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Exploratory Factor Analysis of the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) in Adult Patients with Acquired Brain Injury and Brain Disease

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Abstract

Research has offered limited support for the theoretically derived, five-factor structure of the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). This investigation examined the structure of the RBANS using an exploratory factor analytic approach in a clinical sample of 248 adult patients with acquired brain injury/disease. Extraction using maximum likelihood method and subsequent orthogonal rotation yielded a two-factor model for the data, the first factor largely involving memory and the second factor emphasizing visual-spatial perception. Neither factor was pure, however, and both appeared to involve at least some degree of information processing speed. Consistent with many prior investigations in this specific line of research, our results question the index structure of the RBANS and suggest that it may be more appropriate to place a larger degree of emphasis on the measure's subtests for accurate interpretation of patient functioning.

Introduction

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph, 1998) was developed to provide a concise evaluation of abilities across the central domains of neurocognitive functioning and has become one of the more commonly used measures in professional neuropsychological practice. Although originally conceived as a measure to be utilized primarily for assessing older adults with neurological disorders, in particular dementia, and secondarily for general screening when lengthier batteries are impractical, the test consistently has increased in popularity and expanded in use both in practice and research to a number of clinical populations and diagnostic groups. Since its initial publication, the RBANS has come to include four alternate forms, new norms that allow for examination of performance across the measure's individual subtests, and an extended age range for adolescents (Randolph, 2012).

The RBANS includes 12 subtests that yield five domain-specific indices as well as a Total Scale index. Each subtest contributes to only one index, with two subtests comprising each specific index with the exception of Delayed Memory, which consists of four subtests. Domain-specific indices include Immediate Memory (List Learning and Story Memory subtests), Visuospatial/Constructional (Figure Copy and Line Orientation subtests), Language (Picture Naming and Semantic Fluency subtests), Attention (Digit Span and Coding subtests), and Delayed Memory (List Learning Recall, List Learning Recognition, Story Memory Recall, and Figure Recall subtests).

The index structure of the RBANS was derived theoretically rather than being developed based on factor or component analysis. In this light, numerous researchers have sought to examine more formally whether the theory-based indices of the RBANS are supported by clinical data. For example, Duff et al. (2006) utilized a confirmatory factor analysis (CFA) to test two theoretical models of the RBANS in a sample of elderly individuals, the first being a single common factor consistent with the measure's Total Scale index and the second being reflective of the assumed five domain-specific index structure of the RBANS. Findings revealed that neither CFA model was well supported by the data. Given these results, subsequent exploratory factor analysis utilizing the majority of the measure's subtests indicated that a two-factor model consisting of verbal memory and visual processing was best supported by the data. Based on these findings, caution was recommended in relying upon interpretations based primarily on the index scores of the RBANS.

In a similar investigation, Carlozzi, Horner, Yang, and Tilley (2008) using CFA attempted to replicate a five-factor model to reflect the five domain-specific index scores of the RBANS from the 12 individual subtests. Being unable to identify a five-factor structure for the measure, the authors subsequently subjected the subtests of the RBANS to an exploratory factor analysis with maximum likelihood extraction and orthogonal rotation to determine a new dimensional model. Findings of this exploratory factor analysis yielded a two-factor structure of memory and visuospatial function, and confirmatory factor analysis of this new structure indicated an adequate fit for their sample of veterans. Again, it was suggested that consideration be given by clinicians to placing more emphasis on the individual subtest scores than the index scores during interpretation.

Another study using exploratory factor analysis examined the factor structure of the RBANS in a heterogeneous sample of patients referred for dementia evaluation and likewise reported a two-factor solution for the measure, the first factor being predominantly memory and the second being predominantly visuospatial (Schmitt et al., 2010). In an attempt to validate these factors, their relationship with external neuropsychological variables revealed further support for the first factor as a memory factor. Correlations with the second factor supported its visuospatial features, although it also was found to be associated with other cognitive domains, including attention and general ability.

