International Psychogeriatrics (2011), 23:1, 107–113 © International Psychogeriatric Association 2010
doi:10.1017/S1041610210000967

Executive functioning mediates the link between other neuropsychological domains and daily functioning: a Project FRONTIER study

Sid E. O'Bryant,[1,2] Jed Falkowski,[3] Valerie Hobson,[4] Leigh Johnson,[5,6] James Hall,[7,8] Gregory W. Schrimsher,[9] Ohmar Win,[6] Bichthy Ngo[6] and Andrew Dentino[6,10,11]

[1] *F. Marie Hall Institute for Rural and Community Health, Texas Tech Health Sciences Center, Lubbock, TX, U.S.A.*
[2] *Department of Neurology, Texas Tech University Health Sciences Center, Lubbock, TX, USA*
[3] *West Texas A and M University, Canyon, TX, U.S.A.*
[4] *Department of Psychology, Texas Tech University, Lubbock, TX, U.S.A.*
[5] *Laura W. Bush Institute for Women's Health, Texas Tech University Health Sciences Center, Amarillo, TX, U.S.A.*
[6] *Department of Family and Community Medicine, Texas Tech University Health Sciences Center, Lubbock, TX, U.S.A.*
[7] *Institute of Aging and Alzheimer's Disease Research, University of North Texas Health Sciences Center, Fort Worth, TX, U.S.A.*
[8] *Department of Psychiatry and Neuroscience, University of North Texas Health Sciences Center, Fort Worth, TX, U.S.A.*
[9] *Department of Psychiatry, Texas Tech University Health Sciences Center, Lubbock, TX, U.S.A.*
[10] *Garrison Institute on Aging, Texas Tech University Health Sciences Center, Lubbock, TX, U.S.A.*
[11] *Division of Geriatric and Palliative Medicine, Department of Internal Medicine, Texas Tech University Health Sciences Center, Lubbock, TX, U.S.A.*

ABSTRACT

Background: The purpose of this study was to examine the mediating impact of executive functioning on the link between other neuropsychological domain scores and informant-based rating of functional status.

Methods: Data on 181 participants were analyzed from an ongoing epidemiological study of rural health, Project FRONTIER (mean age = 64.6 ± 13.8 years, 69% women, 42% Mexican American). Executive functioning was assessed by the EXIT25 and other neuropsychological domains were assessed via the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). Informant-based rating of functional status was assessed via the Clinical Dementia Rating Scale sum of boxes scores (CDR SB).

Results: RBANS Index scores were each significantly ($p < 0.05$) related to CDR SB scores and EXIT25 scores. EXIT25 score was a significant partial mediator of the link between four RBANS indices (Immediate Memory, Attention, Visuospatial/Construction, Delayed Memory) and CDR SB scores, and a complete mediator of the fifth index (Language).

Conclusion: Executive functioning is a mediator of the link between other neuropsychological domains and daily functioning. Neuropsychological assessments that do not measure executive functioning will provide only a partial clinical picture with adults and elders.

Key words: executive functioning, cognition, rural, functional status

Introduction

Executive functioning is a compilation of higher order mental processes conceptualized as the cognitive abilities required to plan, initiate, shift, monitor, and inhibit purposeful behavior that are essential for the execution of goal-directed behaviors (Aron, 2008). These mental processes are believed to be crucial for engaging in and successfully completing numerous every day activities. Given that neuropsychological dysfunction in a range of domains has been linked to deficits in daily living and that deficits in activities of daily living (ADLs) are required for the diagnoses of dementia syndromes, much research has been directed at parsing out the specific links between various neuropsychological domains and ADLs.

