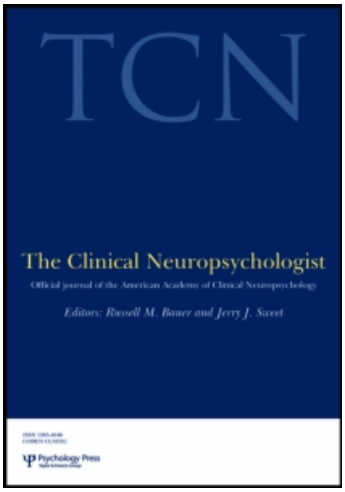

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Development and Validation of the Location Learning Test (LLT): A Test of Visuo-Spatial Learning Designed for Use with Older Adults and in Dementia*

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ABSTRACT

The Location Learning Test (LLT) is a brief, new measure of visuo-spatial learning that has been developed for use with older adults and in dementia. It does not require fine motor control, verbal responses, or complex instructions. The validity of the LLT was established by comparing the performance of three groups of subjects: normal elderly controls, patients with Alzheimer's disease and patients with vascular dementia. There were significant differences between normal subjects and those with dementia, including those with mild dementia (MMSE $\geq$ 20). Performance on the LLT was not predicted by premorbid IQ or age, but did correlate highly with the MMSE ($R = .77$). A cut-off score was selected which yielded a sensitivity of 100%, specificity of 82.8%, and a positive predictive value of 83.3%. Two groups of dementia patients were found; those who were able to improve their performance through learning and those who were not. The ability to learn was not predicted by degree of cognitive impairment as measured by the MMSE. Female subjects with dementia performed significantly worse than male subjects with dementia and this effect was not a consequence of level of impairment as measured by MMSE, premorbid IQ (NART), or diagnosis. Normative data is currently being collected.

Probable Alzheimer's disease (AD) is a progressive degenerative disorder characterised by memory loss, the impairment of other cognitive functions, and by the presence of senile plaques and neurofribrillary tangles (McKhann et al., 1984). Of the areas showing these neuropathological changes, the hippocampus and associated structures (e.g., entorhinal cortex), and the parietal cortex are the two most clearly affected (Van Hoesen & Damasio, 1987). Hippocampal and parietal changes have been associated with episodic or declarative memory deficits (Adelstein, Kesner, & Strassberg, 1992). Episodic memory has been subdivided into verbal and nonverbal (visual) memory. Memory for locations is generally regarded as a separate type of visual memory and is considered to be more impaired by damage to the nondominant hemisphere. The right hippocampal formations and right parietal cortex have been shown to play an important part in memory for spatial location. Support for this comes from the finding that patients with right temporal lobectomy exhibit deficits on the recall of spatial locations (Smith & Milner, 1981) and that patients with parietal cortex lesions show loss of memory for tasks that

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require the recall of spatial information (De Renzi, 1982; Friedrich, 1990).

Despite evidence that dementing disorders in general, and AD in particular, affect both visual and verbal memory (Diesfeldt, 1990, Salmon, Granholm, McCullough, Butters, & Grant, 1989), the majority of published memory tests are verbal in nature. One reason for this may be the relative ease of testing for verbal memory. Examples of such tests include subtests of the Wechsler Memory Scale – Revised (Wechsler, 1987) namely, logical memory, verbal paired associates, and list learning, and the Buschke Selective Reminding test (Buschke, 1973). There are few visual corollaries to these verbal tests. Indeed, some apparently visual tests actually require a verbal response (e.g., Kendrick Object Learning Test, KOLT; Kendrick, 1985). If we wish to arrive at a diagnosis of dementia that accurately reflects the nature and degree of deficits experienced by sufferers, it is important to develop simple, nonverbal tests. These tests should be diagnostically valid and sensitive to change in performance over time.

In addition to the criticism that some nonverbal tests actually require verbal recall, there are a number of drawbacks associated with other nonverbal tests already available. Many memory tests that do assess nonverbal memory performance rely on the ability to write or draw. This is especially true of currently available assessments of visuo-spatial memory functioning, for example, the Rey-Osterrieth Figure (Osterrieth, 1944), the design learning subtest of the WMS-R, and the Revised Visual Retention Test (Benton, 1974). These tests have a number of weaknesses when used in the assessment of older adults. First, they are compromised by the fact that dyspraxia, tremor, or poor co-ordination could falsely impair performance. Second, many older adults express lack of confidence in their drawing abilities. Third, there is often a dearth of adequate normative data because these tests have generally been designed for young subjects or for the broad neurological population (Berg, Franzen, & Wedding, 1987; Lezak, 1983).

