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Construct Validity and Extended Normative Data for Older Adults for the Brief Visuospatial Memory Test, Revised

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Abstract

Purpose: This study examined the construct validity of a visual memory test (Brief Visuospatial Memory Test, Revised [BVMT-R]) in a sample of older adults and provided normative data for adults aged 80+ years. **Method:** The sample included 109 community-dwelling individuals (mean [M] age = 74.9 years, M education = 15.0 years, 62.4% female, and 97.2% European American). **Procedures:** Measures administered included the BVMT-R, California Verbal Learning Test, 2nd edition, and subtests of the Delis-Kaplan Executive Function System and Neuropsychological Assessment Battery. **Results:** The BVMT-R correlated highly with another measure of memory and less so with unrelated measures (e.g., verbal fluency). Age and education were significantly correlated with BVMT-R Total and Delayed Recall scores, with education as the strongest predictor. No significant differences were found for sex. Normative data were provided for adults aged 80 to 88 years ($n = 29$). **Conclusions:** Adequate evidence was found for convergent validity and only partial support for discriminant validity. Normative data should continue to be stratified by age and also by formal education level.

Keywords

BVMT-R, visual memory, normative, older adults, validity

Introduction

Memory is a vital and frequently assessed domain within neuropsychological evaluations, especially when older adults are being evaluated. In particular, performance on visual memory measures has been identified as one of the best predictors of eventual development of dementia due to Alzheimer's disease (AD) in older adults.[1-5] One such measure, the Brief Visuospatial Memory Test, Revised (BVMT-R),[6] is used to assess visuospatial memory and its manual provides normative data for adults aged 18-79 years.

The initial psychometrics of the BVMT-R were investigated through four studies that included data on reliability, validity, and ability to detect cognitive dysfunction within a sample of individuals with HIV, traumatic brain injury, mental health diagnoses, dementia, and other disorders.[6,7] Overall, the BVMT-R was thought to adequately detect deficits in visual memory among adults[7] and has also recently been useful in detecting memory deficits in individuals with multiple sclerosis,[8,9] schizophrenia,[10] infectious diseases (e.g., hepatitis C[11]), blast- and nonblast-related traumatic brain injuries,[12] and concussions sustained while playing sports.[13] The present study aims to extend the initial psychometric studies by exploring the convergent and discriminant validity of the BVMT-R in a sample of older adults, in order to assess its construct validity in this population.

In regard to normative data, to our knowledge there are no published normative data for Form 1 of the BVMT-R with adults aged 80 years and older. Norman et al[14] published norms for adults 20 to 65 years on Form 1 of the BVMT-R and discussed the need for age-corrected norms, particularly for African Americans. Gale et al[15] expanded the age norms up to 89 years, though solely using Form 4. These authors recognized that their sample of older adults often scored below the norms in the BVMT-R manual, and they posited that caution should be used when comparing the norms among the different forms as they may be similar yet not completely equivalent. Additionally, Gale et al defined "Recognition" as the number of true positives, without incorporating the number of true or false negatives or false positives, and thus they did not provide normative data for these variables. This

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differs from the BVMT-R test manual, which provides normative data on these components of recognition memory.[7] The absence of normative data on false positives leaves out information that is often useful when formulating a diagnosis of AD and can be vital in better understanding an individual's memory impairment.[16]

Although norms for Form 4 provided by Gale et al[15] are useful, one additional aim of this study was to provide normative data on Form 1 for adults aged 80 years and older as it may be the most frequently administered. The BVMT-R has multiple forms to avoid the issue of practice effects and having norms available for an additional form for use within the older population could assist with this problem as well,[17,18] thus expanding upon Gale et al[15]. The aims of this study were (1) to investigate the convergent and discriminant validity of the BVMT-R in a sample of adults aged 60 years and older and (2) to provide normative data on healthy adults age 80 years and older.

