The Clinical Neuropsychologist
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ntcn20

Executive Control Functioning and Functional Ability in Older Adults

Monica S. Lewis [a] & L. Stephen Miller [a]
[a] The Department of Psychology , University of Georgia , Athens, GA, USA
Published online: 28 Mar 2007.

To cite this article: Monica S. Lewis & L. Stephen Miller (2007) Executive Control Functioning and Functional Ability in Older Adults, The Clinical Neuropsychologist, 21:2, 274-285, DOI: 10.1080/13854040500519752

To link to this article: http://dx.doi.org/10.1080/13854040500519752

The Clinical Neuropsychologist, 21: 274–285, 2007
http://www.psypress.com/tcn
ISSN: 1385-4046 print/1744-4144 online
DOI: 10.1080/13854040500519752

Psychology Press
Taylor & Francis Group

CE EXECUTIVE CONTROL FUNCTIONING AND FUNCTIONAL ABILITY IN OLDER ADULTS

Monica S. Lewis and L. Stephen Miller
The Department of Psychology, University of Georgia, Athens, GA, USA

The manner in which executive control functioning exerts its influence on functional tasks was investigated. Sixty older adults were administered neuropsychological tasks tapping into four domains of executive control function, including working memory, planning, fluency, and flexibility. A test of performance-based functional ability also was administered. Correlational analyses demonstrated that working memory was most strongly associated with performance-based functional ability; however, impairment in planning appeared to best predict performance-based functional decrement in simultaneous regression models. Results highlight the role of planning in the maintenance of functional ability, as measured by performance-based functional measures.

INTRODUCTION

Aging has profound, but heterogeneous, effects on cognitive aspects of functional ability (Carman, 1997; Tranel, Benton, & Olson, 1997). One factor contributing to this heterogeneity has been demonstrated as differences in executive control functioning (ECF) among older adults. Existing research gives clear evidence that ECF has an important role in maintaining functional ability in later life. Breakdowns in ECF have been associated with impaired ability in activities of daily living (ADLs) and instrumental activities of daily living (IADLs) in later life as well as in age-related diseases. For example, Royall, Chiodo, and Polk (2000) have demonstrated that impairment in ECF has statistically significant effects on level of care and impairment in IADLs among non-institutionalized retirees. Similarly, research by Grigsby, Kayer, Baxter, Shetterly, and Hamman (1998) has suggested that certain kinds of functional and behavioral disturbances are associated with, and may be caused by, impaired executive capacity among older persons. Their research demonstrated that, though general cognitive decrement contributed toward functional decline in their sample of independent older adults, ECF was the most salient predictor of functional impairment on multiple complex functional tasks. Similarly, Cahn-Weiner, Malloy, Boyle, Marran, and Salloway (2000) demonstrated that ECF

Address correspondence to: L. Stephen Miller, Ph.D., The University of Georgia, Department of Psychology, Athens, GA 30602. Tel.: 706-542-1173. Fax: 706-542-8048. E-mail: lsmiller@egon.psy.uga.edu

Accepted for publication: December 8, 2005. First published online: July 22, 2006.

dysfunction was a more accurate predictor of functional ability in community dwelling older adults than were other measures of cognitive function, including tests of memory, language, visuospatial skill, and psychomotor speed. Boyle, Paul, Moser, and Cohen (2004) showed that baseline ECF impairment predicted functional decline in vascular dementia patients a year later and was greater than neuroanatomical pathology.

Because ECF is a complex theoretical construct representing higher order mental processes, it remains unclear as to the ways in which ECF exerts its influence on functional ability. A variety of cognitive skills are theorized as contributing to proper ECF. Defined by A. R. Luria in 1966 as a ''frontal syndrome'' creating ''interference with the processes of regulation of active states of the cerebral cortex responsible for selective, goal-oriented psychological activity,'' ECF is thought to involve those cognitive processes which orchestrate relatively simple ideas, movements and actions into complex goal-directed behavior.

