Published in final edited form as:
Clin Neuropsychol. 2007 September ; 21(5): 811–825. doi:10.1080/13854040600878777.

A NEW MEASURE OF VISUAL LOCATION LEARNING AND MEMORY: DEVELOPMENT AND PSYCHOMETRIC PROPERTIES FOR THE BROWN LOCATION TEST (BLT)

Franklin C. Brown[1,2,3], **Robert M. Roth**[3], **Andrew J. Saykin**[3], and **Gina Beverly-Gibson**[4]

[1]Department of Psychology, Eastern Connecticut State University, Willimantic, CT

[2]Neuropsychology Service, Yale University New Haven, CT

[3]Department of Psychiatry, Dartmouth Medical School, Lebanon, NH

[4]Department of Psychology, Louisiana Tech University, Rushton, LA, USA

Abstract

There are a variety of well-established neuropsychological tests that are helpful in identifying global and specific verbal memory deficits. In contrast, tests of visual memory have produced less consistent results likely due in part to confounding variables such as verbal encodability, administration difficulties, and insufficient differentiation of among types of visual memory. The Brown Location Test (BLT) was designed to specifically measure visual memory for location of identical objects (dots) and address limitations found in commonly employed visual memory tests. This paper describes the empirical basis for the BLT and reports the psychometric properties of the test. Results indicate good internal and alternate form reliabilities. Factor analysis of a brief test battery confirmed that BLT performance is generally independent of verbal memory and global intellectual abilities. BLT performance declined with age, but there was no association between performance and gender, education, or intellectual functioning. In view of the favorable psychometric properties observed during preliminary studies, additional normative and validation studies in healthy and patient populations are warranted.

Keywords

Learning; Location; Memory; Spatial; Visual

INTRODUCTION

There are a variety of verbal memory tests (Delis, Kramer, Kaplan, & Ober, 2000; Reynolds & Bigler, 1994; The Psychological Corporation, 1997a) with demonstrated value in identifying mild cognitive impairment (Bozoki, Giordani, Heidebrink, Berent, & Foster, 2001; Fox, Olin, Erblich, Ippen, & Schneider, 1998) and more advanced forms of dementia

Address correspondence to: Franklin C. Brown, Psychology Department, Eastern Connecticut State University, 83 Windham St., Willimantic, CT 06226, USA. brownf@easternct.edu.

(Zakharov, Akhtina, & Yakhno, 2001). Evidence of the ecological validity of such tests has also been reported (Chaytor & Schmitter-Edgecombe, 2003). Furthermore, criterion validity of verbal memory tests has been obtained in studies of patients with left temporal lobe epilepsy (Sawrie, Martin, Gilliam, Knowlton, Faught, & Kuzinecky, 2001; Siegel et al., 2001; Wilde et al., 2003) and lesions in the left hippocampus (Jutila et al., 2002; Saykin et al., 1992).

Numerous visual or nonverbal memory tests have also been developed (Baxendale, Thompson, & Paesschen, 1998; Benedict, Schretlen, Groninger, Dobraski, & Shpritz, 1996; Bucks & Willison, 1997; Della Sala, Gray, Baddeley, & Wilson, 1997; The Psychological Corporation, 1997a), and shown to have validity in identifying global memory deficits (Benedict & Groninger, 1995; Bucks & Willison, 1997; Shum, Harris, & O'Gorman, 2000). Traditional visual memory tests have, however, demonstrated limited ecological validity (Chaytor & Schmitter-Edgecombe, 2003). In addition, they have shown poor ability to detect deficits in patients with right hippocampus resections, even when such navigational memory deficits are observed using experimental measures (Abrahams et al., 1999; Abrahams, Pickering, Polkey, & Morris, 1997).

Early studies on memory in patients with focal lesions indicated reduced verbal memory test performance for those with damage to the left hippocampus, while visual memory tended to be reduced in patients with damage to the right hippocampus (e.g., Milner, 1965, 1968). Since these early investigations, a sizeable body of literature has lent considerable support to the association of verbal memory with left hemisphere abnormalities, in particular those involving the hippocampus (Jutila et al., 2002; Sawrie et al., 2001; Saykin et al., 1992; Siegel et al., 2001; White et al., 2002; Wilde et al., 2003). By contrast, larger-scale studies have failed to observe a consistent relationship between performance on clinical tests of visual memory and integrity of the right hippocampus (Giovagnoli, Casazza, & Avanzini, 1995; Gleissner, Helmstaedter, Schramm, & Elger, 2002; Kessels, Dehaan, Kappelle, & Postma, 2001; Lee, Yip, & Jones-Gotman, 2002; Plenger et al., 1996; White et al., 2002; Wilde et al., 2003).

Some researchers have argued that the human tendency to rely on language renders it highly unlikely that a “pure” test of visual memory, uncontaminated by verbal memory, could be developed (Heilbronner, 1992). This stance would be understandable if all possible methods for developing a pure test of visual memory were already adequately attempted. However, a review of previous visual-spatial memory research suggests that there remains a great deal of room for improvement in the area of visual-spatial memory assessment, such as reducing drawing demands (Benedict & Groninger, 1995; Benedict et al., 1996; Paolo, Troester, & Ryan, 1998), and using stimuli less affected by verbal abilities and shown to be associated with the right hippocampus by both lesion and neuroimaging studies (Kessels, Hendriks, Schouten, Vanasselen, & Postma, 2004; Lee et al., 2002; Golby et al., 2001).