Method

Participants

The sample consisted of older adults aged 60 years and older who were recruited from a local research volunteer registry (N = 109). This sample had a mean age of 74.9 years (standard deviation [SD] = 6.8 years; range = 60-88 years), average of 15 years of formal education (SD = 2.9 years; range = 8-24), and 62.4% were female. European Americans comprised 97.2% of the sample and Hispanic Americans 2.8%. Participants denied any history of neurological disorders (e.g., strokes and dementia) and were independent in their instrumental activities of daily living (IADLs) determined either by self-report or by collateral report (as measured by a 10-item questionnaire).

Normative data were provided from a subset of the sample ($n = 29$) that were aged 80 years and older and did not meet criteria for cognitive impairment. Cognitive impairment was defined according to the guidelines put forth by Busse et al,[19] which are also consistent with the psychometric criteria set forth in the *Diagnostic and Statistical Manual of Mental Disorders (Fifth Edition)*.[20] Specifically, individuals were considered cognitively impaired if they had a T-score of 39 or lower (more than 1.0 SD below the mean) on a measure of verbal memory (California Verbal Learning Test, 2nd edition [CVLT-II], Trials 1-5) and one other measure, either from the Delis-Kaplan Executive Function System (D-KEFS) or Neuropsychological Assessment Battery (NAB) subtests (described subsequently). Using these criteria, 4 individuals from the sample with cognitive impairment were excluded to create a sample ($n = 29$) that had a mean age of 83.2 years (SD = 2.3 years; range = 80-88 years) and a mean of 14.4 years of formal education (SD = 2.6, range = 8-20 years); just over half were female (51.7%) and all participants were European American (100%).

Measures

Memory measures

Brief Visuospatial Memory Test-Revised (BVMT-R). This measure assesses visual memory.[6] Form 1 was used and 4 variables were analyzed, including Total Recall (total score across 4 trials), Delayed recall (following a 25-minute delay), Percent Retained (percent retained from learning trials following delay), and Recognition Discrimination Index (recognition hits minus false positives), with high scores on each of these variables indicating better memory performance.

California Verbal Learning Test, 2nd edition. The CVLT-II assesses verbal memory.[21] The standard form was used in this study in which individuals are required to remember a list of 16 words from 4 different categories over 5 successive trials. Scores pertinent to this study included Trials 1 to 5 and Long Delay Free Recall, Percent Retained, and Recognition Discriminability Index; higher scores indicated better memory performance.

Executive functioning measures

Delis-Kaplan Executive Function System (D-KEFS), Trail Making test. This subtest assesses a few different executive functioning abilities, including inhibition, organization, and set-shifting abilities.[22] Only the completion time of the fourth condition, number–letter switching, was used in this study, with lower scores indicating a better performance.

D-KEFS Verbal Fluency test. This subtest assesses the executive ability of initiation and self-monitoring.[22] Participants are asked to generate as many words as possible in 1 minute for 3 different letter cues and also for 2 category cues. The total scores were used in this study for both letter and category fluencies, with higher scores indicating better executive functioning abilities.

Naming measure

Neuropsychological Assessment Battery (NAB), Naming subtest. This measure assesses naming ability, requiring individuals to look at a color photograph of an object and name the object, with the help of semantic and phonemic cues if needed.[23] Form 1 was used in this study and higher scores indicated better naming ability.

Procedures

This study was approved by the institutional review board of the University of Colorado at Colorado Springs. All participants consented to their data being used for research purposes. Clinical psychology graduate students, both master and doctoral levels, administered the tests in a quiet room.

Statistical Analyses

All proposed analyses were completed with the entire sample (N = 109), except analyses reporting normative data for older adults aged 80+ years.