Using a slightly different approach, Garcia, Leahy, Corradi, and Forchetti (2008) explored the component structure of the RBANS in a sample of more than 350 individuals diagnosed with memory disorders. Their results suggested a three-component solution for the RBANS, consisting of memory, visuomotor processing, and verbal processing, which together accounted for 61.52% of the test variance. Using a sample of inpatients diagnosed with schizophrenia or schizoaffective disorder, King, Bailie, Kinney, and Nitch (2012) conducted an exploratory factor analysis of the RBANS, with findings being inconsistent with the measure's five-factor structure. Extraction of two factors yielded a memory dimension and a less homogenous visual perception and processing speed dimension. Subsequent higher-order analysis revealed that a second-order factor of general neurocognitive functioning accounted for more than three times the total and common variance than the first two factors combined. Based on these results, it was recommended that clinical interpretation of the RBANS beyond the Total Scale index be done with a degree of caution in inpatients with schizophrenia and schizoaffective disorder.

Hypothesizing that differences in findings across the various factor analytic studies of the RBANS were the result of methodological inconsistencies, Vogt, Prichett, and Hoelzle (2017), utilizing empirically supported extraction criteria, reanalyzed RBANS data from four previously published studies in conjunction with a new data set. The congruence of factor structures was examined by conducting orthogonal vector matrix comparisons, with a robust two-factor structure reliably emerging across samples. This invariant two-factor RBANS structure primarily emphasized memory and visuospatial functioning, thereby offering further support for the two-factor structure identified in previous studies and providing empirical documentation of replication across diverse samples.

Emmert, Schwarz, Vander Wal, and Gfeller (2018) tested the theoretically formulated five-factor structure of the RBANS in conjunction with three alternative factor solutions using a combination of exploratory and confirmatory factor analytic approaches. Four RBANS models were specified using CFA, and results of the five-factor model demonstrated good to excellent fit following modifications. Findings of chi-square difference tests also demonstrated that the five-factor model was statistically superior to the two-factor and three-factor models. Although their results provided support for the theoretically derived five-factor structure of the RBANS, it was suggested that cautious interpretation of the measure's index scores as five distinct cognitive domains may be warranted, particularly when minimal discrepancy across performance on the subtests that comprise each index is observed.

More recently, Holden, Milano, and Horner (2020) examined the factor structure of the RBANS in a sample of patients diagnosed with probable Alzheimer's disease. A CFA of a model reflecting the domain-specific index scores found that the proposed five-factor structure fit the data well, and the authors stressed the importance of testing the construct validity of neuropsychological assessment instruments in specific homogeneous as opposed to heterogenous samples.

Given these divergent findings across studies, additional exploration of the RBANS factor structure is necessary and has important implications for clinical practitioners and researchers using this measure. The aim of this investigation was to examine the factor structure of the RBANS in a large sample of neurological adult patients with central nervous system injury/disease. Based on the results of prior research, it was hypothesized that findings of an exploratory factor analysis would yield a two-factor model for the RBANS, with the primary factor being related to memory and the secondary factor largely involving aspects of visual-spatial perception.

Method

Participants for this investigation consisted of 248 clinical patients referred for inpatient or outpatient neuropsychological evaluation at one of five medical centers or clinics located in the southeastern, midwestern, or western United States. All patients were referred for clinical evaluation by a physician (e.g., neurologist, physiatrist, psychiatrist, etc.) secondary to acquired brain injury or brain disease. As part of a more comprehensive battery of measures, the RBANS was administered and scored according to standardized procedures by a clinical neuropsychologist or a psychology technician under the supervision of a clinical neuropsychologist.

The mean age and educational level of participants was 64.57 (SD = 13.62) years and 12.91(SD = 2.68) years, respectively. Gender composition of the sample was 51% male and 49% female. Approximately 86% of participants were White, with the remainder being 11% Black, 2% Latino/Hispanic, and 1% American Indian. The sample was 92% right-handed, 7% left-handed, and 1% mixed/ambidextrous. Diagnoses of the sample included Parkinson's disease (23%), stroke (15%), probable Alzheimer's disease (11%), traumatic brain injury (11%), multiple sclerosis (10%), parkinsonism/tremors (6%), dementia of indeterminate etiology (6%), vascular disorders other than stroke (4%), mild cognitive impairment (3%), metabolic encephalopathy (2%), anoxic brain injury (1%), central nervous system tumor (1%), and various other forms of acquired brain injury or brain disease (e.g., corticobasal degeneration, primary progressive aphasia, Wernickee-Korsakoff syndrome, viral meningoencephalitis, etc.) each being less than 1% of the total sample (7%).

