were recruited from the regional Alzheimer's Association on the California State University, Northridge (CSUN) campus, the Sepulveda Veterans Administration Medical Center (VAMC), and the University of California, Los Angeles (UCLA) Alzheimer's Disease Center.

Two of the dementia patients were diagnosed with frontotemporal lobar degeneration using the criteria set forth by the Neary et al. (1998). Twenty-one patients entered the study with a diagnosis of probable or possible Alzheimer's disease provided by either healthcare professionals at the Sepulveda VAMC and UCLA, or by private physicians and/or neurologists. The remaining 10 patients with dementia carried a mixed diagnosis of vascular dementia and dementia-not otherwise specified from healthcare professionals at the Sepulveda VAMC. Only patients in the mild-moderate stages of illness were selected for this study (i.e., MMSE ≥ 15). Controls were healthy, community-dwelling older adults who were either the spouse or caregivers of patients who participated in this study or were recruited from the community. Exclusion criteria in both groups included chronic, untreated medical conditions, significant psychiatric illness (other than dementia in the patient group), head injury leading to loss of consciousness, or a substance abuse history. The research methods were reviewed and approved by the VA Greater Los Angeles, the CSUN and the UCLA Institutional Review Boards. Written informed consent was obtained from all participants, or in the case of dementia patients who were unable to provide informed consent, consent was obtained from their legal representative, with the assent of the patient.

As can be seen from Table 1, participants were on average in their 7^{th} decade of life, and were relatively well educated, with no significant differences between the two groups on age or level of education. Additionally, all participants were administered the Mini-Mental State Exam (MMSE; Folstein, Folstein, McHugh, 1975), and while there were differences between the groups, the cognitively impaired patients, were on average in the very mild stages of dementia (MMSE ranged from 17–30, with over 81% scoring above 20).

Measurement Instruments

Neuropsychological/Executive Measures

Mini-Mental State Exam **(MMSE; Folstein et al., 1975):** One outcome score from this brief, 30-item cognitive screening measure was obtained.

Wisconsin Card Sorting Test **(WCST; Heaton, Chelune, Talley, Kay, and Curtiss, 1997):** Participants were required to match stimulus cards to four key cards with very little feedback from the examiner. The cards could be matched based on three abstract principles: color, shape, or number. The number of categories completed, total errors committed, and perseverative responses served as the outcome measures.

Delis-Kaplan Executive Function System (D-KEFS) Sorting Test (Condition 1**; Delis et al., 2001):** Participant were required to sort a set of six cards into two piles based on abstract principles such as size of the cards or gender of the names printed on the cards. The total number of correct free categorical sorts made was used as the outcome measure.

D-KEFS Tower Test **(Delis et al.,2001):** Participants were required to place various sized discs on pegs based on a predetermined design. The Total Achievement Score and Rule Violation Ratio were used as the outcome measures.

D-KEFS Trail Making Test (TMT) – Number-Letter Switching **(Delis et al., 2001):** Participants were required to connect numbers and letters, which are scattered on a 17x11 inch sheet of paper, in sequence as quickly as possible. Time (in seconds) taken to complete the task was used as the outcome measure.

D-KEFS Color-Word Interference Test – Inhibition **(Delis et al., 2001):** Participants were presented with color names (i.e., red, blue, or green) printed in different colored ink (i.e., red,

blue, or green) and asked to name the color of the ink and not read the word itself. Time (in seconds) taken to complete the task was used as the outcome measure.

***Verbal Fluency* (*FAS*; Benton & Hamsher, 1976):** Participants were asked to produce words starting with the letters F, A, & S in one minute per letter. The total number of words produced for all three letters was used as the outcome measure.

Activities of Daily Living Measures—We administered both an informant-rated questionnaire of instrumental activities of daily living and a performance-based measure (described below). Both of theses measures have been shown to be valid and reliable measures in a variety of settings and populations (Pearson, 2000), both were designed to specifically measure instrumental ADLs in patients with dementia, and the combination of these measures allow for informant-ratings and direct observation of patients' basic and complex (intermediate) functional skills.