The first set of analyses centered on the first study aim regarding assessment of the construct validity of the BVMT-R. In order to explore convergent validity, Pearson correlations and Spearman correlations and independent samples *t* tests (for analyses related to participant sex) were conducted among the demographic variables, the raw scores for the 4 BVMT-R variables (Total Recall, Delayed Recall, Percent Retained, and Recognition Discrimination Index scores), and raw scores of comparable variables from another measure of memory, the CVLT-II (e.g., Trials 1-5 [immediate recall], Long Delay Free Recall, Percent Retained, and Discriminability Index scores). Large Pearson correlations ($r \geq .50$) between the BVMT-R and the CVLT-II scores would provide evidence of convergent validity.[24] Discriminant validity was also evaluated with Pearson and Spearman correlations and independent samples *t* tests using the same demographic variables as listed previously, the raw scores from the four BVMT-R variables, and raw scores from the executive functioning (D-KEFS Trail Making test, condition 4 and Verbal Fluency subtests) and the naming (NAB Naming subtest) instruments. Nonsignificant or small Pearson correlations ($r < .30$) between the BVMT-R scores and scores for the executive functioning and naming instruments would demonstrate discriminant validity.[24]

To investigate the need for age-, education-, and sex-related norms, Pearson correlations and independent samples *t* tests (sex only) were carried out with the demographic variables with the raw scores of the four BVMT-R variables. Significant relationships between the BVMT-R scores and the demographic variables of education and sex were then explored within a hierarchical multiple regression analysis to determine whether further stratification of the norms was necessary after controlling for age (block 1: age; block 2: education, sex). If education and/or sex account for a significant amount of the variance in BVMT-R scores beyond age, then norms may be needed to reflect relationships between these variables and older adults' performance on the BVMT-R.

Results

Construct Validity

Correlations for convergent and discriminant validity are presented in Table 1.

Normative Data

Age and education were significantly correlated with BVMT-R Total and Delayed Recall scores. No significant relationships (Spearman ρ) or differences were found between females and males for all BVMT-R variables with *t* tests (2-tailed significance). Total Recall and Delayed Recall scores were significantly predicted by education ($\beta = .31$; $\beta = .33$, respectively) and age ($\beta = -.23$; $\beta = -.26$, respectively; see Table 2), with education having higher β values. Although education was a stronger predictor, the limited sample size precludes further stratifying the norms by education levels and thus normative data were provided for all cognitively intact older adults aged 80+ years (n = 29; see Table 3).

Discussion

Convergent Validity

Convergent validity of the BVMT-R was explored by assessing its correlation with a second memory measure, the CVLT-II. The BVMT-R Total and Delayed Recall variables had large-sized correlations ($r \geq .50$) with similar variables of the CVLT-II (Trials 1-5 [immediate recall], Long Delay Free Recall, and Recognition Discriminability Index). Additionally, of the four BVMT-R scores, the Percent Retained score was the only score to significantly correlate with the CVLT-II Percent Retained score (although small in size, $r = .19$). Also, the BVMT-R Recognition Discrimination Index score had the strongest correlation with the CVLT-II Recognition Discriminability Index variable (medium-sized, $r = .48$). These correlations are similar to results found between other verbal and visual memory tests[25] and suggest that the BVMT-R possesses adequate convergent validity, as predicted. More generally, these data lend support to the idea that the BVMT-R is a valid measure of components of memory.

Discriminant Validity

Discriminant validity of the BVMT-R was explored by examining its correlations with the scores from the D-KEFS Trail Making condition 4 and Verbal Fluency subtests and NAB Naming subtest. The BVMT-R Total Recall score correlated least with the D-KEFS letter and category fluencies ($r = 0.26$; $r = 0.36$, $p < .01$, respectively), as well as did the BVMT-R Delayed Recall score ($r = 0.19$, $p < .05$; $r = .37$, $p < .01$, respectively).