Other visuo-spatial tests rely on recognition of visuo-spatial information previously shown to subjects; for example, the Continuous Visual Memory Test (Trahan & Larrabee, 1988) and Kimura's Recurring Figures Test (Kimura, 1974). One problem with recognition memory measures however, is that they may underestimate memory problems in some patients; Delis et al. (1991) found this to be true of verbal recognition memory. Alternatively, such tests may, by virtue of their design, be unsuitable for older adults. The Warrington Recognition Memory Test for Faces (Warrington, 1984), for example, is very long (50 items) and can be fatiguing. The length of the test is a requirement of the relative ease of recognition testing in general. On the other hand, Grober, Buschke, Crystal, Bang, and Dresner (1988), found that verbal free recall measures overestimated memory impairment, as did Delis et al. (1991). A test of location recall that has good ecological validity forms part of the Rivermead Behavioural Memory Test (Wilson, Cockburn, & Baddeley, 1985). An item provided by the subject is hidden in the room and an alarm set. The subject is instructed to retrieve the item when the alarm goes off. Single trial recall measures certainly discriminate well between those who do and those who do not have a memory problem. However, perhaps of more use to the clinician is information about the person's ability to learn information. Not only do learning tests allow the discrimination of the different causes of failure, for example, primarily memory problems versus primarily attention problems, but they also allow helpful information to be made available to the family about whether or not the ability to learn, albeit impaired, is present. This has implications for managing the memory problems being uncovered. Finally, cued recall has been shown to be highly sensitive in identifying demented patients (Cushman, Como, Booth, & Caine, 1988, Grober et al., 1988). Tuokko and Crockett (1989) found that patients who benefited most from cued recall were least impaired in psychosocial functioning.

A visuo-spatial memory test involving location learning, therefore, offers promise as a useful measure not only because it has ecological validity – dementia sufferers commonly complain that they lose their glasses, keys, purse, or

pills, being unable to remember where they left them or last saw them – but also because the stimulus array offers inherent visual cueing, as would the subject's own home environment, which may trigger their recall of the locations. Finally, the literature on visuo-spatial deficits in dementia has shown that these deficits are related to dementia severity and are good predictors of early change in the dementing process (Sahgal et al., 1992).

Other researchers have explored the idea of visuo-spatial memory testing in dementia. Sahakian et al., (1988) devised a computer-based neuropsychological test battery (CANTAB) which includes visuo-spatial memory tests, though without learning trials. Unfortunately, most clinicians do not have access to the funds required to purchase such systems. In addition, there is controversy over the appropriateness of using computerised assessments with older, possibly dementing individuals (Koss, 1994). Malec et al. (Malec, Ivnik, & Hinkeldey, 1991; Malec et al., 1992) designed the Visual Spatial Learning Test (VSLT), which requires the subject to learn the location of seven abstract designs on a 6 × 4 array over five trials. However, it also requires the subject to choose the seven designs from eight distractors, **at each placement trial**. There appear to be two difficulties with this approach. First, it confuses the effects of repeated testing with the measurement of learning locations. In young adults, repeated recognition testing has little effect on performance accuracy. In older adults and especially in adults with dementia, repeated recognition testing leads to an increase in error rates. Essentially, the distractors from a previous recognition test are remembered as targets at the next recognition phase (Tollworthy, Brown, Surmon, & Wilcock, 1991). The VSLT presents the recognition test five times, leading to a potential confounding of difficulty in recognition with difficulty in learning the locations of the items. Second, the designs are abstract. Although Lee and colleagues (Lee, Loring, & Thompson, 1989) have recommended that nonverbal memory tests should use unfamiliar, complex, and difficult-to-verbalise stimuli, others do not agree. We agree with Heilbronner (1992) that a test which tries "to eliminate the very abilities a person may need in order to perform" (p. 109) effectively may not be very relevant clinically. In young adults, where ceiling effects are likely, or in studies which seek to find evidence of 'pure' visuo-spatial memory, the sorts of abstract stimuli used in the VSLT may be advisable. For older adults and certainly in individuals with dementia, we believe that abstract stimuli might give rise to floor effects or confusion about the task, perhaps leading to a greater number of subjects refusing to complete the test. Because forgetting where an object has been left, glasses, wallet, and so forth is a common complaint of older adults both with and without dementia, the use of pictures of objects was considered to be appropriate for a test aimed at this group.

In the general clinical setting a brief, inexpensive, 'paper-and-pencil' test, that does not require complex or fine motor control, drawing, or verbal recall, and demonstrates face validity, would improve the thoroughness with which we can assess nonverbal memory performance and learning in older adults. The current study reports on the development of the Location Learning Test (LLT). The LLT requires the subject to learn the correct placement of 10 pictures on a 5 × 5 matrix (see Figure 1). Subjects are given five learning trials and a delayed recall trial after 30 minutes.