***Instrumental Activities of Daily Living (I-ADL*; Warren et al., 1989):** This is a modified version of Lawton & Brody's (1969) ADL measure. This is an informant-rated questionnaire that was completed by the patient's caregivers and was designed to assess intermediate functional ability (e.g., ability to use telephone, shop, handle finances) as well as basic abilities (e.g., grooming, bathing, feeding). Each of the questions is rated on a 3-point scale (0–2), with higher scores representing greater functional impairment.

***Direct Assessment of Functional Status (DAFS*; Lowenstein et al., 1989):** This is a direct observational measure in which seven ADL ability areas were assessed. Time orientation assesses participant's ability to tell various clock settings and their orientation to person, place and time, communication skills included the ability to use the telephone, transportation subtest required the participant to identify common road signs and regulations, financial management subtest included balancing a checkbook, shopping subtest required remembering a set of shopping items and selecting them from a mock grocery store, grooming everyday grooming activities such as brushing hair and teeth, and the eating subtest assessed use of utensils. Points are given for correct responses to questions/operations performed within each domain. The total score (sum of all points) and specific subscale/domain scores with the exception of grooming and eating (because of a ceiling effect found in both patients and controls with these subtests) were used as outcome measures.

Procedures

All participants (patients and controls) were administered the MMSE, the executive skills tests, and the DAFS (performance-based ADL). The caregivers' of the dementia patients completed the I-ADL measure regarding the patients' level of functioning.

Results

The results of neuropsychological testing, including executive function tests, and functional status assessment tests (both informant-report and performance-based measures) are listed in Table 1. A series of one-way analyses of variance revealed that the control group outperformed the dementia group on the MMSE, the DAFS Total Score and its individual subscales, and the majority of the executive function tests. The only executive measures for which statistical significance was not reached were the D-KEFS Color-Word Interference Test-Inhibition ($p = .20$), D-KEFS Tower Rule Violation ($p = .57$), and WCST Total Errors ($p = .06$).

While the dementia group was in the very early stages of illness as indicated by the MMSE average score of 24.3, the effect size (η^2) values for DAFS measures, particularly Total Score

and the Shopping subscale score, indicate that this group is already experiencing moderate functional impairment. In fact, when compared to controls, the dementia group seems to display greater functional rather than executive impairment (as observed by the effect sizes). However, moderate effect sizes in WCST Categories Completed and the D-KEFS Tower Achievement scores were also observed.

Bivariate correlations were performed in order to examine the relationship between the functional measures/subscales and the executive test scores in the cognitively impaired patients. The results, presented in Table 2, revealed strong relationships between the MMSE, I-ADL and all DAFS scores. Similarly, verbal fluency correlated with all of the functional measures, with the exception of the DAFS Orientation subscale. The WCST outcome measures also correlated with a number of DAFS and I-ADL measures. The other executive measures only correlated with one or two DAFS outcome measures. The D-KEFS Tower Achievement and the California Sorting Test only correlated with the DAFS Shopping subscale, while the D-KEFS TMT Number-Letter sequencing test correlated with only the DAFS Transportation subscale. Interestingly, the D-KEFS Color-Word Inhibition test did not correlate with either the I-ADL or the DAFS measures.

A series of stepwise regression analyses were performed, using the executive measures as the independent variables and the functional scores (i.e., I-ADL and DAFS) as the dependent variable. Table 3 demonstrates that the WCST Categories Completed was the single best predictor of DAFS Total Score and DAFS Communication subscale score, while FAS was the best predictor of the DAFS Financial outcome scores. The DAFS Shopping subscale score for this group of dementia patients was best predicted by D-KEFS Tower Achievement Score, followed by FAS, and finally by D-KEFS Sorting Test scores, with these three measures accounting for 72% of the total variability.

Discussion

The present study assessed the relationship between traditional tests of executive dysfunction and performance- and informant-based functional measures in a group of patients with varied forms of dementia. The results revealed that these mildly cognitively impaired patients displayed multiple functional impairments relative to their healthy control counterparts, a finding that is consistent with previous studies (Farias et al., 2003; Lowenstein et al., 1989). In fact, greater differences in ADL performance were found between patients and controls than for executive tests. This appears to be due to the fact that there is more variability in the performance of controls on the executive task, while there was nearly a ceiling effect on their ADL test performance.

