Published in final edited form as:

Appl Neuropsychol. 2010 January ; 17(1): 8–17. doi:10.1080/09084280903297719.

Factor Analysis of the Repeatable Battery for the Assessment of Neuropsychological Status

Noelle E. Carlozzi,

Kessler Medical Rehabilitation, Research & Education Center, West Orange, New Jersey, and H. Johnson Department of Veterans Affairs Medical Center, Medical University of South Carolina, Charleston, South Carolina

Michael David Horner,

Ralph H. Johnson Department of Veterans Affairs Medical Center, Medical University of South Carolina, Charleston, South Carolina

Chengwu Yang, and

Medical University of South Carolina, Charleston, South Carolina

Barbara C. Tilley

Medical University of South Carolina, Charleston, South Carolina

Abstract

A sample of 175 veterans' scores on the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph, 1998) was examined to investigate the factor structure of this scale. First, we attempted to replicate a five-factor model to reflect the five Index Scores of the RBANS (immediate memory, visuospatial/constructional, language, attention, and delayed memory) from the 12 individual subtests, using confirmatory factor analysis (CFA). We were unable to identify a five-factor structure of the RBANS. The RBANS subtests were then subjected to an exploratory factor analysis with a maximum likelihood extraction and orthogonal rotation to determine a new dimensional model. Results indicated a two-factor structure that can roughly be described as memory and visuospatial function. CFA of this new structure indicated an adequate fit for this sample. Findings suggest that it may be appropriate to place more emphasis on the individual subtest scores than the index scores during interpretation.

Keywords

confirmatory factor analysis; exploratory factor analysis; neuropsychological assessment; neuropsychology; psychometrics repeatable battery for the assessment of neuropsychological status (RBANS)

Introduction

The RBANS is a brief, neuropsychological screening measure designed to examine attention, language, visuospatial/constructional abilities, and immediate and delayed memory. There are 12 subtests that can be combined into five domains or index scores with high split-half reliability coefficients (ranging from .80 to .88; Randolph, 1998): immediate memory (list learning and story memory), visuospatial/constructional (figure copy and line orientation), language (picture naming and semantic fluency), attention (digit span and coding), and delayed memory (list recall, list recognition, story recall, and figure recall). Further, a nonlinear transformation of the sum of the five Index Scores can be calculated to create a total score (split-half reliability = .94; Randolph, 1998).

Although the reliability coefficients and intercorrelations of Index Scores provide evidence for the internal psychometric validity and reliability of the RBANS (Gontkovsky, Beatty, & Mold, 2004; Randolph, 1998), there are only two published studies that have empirically examined the construction of the Index Scores (Duff et al., 2006; Wilde, 2006). Duff et al.'s examination of the factor structure of the RBANS in 824 elderly participants did not support the existing structure of the RBANS; instead, a two-factor solution representing verbal memory (list learning, story memory, list recall, list recognition, and story recall) and visual processing (figure copy, line orientation, coding and figure recall) was supported. Wilde's examination of the factor structure of the RBANS in 210 acute ischemic stroke patients also did not support the existing factor structure of the RBANS; a two-factor solution representing language/verbal memory (list learning, story recall, story memory, list recall, list recognition, verbal fluency, picture naming and digit span) and visuospatial/visual memory (figure copy, line orientation, figure recall and coding) was supported. Although more research is needed to determine if these findings are generalizable to other samples, these studies may suggest that a two-factor solution representing aspects of verbal and visuospatial functioning may be most representative of RBANS data for both healthy (Duff et al., 2006) and homogeneous clinical samples (Wilde, 2006).

Further empirical validation of the Index Scores is important for clinical interpretation, because this would confirm that the Index Scores represent discrete neuropsychological constructs rather than simply a theoretical combination of disparate abilities. The purpose of this study was to further examine the factor structure of the RBANS in an independent, heterogeneous clinical sample and determine if the factor structure reflects the five index scores generated by this measure. This was then followed by exploratory analyses to compare our factor structure to those found by Duff et al. (2006) and Wilde (2006). The interpretation of study findings is facilitated by understanding that our sample is more impaired than Duff et al.'s (2006) sample; this helps explain differences in score distributions, as well as other differences between these two samples.