METHOD

Subjects

These comprised 29 healthy elderly volunteers (NC: 11 male; 18 female), 19 patients with probable Alzheimer's disease (AD: 5 male; 14 female) and 12 patients with vascular dementia (VAD: 6 male; 6 female). Predicted premorbid IQ (NART; Nelson & Willison, 1991), Mini-Mental State Examination score (MMSE; Folstein & Folstein, 1975), age and gender for each subject group are shown in Table 1. MMSE scores for the control subjects were all ≥ 25; AD and VAD subjects all scored in the very mild (MMSE ≥ 25: $n = 3$); mild (MMSE 20 – 24: $n = 10$), or moderate range (MMSE 11 – 19: $n = 12$), there were no subjects with severe dementia (MMSE ≤ 10). For these scores, only serial 7s was applied; the option of the

word "*WORLD*" backwards was not used. Recent evidence suggests that treating these two tests as equivalent gives rise to inconsistency in scoring (Otlin & Zelinski, 1991). All subjects with dementia were living at home with a carer or alone, and all subjects were assessed in their homes.

Patients were diagnosed at the Bristol Memory Disorders Clinic (BMDC), where they underwent a comprehensive physical and mental examination to rule out any other cause for their dementia (including Computed Tomography Head Scanning, laboratory blood testing, and neurological examination). The diagnoses were established in a multidisciplinary conference attended by all BMDC staff, according to DSM-III-R criteria for dementia (American Psychiatric Association, 1987), NINCDS-ADRDA criteria for probable Alzheimer's disease (McKhann et al., 1984), and Hachinski scores greater than 7 for probable vascular dementia (Hachinski et al., 1975). The elderly volunteers were the spouses or siblings of the patients and had no history of neurological or psychiatric disorder. Informed consent for neuropsychological testing was obtained and the project had Ethics Committee approval.

Materials

The LLT is a 5 × 5 array composed of 25 squares, each 8 cm by 5 cm. Ten squares were randomly selected for the placement of stimulus pictures, with the restriction that no pictures could be placed at the corners of the array. The locations used were the same for each subject and the items were presented in the same orientation relative to each subject (see Fig. 1). The 10 target items were coloured line drawings of common objects: cow, rose, fish, trophy, stepladder, umbrella, balloons, camera, bicycle, and butterfly.

Procedure

All subjects were seen in their own homes and were assessed seated at a table. Subjects were given an example of the task. They were shown a 2 × 2 array with pictures of two items on each of two squares. This display was studied for 6 s (3 s per picture) and then removed. Subjects were then shown a blank 2 × 2 array, given the two stimulus pictures one by one and asked to place them in their correct locations. This example of the testing procedure served two purposes. First, it introduced the demands of the task with a minimum of verbal instruction, and second it screened out individuals who would find the larger 5 × 5 version too difficult. Any subject who was unable to complete the 2 × 2 screening test was not given the LLT.

Subjects were then told that they would be shown a larger version of the same test. They were reassured that they would not be expected to learn

Table 1. Predicted Premorbid IQ, MMSE, Age Groups And Gender For Normal Controls And Patients With Dementia.

Variable	N C	AD	VAD
n	29	19	12
			110.1
NART Predicted FSIQ	110.0	108.5	10.8
M	9.8	10.6	
SD			
range	89 – 128	90 – 124	91 – 124
MMSE Score			
M	27.6	19.5	18.2
SD	1.6	4.5	4.2
range	25 – 30	11 – 26	11 – 24
Age (years)			
M	72.2	70.4	78.2*
SD	8.3	6.5	8.1
range	60 – 92	62 – 79	62 – 90
Gender	11 male; 18 female	5 male; 14 female	6 male; 6 female

Note. NC = normal control; AD = Alzheimer's disease; VAD = vascular dementia; NART = National Adult Reading Test; MMSE = Mini-Mental State Examination.

* Vacular dementia patients were significantly older than Alzheimer's patients ($p < .05$).