In conclusion, it would appear that the field of clinical neuropsychology is in need of a visual memory test with a greater likelihood of measuring deficits associated with right hippocampal abnormalities, that is stronger in its ability to measure practical difficulties (such as becoming lost or losing one's keys), and which provides data that are distinct from

already established verbal and visual memory tests. We begin by reviewing the strengths and limitations of established visual memory tests in differentiating visual and verbal memory, discuss how these strengths are incorporated into a new measure of visual memory (Brown Location Test, BLT), and report the psychometric properties of the BLT along with preliminary findings supporting the discriminant validity of the BLT.

STRENGTHS AND LIMITATIONS OF PREVIOUSLY DEVELOPED MEASURES

Dependence on Drawing Skills

Since the early days of memory assessment, clinicians have been using visual-spatial memory tests that rely heavily on drawing skills (Benton, 1974; Osterrieth, 1944; Wechsler, 1945). These tests typically involve showing either a series of abstract designs (Benton, 1974; The Psychological Corporation 1997a; Wechsler, 1945) or more complex designs (Osterrieth, 1944) to an examinee who is then asked to reproduce the designs from memory. More recently developed tests have attempted to measure individual learning rates by including multiple trials (Benton, 1974; Jones-Gotman, 1986), but the basic aspect of reproducing abstract designs is similar.

An extensive review of drawing based tests is beyond the scope of this article (see Moye, 1997, for review), but there are some clear limitations to such tests. One problem is that it may be difficult to disentangle whether performance deficits are due to impoverished drawing skills, memory impairment, or some combination of memory and drawing difficulties. As a result, drawing-based tests may have restricted utility for patients with limited upper extremity mobility or dexterity, such as many patients with Parkinson's disease, even though other evidence suggests that visual memory deficits may be present (Cousins, Hanley, Davies, Turnbull, & Playfer, 2000; Leplow, Holl, Zeng, Herzog, Behrens, & Mehdorn, 2002; Whittington, Podd, & Kan, 2000). Instructions to allow for more lenient scoring of drawing-based test protocols in patients with impaired motor skills are questionable on the grounds that they may reduce inter-rater reliabilities on such measures (Moye, 1997). In addition, large-scale empirical studies do not typically support the efficacy of drawing-based tests in assessing specific visual memory deficits (Bornstein & Chelune, 1988; Gleissner et al., 2002; Lee et al., 2002; Weiss & Price, 2001).

Verbal Encoding

Several tests of visual memory have been developed that place little or no demand on drawing or other motor skills, but have demonstrated inconsistent clinical validity and/or measure constructs closely related to those in previously established drawing-based visual memory tests that have also demonstrated limited validity. For example, the Visual Spatial Learning Test (Malec, Ivnik, & Hinkeldey, 1991) requires the individual to place abstract designs in a previously shown location. Unfortunately this test has not demonstrated the expected material specifically associated with right hemisphere functioning (Malec et al., 1991). The Continuous Visual Memory Test (CVMT: Larrabee, Trahan, & Curtis, 1992) also eliminated manual skill requirements by using only a recognition memory format. However, the validity of the CVMT was examined by correlating participants' performance

with more established drawing-based tests, which is of limited usefulness given that such tests are strongly associated with verbal abilities (Lee et al., 2002; The Psychological Corporation 1997a).

Traditional methods of assessing test validity such as factor analysis (Bornstein & Chelune, 1988; Weiss & Price, 2001) and lesion-based studies (Lee et al., 2002) suggest that verbal and visual memory tests are often strongly correlated. However, it has been the advent of functional neuroimaging studies that has allowed researchers to more directly assess the relationship of test stimuli, brain structures, and verbalization of visual material. Kelley and colleagues (1998) presented healthy controls with word lists, faces, and abstract line drawings, which they were asked to encode. Results revealed primarily left hemisphere activation for the word list, bilateral activation for the line drawings, and stronger activation in the right than left hemisphere for faces.

These findings were expanded to include information about the effects of verbal interference by Golby and colleagues (2001) who examined the impact of verbal interference on visual mnemonic processing, as well as medial temporal lobe activation, during fMRI scanning in two experiments. Participants were visually presented information (words, scenes, faces, and random patterns) in either a noninterference or verbal interference condition. Verbal interference consisted of presenting participants with a five-letter consonant string that they would later be asked to recall. Longer response latencies were assumed to reflect verbal task interference with perceptual cognitive processing. The reaction time during scenes was the slowest, followed by the response to faces, while participants responded the fastest to the random noise patterns, suggesting the latter was the least impacted by the verbal task. In a second experiment using fMRI, participants were presented with words, faces, scenes, or visual patterns and were asked to remember the words for a later test. Encoding of the words resulted in left medial temporal lobe (MTL) activation. Pattern encoding resulted in significantly greater right than left MTL activation, whereas scenes and faces resulted in bilateral activation that was only slightly greater for the right than left hemisphere (Golby et al., 2001) indicating a high agreement between the functional imaging and verbal interference aspects of mnemonic functioning.

In summary, reaction time and functional neuroimaging studies provide additional evidence that many clinical measures of “nonverbal” memory-use stimuli that may be relatively easy to verbalize. Furthermore, there appear to be degrees to which stimuli may be influenced by verbal skills, with line drawings and scenes most strongly correlated with left hemisphere activation, followed by slightly more right hemisphere activation when encoding facial stimuli, and even greater right hemisphere activation with random visual patterns (Golby et al., 2001; Kelley et al., 1998). Thus, these results suggest that a memory test designed to minimize verbal encoding should not use line drawings or scenes as stimuli.

Differentiating Types of Visual Memory

Another aspect of visual memory tests that may be contributing to the difficulty in establishing a strong association with right MTL integrity is the confounding of memory for objects and designs with memory for specific locations. Several recent studies suggest that tasks which combine object and location memory may produce a binding effect associated

with the left hippocampus, while tasks requiring memory for identical objects (e.g., dots or squares) are more strongly associated with the right hippocampus (Abrahams et al., 1999; Abrahams et al., 1997; Kessels et al., 2004; Kessels, Postma, Kappelle, & deHann, 2000).