Method

Two hundred fifty-eight veterans referred for clinical neuropsychological assessment through the memory disorders clinic at a southeastern Virginia hospital were included in this study (all referrals for this clinic were included in the initial sample). Patients seen through

the memory disorders clinic receive a multidisciplinary evaluation that includes clinical interviews, neuropsychological testing, and psychiatric and neurological evaluation. Two participants were excluded because they exceeded the upper age limit of the RBANS (Randolph, 1998). Thirty-one participants were excluded due to insufficient effort during testing; effort was determined by both formal assessment and behavioral observations made by the multidisciplinary team. More specifically, thirty participants were excluded for failing the Test of Memory Malinger (TOMM; scores less than 45 on Trials 2 or the Retention Trial; Tombaugh, 1996) and one participant was excluded due to questionable motivation because of inconsistencies in reported and observed memory complaints (determined by clinical judgment made at the time of the assessment). There were also eight participants that failed formal effort testing (either Trial 2 or the Retention Trial of the TOMM) but were included in subsequent analyses; this determination was made by the multidisciplinary team (clinical judgment, medical examination, or neurological evaluation provided information to suggest that these persons had sufficiently severe memory impairments to fail formal effort tests despite adequate motivation during testing). All such determinations were made at the time of evaluation and prior to the present study. Forty-three participants were excluded from analyses due to missing data (39 participants were not administered the RBANS, and five participants had missing data within the RBANS). Of the remaining 182 participants, only two (1.1%) were females; these participants were excluded in order to ensure both homogeneity and representativeness of this sample. Among the remaining 180 veterans, five were detected as multi-variate outliers with respect to the 12 subtest scores and were excluded from the final analysis dataset (Kline, 2005). Therefore, a total of 175 veterans were included in this study.

Participants ranged in age from 44 to 87 years (mean = 74.1, $SD = 8.0$). The majority of participants were caucasian (71.4%), and the remaining 28.6% were African American. Participants' education ranged from 1 to 20 years (mean = 11.3 years, $SD = 4.0$). On the basis of this multidisciplinary evaluation, patients received clinical diagnoses; these included 13.7% with Alzheimer's disease, 19.6% mild cognitive impairment, 23.2% cognitive disorder not otherwise specified, 8.3% vascular dementia, 0.6% possible vascular dementia, 5.4% mixed dementia, 1.1% Lewy Body dementia, 6.0% dementia not otherwise specified, 1.1% depression not otherwise specified, and 0.6% frontotemporal dementia. Diagnosis was deferred for 4.8%, and 15.0% did not receive a diagnosis because their performance and presentation were within normal limits (seven patients with missing data on diagnosis were excluded in the calculation of these percentages). All participants were evaluated in individual sessions conducted by either a clinical neuropsychologist or a predoctoral psychology intern. Participants completed the RBANS as part of a standard, routine clinical evaluation. All 12 subtests of the RBANS were administered and scored according to standard instructions in the test manual. Please note that the Index and Total Scale Scores of the RBANS are standardized to have a mean of 100 and SD of 15.

Results

Prior to the examination of the factor structure of the 12 subtests of the RBANS, we examined the descriptive statistics for performance on the five Index Scores and the Total Scale Score. Relative to the normative sample, participants in this sample were impaired

(Table 1). The interrelationships between the five Index Scores and the Total Scale Score were also examined (Table 2). In comparison to corresponding correlations in the normative sample (Randolph, 1998, p. 45), this sample had one distinctive characteristic: the correlations among the five Index Scores and the Total Score were higher than in the normative sample. The intercorrelations between subtests are also reported (Table 3).

Confirmatory Factor Analysis

The 12 subtest scores were examined for multicollinearity and normality. Variance Inflation Factors, Skewness, and Kurtosis Indices (Table 4) were below recommended cutoffs (Kline, 2005, pp. 48–57), indicating that the data did not suffer from problems with multicollinearity and did not violate assumptions of normality.