The differential contribution of specific, commonly used neuropsychological tests of ECF in predicting functional ability in geriatric populations has been examined in at least two studies. Bell-McGinty, Podell, Franzen, Baird, and Williams (2002) found that among a group of both demented and non-demented older adults, performance on the Trail Making Test part B and the Wisconsin Card Sorting Test—64-card version significantly predicted functional ability on an observational measure. Results were interpreted as suggestive that mental flexibility, psychomotor speed and novel problem solving skills are of central importance in the maintenance of functional capacity in later life. Cahn-Weiner, Boyle, and Malloy (2002) demonstrated that among independent, community-dwelling older adults, performance on the Trail Making Test part B, as suggestive of cognitive shifting and complex sequencing ability, was related to functional ability as measured by both a performance-based and a caregiver report measure of IADLs. Performance on the COWAT, however, appeared most predictive of functional ability for everyday tasks in which there is little external structure, such as those reflected by caregiver report measures (Cahn-Weiner et al., 2002).

The purpose of the current study was to further investigate the differential contribution of specific executive skills to the maintenance of functional ability in healthy older adults. This was accomplished through the measurement of four important components of ECF: working memory, planning, cognitive fluency, and cognitive flexibility. Although there is as yet no clear theoretical evidence for which are the most important components of ECF, or even how to define the universe of ECF components, research does support these cognitive processes as being of central relevance. The four domains noted are furthermore consistent with areas considered important in past discussions of ECF and aging in the literature and discussed below.

Working memory has been considered inherent to the construct of ECF in both animal and human studies. Animals with prefrontal lesions have been shown to be unable to sustain movement toward a goal (Fuster, 1997). Similarly, humans who experienced impairment in working memory following frontal lobe lesions and prefrontal brain injury have been found to be unable to sustain concentration, making task completion difficult (Fuster, 1997). Further, working memory changes are consistently seen in older adults (Reuter-Lorenz & Lustig, 2005) and have been related to prefrontal cortex changes (Rajah & D'Esposito, 2005) in aging.

The ability to plan and demonstrate intact foresight has been implicated as a central indicator of ECF by researchers throughout the neuropsychological literature (Krikorian, Bartok, & Gay, 1994; Brennan, Welsh, & Fisher, 1997). Lezak, Howieson, and Loring (2004) presented it as one of the four components of ECF in their review of the executive functions. While some loss of planning ability is considered part of the normal aging process, research has demonstrated that marked deficits in planning ability are associated with the presence of dementia and impaired execution of movement (Das & Mishra, 1995; Richards, Cote, & Stern, 1993).

In addition to being able to plan one's behavior and have sufficient working memory capacities to perform a task, other literature points to the translation of one's intention or plan into productive, self-serving activity as the central component of ECF. Such a skill corresponds to Lezak's description of self-regulation (Lezak et al., 2004). This ability to produce effective performance has at times been described by cognitive researchers as comprised of two distinct skills: cognitive fluency and cognitive flexibility. Cognitive fluency has been found to steadily decline with increasing age (Ylikoski et al., 1999) and it has been theorized as being at the root of functional decline in older adults (Pillon, Dubois, Lhermitte, & Agid, 1986).

Cognitive flexibility, or the ability to switch between tasks, monitor one's own behavior, and appropriate attentional skills in an effective manner, has long been included in the construct of ECF (Luria, 1966) and is associated with frontal lobe functioning (Dywan, Segalowitz, & Unsal, 1992). While these areas of ECF arguably may not encompass the entire construct of ECF, the extant literature supports them as major contributors to the construct and are of interest in understanding how ECF exerts its influence on functional ability.

In this study, functional ability was measured using an observational measure of task performance. Observational measures of functional ability have been found to possess high levels of face validity when used in older populations because they focus primarily on tasks encountered by older persons in daily living (Myers, Holiday, Harvey, & Hutchinson, 1993). In comparison to self-report measures of functional status, on which individuals often overestimate their true level of competence (Myers et al., 1993), observational measures of functional ability offer the advantage of being an objective measure of competence on which one cannot exaggerate functional abilities. Thus, within an older, community-dwelling population, the influence of working memory, planning, fluency, and cognitive flexibility on performance-based functional ability was assessed in order to determine which domains of ECF may be most influential in maintaining functional ability in later life, beyond the effects of demographic variables including age, education, and gender. When possible, domains were comprised of multiple neuropsychological measures combined to create internally consistent measures of central ECF skills. While this study was designed to be essentially exploratory in nature, it was hypothesized that individuals demonstrating the greatest impairment in overall ECF would likewise demonstrate the greatest impairment in functional ability. Furthermore, it was thought that the separate ECF domains would account for differing degrees of variance in functional status, over and beyond the variance accounted for by demographic variables.

Illuminating specific differential effects of the ECF domains was a major focus of the current study.