Seven correlations (44%) were not as hypothesized, being significant and medium to large in effect size (−.63-.40).[24] Interestingly, the D-KEFS Trail Making condition 4 was highly correlated with all four BVMT-R variables (ranging from −0.63 to −0.29). One possible reason for these relationships is that the D-KEFS Trail Making condition 4 subtest may tap into working memory and visual processing (i.e., remembering the sequence of letters and numbers and the last letter and number used), which one could argue is also assessed by the BVMT-R. Additionally, this overlap may also be understood in that there are some executive functioning components active during memory processes (i.e., encoding, retrieval). Indeed, D-KEFS Trail Making condition 4 also correlated with CVLT-II Trials 1-5 ($r = -.43$, $p < .01$), CVLT-II Long Delay Free Recall ($r = -.42$, $p < .01$), and CVLT-II Recognition Discriminability ($r = -.36$, $p < .01$), suggesting this may illustrate how executive processes are involved in memory. Although many significant correlations were found between the BVMT-R, D-KEFS Trail Making condition 4 and NAB Naming scores, smaller correlations were found with the D-KEFS Verbal Fluency subtest, providing some evidence for discriminant validity. However, overall, the

Table 1. Correlations for Participants' Demographics and Test Data.[a]

	Age	Sex[b]	Edu	CVLT-II Trials 1-5	CVLT-II LDFR	CVLT-II Percent Retained	CVLT-II Recog Discrim	D-KEFS Trails Making condition 4	D-KEFS Letter Fluency	D-KEFS Category Fluency	NAB Naming Form 1[b]
BVMT-R Total Recall	−.29[c]	−.13	.35[c]	.57[c]	.54[c]	−.02	.52[c]	−.57[c]	.26[c]	.36[c]	.38[c]
BVMT-R Delayed Recall	−.32[c]	−.07	.38[c]	.59[c]	.58[c]	.01	.50[c]	−.63[c]	.19[d]	.37[c]	.40[c]
BVMT-R Percent Retained	−.10	.00	.14	.32[c]	.32[c]	.19[d]	.26[c]	−.29[c]	−.04	.18	.16
BVMT-R Discrim Index	−.15	.01	.20[d]	.34[c]	.32[c]	.08	.48[c]	−.35[c]	.04	.28[c]	.27[c]

Abbreviations: BVMT-R, Brief Visuospatial Memory Test, Revised; Edu, education (years); CVLT-II, California Verbal Learning Test, 2nd edition; LDFR, long delay free recall; D-KEFS, Delis-Kaplan Executive Function System; NAB, Neuropsychological Assessment Battery; recog discrim, recognition discriminability; discrim, discrimination.
[a] $N = 109$.
[b] Spearman ρ correlations used.
[c] $p < .01$.
[d] $p \leq .05$.

Table 2. Summary of Hierarchical Multiple Regression Analysis for Variables Predicting BVMT-R Total and Delayed Recall Scores.[a]

	Step 1				Step 2			
Variable	B	SE B	95% CI	β	B	SE B	95% CI	β
Total Recall								
Age	−0.27	0.09	−0.44-0.10	−0.29[b]	−0.21	0.08	−0.38-−0.05	−0.23[b]
Education					0.65	0.19	0.27-1.03	0.31[b]
R^2	0.09				0.17			
F for change in R^2	9.93[c]				11.50[c]			
Delayed Recall								
Age	−0.12	0.04	−0.19-−0.05	−0.32[c]	−0.10	0.03	−0.16-−0.03	−0.26[c]
Education					0.29	0.08	0.13-0.44	0.33[c]
R^2	0.10				0.21			
F for change in R^2	12.23[c]				13.79[c]			

Abbreviations: BVMT-R, Brief Visuospatial Memory Test Revised; CI, confidence interval; SE, standard error.
[a] $N = 109$.
[b] $p < .05$.
[c] $p < .01$.

Table 3. Normative Data for Adults Age 80 to 88 on All BVMT-R Scores.[a]

	M	SD
BVMT-R Total Recall	15.52	5.40
BVMT-R Delayed Recall	6.41	2.01
BVMT-R Percent Retained	94.93	23.84
BVMT-R Discrimination Index	5.34	1.26

Abbreviations: BVMT-R, Brief Visuospatial Memory Test, Revised; M, mean; SD, standard deviation.
[a] $N = 29$.