Several measures have been developed that assess memory for location without using different objects as stimuli. The 7/24 Spatial Recall Test (Barbizet & Caney, 1968) requires individuals to demonstrate knowledge of spatial location by placing checkers on a grid, but data suggest that it is prone to ceiling effects in healthy adults (Rao, Hammeke, Mcquillen, Khatri, & Lloyd, 1984). This ceiling effect may also have contributed to the 7/24's inability to identify visual memory difficulties in left and right temporal lobe epilepsy patients (Barr, 1997). Similarly, the 10/36 Spatial Recall Test, based on the 7/24, also appears susceptible to ceiling effects (Weinstein, Schwid, Schiffer, McDermott, Giang, & Goodman, 1999). The use of a grid may have affected performance on these tests by increasing the ability to use verbal strategies (e.g., first stimulus is located in first row, second column).

Development of a visual memory test that uses a single type of stimulus (e.g., dots) that does not use a grid pattern may help reduce verbalization, and to some extent this has been previously attempted. The nonverbal selective reminding test (NVSR) is a dot location learning test that correctly identified 70% of right temporal lobe epilepsy patients with visual memory difficulties (Fletcher, 1985). This test was later adapted and normed for children and adolescents as part of the Test of Memory and Learning (TOMAL; Reynolds & Bigler, 1994). Performance on the NVSR was worse in pre-surgical patients with right as compared to left temporal lobe epilepsy when patients with co-occurring dyslexia were excluded (Breier, Fletcher, Thomas, & Brookshire, 1997). However, this test takes practice to administer and score correctly, which may have contributed to limited reliability in the standardization study of the TOMAL-2, an updated version of the TOMAL for use with adults (Reynolds, personal communication 2002). Nonetheless, the test has some important characteristics such as pointing to the dots one at a time in a non-grid pattern, instead of simultaneous presentation of dots in a grid (such as the 7/24 and 10/36). Thus, it may be useful to develop a visual memory test that uses a flip-book format to ensure ease of administration (such as used in the 7/24) as well as presenting dots one at a time in a random array (such as used in the NVSR).

Multiple Learning Trials

An additional strength of tests such as the NVSR and 7/24 is that they use multiple learning trials. Data on the Benton Visual Retention Test (Benton, 1974) and Biber Figure Learning Test–Extended version (Glosser, Cole, Khatri, Dellapietra, & Kaplan, 2002) suggest, albeit weakly, that right temporal lobe dysfunction may be associated with impaired learning curves, but not necessarily delayed recall, on drawing-based tests with multiple learning trials (Glosser et al., 2002; Majdan, Sziklas, & Jones-Gotman, 1996). Such results suggest that tests with multiple learning trials may be more sensitive to certain clinical conditions than single trial measures. Furthermore, multiple learning trials allow for greater comparison between well-established verbal memory measures such as the California Verbal Learning Test (CVLT-II; (Delis et al., 2000). Therefore, a new visual memory measure would benefit from inclusion of multiple learning trials.

DESCRIPTION OF THE BROWN LOCATION TEST

In the present paper, we discuss the development of a new visual-spatial memory test, the Brown Location Test (BLT). Development of this test was informed by our review of the empirical literature on currently available visual memory tests and their strengths and limitations. The BLT consists of five recall learning trials, an interference trial, short delay recall, and long delay free recall and recognition trials, a design characteristic comparable to the CVLT-II (Delis et al., 2000).

Similar to the NVSR (Fletcher, 1985), the BLT uses identical large dots whose locations are presented individually. However, instead of pointing to a group of dots all on a single page, the examiner presents a series of 12 pages in a flip-book format, for 4 seconds each, in the learning trials. Each page consists of an identical array of 58 circles in a non-grid pseudo-random format with a different circle on each page filled with a red dot. After the 12 pages, the examinee is presented with a blank page of the circle array, but without any dots present. The examinee is given 12 red checker-like chips, which he/she places on the circle where they believe a dot was presented earlier. The red chips are 1 inch in diameter and 0.5 inches thick to reduce the demands of fine motor dexterity. Following completion of the first learning trial, the chips are cleared away, and the 12 pages presented again, followed by the individual placing the chips again. This is repeated for a total of five learning trials.

Following the five learning trials, the examiner presents another series of 12 pages that have one black dot on each page. The black dots are presented in different locations than the red dots, but the random circle array is identical to that used in the learning trials. The examinee then places black chips on the circle array to indicate the locations of the black dots. After this interference trial, the examinee is asked to place the red chips on the circle array to indicate the locations of the red dots in a free recall format (short delay recall). Twenty minutes after the immediate recall trial, the examinee again places the red chips on the circle array (long delay recall). After the long delay recall is completed, the examiner then turns the circle array 90 degrees to the right and again asks the examinee to place the red chips on the circle array. The rotation trial was created to measure allocentric memory, or the memory for location from a view other than originally encoded, which has been associated with right-hemisphere dysfunction (Abrahams et al., 1997; Parslow et al., 2004). The test concludes with the examiner presenting 24 pages, each with a red dot in one circle. The examinee is asked to indicate with a yes or no whether there was a dot in that location earlier. The yes/no recognition trial includes the 12 correct red dot locations and 12 distracter locations. The Learning and Free Recall Trials are scored according to the total correctly identified locations. The BLT Recognition subtest yields an overall total correct score, a true positive score, and false positive score.