Several studies investigating the association between executive dysfunction and decreases in level of daily functioning have found tests of executive measures to correlate with functional status more so than measures of other cognitive domains (Royall *et al.*, 2004; 2007, Whelihan *et al.*, 2005; Mitchell and Miller, 2008), with some studies

Correspondence should be addressed to: Sid. E. O'Bryant, F. Marie Hall Institute for Rural and Community Health, Texas Tech University Health Sciences Center, 3601 4th Street, STOP 6232, Lubbock, TX, 79430-6232, U.S.A.. Phone: +1 806-743-1338. Fax: +1 806-743-4510. Email: sid.obryant@ttuhsc.edu. Received 10 Mar 2010; revision requested 13 Apr 2010; revised version received 16 Apr 2010; accepted 19 Apr 2010. First published online 19 July 2010.

https://doi.org/10.1017/S1041610210000967 Published online by Cambridge University Press

finding executive measures to be a better predictor of functional status than demographic variables such as age, sex, and education(Cahn-Weiner *et al.*, 2000). In 2007, Royall *et al.* (2007) conducted a review of 68 articles investigating the capacity to predict functional outcomes by cognitive task performance and found that executive functioning accounted for more variance than memory, visuospatial, attention, and verbal domains. In a longitudinal study following 47 elderly individuals, it was found that executive functioning, measured by the Executive Interview (EXIT25), was more sensitive to cognitive impairments and decline than the Mini-mental State Examination (MMSE), a general measure of cognition (Royall *et al.*, 2004).

It has also been reported that the domain of executive functioning accounted for more of the variance in instrumental activities of daily living (IADL) than in activities of daily living (ADL) (Royall *et al.*, 2007). This suggests that executive dysfunction has a greater impact on an individual's ability to perform tasks such as balancing a checkbook, driving, and housekeeping than on performing general hygiene and self care-related activities (Cahn-Weiner *et al.*, 2000; Bell-McGinty *et al.*, 2002; Farias *et al.*, 2008.

When looking at clinical populations, several other neuropsychological domains have been linked to ADLs as well. Freilich and Hyer (2007) examined the relation of daily functioning in individuals with dementia using the Repeatable Battery for Assessment of Neuropsychological Status. Overall, their results found that the domains of Attention and Visuospatial/Constructional had the highest correlations with daily functioning, followed by Immediate Memory. In a more recent study, we found that the RBANS indices of Language and Immediate Memory were significantly related to informant-ratings of functional loss in the areas of community and home activities, judgment and problem solving, as well as memory in a sample of patients diagnosed with Mild Cognitive Impairment (MCI) and Alzheimer's disease (AD) (Hobson *et al.*, 2010).

Prior findings (Farias *et al.*, 2008) are suggestive of some form of interaction between executive and non-executive neuropsychological domains and functional status. In fact, Royall *et al.* (2005) proposed that executive functioning mediated the link between memory and functional status. Using data from the EXIT25 and the California Verbal Learning Test (CVLT), these authors reported that EXIT25 scores were independently associated with IADL scores at baseline and that the change in EXIT25 was independently associated with change in IADL scores, yet there was no association between CVLT scores and IADL scores independent of EXIT25 scores. The authors are not aware of any study to date formally examining the mediating impact of executive functioning on the link between a broad range of neuropsychological domains (non-executive) and functional status of adults and elders.

The purpose of the current study was to formally test the potential mediating impact of executive functioning scores on the link between other neuropsychological domains (immediate and delayed memory, attention, language, and visuospatial skills) and informant ratings of functional status in a rural sample of community-dwelling adults and elders. It was hypothesized that (1) RBANS Index scores would be significantly related to informant report of daily functioning (Clinical Dementia Rating Sum of Boxes scores), and (2) executive functioning (EXIT25 scores) would significantly mediate (partial or complete) that relationship.

Methods

Participants

Data were evaluated from 181 participants (55 men and 126 women) from an ongoing study of the epidemiology of health issues among rural-dwelling adults and elders called Project FRONTIER (Facing Rural Obstacles to healthcare Now Through Intervention, Education and Research). The mean age and education of the sample was 64.6 (SD = 13.8, range = 41–97) and 10.0 (SD = 4.1, range = 0–20), respectively. Self-report of racial status was white (n = 151), African American (n = 19), American Indian (n = 4), and not reported (n = 7). There were 95 participants who reported being not of Hispanic origin while 76 reported being Mexican American and 7 reported being Hispanic not of Mexican American origin. Current reported annual household income was: ≤$10,000 (23%), $10,001–$20,000 (36%), $20,001–$30,000 (11.8%), $30,001–$40,000 (7.9%), $40,001–$50,000 (5.1%), $50,001–$60,000 (1.7%), $60,001–$70,000 (2.8%), ≥ $70,000 (10.1%), not reported (1.6%).