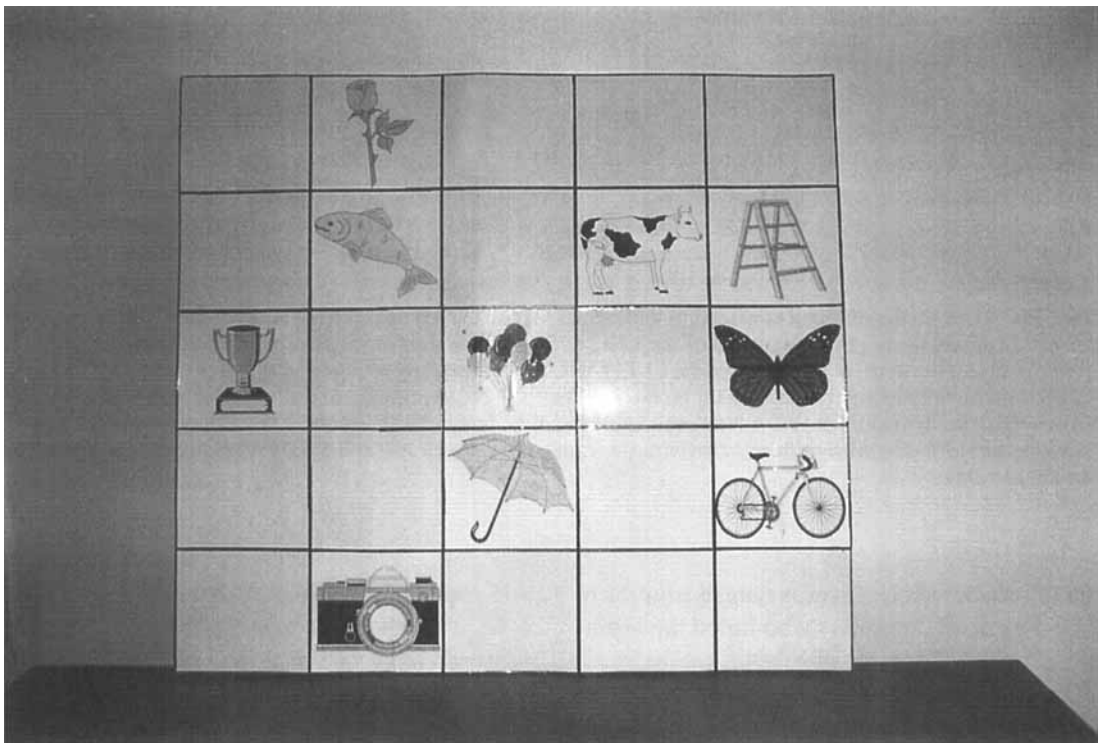

Fig. 1. Location Learning Test board and 10 pictures. (Copyright, Bucks & Willison.)

the locations in one trial but would be given a number of trials. The 5 × 5 array with the 10 target items placed in selected locations was shown to the subjects for 30 s, after which time a blank array was used to cover the target array. The subject was then handed, in random order, the target pictures one by one and asked to place them in the correct location. Subjects were encouraged not to spend too much time on each choice of location and were free to move the items around until all 10 were located as accurately as they could remember. Subjects were allowed to work at their own speed but never required more than 3 min to complete the placements.

In order to establish the relationship between recognition and location learning, a recognition test was devised for the 10 pictures. Following the first trial only, subjects were given a recognition task in which they were presented in random order with the 10 target pictures and 10 distractor pictures and asked to decide if each picture was, or was not, one of the original items.

The target grid was then immediately re-presented to the subjects for another 30 s and the test phase carried out once more as outlined above. Subjects were given a total of five trials. If a subject correctly placed all 10 pictures in two successive trials, the test was halted and maximum points awarded for the remaining trials.

A number of the subjects (7 patients with dementia, 6 NC) were also presented with a delayed recall trial after 30 min. The interval was filled with a verbal memory task but no other visual stimuli. After this delay subjects were shown the blank array and asked to place the pictures on this array in the locations they could remember from earlier trials.

RESULTS

Of the 60 subjects, 1 refused to carry out the full version of the assessment although he passed the example test, 2 subjects declined to continue after the recognition trial, and 3 subjects failed the example test. There was no relationship between degree of cognitive impairment and fail-

Table 2. Means and Standard Deviations for LLT Measures for Each Subject Group.

GROUP	PIC:SUM max. 50		LOC:SUM max. 50		DISP:SUM		TARGETS max. 10		FALSE +VES max. 10	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
NC	40.1*	8.8	43.4*	6.4	14.8*	13.5	10.0*	0	0.0*	0.2
AD	13.3	9.8	25.3	7.0	85.8	42.9	9.1	1.0	1.2	2.2
VAD	9.3	7.7	24.9	5.3	103.6	33.4	9.3	0.5	2.1	1.6

Note. PIC:SUM = sum of pictures placed in the correct locations on Trials 1-5 of the LLT; LOC:SUM = sum of correct locations recalled on Trials 1-5 of the LLT; DISP:SUM = sum of displacement scores for each picture from its correct location on Trials 1-5 of the LLT; TARGETS = correctly recognised pictures of the LLT; FALSE +VES = incorrectly recognised distractor pictures of the LLT; NC = normal control; AD = Alzheimer's disease; VAD = vascular dementia; NART = National Adult Reading Test; MMSE = Mini-Mental State Examination.
* Control subjects scored significantly differently from subjects with AD and VAD (ANOVA with post hoc test Sheffé, $p < .05$).

ure or refusal (MMSE scores ranged from 11 to 24), though all 3 subjects who failed the example test had a diagnosis of VAD.