This retrospective study utilizing archival clinical data received full institutional review board approval and was conducted in accordance with the Helsinki declaration and the ethical principles of the American Psychological Association (2002).

Results

Descriptive statistics were calculated to evaluate the overall performance of the sample across the five domain-specific indices and the Total Scale index of the RBANS. A series of one-sample *t*-tests revealed that participants in this study demonstrated significantly reduced performances across all RBANS index scores relative to the measure's normative sample mean of 100 and standard deviation of 15, all *p*'s < .0005 (see Table 1). Overall index score reductions for the sample ranged from more than one standard deviation below the mean (Language) to nearly two standard deviations below the mean (Total Scale), although the range of scores on all indices varied from severely impaired to above average.

Table 1
Scores of Participants Across RBANS Indices

RBANS Index	Mean	Standard Deviation	Range	*t**
Immediate Memory	74.01	19.43	40-129	-21.07
Visuospatial/Constructional	77.88	21.00	50-131	-16.59
Language	82.92	15.06	40-122	-17.86
Attention	75.72	18.32	40-132	-20.88
Delayed Memory	72.25	20.46	40-118	-21.36
Total Scale	70.97	16.56	43-123	-27.62

Note. * *df* = 247, *p* < .0005

Pearson correlation coefficients were computed to examine the relationships among the RBANS indices (see Table 2) and among its subtests (see Table 3). Associations among all RBANS indices were highly significant, all *p*'s < .0005. The weakest correlation was found between the Immediate Memory index and the Visuospatial/Constructional index, and the strongest association was found between the Immediate Memory index and the Total Scale index.

Table 2
RBANS Index Correlation Matrix

RBANS Index	1	2	3	4	5	6
1 Immediate Memory	-					
2 Visuospatial/Constructional	.33	-				
3 Language	.60	.35	-			
4 Attention	.51	.44	.38	-		
5 Delayed Memory	.74	.36	.55	.38	-	
6 Total Scale	.83	.67	.71	.72	.80	-

Note. All correlations significant at $p < .0005$

Computations revealed marked variability in relationships between individual RBANS subtests, with specific correlation coefficients ranging from .09 (Picture Naming and Digit Span) to .79 (Story Memory and Story Memory Recall). The large majority of associations were significant at $p < .0005$.

Table 3
RBANS Subtest Correlation Matrix

RBANS Subtest	1	2	3	4	5	6	7	8	9	10	11	12
1 List Learning	-											
2 Story Memory	.67**	-										
3 Figure Copy	.30**	.30**	-									
4 Line Orientation	.28**	.28**	.56**	-								
5 Picture Naming	.34**	.43**	.22**	.20**	-							
6 Semantic Fluency	.62**	.52**	.37**	.38**	.38**	-						
7 Digit Span	.37**	.34**	.17**	.22**	.09	.24**	-					
8 Coding	.55**	.43**	.53**	.62**	.20**	.58**	.31**	-				
9 List Learning Recall	.71**	.51**	.14*	.23**	.22**	.56**	.19**	.45**	-			
10 List Learning Recognition	.63**	.55**	.24**	.31**	.34**	.47**	.21**	.43**	.57**	-		
11 Story Memory Recall	.63**	.79**	.25**	.28**	.39**	.54**	.23**	.44**	.63**	.61**	-	
12 Figure Recall	.45**	.44**	.53**	.45**	.25**	.42**	.19**	.47**	.44**	.41**	.51**	-

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

An exploratory factor analysis using maximum likelihood method for extraction and orthogonal rotation was employed to examine the factor structure of the RBANS. Scree plot analysis and selection of factors with eigenvalues > 1 yielded a two-factor model, with goodnessof-fit being highly significant χ^2 (43) =196.65, $p < .0005$. These two factors together accounted for 52.26% of the overall test variance.