The current findings also revealed that not all executive measures correlated equally with the functional tests. For example, verbal fluency (i.e., FAS) correlated most strongly with the observation-based functional test. These findings are consistent with previous reports (Farias et al., 2003) and suggest that the skills underlying the verbal fluency task are quite useful for complex tasks such as managing finances and planning and carrying out a shopping task. The moderate relationship found between the WCST and ADL tasks highlights the importance of adequate planning, organization, and the ability to maintain and shift set when carrying out routine daily activities. Surprisingly, the D-KEFS measures did not correlate with very many of the functional measures. In fact, the Color-Word Inhibition test did not correlate with a single informant- or performance-based outcome score. The lack of relationship between the D-KEFS and the functional measures may be due to the mild stage of dementia of the current sample, the small effect sizes between patients and controls on these tasks, and/or the fact that these tests are not good predictors of the types of ADL activities measured in this study. Further studies are needed to better understand this finding.

Interestingly the MMSE demonstrated the strongest relationship with both of the functional measures and their subscales, a finding that is consistent with the existing literature (Ford et al., 1996; Lecky & Beatty, 2002). Brief screening measures, such as the MMSE, tap into a wide range of abilities thus it is not surprising that they correlate with ADLs. However, the current findings revealed that, unlike the executive measures, the MMSE does not discriminate in the strength of its correlations with the various aspects of ADLs.

Selected executive tests were useful for predicting specific aspects of functional abilities. The WCST categories completed, verbal fluency, the Tower and California Sorting tests were among the executive tests that best uniquely accounted for functional skills, such as financial management, communication skills, and shopping ability. These findings are in line with those of Farias et al. (2003) who also found executive measures to be important predictors of financial and shopping skills.

It should be noted that we are not suggesting that the neuropsychological tests selected for this study exclusively measure the executive functioning domain. It is understood that these tasks tap into multiple non-executive functions such as memory, information processing speed, and psychomotor skills. The purpose of the current study was to characterize the relationship between commonly used tests of executive functioning and ADLs. Given the design of the present study, it is difficult to tease apart the degree to which the relationships found between the selected neuropsychological measures and the ADLs are uniquely due to executive functioning skills. Future studies should focus on differentiating how the non-excutive and executive aspects of these measures relate to ADLs. Additionally, there were greater numbers of male than female patients in the current study. For the purposes of better generalization, future studies should aim to have a more balanced gender distribution.

In summary, we found that the relationship between ADLs and executive functioning was strongest with tests of verbal fluency (i.e., FAS) and the WCST, but not necessarily with selected D-KEFS. Future studies are needed to better understand these relationships, and should include a larger neuropsychological batteries that assess a greater number of cognitive domains. Also if importance, the findings from the current study and those from previous studies (Faria et al., 2003; Lowenstein et al., 1992) suggest that neuropsychological tests do have ecological validity and can be useful in guiding clinical decisions.

Acknowledgements

This study was supported by NIGMS grant S06GM48680 to JR. Additional support for the project was provided by NIGMS grants GM63787 (Minority Biomedical Research Support Program-Research Initiative for Scientific Enhancement) & GM08395 (Minority Access to Research Career).

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Table 1

Descriptive characteristics and results of neuropsychological and functional status testing in patients (n = 33) and controls (n = 35).

	Dementia Patients	Normal Controls	Effect Size (η^2)
Demographic Information			
Age	73.82 (± 8.76)	73.97 (±10.33)	.01
Education	15.08 (± 3.11)	15.00 (± 2.62)	.01
Gender (M/F)	26/7	6/29	
Ethnicity			
Caucasian	30	31	
Hispanic	0	1	
African-American	2	2	
Asian	1	1	
NP & Executive Measures			
MMSE[c]	24.27 (± 5.13)	29.08 (± 1.08)	.31
D-KEFS TMT (Number-Letter)[c]	184.74 (±85.37)	114.53 (±53.40)	.21
D-KEFS Color-Word (Inhibition)	95.93 (±41.85)	84.43 (±29.31)	.03
D-KEFS Sorting Test (Total Score)[b]	3.21 (± 1.60)	4.17 (± 1.32)	.10
D-KEFS Tower (Achievement Score)[c]	9.40 (± 5.56)	15.88 (± 6.00)	.24
D-KEFS Tower (Rule Violation Ratio)	1.69 (± 2.04)	1.02 (± 1.57)	.01
Verbal Fluency (F, A, S)[a]	24.85 (±14.44)	32.00 (±11.83)	.07
WCST Categories Completed[c]	1.88 (± 1.54)	3.23 (± 1.20)	.21
WCST Total Errors	24.38 (±10.07)	19.03 (±12.45)	.06
WCST Perseverative Responses[c]	20.03 (±14.04)	10.81 (± 5.65)	.16
Direct Assessment of Functional Status (DAFS)			
DAFS Total[c]	75.33 (±13.64)	88.54 (± 3.94)	.36
DAFS Orientation[c]	13.42 (± 3.25)	15.70 (± 1.13)	.19
DAFS Communication[c]	11.52 (± 3.19)	13.49 (± 0.61)	.17
DAFS Transportation[b]	11.33 (± 2.50)	12.70 (± 0.62)	.13
DAFS Financial[c]	15.42 (± 3.82)	17.86 (± 1.32)	.20
DAFS Shopping[c]	8.85 (± 3.62)	14.11 (± 2.35)	.44
I-ADL (Total Score)	18.39 (± 4.12)	--	--