To examine the psychometric properties and validity of the BLT, we examined split-half reliabilities of the learning trials, and test-retest reliability using an alternate form. We also examined the discriminate validity and factor structure of the BLT in a brief test battery that included verbal memory, visual-scanning speed, and intellectual functioning measures. It was hypothesized that the BLT scores would load on a distinct factor than measures of verbal memory and intellectual functioning. Finally, we examined the relationship between

BLT performance and demographic characteristics (age, gender, education, and intellectual functioning), and predicted decreasing performance with increasing age, consistent with results for other memory tests (Delis et al., 2000; The Psychological Corporation, 1997a; Wechsler, 1987).

METHOD

Participants

The overall sample consisted of 110 participants (79 females, 31 males). The ethnic composition of the sample included 84% Caucasian, 11% African American, 4% Asian American, and 1% Hispanic individuals. The average age was 33.15 years (*SD* = 16.1), the average education was 14.8 years (*SD* = 2.43). Participants were recruited via word of mouth, newspaper advertising, flyers, and onsite advertising. Participants who reported a history significant for neurological, cardiovascular, or psychiatric disorders were excluded from analysis in this study. All participants provided informed consent and signed a form indicating their understanding that participation was voluntary and that they could withdraw at any time. The human subjects committees at each appropriate institution reviewed and approved this study. Participants were recruited at universities in Louisiana, New Hampshire, and Connecticut.

Participants were administered the Vocabulary and Matrix Reasoning subtests from the Wechsler Abbreviated Scale of Intelligence (WASI: The Psychological Corporation, 1999) or the Wechsler Adult Intelligence Scale, Third Edition (WAIS-III: The Psychological Corporation, 1997b) to provide an estimate of overall intellectual functioning. These two subtests correlate most highly with overall intellectual functioning as measured by the WAIS-III (The Psychological Corporation, 1997b, 1999). The two versions of these tests were used for practical reasons and are supported by the high correlations between both versions of the Vocabulary (r = .84) and Matrix Reasoning (r = .68) subtest. These correlations are similar to the test-retest correlations on the Vocabulary (r = .89 to .94, depending on the age group) and Matrix Reasoning (r = .75) subtests from the WAIS-III (The Psychological Corporation, 1997).

Average intellectual functioning as estimated from Vocabulary and Matrix Reasoning subtests was 115.3 (*SD* = 11). Out of the overall sample, 78 participants (54 female, 24 males) completed the entire short battery required for factor analysis. In addition, 41 participants (30 females and 11 males) agreed to an alternate form test–retest condition where they were administered BLT-A and BLT-B (two versions of the test). Selection for these groups was based entirely on practical considerations; those willing to complete the entire battery and return for retesting. This subgroup did not significantly differ from the overall sample according to age, education, ethnicity, gender, or estimated intellectual functioning according to one-way ANOVAs (all $p > .05$).

Materials

All participants were administered the BLT-A (Form A) which is described above, Matrix Reasoning and Vocabulary from the WASI (The Psychological Corporation, 1999) or

WAIS-III (The Psychological Corporation, 1997b), and a mental health screening questionnaire pertaining to neurological and psychiatric problems; only individuals who denied a history of such illnesses were included in the study. Individuals who agreed to participate in the test–retest condition were also administered the BLT-B, an alternate form of the BLT-A. The BLT-B used a different random circle array than the BLT-A, and had different dot locations. However, it was otherwise identical to the BLT-A with the same number of dot locations in the interior and exterior sections of the circle array, and the same amount of potential false and true positive items in the recognition section. Those willing to complete the entire brief battery for factor-analysis were also administered the California Verbal Learning Test, Second Edition (CVLT-II; Delis et al., 2000) to measure the participants' verbal memory, and the Mesulam Nonverbal Cancellation Test (Mesulam, 1985) to evaluate visual scanning speed.

Procedure

Tests were administered in a distraction-reduced office. The examiners consisted of a licensed psychologist with postdoctoral neuropsychology training, two graduate students, and two upper-level undergraduate students trained by the psychologist and test developer in administration and scoring of the tests. A one-way ANOVA did not reveal any significant examiner difference in BLT scores between the examiners.

The learning, interference, and immediate recall trials of the either the BLT or CVLT-II were administered first, depending on a randomly assigned order and whether the participants agreed to complete the entire battery. During the 20-minute delay of the first test, the learning, interference, and immediate recall trials of the second test were administered. Since the first half of both the BLT and CVLT-II each take about 10 minutes to administer, demographic, mental health surveys were administered during the remaining time delay. At the time of this study, there was no research to suggest that the completion of questionnaires during the time delay of verbal memory tests substantially influences performance. Following the administration of the BLT and CVLT-II Delay Recall and Recognition trials, the examiner administered the Matrix Reasoning, Vocabulary, and Nonverbal Cancellation tests. Those participants who reported less than an hour of available time for the study were not administered the CVLT-II or Nonverbal Cancellation Test. Instead, they were administered the BLT with the surveys and Vocabulary subtest administered during the delay. The Matrix Reasoning Subtest was administered after the BLT was completed.

Similar to the CVLT-II standardization study (Delis et al., 2000), the unequal-length Spearman-Brown formula was used to determine internal reliability of Trials 1–5. The relationship between scores on the BLT-A and BLT-B was analyzed using Pearson correlation coefficients and *t*-tests. Linear regressions were performed to examine the relationship between the continuous demographic variables and BLT performance, and gender effects were assessed with a one-way analysis of variance. Factor analysis was conducted to determine whether the BLT may have significant associations with other cognitive skills. The analysis included scores from the BLT, the CVLT-II, the Vocabulary and Matrix Reasoning subtest scaled scores, and time to complete the Mesulam Cancellation

Test. Principal component analysis with eigenvalues set at 2.0 and varimax rotation was used to simplify the interpretation of factors.