METHOD

Participants

The project was approved by the Institutional Review Board, Human Subjects Review Committee of the University of Georgia. Participants recruited included both independently dwelling older adults and persons residing in assisted care facilities. Initially, 83 participants were recruited for screening for participation in the current study. Efforts were made to include participants with a wide range of ECF abilities through a screening process in which potential participants were administered the Executive Interview (EXIT; Royall, 1992), a 15-minute gross ECF screening measure tapping into a broad spectrum of abilities included in the construct of ECF. Using the EXIT as a screening measure, participants were recruited with ECF abilities in the average (scores lower than 15 on the EXIT; $N = 35$), mildly impaired (scores between 15 and 18; $N = 16$) and moderately to severely impaired level (EXIT scores of 19 and higher; $N = 9$). Nine participants found to have EXIT scores in the average range after the initial 35 participants in the average range had already been recruited were excluded from the study, as financial resources did not allow inclusion of more than 60 participants. All potential participants were also administered the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), and persons with scores greater than 16 ($N = 5$), indicating significant levels of depression, were not included as participants in the current study. Past studies have indicated that depression should be viewed as a determinant of problem behavior (Beck, Rossby, & Baldwin, 1991). Finally, 9 potential participants were excluded from the study due to gross medical or physical impairments such as loss of hearing, vision, or independent mobility, as such variables would likely have served as confounding variables in the relationship between cognition and functional ability. Following the screening process, 60 older adult participants were included in the study. The final 60 participants were paid $20.00 for their participation in the project.

Protocol

Cognitive measures. Four domains of ECF were measured in the current study: working memory, planning, cognitive fluency, and cognitive flexibility. Working memory (WM) was measured using the Working Memory Index of the Weschler Adult Intelligence Scale—III (WAIS-III; The Psychological Corporation, 1997). The index includes the Digit Span, Arithmetic, and Letter-Number Sequencing subtests and is considered in neuropsychological literature to be a relatively pure measure of simple working memory free from the intervening effects of other cortical processes (Lezak et al., 2004).

Planning (PLAN) was measured using two neuropsychological measures, the Tower of London, Drexel University Version (TOLdx, Culberston & Zillmer, 1998) and the Porteus Maze Test (PMT; Porteus, 1965; Porteus & Peters, 1947).

The TOL score was based on the total number of target stimuli trials correctly completed (Target score), the number of seconds between the introduction of a problem and the initiation of the first move of a trial (Planning Time), and the total number of seconds from initiation of the first move of a trial to completion of the final move of that trial (Execution Time). PMT score was reported in terms of test age, which is the age level equivalent of the most difficult maze the participant completed successfully. The upper score of the PMT was 17 for success on the adult level maze. These two neuropsychological tests have been found to load on a "planning factor," and both involve problem-solving in a configural context and anticipatory planning skills (Krikorian, Bartok, & Gay, 1994).

Fluency (FLU) was assessed using the Controlled Oral Word Association (COWAT; Benton & Hamsher, 1976), which measures the spontaneous oral production of words beginning with the designated letters C, F, and L. COWAT score was the number of novel outputs produced by participants. Perseverations and incorrect answers were not counted.

Flexibility (FLEX) was assessed using a computerized version of the Wisconsin Card Sorting Test (WCST; Heaton, 1993), which required the categorization of sensory (visual) items in accord with a temporally changing principle. The WCST generated three different measures of participant flexibility including measures of categories achieved, total errors, and percentage correct. Taken together, these scores formed a unique flexibility factor (Mirsky, Anthony, Duncan, Ahearn, & Kellan, 1991) that was used to reflect participant's level of mental flexibility in the current study.

Functional ability measure. Functional ability was measured using the Direct Assessment of Functional Status (DAFS; Lowenstein et al., 1989; Lowenstein & Bates, 1989), an observational measure of participant functioning. The DAFS was developed with the purpose of directly evaluating a broad array of functional capacities in the older person with and without cognitive impairment. The scale has been extensively validated within both memory disordered and normal older adults controls, with the older adult controls' interrater reliability for functional domains measured by the test ranging from .988 to 1.00 ($p < .001$), and test–retest reliabilities ranging from .917 to 1.00 ($p < .001$). Using memory disordered participants, convergent validity of the DAFS with the Blessed Dementia Rating Scale, a well established measure of general functional status, was found to be $-.588$ ($p < .01$; Lowenstein et al., 1989). The test required approximately 45 minutes to complete and required each participant to perform 14 different functional tasks associated with seven domains of functional skills. The total number of incorrect responses exhibited by the participant on the test was calculated to form an overall impairment summary score for each participant, with higher scores representing greater impairment. Table 1 lists the domains and specific functional tasks measured by the DAFS.