Project FRONTIER is a recently established epidemiological study of health among rural-dwelling individuals. This community-based participatory research (CBPR) study includes a standardized medical examination, clinical labs, neuropsychological testing (including the RBANS and EXIT25), as well as a detailed interview with participant and a brief interview with an informant. Inclusion criteria are (1) age 40 years and above, and (2) residing in one of the counties that form part of Project FRONTIER. The two communities currently part of project FRONTIER are Cochran

https://doi.org/10.1017/S1041610210000967 Published online by Cambridge University Press

County and Parmer County, both located on the Texas–New Mexico border. The process utilized for establishing and maintaining this epidemiological research program has been described previously (O'Bryant *et al.*, 2009). Participant recruitment is conducted by community recruiters through brochures/flyers, community presentations and events, as well as door-to-door solicitation.

Project FRONTIER is conducted under an IRB approved protocol (Texas Tech University Health Sciences Center) and all participants signed written informed consent. After completing the informed consent process, participants are scheduled for the medical examination (completed by community clinicians), fasting blood work at the local hospital laboratory, a detailed interview, and neuropsychological testing. Informants are called and interviewed by telephone after the participant interview and cognitive testing is completed. All examiners receive extensive training on neuropsychological testing according to the standardized instructions provided for the respective instrument; all results are reviewed by neuropsychologists at the weekly consensus review, with administration questions raised and addressed at that time. In-person administration quality checks (to correct for drift) are conducted semi-annually.

Once all data are collected, the information is reviewed by a consensus diagnostic committee that consists of a neuropsychologist, a psychologist, a geriatric psychiatrist, and multiple geriatricians. Diagnoses of medical, psychiatric, and cognitive conditions are assigned according to standard criteria. Cognitive status assigned are normal cognition (no observed deficits on cognitive examination and no self- or informant-report of cognitive dysfunction – adapted from the Mayo criteria), Age Associated Cognitive Impairment (AACI; Crook *et al.*, 1986), Mild Cognitive Impairment (MCI; Petersen, 2003), Alzheimer's disease (McKhann *et al.*, 1984), vascular dementia (Chui *et al.*, 1992), or dementia not otherwise specified (NOS; meets criteria for dementia but does not fit into one of the other categories). The breakdown of cognitive diagnoses was as follows: normal cognition n = 94, AACI n = 22, MCI n = 52 (amnestic single domain n = 13, amnestic multi-domain n = 20, non-amnestic single domain n = 12, non-amnestic multi-domain n = 6), dementia n = 11 (AD n = 6, dementia NOS n = 5), not sufficient information for a diagnosis n = 2.

Measures

Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (Randolph, 1998). The RBANS was developed as a brief screening measure for dementia. It contains 12 subtests which combine to create five index scores: Immediate Memory (subtests include List and Story Memory), Visuospatial/Constructional (subtests include Line Orientation and Figure Copy), Language (subtests include Semantic Fluency and Picture Naming), Attention (subtests include Coding and Digit Span), and Delayed Memory (subtests include List Recall and Recognition, Story Recall, and Figure Recall). The RBANS demonstrates good reliability and validity (Randolph, 1998) as well as excellent diagnostic accuracy in Alzheimer's disease (Duff *et al.*, 2008). Administration time is approximately 30 minutes.

The Exit Interview (EXIT25 (Royall *et al.*, 1992). The EXIT25 is a well-validated global measure of executive control that covers a range of tasks including sequencing, fluency, anomalous sentence repetition, thematic perception, automatic behaviors, go-no-go, automatic behavior, as well as others. EXIT25 scores are significantly related with other validated measures of executive functioning. Scores range from 0 to 50 with higher scores suggestive of greater impairment; a cut-off point of 15 out of 50 best discriminates non-demented elderly controls from both cortical and non-cortical dementing illnesses. Administration time is approximately 10 minutes (Royall *et al.*, 1992).