To determine whether the standard five-dimensional structure of the RBANS fits this sample, a CFA was implemented using both Mplus (Version 3.01) and SAS (Version 9.1). The estimated correlation among factors and model fit indices was checked to assess model fit. In order to have acceptable fit, a model should have a comparative fit index (CFI) greater than 0.90, Tucker-Lewis index (TLI) greater than 0.90, and Root Mean Square Error of Approximation (RMSEA) less than 0.10 (Hatcher, 1994; Kline, 2005). The results from SAS and Mplus were consistent. Results indicated that two pairs of factors (immediate memory and language, immediate memory, and delayed memory) had estimated Pearson correlation coefficients greater than 1, indicating that these pairs were not statistically distinguishable (Table 5). Further, this model has CFI = 0.92, TLI = 0.89, and RMSEA = 0.11. Therefore, the five-factor structure of RBANS cannot be confirmed in this sample. Further, preliminary CFA results did not support a one factor solution for the original 12 subtest scores: CFI = 0.89, TLI = 0.86, RMSEA = 0.12, although Cronbach's alpha = 0.88. Using a second-order factor structure that is more relevant to the organization of the 12 items according to the RBANS manual (Randolph, 1998), the results do not change (data not shown); i.e., the second factor-factor structure does not fit the sample either.

Exploratory Factor Analysis

Since we were unable to confirm a five-dimension structure of the RBANS, an Exploratory Factor Analysis was conducted to determine a new factor structure. Two methods, Maximum Likelihood with an orthogonal rotation in SAS and Maximum Likelihood with an orthogonal rotation in Mplus (computes standard errors and a mean-adjusted chi-square test statistic that are robust to nonnormality) were used to extract factors. Results were consistent across both methods. Several criteria (proportion of variance accounted for, chi-square test, interpretability) suggested that the data could be explained by two factors (Table 6); one factor included measures of memory (list learning, story memory, list recall, list recognition, delayed story memory and figure recall), a nonspecific visual-motor task (coding) and a word generation task (semantic fluency), while the second included visuospatial functions (figure copy, line orientation, figure recall and coding) and picture identification (naming). The first factor accounted for 89.4% of the variance, whereas the second factor accounted for 10.6% of the variance. (Note that the remaining factors accounted for only a small proportion of the variance, <2.7%. However, because prior communality estimates cannot be precisely estimated, and the cumulative proportion must equal 1.00, some of remaining

factors in the exploratory factor analysis accounted for a negative percentage of the variance; Hatcher, p. 85).

One of the 12 subtest scores, digit span, was dropped because it had factor loading less than 0.40 on both of the identified factors. Among the remaining 11 subtest scores, two (coding, figure recall) cross-loaded on both of the factors (factor loadings greater than 0.4 on both) and these factor loadings did not differ by more than 20%.

Confirmatory Factor Analysis

In order to confirm this new two-dimensional structure, another CFA was conducted on the remaining 11 sub-test scores. The two-dimensional structure was identifiable, and the correlation coefficient between the two factors was 0.73. The two-dimensional structure in this sample was also supported by CFI = 0.95, TLI = 0.93, and RMSEA = 0.10.

Discussion

The purpose of this study was to examine the factor structure of the RBANS and to determine if factors would be identified that reflect the five Index Scores. Consistent with previous research, results indicated that the RBANS is best conceptualized in this sample as a two-dimensional index of cognitive function, although the first factor accounted for more than 80% of the variance. Further, the five factor solution in the present study did not replicate the construction of the five Index Scores (immediate memory, visuospatial/constructional, language, attention, and delayed memory). The obtained factor solution might instead suggest that a two-factor solution examining memory and visuospatial function may be the most informative for clinical interpretation.

In general, our two-factor solution was similar to both Duff et al.'s (2006) solution and Wilde's (2006) solution, with a few minor differences (Table 7). This study included picture naming, semantic fluency, and digit span in the factor model, whereas Duff et al. (2006) were forced to eliminate these subtests from analyses due to assumption violations in their sample. Regardless, the factor solutions in both studies were similar, with the exception that both coding and figure recall cross-loaded on both factors in our sample, whereas they loaded independently in Duff et al.'s study. These minor differences were likely due to the inclusion of additional subtests in our factor model. Further, our two-factor solution was similar to Wilde's (2006) solution, with a few minor differences; digit span did not load on either factor in our analysis, picture naming loaded on different factors in our analysis and Wilde's analysis, and figure recall and coding cross-loaded on both factors in our sample, whereas they loaded independently in Wilde's sample. Therefore, although there are minor differences in our factor structure and these two other studies, results suggest that the RBANS might be best represented by a two-factor scoring system, instead of the current use of a Total Score, or the Index scores.