BVMT-R had more significant correlations with the CVLT-II than with subtests of the D-KEFS and NAB naming.

Normative Data

This study investigated whether age-, education-, and sex-based norms were necessary for the BVMT-R. As predicted, age was significantly correlated with some of the BVMT-R scores, the Total and Delayed Recall scores, but not with the Percentage Retained or Recognition Discrimination Index scores (similarly to Benedict et al),[7] and education was significantly correlated with 3 of the 4 BVMT-R variables (Total Recall, Delayed Recall, and Recognition Discrimination Index). There were no significant differences found between males and females with any of the BVMT-R scores examined. Hierarchical multiple regression analyses revealed that both age and education were significant predictors of BVMT-R Total and Delayed Recall scores and that education had the greater β-weight.

As mentioned previously, thus far normative data for the BVMT-R have only been stratified by age groups,[6,7,14,15] and the present study supports some of the findings of Gale et al[15] and Norman et al[14], in that the stratification of BVMT-R norms by age continues to be needed and stratification by sex was not necessary for adults. However, unlike Gale et al[15] and more similar to results previously obtained among younger adults assessed by the BVMT-R and another visual memory measure, the Benton Visual Retention Test,[14,26,27] this study found a significant effect of formal education level, specifically for older adults that had 13 years or less of education having lower scores. Mean scores for total recall were 16.39 for participants with 14 years or more of education, compared to 14.10 for those with 13 or fewer years of education. This suggests a need to incorporate education level in the creation of normative data. Likewise, participants with 13 or fewer years of education obtained mean scores of 5.55 and participants with 14 or more years of education obtained mean scores of 6.94 on delayed recall.

The current normative sample size included 29 community-dwelling older adults aged 80+ years, which is similar to normative data provided in the BVMT-R manual for adults aged 54 years and older, with cell sizes ranging from 26 to 34 individuals.[6,7] Cell sizes for data stratified by both age and education level could be comparable to Gale et al's[15] sample that ranged from 14 to 41 adults as well as recently published BVMT-R normative data for young children and teenagers (6-17 years) which included 9 to 20 individuals within their cells.[28] It was deemed for this sample that the limited size precluded the data from being stratified by both age and education (as was indicated with education having a stronger β-weight) and again, a larger sample size would have been preferred.

Potential limitations for the present study centered on sample characteristics. The present sample was small in size, highly educated, mostly female, and not ethnically diverse, which is not nationally representative and may affect the range of individuals to which the normative data can be applied (i.e., generalizability). Also, the sample size limited the potential range of raw scores for the neuropsychological data as well as the possible statistical analyses that could be conducted (i.e., factor analysis[29]). Although utilizing neuropsychological data to screen for and exclude older adults with significant cognitive impairment was a strength for the present study, we did not have access to neurologic or imaging data as did Gale et al[15]. Other potential limitations include utilizing only the first of six forms of the BVMT-R; thus, the resulting norms should only be applied to individuals who were assessed with Form 1. Additionally, we did not assess alternate forms reliability to investigate whether our normative data could be applied to other forms. These limitations leave room for future directions for this line of research. One such direction could be increasing the sample sizes and matching demographic variables among the samples (e.g., age and education levels, sex and ethnicity percentages) and perhaps also matching them to US Census data to achieve a nationally representative sample.

In conclusion, evidence was provided for adequate convergent validity and partial support for discriminant validity for the BVMT-R among a sample of older adults and normative data were expanded to 88 years of age. The need for age-, education-, and sex-based norms was examined, with significant results for both age and education. Education was the largest contributor for most of the BVMT-R scores, suggesting that normative data for older adults should be stratified by both age and education.

Declaration of Conflicting Interests

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