Five sets of scores were generated for each of the five trials as follows: recall of correct picture in correct location (PIC); recall of correct location (LOC); displacement from correct position[1] (DISP); correct recognition of the target pictures (TARGETS); and incorrect recognition of the distractors (FALSE +VES). The first three scores were also summed across all five trials to give PIC:SUM, LOC:SUM, and DISP:SUM, respectively. Table 2 shows means and standard deviations for LLT measures for each subject group.

Normal subjects scored significantly differently from demented subjects on all measures, but there were no significant differences between patients with AD and VAD, despite the difference in their mean age (PIC:SUM – $F(2,51) = 64.13$, $MS_e = 81.95$, $p < .001$; LOC:SUM – $F(2,51) = 53.23$, $MS_e = 42.19$, $p < .001$; DISP:SUM – $F(2,51) = 46.83$ $MS_e = 845.04$, $p < .001$; post hoc tests, Scheffé $p < .05$). There was, however, a trend for subjects with VAD to perform worse than subjects with AD, especially with regard to their displacement scores which were greater. The small sample sizes and large variances may have been the reason for this difference not being statistically significant.

Table 3 shows correlations among measures for all subjects. Inspection of this table shows that the MMSE correlated significantly with all five LLT measures, though more highly with the learning (PIC:SUM $r = .77$, LOC:SUM $r = .77$, DISP:SUM $r = -.74$) than recognition measures (TARGETS $r = .60$, FALSE +VE $r = -.43$). MMSE did not correlate significantly with AGE or NART IQ. AGE and NART IQ did not correlate significantly with any of the other variables except for the number of false positives (FALSE +VES), where NART IQ correlated negatively; $R = -.31$ ($p < .05$). All LLT variables correlated highly with each other, especially the three learning scores (PIC, LOC, and DISP:SUM), suggesting that they were tapping into the same psychological ability.

Correlating the MMSE separately with the three learning scores for each subject group produced nonsignificant results (see Table 4), in part because of the small samples sizes.

Figure 2 shows a plot of MMSE score against PIC:SUM score. Inspection of this plot makes it clear that although MMSE score predicts performance on the test overall, there is heterogeneity in the learning of picture locations within each

[1] DISP was calculated by the number of squares required to move from the true location to the location chosen by the subject in horizontal or vertical steps – as a knight moves on a chess board.

Table 3. Correlations Among Measures for All Subjects ($N = 60$).

Measure	MMSE	NART IQ	AGE	PIC:SUM	LOC:SUM	DISP:SUM	TARGETS
MMSE							
NART IQ	.11						
AGE	−.05	−.26					
PIC:SUM	.77**	.17	−.22				
LOC:SUM	.77**	.18	−.18	.96**			
DISP:SUM	−.74**	−.10	.18	−.94**	−.89**		
TARGETS	.60**	.10	.08	.53**	.51**	−.62**	
FALSE +VES	−.43**	−.31*	.06	−.44**	−.44**	.48**	−.22

Note. MMSE = Mini-Mental State Examination; NART IQ = National Adult Reading Test Predicted Premorbid Full Scale IQ; PIC:SUM = sum of pictures placed in the correct locations on Trials 1-5 of the LLT; LOC:SUM = sum of correct locations recalled on Trials 1-5 of the LLT; DISP:SUM = sum of displacement scores for each picture from its correct location on Trials 1-5 of the LLT; TARGETS = correctly recognised pictures of the LLT; FALSE +VES = incorrectly recognised distractor pictures of the LLT.
* $p < .05$, ** $p < .01$.

Table 4. Correlations between Learning Measures and MMSE for Each Subject Group.

Measure	NC $n = 29$	AD $n = 18$	VAD $n = 7$
MMSE & PIC:SUM	.34	.27	.42
MMSE & LOC:SUM	.35	.32	.43
MMSE & DISP:SUM	−.24	−.27	−.50

Note. MMSE = Mini-Mental State Examination; PIC:SUM = sum of pictures placed in the correct locations on Trials 1-5 of the LLT; LOC:SUM = sum of correct locations recalled on Trials 1-5 of the LLT; DISP:SUM = sum of displacement scores for each picture from its correct location on Trials 1-5 of the LLT; NC = normal control: AD = Alzheimer's disease; VAD = vascular dementia.
(all $p > .05$)

subject group, which is not explained by this general measure of cognition.