RESULTS

Reliability

Unequal-length Spearman-Brown formula split-half reliabilities for Learning Trials 1–5 were .82 for the BLT-A (N = 110) and .78 for the BLT-B (N = 41). Alternate form test-retest reliabilities based on Pearson correlation coefficients were significant ($p < .01$) for each subtest of the BLT and were comparable to those reported for the CVLT-II standardization sample (Table 1). The means and standard deviations of BLT Trials 1–5 suggest a steady learning curve, and subtest scores were comparable for forms A and B (Table 2).

Demographic Variables and Performance

Performance on all of the BLT subtests decreased with age; including Trials 1–5 (r = .36, $p < .001$), the Interference Trial (r = .35, $p < .001$), Short Delay Recall (r = .29, p = .002), Long Delay Recall (r = .42, $p < .001$), Rotated Long Delay Recall (r = .27, p = .004), Recognition Total (r = .39, $p < .001$), Recognition True Hits (r = .35, $p < .001$), and Recognition False Positives (r = .42, $p < .001$). There were no significant relationships between education or estimated intellectual functioning and BLT performance. One-way analyses of variance did not reveal any gender effects for the BLT.

Factor Analysis

Results revealed three factors that accounted for 59% of the variance (see Table 3). The first factor accounted for 31.31% of total variance and consisted of all the BLT subtest scores. The second factor accounted for 19.65% of variance and consisted of all the CVLT-II subtest scores. The third factor accounted for 8.17% of variance and consisted of the Vocabulary, Matrix Reasoning, and Estimated Intellectual Functioning standardized scores. The Cancellation test loaded minimally on each of the three factors.

DISCUSSION

The BLT learning trials demonstrated good internal reliability, with results being very similar to those obtained during the development of the CVLT-II (Delis et al., 2000). This is particularly promising since the BLT was designed to be a visual-spatial memory test comparable in structure to the CVLT-II. Alternate form reliability of BLT Forms A and B was also comparable to those for the CVLT-II and its alternate form (Delis et al., 2000), and the means and standard deviations for the two forms were generally equivalent. The BLT may thus be a useful measure for examining cognitive changes over time given its relative stability across forms in a healthy population.

It should be noted that, while alternate-form reliabilities were strong, the first two learning trials of the BLT in this study and the CVLT-II in the standardization study are both slightly lower (.51–.65) than the alternate form reliabilities for the later learning trials, the total of 1–5 trials, and the delay recall subtests (.70–.90). This pattern may be due to the early learning

and interference trials being more influenced by attentional capacity (Blagrove, Alexander, & Horne, 1995), whereas later trials reflect longer-term memory capacities, which may be more stable. Further investigations to determine what other cognitive skills or non-cognitive variables (e.g., fatigue and caffeine use) may be impacting on early versus later learning trials of the BLT would be informative.

The reasons for the lower reliabilities of the recognition subtest of the BLT are less clear. The nature of the stimuli (numerous circles) may have contributed to reduced examinee certainty since there are only subtle differences between the correct and incorrect locations. Anecdotally, examinees often appeared less certain of their responses during the recognition trial of the BLT, making spontaneous comments such as “I feel like I am guessing.” It may be that the recognition formats of the BLT-A and BLT-B are not comparable; however, each version has the same amount of true positives, true negatives, and interference stimuli, which makes that explanation less likely.

Examination of the relationship between BLT performance and demographics revealed that test scores were not associated with education or gender, but decreased performance was observed with increasing age. This finding is consistent with prior studies showing decrements in visual memory with age (e.g., Delis et al., 2000; The Psychological Corporation, 1997a; Wechsler, 1987). Further study in samples consisting of a wider range of ages among participants is required to confirm this finding. BLT scores were not significantly associated with estimated intellectual functioning. The present sample, however, consisted largely of individuals with average to higher than average estimated intellectual functioning. It remains to be determined whether there is an association between BLT performance and intelligence at lower levels of intellectual functioning or in combined samples. Although gender differences were not noted on the BLT, further examination of gender in larger samples appears warranted given contradictory findings regarding gender effects on other tests of memory functioning (Duff & Hampson, 2001; Postma, Jager, Kessels, Koppeschaar, & Vanhonka, 2004).

Evidence for the construct validity of the BLT was also obtained in the present investigation. Factor analysis of a brief neuropsychological test battery revealed that all of the BLT subtests loaded on a single visual memory factor. BLT scores did not load on the other two factors, which consisted of the CVLT-II scores that formed a verbal memory factors, and an intellectual functioning factor composed of the Vocabulary, Matrix Reasoning, and Full Scale IQ scores. This factor structure suggests that performance on the BLT is not influenced significantly by either verbal memory or intellectual functioning. Furthermore, performance on the Nonverbal Cancellation Test was only weakly associated with the visual memory factor, indicating that visual scanning and attention skills likely have a limited impact on BLT scores, at least in the current healthy adult sample.

Future studies will be needed to examine the structure of the BLT in the context of a larger neuropsychological battery that includes additional measures of verbal and visual memory, as well as measures tapping other cognitive processes that may impact the learning and retention of spatial information. Factor-analytic and discriminative validity studies in clinical populations would also provide additional information about the validity of the BLT,

particularly in patient samples with neurological disorders that affect visual or verbal memory functions, such as left and right medial temporal lobe epilepsy, mild Alzheimer's disease, and Parkinson's disease.

In summary, the current findings support the reliability and validity of the BLT, a new measure of visual-spatial learning and memory. Additional studies in clinical populations and larger factor-analytic studies will be useful to further characterize the structure and clinical utility of the test. Normative data from individuals who are beyond 60 years of age and from a wider range of educational backgrounds will be especially useful to improve the clinical utility of the test. Finally, we are currently developing a computerized version of the BLT for administration during fMRI to examine the neural circuitry engaged by this task.