The Clinical Dementia Rating Scale (CDR; Morris, 1997). The CDR is a semi-structured interview of patients and informants. Once completed, the patient's level of functional impairment due to cognitive decline is rated in six domains including memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. Each domain is rated on a five-point scale of functioning as follows: 0 = no impairment, 0.5 = questionable impairment, 1 = mild impairment, 2 = moderate impairment and 3 = severe impairment. (Note: Personal Care is scored on a 4-point scale without a 0.5 rating available.) The CDR demonstrates good reliability (Burke *et al.*, 1988; Morris *et al.*, 1997) and has been validated against neuropathological findings (Berg *et al.*, 1993; Morris, *et al.*, 1991; Morris, 1997). The CDR yields two scores, a Global Score and Sum of Boxes score. The standardized interview asks questions regarding the participant's ability to find his/her way around familiar streets; getting lost; ability to solve problems; manage money and financial affairs/transactions; ability to function in his/her job; ability to drive and problems associated with this activity; ability to shop independently; and carrying out household activities such as cooking, cleaning, sewing, crafts, as well as ability to manage

https://doi.org/10.1017/S1041610210000967 Published online by Cambridge University Press

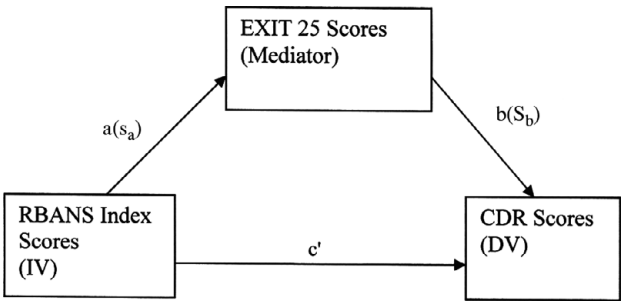


Figure 1. Mediational impact of EXIT25 scores on the link between RBANS Index scores and CDR Sum of Boxes scores.

dress, bathe, eat, etc. independently. The Sum of Boxes (CDR SB) score, which ranges from 0 to 18, can therefore be considered a global estimate of informant-based rating of participant functional impairment (ADL and IADL).

Regression models were created to formally test the mediating impact of EXIT25 scores on the link between RBANS Index scores and CDR SB scores. The criteria for a variable to be confirmed as a mediator are as follows: (1) there is a significant relationship between the independent variable (IV) and the dependent variable (DV), (2) there is a significant relationship between the IV and the mediator, (3) the mediator still predicts the DV after controlling for the IV, and (4) the relationship between the IV and DV is reduced when the mediator is in the equation (Tabachnick and Fidell, 2001). Significance of mediation was tested using the Sobel test (Sobel, 1982) using the following procedures. Regression models were first run to determine if there was a significant link between RBANS indices (IV) and CDR SB scores (DV). Next, regression analyses were run using the IV (RBANS Index scores) and EXIT25 scores (mediator) as the dependent variable, which provided a (raw, unstandardized, regression coefficient for the association between the IV and the mediator), and s_a (standard error of a). Next, regression models were conducted with the IVs (RBANS indices) and mediator (EXIT25 scores) entered into the model with CDR-SB scores as the DV, which provided b (raw coefficient of association between the mediator and the DV when the IV is also entered into the equation) and s_b (standard error of b) (see Figure 1).

Results

In the first step of the meditational analyses all RBANS indices (IV) were found to be significantly related with CDR SB scores (DV): Immediate Memory, B = −0.018, standard error (SE) = 0.004, t = −5.64, p < 0.001; Visuospatial/Construction B = −0.013, SE = 0.004, t = −3.12, p = 0.002; Language B = −0.013, SE = 0.005, t = −2.33, p = 0.02; Attention B = −0.015, SE = 0.004, t = −3.70, p < 0.001; Delayed Memory B = −0.019, SE = 0.004, t = −5.11, p < 0.001. Next, all RBANS indices (IV) were found to be significantly associated with EXIT25 scores (mediator): Immediate Memory B = −1.749, SE = 0.272, t = −6.44, p < 0.001; Visuospatial/Construction B = −0.830, SE = 0.265, t = −3.13, p = 0.002; Language B = −1.066, SE = 0.207, t = −5.14, p < 0.001; Attention B = −2.123, SE = 0.297, t = −7.15, p < 0.001; Delayed Memory B = −1.337, SE = 0.253, t = −5.29, p < 0.001. In step 3, EXIT25 scores were significantly related to CDR scores with all RBANS indices entered into the model (Table 1). As can be seen from Table 1, all RBANS indices, with the exception of Language, continued to be significantly related to CDR SB scores with EXIT25 scores (and education) entered into the model. These results indicate complete mediation of the Language index and partial mediation of all other indices; see