Learning

Subjects with dementia (AD or VAD) showed learning over the five trials (see Figure 3) though the curve is shallower than that for NC subjects. A repeated measures analysis of variance (ANOVA) with group as the between-subjects variable (AD, VAD, or NC) and PIC trial as the within-subjects variable (Correct picture in correct location scores for trials 1–5) revealed a significant main effect for group ($F(2,51) = 64.13$, $MS_e = 1051.02$, $p < .001$), a significant effect of PIC trial ($F(4,51) = 19.18$, $MS_e = 29.08$, $p < .001$), and a significant interaction between group and PIC trial ($F(8,51) = 5.26$, $MS_e = 7.98$, $p < .001$). Repeated measures ANOVAs using LOC trial (correct locations for trials 1–5) and DISP trial (displacement scores for trials 1–5) as the within-subjects variables yielded significant main effects for group (LOC trial – $F(2,51) = 53.05$, $MS_e = 451.08$, $p < .001$ and DISP trial – $F(2,51) = 46.83$, $MS_e = 7914.80$, $p < .001$, respectively) and for trials (LOC trial – $F(4,51) = 13.61$, $MS_e = 16.68$, $p < .001$ and DISP trial – $F(4,51) = 12.50$, $MS_e = 172.64$, $p < .001$, respectively) with a significant interaction for LOC scores (LOC trial – $F(8,51) = 2.98$, $MS_e = 3.65$, $p < .01$) but a nonsignificant interaction term for DISP scores (DISP trial – $F(8,51) = 0.76$, $MS_e = 10.46$, $p > .50$).

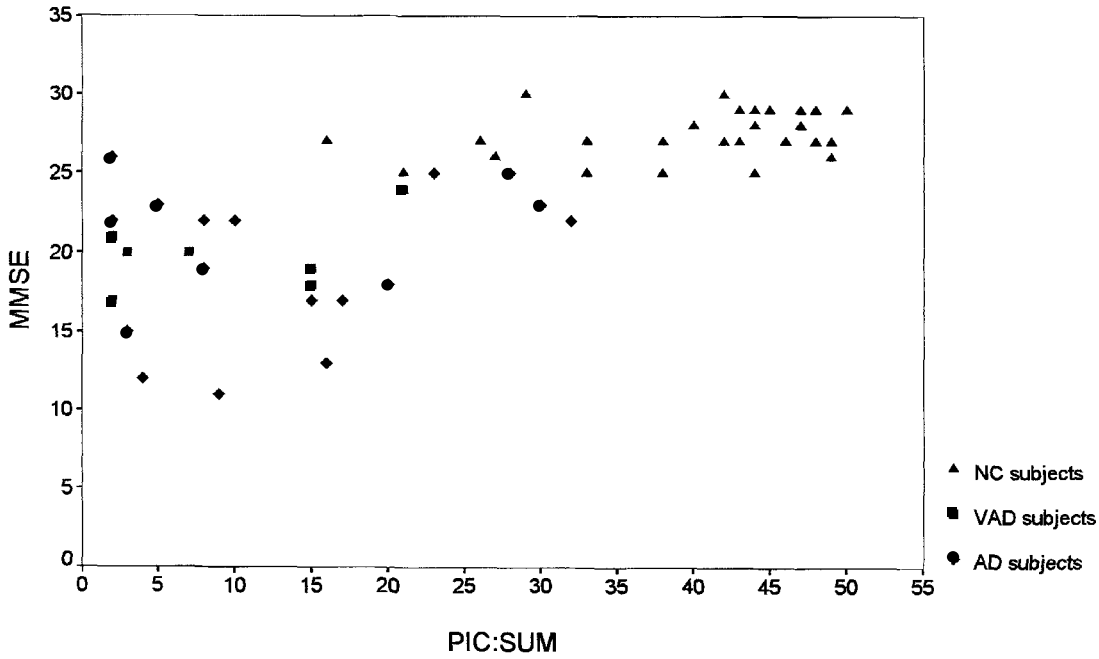

Fig 2. Plot of MMSE scores against PIC:SUM scores (correct picture in correct location) showing group membership.