Statistics. All analyses were conducted using SPSS 10.0 (Chicago, IL). A p value of $\leq .05$ was considered significant. Initially, because the neuropsychological tests used in the measurement of the ECF domains in this study yielded a large number of variables, internally consistent summary scales were constructed for each ECF domain (ATT, PLAN, FLU, FLEX). To compute these scales, for each domain of ECF the obtained participant raw scores derived from each neuropsychological

Table 1 DAFS domains and skill requirements

Domain	Skill requirements
Time orientation	Telling time
	Orientation to date
Communication	Using the telephone
	Preparing a letter for mailing
Transportation	Correct identification of road signs
Financial ability	Identifying currency
	Counting change
	Writing a check
	Balancing a checkbook
Shopping	Memory for grocery items
	Selecting grocery items with a list
	Making correct change
Grooming	Performing basic grooming skills
Eating	Using eating utensils correctly

Note. DAFS = The Direct Assessment of Functional Status.

measure were rescaled to standard equivalents (*z* transformations). Coefficient alpha levels were then computed for each collective set of transformed measures to ensure internal consistency (see Table 2 for ECF domain scale construction). Summary scales were then computed by obtaining a summed average of the *z*-transformed scores for each of the four ECF dependent variables, with lower scores reflecting greater ECF impairment. This method of analyzing a large battery of neuropsychological tests has been adopted by several researchers (e.g., Hoff et al., 1992; Saykin et al., 1991) and has the advantages of enhanced reliability of measurement and reduction of error variance compared with data analysis using individual neuropsychological tests (Miller & Rohling, 2001).

Normal distributions of data were checked by using the Kolmogorov-Smirnov test. Bivariate correlations were analyzed using the Pearson correlation coefficient to

Table 2 Construction of ECF summary scales

Scale	Test	Coefficient Alpha
Working memory	WAIS-III Digit Span score	.7875
	WAIS-III Arithmetic score	
	WAIS-III Letter-Number Sequencing score	
Planning	Tower of London test score	.8249
	Tower of London planning time score	
	Tower of London execution time score	
	Porteus Maze Test age score	
Cognitive fluency	COWAT Fluency novel output score	N/A
Cognitive flexibility	WCST category score	.9263
	WCST total error score	
	WCST percentage conceptual level response	

Note. ECF = Executive Control Function; WAIS-III = Wechsler Adult Intelligence Scale, Third Edition; COWAT = Controlled Oral Word Association Test; WCST = Wisconsin Card Sorting Test.

Table 3 Descriptive statistics for cognitive measures by EXIT score

	Full group	EXIT <15 ($N = 35$)	EXIT 15–18 ($N = 16$)	EXIT >19 ($N = 9$)
Attention				
Working Memory Index, WAIS-III	Scaled score = 30 (3.5)	Scaled score = 35 (7.1)	Scaled score = 25 (7.7)	Scaled score = 23 (8.9)
Planning				
Tower of London test score	43.5 (23.2)	36 (15.6)	53.0 (17.5))	62.86 (43.5)
Tower of London initiation time	90.2 (60.8)	75.5 (40.5)	106.92 (67.4)	132.86 (104.5)
Tower of London execution time	382.4 (186.7)	319.3 (134.2)	466.77 (176.7)	541.29 (285.02)
Tower of London total time	472.5 (216.8)	394.5 (152.5)	574.0 (202.5)	674.14 (322.75)
Verbal Fluency				
COWAT # Words	36.8	43.2	27.9	27.2
Flexibility				
WCST categories completed	1.90 (1.98)	2.29 (2.28)	1.53 (1.24)	0.67 (0.82)
WCST perseverative errors	36.2 (22.86)	33.39 (22.56)	46.93 (23.47)	24.83 (13.7)
WCST non-perseverative errors	30 (19.05)	24.76 (14.92)	32.87 (22.78)	51.67 (14.2)
WCST % conceptual level response	31.44 (23.59)	39.22 (24.95)	18.10 (14.35)	20.7 (15.4)

Note. standard deviations in parentheses; EXIT = Executive Interview; WAIS-III = Wechsler Adult Intelligence Scale, Third Edition; COWAT = Controlled Oral Word Association Test; WCST = Wisconsin Card Sorting Test.

identify associations among normally distributed variables. Multiple simultaneous regression analysis was used to assess the independent effects of ECF factors on observational functional ability and to evaluate the best model for predicting impairment in functional ability.