Acknowledgments

Portions of this project were funded by the National Institutes of Health grants R01-CA101318 and R01-AG19771. We would like to thank the Neuropsychology Program, Department of Psychiatry, Dartmouth Medical School, and the Psychology Departments at Louisiana Tech University and Eastern Connecticut State University for assistance in carrying out this project.

REFERENCES

Abrahams S, Morris RG, Polkey CE, Jarosz JM, Cox TCS, Graves M, et al. Hippocampal involvement in spatial and working memory: A structural MRI analysis of patients with unilateral mesial temporal sclerosis. Brain and Cognition. 1999; 41:39–65. [PubMed: 10536085]

Abrahams S, Pickering A, Polkey CE, Morris RG. Spatial memory deficits in patients with unilateral damage to the right hippocampal formation. Neuropsychologia. 1997; 35:11–24. [PubMed: 8981373]

Barbizet J, Caney E. Clinical and psychometrical study of a patient with memory disturbances. International Journal of Neurology. 1968; 7:44–54. [PubMed: 5730403]

Barr WB. Examining the right temporal lobe's role in nonverbal memory. Brain and Cognition. 1997; 35:26–41. [PubMed: 9339300]

Baxendale SA, Thompson PJ, Paesschen WV. A test of spatial memory and its clinical utility in the pre-surgical investigation of temporal lobe epilepsy patients. Neuropsychologia. 1998; 36(7):591–602. [PubMed: 9723931]

Benedict RHB, Groninger L. Preliminary standardization of a new visuospatial memory test with six alternate forms. The Clinical Neuropsychologist. 1995; 9(1):11–16.

Benedict RHB, Schretlen D, Groninger L, Dobraski M, Shpritz B. Revision of the Brief Visuospatial Memory Test: Studies of normal performance, reliability, and validity. Psychological Assessment. 1996; 8(2):145–153.

Benton, AL. Revised Visual Retention Test. 4th ed.. Psychological Corporation; New York: 1974.

Blagrove M, Alexander C, Horne JA. The effects of chronic sleep reduction on the performance of cognitive task sensitive to sleep deprivation. Applied Cognitive Psychology. 1995; 9:21–40.

Bornstein RA, Chelune GJ. Factor structure of the Wechsler Memory Scale- Revised. The Clinical Neuropsychologist. 1988; 2:107–115.

Bozoki A, Giordani B, Heidebrink JL, Berent S, Foster NL. Mild cognitive impairments predict dementia in nondemented elderly patients with memory loss. Archives of Neurology. 2001; 58:411–416. [PubMed: 11255444]

Breier JI, Fletcher JM, Thomas AB, Brookshire BL. Identification of side seizure onset in temporal lobe epilepsy using memory tests in the context of reading deficits. Journal of Clinical and Experimental Neuropsychology. 1997; 19(2):161–171. [PubMed: 9240476]

Bucks RS, Willison JR. Development and validation of the Location Learning Test (LLT): A test of visuospatial learning designed for use with older adults and in dementia. The Clinical Neuropsychologist. 1997; 11(3):273–286.

Chaytor N, Schmitter-Edgecombe M. The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. Neuropsychology Review. 2003; 13(4):181–197. [PubMed: 15000225]

Cousins R, Hanley JR, Davies ADM, Turnbull CJ, Playfer JR. Understanding memory for faces in Parkinson's disease: The role of configural processing. Neuropsychologia. 2000; 38:837–847. [PubMed: 10689058]

Delis, DC.; Kramer, JH.; Kaplan, E.; Ober, BA. California Verbal Learning Test-second edition. The Psychological Corporation; San Antonio, TX: 2000.

Della Sala, S.; Gray, C.; Baddeley, A.; Wilson, L. The Visual Patterns Test: A new test of short-term visual recall. Thames Valley Test Company; Feltham, UK: 1997.

Duff SJ, Hampson E. A sex difference on a novel spatial working memory task in humans. Brain and Cognition. 2001; 47:470–493. [PubMed: 11748902]

Fletcher JM. Memory for verbal and nonverbal stimuli in learning disability subgroups: Analysis of selective reminding. Journal of Experimental Child Psychology. 1985; 40:244–259. [PubMed: 4045379]

Fox LS, Olin JT, Erblich J, Ippen CG, Schneider LS. Severity of cognitive impairment in Alzheimer's disease affects list learning using the California Verbal Learning Test (CVLT). International Journal of Geriatric Psychiatry. 1998; 13:544–549. [PubMed: 9733335]

Giovagnoli AR, Casazza M, Avanzini G. Visual learning on a selective reminding procedure and delayed recall in patients with temporal lobe epilepsy. Epilepsia. 1995; 36(7):704–711. [PubMed: 7555989]

Gleissner U, Helmstaedter C, Schramm J, Elger CE. Memory outcome after selective amygdalohippocampectomy: A study in 140 patients with temporal lobe epilepsy. Epilepsia. 2002; 43(1):87–95. [PubMed: 11879392]

Glosser G, Cole L, Khatri U, DellaPietra L, Kaplan E. Asessing nonverbal memory with the Biber Figure Learning Test–Extended in temporal lobe epilepsy patients. Archives of Clinical Neuropsychology. 2002; 17:25–35. [PubMed: 14589750]

Golby AJ, Poldrack RA, Brewer JB, Spencer D, Desmond JE, Aron AP, et al. Material-specific laterization in the medial temporal lobe and prefrontal cortex during memory encoding. Brain. 2001; 124:1841–1854. [PubMed: 11522586]

Heilbronner RI. The search for a “pure” visual memory test: Pursuit of perfection? The Clinical Neuropsychologist. 1992; 6:105–112.