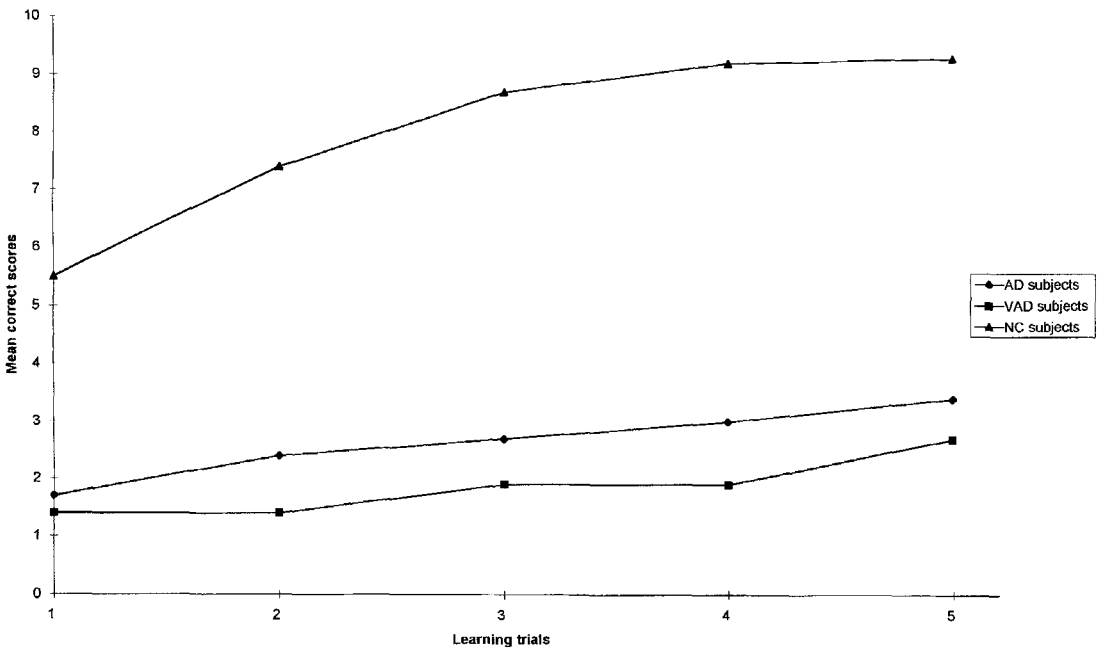

Fig. 3. Number of correct pictures in correct locations (PIC) for each subject group.

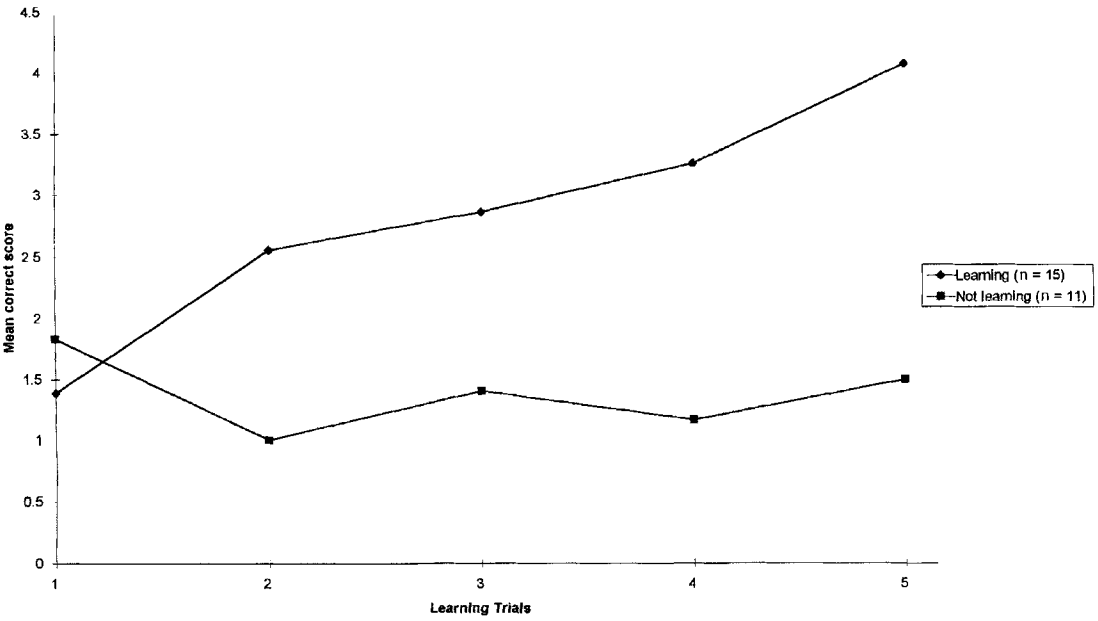

Fig. 4. Number of correct pictures in correct locations (PIC) for subjects with dementia, divided into those who show learning over the trials and those who do not.

Figure 4 shows the mean number of correct pictures in correct locations (PIC) for subjects with dementia, divided according to whether they evidenced any learning over the five trials. Learning was defined as a PIC Trial 5 minus Trial 1 score of 1 or more (PIC Trial 5 – PIC Trial 1). Those who showed an increase in PIC scores of 1 or more pictures correctly placed over the five trials irrespective of their starting score were deemed to have shown learning. Clearly, some subjects with dementia were able to benefit from repeated presentation of the grid, some were not. This discrepancy could not be explained by the degree of cognitive deficit (MMSE: $t = 1.56$, $df = 23$, $p = .131$). Fifteen subjects with dementia (57.7%) were able to learn, and their mean MMSE score was 18.6 ($SD = 4.4$), whereas the 11 subjects with dementia (42.3%) who were unable to learn additional picture locations had a mean MMSE score of 21.1 ($SD = 3.1$).