RESULTS

The 60 study participants (20 men, 40 women; 57 Caucasian) were generally well educated (83% high school graduate or better; 43.4% college graduates) and from a primarily upper-middle socio-economic background (46.6% self-reported > $30K annual income). However, they scored overall similarly in comparison to scores of older adult populations on similar measures and sets of scales reported in the geriatric literature.

Descriptive statistics for all cognitive and functional measures are presented in Table 3, while Table 4 presents the Pearson product-moment correlation coefficients between demographic variables, the EXIT score, cognitive predictors (4 cognitive summary scores) and DAFS performance. As expected, all measures of ECF were significantly related to one another. Furthermore, all ECF variables were significantly related to observed functional ability on the DAFS. The absolute value of Pearson correlation coefficients between ECF summary scores and the DAFS ranged from −0.415 to −0.679, with working memory being most highly related followed by planning, fluency and flexibility. As a summary indicator of these domains as they relate to ECF, an increasing level of overall ECF impairment according to the EXIT (by category) was associated with increasing levels of impairment on each of the four ECF domains. Further, moderately strong correlations were observed between all domains of ECF and the EXIT (Pearson correlations ranged from −.514 with FLEX to −.708 with PLAN).

To elucidate the question of primary interest, the relative influence of ECF domains on functional ability, a multiple regression analysis was conducted entering the four ECF summary and demographic variables simultaneously to predict total

Table 4 Pearson intercorrelations between demographic, predictor, and criterion variables in elderly population

Variable	1	2	3	4	5	6	7	8	9
Age	—	−.22	.138	.328*	−.063	−.314*	−.100	−.196	.174
Gender		—	−.235	.111	−.103	−.214	−.147	−.004	.123
Education			—	−.155	.198	.229	.261*	.335*	−.135
EXIT score				—	−.696**	−.708**	−.652**	−.514**	.718**
WM					—	.557**	.679**	.423**	−.678**
PLAN						—	.495**	.343*	−.623**
FLU							—	.530**	−.613**
FLEX								—	−.415**
DAFS									—

Note. EXIT = Executive Interview; WM = Working Memory; PLAN = Planning; FLU = Verbal fluency; FLEX = Flexibility; DAFS = The direct assessment of functional status.

*$p<.05$, **$p<.01$.

Table 5 Results of multiple regression analysis for prediction of DAFS performance by ECF domains (all variables entered)

Variable	Beta	*t*	Significance of *t*	Zero-order	Correlations partial	Semi-partial
(Constant)		6.740	<.001			
AGE	−.014	−.125	NS	−.158	−.019	−.013
EDUC	.038	.316	NS	.315	.048	.033
SEX	.046	.425	NS	−.109	.064	.044
WM	.126	.835	NS	.539	.125	.087
PLAN	.495	3.641	<.001	.669	.481	.381
FLU	.208	1.398	NS	.525	.206	.146
FLEX	.006	.045	NS	.348	.007	.005

Note. DAFS = The direct assessment of functional status; ECF = Executive Control Function; EDUC = Education; WM = Working Memory; PLAN = Planning; FLU = Verbal Fluency; FLEX = Flexibility. Model: R = .720[a]; R^2 = .519, Adj R^2 = .442, Std. Err. of Est. = 9.008, $F = 6.777$ (4,47), $p < .001$.

[a]Dependent variable: DAFS summary impairment score.

DAFS performance. A significant association was found (adjusted $R^2 = 0.44$, $F(7, 51) = 6.78$, $p < 0.001$). Summary statistics, beta values, *t* values and component correlation coefficients for the tests of ECF summary scores are presented in Table 5. Analysis of the standardized regression coefficients revealed that no demographic variables were significant contributors of the regression model. Further, only the ECF summary score of Planning ($\beta = .495$, $t = 3.641$, $p < .001$) was a significant predictor of performance on the DAFS.