Table 1. Regression models with EXIT25 (mediator) scores and RBANS Indices (IV) predicting CDR SB (DV) scores

		β	SE	*t*-TEST	*p*-VALUE
Model 1	EXIT25	0.033	0.014	2.35	0.02
	Immediate Memory	−0.015	0.004	−4.29	<0.001
Model 2	EXIT25	0.042	0.015	2.83	0.005
	Attention	−0.010	0.004	−2.27	0.03
Model 3	EXIT25	0.051	0.014	3.69	<0.001
	Visuospatial/Construction	−0.010	0.004	−2.41	0.02
Model 4	EXIT25	0.050	0.014	3.58	<0.001
	Language	−0.007	0.005	−1.33	.19
Model 5	EXIT25	0.039	0.014	2.78	0.006
	Delayed memory	−0.016	0.014	2.78	0.006

Note: Education was entered as covariate for all models.

https://doi.org/10.1017/S1041610210000967 Published online by Cambridge University Press

Table 2. Mediating impact of EXIT scores on the link between RBANS Index scores and CDR-SB scores

RBANS INDEX	A	S_A	B	S_B	SOBEL *t*-STATISTIC	*p*-VALUE	MEDIATION EFFECT
Immediate Memory	−0.94	0.018	0.033	0.014	−2.35	0.02	Partial
Attention	−0.122	0.020	0.042	0.015	−2.54	0.01	Partial
Visuospatial/Construction	−0.063	0.022	0.051	0.014	−2.25	0.02	Partial
Language	−0.098	0.029	0.050	0.014	−2.45	0.01	Complete
Delayed memory	−0.082	0.021	0.039	0.014	−2.27	0.02	Partial

Table 2 for results of Sobel tests for significance of mediation (step 4).

In order to determine if our findings were moderated by age and education, we re-ran the analyses separating the sample by years of education ($\leq$10 versus $>$ 10) and age in years ($<$65 versus $\geq$ 65). The findings were largely unchanged, with a few exceptions. When looking by age categories, RBANS Visuospatial Index scores were not significantly related to CDR scores ($p > 0.05$) among those less than 65 years of age or EXIT25 ($p > 0.05$) scores among those aged 65 years and above. Language Index scores were not significantly related to CDR scores ($p > 0.05$) among those under 65 or EXIT25 scores ($p > 0.05$) among those 65 or older. When looking by education categories, RBANS Visuospatial Index scores were not significantly related to CDR scores ($p > 0.05$) among those with ten or fewer years of education or EXIT25 scores ($p > 0.05$) among those with more than ten years of education. Lastly, Delayed Memory scores were not significantly related to EXIT25 ($p > 0.05$) scores among those with more than 10 years of education. Therefore, mediation was not possible with any of these particular follow-up models.

Discussion

Executive functioning is of primary importance to nearly all human neuropsychological functioning and, as the current results demonstrate, they mediate the link between other neuropsychological domains and daily functioning abilities. These results hold importance for many reasons.

First, they point to the fact that neuropsychological assessments without assessment of executive functioning (screening or comprehensive assessments) will yield only a partial view of the clinical picture, particularly when questions regarding ability to sustain independent living and/or decision-making capacity are at hand.