Hoddes E, Zarcone V, Smythe H, Phillips R, Dement WC. Quantification of sleepiness: A new approach. Psychophysiology. 1973; 10:431–436. [PubMed: 4719486]

Jones-Gotman M. Right hippocampal excision impairs learning and recall of a list of abstract designs. Neuropsychologia. 1986; 24:659–670. [PubMed: 3785653]

Jutila L, Immonen A, Mervaala E, Partanen J, Partanen K, Puranen M, et al. Long-term outcome of temporal lobe epilepsy surgery: Analyses of 140 consecutive patients. Journal of Neurology, Neurosurgery & Psychiatry. 2002; 73(5):486–494.

Kelley WM, Miezin FM, McDermott KB, Buckner RL, Raichle ME, Cohen NJ, et al. Hemispheric specialization in human dorsal frontal cortex and medial temporal lobe for verbal and nonverbal memory encoding. Neuron. 1998; 20:927–936. [PubMed: 9620697]

Kessels RPC, deHaan EHF, Kappelle LJ, Postma A. Varieties of human spatial memory: A meta-analysis on the effects of hippocampal lesions. Brain Research Reviews. 2001; 35:295–303. [PubMed: 11423159]

Kessels RPC, Hendriks MPH, Schouten J, VanAsselen M, Postma A. Spatial memory deficits in patients after unilateral selective amygdalaohippocampectomy. Journal of the International Neuropsychological Society. 2004; 10:907–912. [PubMed: 15637783]

Kessels RPC, Postma A, Kappelle LJ, deHann EHF. Spatial memory impairment in patients after tumor resection: Evidence for a double dissociation. Journal of Neurology, Neurosurgery & Psychiatry. 2000; 69:389–391.

Larrabee GJ, Trahan DE, Curtiss G. Construct validity of the Continuous Visual Memory Test. Archives of Clinical Neuropsychology. 1992; 7:395–405. [PubMed: 14591274]

Lee TMC, Yip JTH, Jones-Gotman M. Memory deficits after resection from left or right anterior temporal lobes in humans: A meta-analytic review. Epilepsia. 2002; 43(3):283–291. [PubMed: 11906514]

Leplow B, Holl D, Zeng L, Herzog A, Behrens K, Mehdorn M. Spatial behaviour is driven by proximal cues even in mildly impaired Parkinson's disease. Neuropsychologia. 2002; 40:1443–1455. [PubMed: 11931948]

Majdan A, Sziklas V, Jones-Gotman M. Performance of healthy subjects and patients with resection from the anterior temporal lobe on matched tests of verbal and visuoperceptual learning. Journal of Clinical and Experimental Neuropsychology. 1996; 18(3):416–430. [PubMed: 8877625]

Malec JF, Ivnik RJ, Hinkeldey NS. Visual spatial learning test. Psychological Assessment. 1991; 3(1): 82–88.

Mesulam, MM. Verbal and nonverbal cancellation tests. In: Mesulam, MM., editor. Principles of behavioral neurology. F. A. Davis; Philadelphia: 1985.

Milner B. Visually guided maze-learning in man: Effects of bilateral hippocampal, bilateral frontal, and unilateral cerebral lesions. Neuropsychologia. 1965; 3:317–338.

Milner B. Visual recognition and recall after right temporal-lobe excision in man. Neuropsychologia. 1968; 6:191–209.

Moore PM, Baker GA. Psychometric properties and factor structure of the Wechsler Memory Scale-Revised in a sample of persons with intractable epilepsy. Journal of Clinical and Experimental Neuropsychology. 1997; 19(6):897–905. [PubMed: 9524884]

Moye J. Nonverbal memory assessment with designs: Construct validity and clinical utility. Neuropsychology Review. 1997; 7(4):157–170. [PubMed: 9471111]

Osterrieth PA. Le test de copie d'une figure complexe. Archives de Psychologie. 1944; 30:206–356.

Paolo AM, Troester AI, Ryan JJ. Continuous Visual Memory Test performance in healthy persons 60 to 94 years of age. Archives of Clinical Neuropsychology. 1998; 13(4):333–337. [PubMed: 14590612]

Parslow DM, Fleminger S, Rose D, Brooks B, Gray JA, Giampietro V, et al. Allocentric spatial memory activation of the hippocampal formation measured with fMRI. Neuropsychology. 2004; 18(3):450–461. [PubMed: 15291723]

Plenger PM, Breier JI, Wheless JW, Papanicolaou AC, Brookshire B, Thomas A, et al. Nonverbal selective reminding test: Efficacy in the assessment of adults with temporal lobe epilepsy. Epilepsy. 1996; 9:65–69.

Postma A, Jager G, Kessels RPC, Koppeschaar HPF, vanHonka J. Sex differences for selective forms of spatial memory. Brain and Cognition. 2004; 54:24–34. [PubMed: 14733897]

Rao SM, Hammeke TA, McQuillen MP, Khatri BO, Lloyd D. Memory disturbance in chronic progressive multiple sclerosis. Archives of Neurology. 1984; 41:625–631. [PubMed: 6721737]

Reynolds, CR.; Bigler, ED. Test of memory and learning: Examiner's manual. Pro-Ed; Austin, TX: 1994.

Sawrie SM, Martin RC, Gilliam F, Knowlton R, Faught E, Kuzniecky R. Verbal retention lateralizes patients with unilateral temporal lobe epilepsy and bilateral hippocampal atrophy. Epilepsia. 2001; 42(5):651–659. [PubMed: 11380574]

Saykin, AJ.; Robinson, LJ.; Stafiniak, P.; Kester, DB.; Gur, RC.; O'Connor, MJ., et al. Neuropsychological changes after anterior temporal lobe epilepsy. In: Bennett, TL., editor. The neuropsychology of epilepsy. Plenum Press; New York: 1992. p. 263-290.