Although these results do not confirm the theoretical structuring of the RBANS, as Duff et al. have already suggested, this is not all that surprising given that confirmation of theoretical structures for other dementia screening measures (such as the CERAD) have also been unsupported (Strauss, 2004). Further, while it may be that the RBANS functions

differently in this specialized clinical population (referrals to a memory disorders clinic in a veteran's administration hospital), the consistency of our findings with both Duff et al. (2006) and Wilde's (2006) samples suggest that this interpretation is unlikely, and instead suggest that results might be generalizable to both community and clinical samples. Regardless, the sample size in this study is considered small (MacCallum, 1986), and therefore the present results must be interpreted with caution. Further replication is still needed with other, larger samples of a similar population, as well as with samples drawn from different populations (Delis et al., 2003).

Findings from this study do not provide empirical support for the Index Scores of the RBANS, and suggest that clinicians place more emphasis on the individual subtest scores during interpretation. Regardless, the present findings do not diminish the capacity of the RBANS as a very useful screening measure that covers many cognitive domains.

Acknowledgments

Work on this manuscript was supported, in part, by grants U01 NS043127 and 3P30 AG021677.

References

- Delis DC, Jacobson M, Bondi MW, Hamilton JM, Salmon DP. The myth of testing construct validity using factor analysis or correlations with normal or mixed clinical populations: Lessons from memory assessment. *Journal of the International Neuropsychological Society*. 2003; 9(6):936–946. [PubMed: 14632252]
- Duff K, Langbehn DR, Schoenberg MR, Moser DJ, Baade LE, Mold J, et al. Examining the RBANS: Factor analytic studies in an elderly sample. *American Journal of Geriatric Psychology*. 2006; 14:976–979.
- Gontkovsky ST, Beatty WW, Mold JW. Repeatable battery for the assessment of neuropsychological status in a normal, geriatric sample. *Clinical Gerontologist*. 2004; 27(3):79–86.
- Hatcher, L. A step-by-step approach to using SAS system for factor analysis and structure equation modeling. Cary, NC: SAS Institute Inc; 1994.
- Kline, RB. Principles and practice of structural equation modeling. 2nd. New York: The Guilford Press; 2005.
- MacCallum R. Specification searches in covariance structure modeling. *Psychological Bulletin*. 1986; 100(1):107–120.
- Randolph, C. Repeatable battery for the assessment of neuropsychological status: Manual. San Antonio, TX: The Psychological Corporation; 1998.
- Tombaugh, TN. Test of memory malingering. Los Angeles: Western Psychological Services; 1996.
- Wilde MC. The validity of the repeatable battery of neuropsychological status in acute stroke. *The Clinical Neuropsychologist*. 2006; 20(4):702–715. [PubMed: 16980256]

Table 1
Means and Standard Deviation for RBANS Index Scores and Total Scale Score of the 175 Participants

	Mean	SD
<i>Index Scores</i>		
Immediate memory	70.1	16.1
Visuospatial/constructional	79.2	18.8
Language	83.1	15.1
Attention	76.1	17.8
Delayed memory	68.7	20.5
Total scale	69.8	15.9

Note. Index Scores and Total Scale Score are standardized to have a mean of 100 and *SD* of 15.

Table 2
Pearson Correlation Coefficients between RBANS Index Scores and the Total Scale Score

	Immediate Memory	Visuospatial/Constructional	Language	Attention	Delayed Memory
<i>Immediate memory</i>					
Visuospatial/Constructional	0.47				
Language	0.61	0.45			
Attention	0.59	0.50	0.55		
Delayed memory	0.75	0.53	0.64	0.53	
Total Scale	0.84	0.74	0.76	0.78	0.87

Note. All of the coefficients are significant at $\alpha = 0.001$.

Table 3

Pearson Correlations Among RBANS Subtest Scores

	LL	SIM	FC	LO	PN	SF	DS	Co	LRL	LRN	SDR	FR
List learning (LL)	1.00											
Story immediate memory (SIM)	0.66	1.00										
Figure copy (FC)	0.44	0.43	1.00									
Line orientation (LO)	0.48	0.45	0.60	1.00								
Picture naming (PN)	0.47	0.51	0.40	0.52	1.00							
Semantic fluency (SF)	0.62	0.51	0.34	0.45	0.41	1.00						
Digit span (DS)	0.41	0.35	0.24	0.36	0.27	0.37	1.00					
Coding (Co)	0.65	0.66	0.57	0.65	0.51	0.58	0.44	1.00				
List recall (LRL)	0.63	0.52	0.34	0.35	0.33	0.52	0.19	0.56	1.00			
List recognition (LRN)	0.61	0.61	0.39	0.50	0.54	0.47	0.19	0.59	0.50	1.00		
Story delayed recall (SDR)	0.61	0.78	0.40	0.42	0.42	0.54	0.36	0.67	0.64	0.61	1.00	
Figure recall (FR)	0.56	0.58	0.60	0.50	0.45	0.53	0.33	0.61	0.51	0.52	0.62	1.00