Another important aspect of the current study is the choice of assessment battery. The RBANS is a recently developed, well-validated neuropsychological instrument that has excellent diagnostic accuracy in identifying dementia (Duff *et al.*, 2008). The RBANS is rapidly being adopted in clinical and research settings (particularly geriatric) owing to its brevity combined with good psychometric properties that allows for optimization of time. While recent work has also demonstrated a significant link between RBANS scores and activities of daily living (Freilich and Hyer, 2007; Hobson *et al.*, 2010), this battery only minimally assesses the executive functioning domain (i.e. coding and verbal fluency). In dementia evaluations a common question that arises is the ability of the patient to maintain his/her ADLs independently; however, informants are not always available or amenable to questioning. The current results suggest that supplementation of RBANS administrations with the EXIT25 will add very valuable information to the clinical examination without addition of significant time requirements (approximately 10 minutes).

When we divided up the sample by age ($<$65 versus $\geq$65 years) and education ($\leq$10 versus $>$10 years) our findings were largely unchanged; however, there were noteworthy differences. The RBANS Visuospatial Index score was not significantly related to functional status among those $<$65 or with 10 or fewer years of education. The Language Index was also not related to functional status among those 65 years or younger. The current sample size is insufficient to examine the potential causes for this change; however, it is possible that there was not sufficient variability in these two scores (RBANS indices and CDR) for a relationship to be observed. Regardless, we will investigate this further as the Project FRONTIER sample size continues to grow.

Finally, the current study offers valuable information for rural practitioners. Even though nearly 20% of the U.S. population resides in rural locales (U.S. Census Bureau, 2004), there is minimal research-based information available related to best practice guidelines among this segment of the population, and urban-based studies may not be applicable (Upper Midwest Rural Health Research Center, 2009). Therefore, the

https://doi.org/10.1017/S1041610210000967 Published online by Cambridge University Press

current findings offer rural healthcare providers with an option for a brief yet valid assessment battery to use with their elder patients. As with prior clinic-based studies, the RBANS is significantly related to functional status in a community-based setting of rural adults and elders, and supplementation with the EXIT25 offers important additional information that will assist in generating a better clinical picture. The current study provides the first formal demonstration of the mediating impact of executive functioning on the link between other cognitive domains and functional status.

Conflict of interest

None.

Description of authors' roles

S. E. O'Bryant designed the study, data collection, and participated in preparation of the paper. J. Falkowski participated in preparation of the paper. V. Hobson and L. Johnson participated in data analysis and preparation of the paper. J. Hall assisted in study design and preparation of the paper. G. W. Schrimsher assisted in study design, collection of data, and preparation of the paper. O. Win participated in data collection and preparation of the paper. B. Ngo participated in data collection and preparation of the paper. A. Dentino participated in study design, data collection, and preparation of the paper.

Acknowledgments

The authors would like to thank the entire research team, and especially the people of Cochran County and Parmer County as well as the respective Community Advisory Boards. We thank Cochran County Memorial Hospital, Parmer Medical Center, the Parmer County Rural Health Clinic and their staff for their assistance and provision of office space. This work would not have been possible without the assistance of our community recruiters Joel Torango, Bennie O'Brien, and Rosemary McCallum.

References

Aron, A. R. (2008). Progress in executive-function research: from tasks to functions to regions to networks. *Current Directions in Psychological Science*, 17, 124–129.

Bell-McGinty, S., Podell, K., Franzen, M., Baird, A. D. and 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.

Berg, L., McKeel, D. W. Jr., Miller, J. P., Baty, J. and Morris, J. C. (1993). Neuropathological indexes of Alzheimer's disease in demented and nondemented persons aged 80 years and older. *Archives of Neurology*, 50, 349–358.

Burke, W. J. *et al.* (1988). Reliability of the Washington University Clinical Dementia Rating. *Archives of Neurology*, 45, 31–32.

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

Chui, H. C., Victoroff, J. I., Margolin, D., Jagust, W., Shankle, R. and Katzman, R. (1992). Criteria for the diagnosis of ischemic vascular dementia proposed by the State of California Alzheimer's Disease Diagnostic and Treatment Centers. *Neurology*, 42, 473–480.

Crook, T. *et al.* (1986). Age-associated memory impairment: proposed diagnostic criteria and measures of clinical change. Report of a National Institute of Mental Health Work Group. *Developmental Neuropsychology*, 2, 261–276.