Rotated factor loadings are presented in Table 4, with loadings below .30 being omitted. Each rotated factor was comprised of subtests with loadings ≥ .40. Nine RBANS subtests loaded on factor 1. These nine subtests included the six subtests of the measure devoted directly to the assessment of memory functioning. Both subtests comprising the Language index also loaded on factor 1. Five subtests loaded on factor 2, including both subtests comprising the Visuospatial/Constructional index as well as Figure Recall from the Delayed Memory index. Three subtests (Semantic Fluency, Coding, and Figure Recall) loaded on both extracted factors.

Table 4
Rotated Factor Matrix Illustrating RBANS Subtest Loadings

RBANS Subtest	Factor 1	Factor 2
List Learning	.79	
Story Memory	.79	
Figure Copy		.72
Line Orientation		.76
Picture Naming	.41	
Semantic Fluency	.60	.41
Digit Span		
Coding	.40	.70
List Learning Recall	.74	
List Learning Recognition	.68	
Story Memory Recall	.83	
Figure Recall	.44	.51

Discussion

This study analyzed the theoretically derived, five-factor structure of the RBANS using an exploratory factor analytic approach. Prior investigations examining the factor structure of the RBANS have yielded somewhat divergent results. Most commonly, a two-factor solution has been reported, and our results supported the study hypothesis that two extracted factors would yield the best fit for the data. A relatively consistent finding within this line of research is that of the presence of a factor for memory. Our findings revealed a primary factor largely involving memory and a secondary factor emphasizing visual-spatial perception, although neither factor was pure. A factor for memory might be expected given that six of the measure’s 12 subtests assess memory in some form (e.g., immediate vs. delayed, recall vs. recognition, verbal vs. nonverbal, etc.). It also could be argued that the Picture Naming subtest involves semantic memory as much as it does language (Forseth et al., 2018). The loadings of the Semantic Fluency and Coding subtests on the memory factor are more difficult to explain. Derivation of words within a specific category may utilize semantic memory in a similar or parallel manner as does the identification of pictures of objects while Coding necessarily involves a large degree of working memory.

In addition to the loading of the three RBANS subtests involving visuospatial/construction abilities (Figure Copy, Line Orientation, and Figure Recall), the second factor likewise included the Semantic Fluency and Coding subtests. Clearly, Coding possesses an element of visual-spatial perception for performance. Beyond the potential basic visualization of fruits and vegetables required to be identified in the Semantic Fluency subtest, there does not seem to be any element of visual-spatial perception for performance of this task. Both Coding and Semantic Fluency are timed, however, and better scores on these subtests is associated with rapid performance. Although perhaps not necessarily intended to primarily measure speed of information processing, it has been suggested that timed tests assessing language, visual-spatial perception, and other cognitive domains may be used as proxy measures of processing speed (Gontkovsky & Beatty, 2006). It therefore may be that this second factor, and arguably the first factor, are either comprised of or affected by, but not comprised of speed of information processing. Other research, including that of King et al. (2012), also has reported some influence of information processing speed in the factor structure of the RBANS.

Consistent with the findings and recommendations from several prior studies examining the factor structure of the RBANS, our results suggest the measure may be best conceptualized as a two-dimensional index of neurocognitive functioning. It should be noted that the two factors identified in this study accounted for only 52.26% of the test variance. This contrasts with some of the prior research. For example, in the two-factor solution involving memory and visuospatial functioning identified by Carlozzi et al. (2010), the memory factor alone accounted for more than 80% of the RBANS variance. Nevertheless, some degree of caution appears warranted in the clinical interpretation of test results based solely or largely upon the index scores of the RBANS.

Although our findings mirror those of many prior investigations examining the factor structure of the RBANS, the more subtle differences across studies, such as the percent of variance explained by the extracted factors, at least in part represents the divergent samples under analysis. In light of the recent findings of Holden et al. (2020) supporting the five-factor structure of the RBANS in patients with Alzheimer's disease and the associated recommendation that the construct validity of neuropsychological assessment instruments be tested in specific homogeneous as opposed to heterogenous samples, additional research with such groups is necessary. Despite the limited support of the five-factor structure of the RBANS, a good deal of research exists generally supporting its reliability and validity, and the measure remains a quality tool for the screening of neurocognitive functioning.

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