Note. All of the coefficients are significant at $\alpha = 0.05$ level.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 4
Basic Descriptive Statistics and Variance Inflation Factors (VIF) for RBANS Subtests (N = 175)

RBANS Subtest	Mean	SD	Skewness	Kurtosis	VIF
List learning	16.05	5.49	-0.13	0.47	2.88
Story immediate memory	10.56	5.03	-0.13	-0.72	3.21
Figure copy	13.24	4.63	-0.84	0.25	2.02
Line orientation	13.35	5.18	-0.82	-0.27	2.27
Picture naming	9.06	1.31	-1.87	3.94	1.73
Semantic fluency	12.46	5.29	0.30	0.17	1.95
Digit span	8.70	2.41	0.23	0.17	1.44
Coding	20.47	13.45	0.14	-0.93	3.23
List recall	1.28	1.75	1.51	1.73	2.20
List recognition	16.13	3.02	-0.63	-0.59	2.27
Story delayed recall	4.02	3.37	0.47	-0.87	3.61
Figure recall	6.01	4.92	0.51	-0.58	3.37

Table 5
Estimated Pearson Coefficient of Correlation Matrix for the Five Factors

IM	VC	LA	ATT	DM
IM				
VC	0.70			
LA	1.02**	0.87		
ATT	0.88	0.85	0.94	
DM	1.00*	0.70	0.97	0.87

Note. IM = immediate memory; VC = visuospatial/constructional; LA = language; ATT = attention; DM = delayed memory;

* = the estimated correlation coefficient between two factors is greater than 1, which means the pairs of factors cannot be distinguished from one another.

Table 6
Factor Loadings for a Two-Factor Solution

RBANS Subtest	Factor 1	Factor 2
List learning	0.66	0.42
Story memory	0.77	0.33
Figure copy	0.26	0.65
Line orientation	0.23	0.82
Picture naming	0.37	0.52
Semantic fluency	0.55	0.40
Digit span	0.30	0.34
Coding	0.59	0.62
List recall	0.67	0.25
List recognition	0.59	0.42
Delayed story memory	0.85	0.26
Figure recall	0.56	0.49
Eigenvalue	17.23	2.04
Variance accounted for by the factor	89.4%	10.6%

Table 7
Comparison of Published Factor Structures for the RBANS

Study	Carlozzi et al.	Duff et al., 2006	Wilde, 2006
Primary focus	Factor structure	Factor structure	Validity
Population profile	Clinical sample	Community sample	Acute ischemic stroke
Sample size	175	824	210
Age	44~87 (74.1 ± 8.0)	65 (73.4 ± 5.8)	61.91 ± 13.97
Gender	Male: 100%	Male: 43%	Male: 49.5%
Race	Caucasian: 71.4% AA: 28.6%	Caucasian: 86%	Caucasian: 59.5% AA: 41.9% Hispanic: 7.6% Asian: 1.0%
Education	1 ~ 20 (11.3 ± 4.0) 36% High School	59% High School	12.27 ± 3.1
Factor analysis techniques	CFA/EFA/Re-CFA	CFA/EFA	PCA
CFA to original 5-factor structure of RBANS	Failed	Failed	N/A
Items excluded from the new factor structure	Digital span (low loading on either factors)	Picture naming (ceiling effects), semantic fluency (low correlation with other items), digital span (low correlation with other items)	None
New factor structure identified	2-Factor structure (11 items; 2 items with cross-loadings)	2-Factor structure (9 items)	2-Factor principal components structure (12 items)
Items with modified scoring procedure	None	Figure copy Figure recall	None

Note. CFA = confirmatory factor analysis; EFA = exploratory factor analysis; PCA = principal components analysis.