Duff, K., Humphreys, J. D., O'Bryant, S. E., Mold, J. W., Scheffer, R. B. and Sutker, P. B. (2008). Utility of the RBANS in detecting cognitive impairment associated with Alzheimer's disease: sensitivity, specificity, and positive and negative predictive powers. *Archives of Clinical Neuropsychology*, 23, 603–612.

Farias, S. *et al.* (2008). Longitudinal changes in memory and executive functioning are associated with longitudinal changes in instrumental activities of daily living in older adults. *Clinical Neuropsychologist*, 23, 446–461.

Freilich, B. M. and Hyer, L. A. (2007). Relation of the Repeatable Battery for Assessment of Neuropsychological Status to measures of daily functioning in dementia. *Psychological Reports*, 101, 119–129.

Hobson, V. L., Hall, J. R., Humphreys-Clark, J. D., Schrimsher, G. W. and O'Bryant, S. E. (2010). Identifying functional impairment with scores from the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). *International Journal of Geriatric Psychiatry*, 25, 525–530.

McKhann, D. *et al.* (1984). Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group. *Neurology*, 34, 939–944.

Mitchell, M. and Miller, L. S. (2008). Prediction of functional status in older adults: the ecological validity of four Delis-Kaplan Executive Function System tests. *Journal of Clinical and Experimental Neuropsychology*, 30, 683–690.

Morris, J. C. (1997). Clinical dementia rating: a reliable and valid diagnostic and staging measure for dementia of the Alzheimer type. *International Psychogeriatrics*, 1, 173–176.

Morris, J. C. *et al.* (1997). Clinical dementia rating training and reliability in multicenter studies: the Alzheimer's Disease Cooperative Study experience. *Neurology*, 48, 1508–1510.

O'Bryant, S. E. *et al.* (2009). The Cochran County Aging Study: methodology and descriptive statistics. *Texas Public Health Journal*, 61, 5–7.

https://doi.org/10.1017/S1041610210000967 Published online by Cambridge University Press

Peterson, R. C. (ed.) (2003). *Mild Cognitive Impairment: Aging to Alzheimer's Disease*, New York: Oxford University Press.

Randolph, C. (1998). *Repeatable Battery for the Assessment of Neuropsychological Status*, San Antonio, TX: The Psychological Coporation.

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

Royall, D. R., Palmer, R., Chiodo, L. K. and Polk, M. J. (2004). Declining executive control in normal aging predicts change in functional status: the Freedom House Study. *Journal of the American Geriatrics Society*, 52, 346–352.

Royall, D. R., Palmer, R., Chiodo, L. K. and Polk, M. J. (2005). Executive control mediates memory's association with change in instrumental activities of daily living: the Freedom House Study. *Journal of the American Geriatrics Society*, 53, 11–17.

Royall, D. R., Lauterbach, E. C., Kaufer, D., Malloy, P., Coburn, K. L. and Black, K. J. (2007). The cognitive correlates of functional status: a review from the Committee on Research of the American Neuropsychiatric Association. *Journal of Neuropsychiatry and Clinical Neurosciences*, 19, 249–265.

Sobel, M. (1982). Asymptotic intervals for indirect effects in structural equations models. In S. Leinhart (ed.), *Sociological Methodology*. San Francisco, CA: Jossey-Bass.

Tabachnick, B. G. and Fidell, L. S. (2001). *Using Multivariate Statistics*, Needham Heights, MA: Allyn and Bacon.

Upper Midwest Rural Health Research Center (2009). *Rural Issues Related to Comparative Effectiveness Research and Dissemination*. Available at: http://www.uppermidwestrhrc.org/pdf/policybrief_effectiveness.pdf

U.S. Census Bureau (2004). *American Fact Finder*. U.S. Department of Commerce. Available at http://www. census.gov; last accessed 2005.

Whelihan, W. M., Dicarlo, M. A. and Paul, R. H. (2005). The relationship of neuropsychological functioning to driving competence in older persons with early cognitive decline. *Archives of Clinical Neuropsychology*, 20, 217–228.

https://doi.org/10.1017/S1041610210000967 Published online by Cambridge University Press