Shum DH, Harris D, O'Gorman JG. Effects of severe traumatic brain injury on visual memory. Journal of Clinical Experimental Neuropsychology. 2000; 22(1):25–39. [PubMed: 10649543]

Siegel AM, Jobst BC, Thadani VM, Rhodes CH, Lewis PJ, Roberts DW, et al. Medically intractable, localization-related epilepsy with normal MRI: Presurgical evaluation and surgical outcome in 43 patients. Epilepsia. 2001; 42(7):883–888. [PubMed: 11488888]

The Psychological Corporation. Wechsler Memory Scale-third edition. The Psychological Corporation; San Antonio, TX: 1997a.

The Psychological Corporation. Wechsler Adult Intelligence Scale-Third Edition. The Psychological Corporation; San Antonio, TX: 1997b.

The Psychological Corporation. Wechsler Abbreviated Scale of Intelligence: WASI. The Psychological Corporation; San Antonio, TX: 1999.

Wechsler D. A standardized memory scale for clinical use. Journal of Psychology. 1945; 19:87–95.

Wechsler, D. Wechsler Memory Scale Manual–Revised. The Psychological Corporation; San Antonio, TX: 1987.

Weinstein A, Schwid SIL, Schiffer RB, Mcdermott MP, Giang DW, Goodman AD. Neuropsychologic status in multiple sclerosis after treatment with Glatiramer. Archives of Neurology. 1999; 56:319–324. [PubMed: 10190822]

Weiss, L.; Price, L. An update on the factor structure of the Weschler Memory Scale–Third Edition. 2001. Retrieved May 6, 2002, from http://www.psychcorp.com/sub/resource/library/Wms/wmsfactor.html

White JR, Matchinsky D, Beniak TE, Arndt RC, Walczak T, Leppik IE, et al. Predictors of postoperative memory function after left anterior temporal lobectomy. Epilepsy and Behavior. 2002; 3:383–389. [PubMed: 12609337]

Whittington CJ, Podd J, Kan MM. Recognition memory impairment in Parkinson's disease: Power and meta-analyses. Neuropsychology. 2000; 14(2):233–246. [PubMed: 10791863]

Wilde NJ, Strauss E, Hermann BP, Loring DW, Chelune GJ, Hunter M, et al. Confirmatory factor analysis of the WMS-III in patients with temporal lobe epilepsy. Psychological Assessment. 2003; 15(1):56–63. [PubMed: 12674724]

Zakharov VV, Akhtina TV, Yakhno NN. Memory impairment in Parkinson's disease. Neuroscience and Behavioral Physiology. 2001; 31(2):17–22.

Table 1

Alternate form reliabilities for the BLT and CVLT-II

Alternate form reliability (BLT-A and BLT-B)	BLT *N* = 41	CVLT-II[a] *N* = 288
Trial 1	.67**	.52**
Trial 2	.52**	.61**
Trial 3	.72**	.71**
Trial 4	.71**	.70**
Trial 5	.90**	.71**
Trials 1–5 total	.84**	.79**
Interference Trial	.50**	.51**
Short Delay	.78**	.73**
Long Delay	.84**	.76**
Rotated Long Delay	.78**	N/A
Recognition Total Correct	.46*	N/A
Recognition True Hits	.36*	.64**
Recognition False Positives	.39*	.76**

*Correlation is significant at the 0.05 level (two-tailed).

**Correlation is significant at the 0.01 level (two-tailed).

[a]CVLT-II data taken from the standardization sample (Delis et al., 2000).

Table 2

Mean scores for the two forms of the BLT

Subtest score	BLT-A *N* = 105		BLT-B *N* = 46	
	M	***SD***	***M***	***SD***
Trial 1	5.02	1.87	5.17	2.28
Trial 2	6.80	2.21	6.63	2.11
Trial 3	8.06	2.45	8.15	1.99
Trial 4	9.24	2.15	9.46	2.00
Trial 5	10.17	1.92	10.43	1.72
Trials 1–5	39.28	8.57	39.85	8.35
Interference	4.58	2.13	4.59	1.64
Short Delay	8.80	2.50	9.00	2.40
Long Delay	8.81	2.59	8.93	2.48
Rotated Long Delay	7.56	2.71	8.33	2.33
Recognition total	19.02	2.73	19.41	2.68
True hits	9.87	1.57	10.04	1.30
False positives	2.70	1.75	2.46	1.95

Table 3

Factor-analytic study of the BLT

Subtest score	Factor 1	Factor 2	Factor 3
BLT Total 1–5	.937	.095	.002
BLT Interference trial	.490	.095	−.043
BLT Short Delay	.889	.085	.057
BLT Long Delay	.919	.068	−.051
BLT Rotated Long Delay	.850	.051	.019
BLT Recognition Total	.878	.056	.067
BLT True Positives	.642	.081	.070
BLT False Positives	−.794	−.012	−.117
CVLT-II Trials 1–5 Total	.063	.961	.009
CVLT Interference	.002	.474	−.200
CVLT Short Delay	.139	.779	.114
CVLT Long Delay	−.022	.792	.073
CVLT True Positives	.086	.470	.051
CVLT False Positive	.007	−.054	.080
Vocabulary T-Score	−.113	.239	.798
Matrix Reasoning T-Score	.203	−.068	.765
Full Scale IQ	−.042	.128	.978
Visual Cancellation (ms)	−.244	.138	−.114