DISCUSSION

Results of the present study support the construct of ECF as an important factor to consider when assessing one's ability to function independently in later life. First, participant performances in each domain of ECF assessed (WM, PLAN, FLU, FLEX) were significantly related to observed functional performance. Second, impairment level on the EXIT was associated with greater impairment on tasks of daily living than persons not impaired on the EXIT, supporting the broad construct of ECF as important in the maintenance of ADLs and IADLs, as suggested by past researchers (Grigsby et al., 1998; Royall et al., 2000; Royall, Mahurin, & Gray, 1992). Finally, the current study expands previous findings in the geropsychological literature by underscoring the importance of the specific ECF domain of planning in maintaining functional ability in later life. Planning appeared in our regression model to be *the* significant ECF domain predicting independent functioning, while demographic variables of age, education, and gender did not appear to predict observed functional ability in these older adults.

A methodological issue is the potential construct overlap of our identified domains. All of the ECF domains were associated with functional decline in correlational analyses, accounting for *common* variance in the DAFS of approximately 12% (FLEX), 27% (FLU), 29% (WM), or 45% (PLAN), respectively. However, when adjusted for unique variance (see partial and semi-part correlations, Table 5), it is clear that only Planning accounted for the unique portion of the

observed variance in our multiple regression model predicting performance on the DAFS. While we feel that this indicates Planning as an essential ECF process for successful independent function, the possibility remains that construct overlap among the composite domains is explaining some of the same variance in functional ability in regression analyses. This warrants further research.

Another limitation is our use of composite scores of varying numbers of scores, which could potentially limit our confidence in how well each domain is represented. However, past studies (e.g., Hoff et al., 1992) have successfully compared such scores and found them useful in describing the relative importance of different cognitive domains.

Finally, the current study population was generally of relatively high socioeconomic status and well educated. Such participant characteristics are not necessarily representative of the older adult population at large and thus data results may not be generalizable to older adults of different SES or educational backgrounds. Future research may focus on more diverse older adult populations. Results of the current study are clearly sample specific and replication on a different sample is necessary for examination of the reliability of observed relationships.

Despite such limitations, results of the current study provide valuable insight into relationships among ECF variables and observed functional ability in later life. Specifically, there appears to be a strong link between functional ability and ECF and, more precisely, the cognitive factor of planning ability. Suggestions for future work in this area include exploration of cutoff levels among these ECF domains, as well as broader ECF domains for identification of older adults at risk for injury in independent living situations. It may be possible to increase the sensitivity of various specific ECF tests to detect poor ADLs and IADLs in persons who fall within normal levels of overall cognition or overall ECF performance. Additionally, a large percentage of variance remains unaccounted for in the prediction and understanding of functional ability among older adults. This warrants further investigation of the ecological validity of ECF tests and other potential explanatory factors for functional capacity in later life.

ACKNOWLEDGEMENT

This work was supported by a University of Georgia Gerontology Center Seed Grant.

REFERENCES

Beck, C., Rossby, L., & Baldwin, B. (1991). Correlates of disruptive behavior in cognitively impaired older adult nursing home residents. *Archives of Psychiatric Nursing*, *5*(5), 281–291.

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

Benton, A. L. & Hamsher, K. (1976). *Multilingual aphasia examination*. Iowa City, IA: University of Iowa.

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

Brennan, M., Welsh, M. C., & Fisher, C. B. (1997). Aging and executive function skills: An examination of a community-dwelling older adult population. *Perceptual and Motor Skills*, *84*, 1187–1197.

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

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

Carman, M. B. (1997). The psychology of normal aging. *The Psychiatric Clinics of North America*, *20*, 15–24.

Culbertson, W. C. & Zillmer, E. A. (1998). *Tower of London, drexel university manual*. North Tonawanda, NY: Multi-Health Systems Inc.

Das, J. P. & Mishra, R. K. (1995). Assessment of cognitive decline associated with aging: a comparison of individuals with Down syndrome and other etiologies. *Research in Developmental Disabilities*, *16*, 11–25.

Fuster, J. M. (1997). *The Prefrontal cortex: Anatomy, physiology, and neuropsychology of the frontal lobe* (3rd ed.). Philadelphia, PA: Lippencott-Raven.

Grigsby, J., Kaye, K., Baxter, J., Shetterly, S. M., & Hamman, R. F. (1998). Executive cognitive abilities and functional status among community dwelling older persons in the San Luis valley health and aging study. *Journal of the American Geriatric Society*, *46*, 590–596.

Heaton, R. K. (1993). *Wisconsin card sorting test: Computer version-2, research edition*. Odessa, FL: Psychological Assessment Resources.