MMSE= Mini Mental State Exam; D-KEFS= Delis-Kaplan Executive Function System; TMT = Trail Making Test; WCST = Wisconsin Card Sorting Test; DAFS = Direct Assessment of Functional Status; I-ADL = Instrumental Activities of Daily Living

[a] $p \leq .025$,

[b] $p \leq .01$,

[c] $p \leq .001$

Table 2

Correlation coefficients for DAFS, I-ADL, and executive scores for cognitively impaired patients.

		Direct Assessment of Functional Status					
Measures	**I-ADL**	**Total Score**	**Orientation**	**Communication**	**Transportation**	**Financial**	**Shopping**
MMSE	.75***	.72***	.59**	.67***	.61***	..63***	.71***
D-KEFS TMT (Number-Letter)	.27	.29	.09	.30	**.60****	.15	.15
D-KEFS Color-Word (Inhibition)	.11	.04	−.04	−.08	.27	.03	−.01
D-KEFS Sorting Test (Total Score)	.23	.30	.06	.28	.28	.07	**.47****
D-KEFS Tower (Ach. Score)	.28	.32	.24	.26	.06	.18	**.52****
D-KEFS Tower (Rule Viol. Ratio)	−.04	−.24	−.12	−.10	**−.43****	−.14	−.23
Verbal Fluency (F, A, S)	**.48****	**.49****	.17	**.42****	**.49****	**.54*****	**.44****
WCST (Categories Completed)	.28	**.50****	**.38***	**.37***	.28	**.43****	**.38***
WCST (Total Errors)	**−.35***	**−.47****	**−.36***	−.24	−.30	**−.45****	−.32
WCST (Perseverative Responses)	−.33	**−.41****	−.18	−.24	**−.50****	−.24	**−.43****

I-ADL = Instrumental Activities of Daily Living; MMSE= Mini Mental State Exam; D-KEFS= Delis-Kaplan Executive Function System; TMT = Trail Making Test; WCST = Wisconsin Card Sorting Test

* p< .05,

** p< .01,

*** p<.001

Appl Neuropsychol. Author manuscript; available in PMC 2008 May 14.

Table 3

Results of Stepwise Regression for patients using executive scores as the independent variable to predict various DAFS and I-ADL performance.

Functional Measures	Variables Entered	R^2	R^2 Change	Standardized *B*	F Change	*p* value
I-ADL	--	--	--	--	--	--
DAFS (Total Score)	WCST Cat. Completed	.32	--	.57	10.0	.005
DAFS (Orientation)	--	--	--	--	--	--
DAFS (Communication)	WCST Cat. Completed	.17	--	.42	4.4	.05
DAFS (Transportation)	--	--	--	--	--	--
DAFS (Financial)	Verbal Fluency (F, A, S)	.17	--	.42	4.3	.05
DAFS (Shopping)	D-KEFS Tower Ach. Score	.50	--	.61	21.3	<.001
	FAS	.64	.14	.35	7.6	.01
	D-KEFS Sorting tests	.72	.08	.32	5.1	.03

I-ADL = Instrumental Activities of Daily Living; DAFS = Direct Assessment of Functional Status; WCST= Wisconsin Card Sorting Test; D-KEFS= Delis-Kaplan Executive Function Systems