Hoff, A. L., Roirdan, H., O'Donnell, D., Stritzke, P., Neale, C., Boccio, A., et al., (1992). Anomalous lateral sulcus asymmetry and cognitive function in first-episode schizophrenia. *Schizophrenia Bulletin*, *18*, 257–272.

Krikorian, R., Bartok, J., & Gay, N. (1994). Tower of London procedure: A standard method and developmental data. *Journal of Clinical and Experimental Neuropsychology*, *16*, 840–850.

Lezak, M. D., Howieson, D. B., & Loring, D. (2004). *Neuropsychological Assessment* (4th ed. 611–646). New York: Oxford University Press.

Loewenstein, D. A., Amigo, E., Duara, R., Guterman, R., Hurwitz, D., Berkowitz, N., et al. (1989). A new scale for the assessment of functional status in Alzheimer's disease and related disorders. *Journal of Gerontology*, *44*, 114–121.

Luria, A. R. (1966). *Higher cortical functions in man*. New York: Basic Books.

Miller, L. S. & Rohling, M. L. (2001). A statistical interpretive method for neuropsychological test data. *Neuropsychology Review*, *11*, 141–167.

Mirsky, A. F., Anthony, B. J., Duncan, C. C., Ahearn, M. B., & Kellam, S. G. (1991). Analysis of the elements of attention: A neuropsychological approach. *Neuropsychology Review*, *2*, 109–145.

Myers, A. M., Holliday, P. J., Harvey, K. A., & Hutchinson, K. S. (1993). Functional performance measures: are they superior to self-assessments? *Journal of Gerontology*, *48*, M196–M206.

Pillon, B., Dubois, B., Lhermitte, F., & Agid, Y. (1986). Heterogeneity of cognitive impairment in supranuclear palsy, Parkinson's disease, and Alzheimer's disease. *Neurology*, *36*, 1179–1185.

Porteus, S. (1965). *Porteus maze test: Fifty years' application*. Palo Alto, CA: Pacific Books.

Porteus, S. D. & Peters, H. N. (1947). Psychosurgery and test validity. *Journal of Abnormal and Social Psychology*, *42*, 473–475.

Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*, 385–401.

Rajah, M. N. & D'Esposito, M. (2005). Region-specific changes in prefrontal function with age: A review of PET and fMRI studies on working and episodic memory. *Brain 128*, 1964–1983.

Reuter-Lorenz, P. A. & Lustig, C. (2005). Brain aging: reorganizing discoveries about the aging mind. *Current Opinions in Neurobiology*, *15*, 245–251.

Richards, M., Cote, L. J., & Stern, Y. (1993). Executive function in Parkinson's disease: Set-shifting or set-maintenance? *Journal of Clinical and Experimental Neuropsychology, 15*,266–279.

Royall, D. R. (1992). Bedside assessment of executive cognitive impairment: the executive interview. *Journal of the American Geriatrics Society*, *40*, 1221–1226.

Royall, D. R., Chiodo, L. K., & Polk, M. J. (2000). Correlates of disability among elderly retirees with subclinical cognitive impairment. *Journal of Gerontology*, *9*, M541–M546.

Royall, D. R., Mahurin, R. K., & Gray, K. F. (1992). Bedside assessment of executive cognitive impairment: the executive Interview. *Journal of the American Geriatric Society*, *40*, 1221–1226.

Saykin, A. J., Gur, R. C., Gur, R. E., Mozley, D., Mozley, L. H., Resnick, S. M., et al. (1991). Neuropsychological function in schizophrenia: selective impairment in memory and learning. *Archives of General Psychiatry*, *48*, 618–624.

Segalowitz, S. J., Unsal, A., & Dywan, J. (1992). CNV evidence for the distinctiveness of frontal and posterior neural processes in a traumatic brain injured population. *Journal of Clinical and Experimental Neuropsychology*, *14*, 545–565.

Tranel, D., Benton, A., & Olson, K. (1997). A 10-year longitudinal study of cognitive changes in elderly persons. *Developmental Neuropsychology*, *13*, 87–96.

Wechsler, D. (1997). *WAIS-III administration and scoring manual*. San Antonio, TX: The Psychological Corporation.

Ylikoski, R., Ylikoski, A., Keskivaara, P., Tilvis, R., Sulkava, R., & Erkinjuntti, T. (1999). Heterogeneity of cognitive profiles in aging: successful aging, normal aging, and individuals at risk for cognitive decline. *European Journal of Neurology*, *6*, 645–652.