Cut-Off Scores

On the grounds that no significant differences were found in the LLT scores of patients with Alzheimer's disease and vascular dementia, these two subject groups were treated as one 'demented' group for the purposes of establishing a cut-off score for normal and abnormal performance. Using PIC:SUM (sum of correct pictures in correct locations over the five trials) a cut-off of 32 of a maximum of 50 points was established. Sensitivity at this cut-off was 100%, specificity 82.8%, and positive predictive value was 83.3%. Thus, 5 of the 29 NC subjects fell into the category of having difficulty with the learning requirements of the test.

Delayed Recall

Thirteen of the subjects (7 with dementia and 6 NC subjects) were also given a delayed recall trial for the LLT. Table 5 shows the means and standard deviations for this delayed recall performance with PIC, LOC, and DISP TRIAL 5 scores for comparison purposes.

Again, NC subjects performed significantly better than demented subjects on all measures. After a delay, NC subjects recalled correctly a mean of 8.7 pictures in their correct locations, with a mean of 9.2 correct locations. Demented

Table 5. Means and Standard Deviations for PIC TRIAL 5, PIC:DEL, LOC:DEL, and DISP:DEL for Each Subject Group.

	PIC TRIAL 5 max. 10		PIC:DEL max. 10		LOC TRIAL 5 max. 10		LOC:DEL max. 10		DISP TRIAL 5		DISP:DEL	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control ($n = 6$)	9.3*	1.6	8.7*	1.8	9.6	1.1	9.2*	1.2	0.9	2.2	1.8*	2.4
Demented ($n = 7$)	3.2	2.4	1.9	1.6	5.7	1.9	5.3	1.5	17.1	9.1	18.0	6.1

Note. PIC TRIAL 5 = number of pictures placed in the correct locations on Trial 5 of the LLT; PIC:DEL = number of pictures placed in the correct locations on delayed recall trial of the LLT; LOC TRIAL 5 = number of correct locations chosen on Trial 5; ; LOC:DEL = number of correct locations chosen on delayed recall trial of the LLT; DISP TRIAL 5 = displacement scores for each picture from its correct location for Trial 5; DISP:DEL = displacement scores for each picture from its correct location on delayed recall trial of the LLT.
* Control subjects scored significantly differently from subjects with AD and VAD (one-way ANOVA, $p < .05$).

subjects only recalled correctly a mean of 1.9 correct pictures in their correct locations, but recalled 5.3 correct locations. For the whole sample ($n = 13$), PIC:DEL (correct pictures in correct locations at delayed recall) correlated significantly .90 ($p < .001$) with MMSE, .92 ($p < .001$) with PIC:SUM, –.66 ($p < .05$) with age, .72 ($p < .01$) with the number of targets recognised and –.61 ($p < .05$) with the number of false positives.

Percent savings was calculated for both groups, where percent savings equalled the number of pictures in correct locations at delayed recall as a percentage of the Trial 5 score [(PIC:DEL/PIC TRIAL 5) * 100]. The 6 NC subjects retained a mean of 97.5 % of the information learned by Trial 5 ($SD = 16.3\%$) whereas 6 of the subjects with dementia retained a mean of 53.3 % of the information learned by Trial 5 ($SD = 45.3\%$). The data of 1 subject with dementia could not be used in this analysis because the subject recalled no correct pictures in their correct locations at Trial 5, but recalled one after a delay. This difference in mean percentage savings did not reach significance due, perhaps, to the small sample sizes and the large variance in scores.

Gender

A final area of interest was whether male and female subjects performed differently on the LLT. An analysis of variance (ANOVA) with PIC:SUM as the dependent variable, and gender, and dementia/nondementia as the independent variables revealed the surprising finding that although there was no main effect for gender ($F(1,49) = 0.79$, $MS_e = 55.57$, $p > .10$), there was a significant interaction between dementia and gender ($F(1,49) = 6.7$, $MS_e = 474.07$, $df = 1$, $p < .02$). This interaction remained significant even when analyses of covariance were carried out controlling for MMSE and NART-predicted premorbid IQ, respectively. As expected there was a highly significant effect of dementia ($F(1,49) = 25.08$, $MS_e = 1771.47$, $p < .001$). It can be seen from Figure 5 that female subjects suffering from dementia performed significantly more poorly on the LLT test overall than did male subjects with dementia. This finding was not affected by the diagnosis of the subjects with dementia.

DISCUSSION

The purpose of this study was to design a brief test of location learning that does not require drawing or verbal responses, is ecologically valid, is sensitive enough to pick out difficulties in normal elderly subjects but not so difficult as to cause floor effects in patients with dementia, and to evaluate its validity. The LLT is brief, taking less than 15 min to administer (excluding the delay); it does not require drawing, only relatively gross motor movements; and it is not reliant on verbal expression. It does not matter if

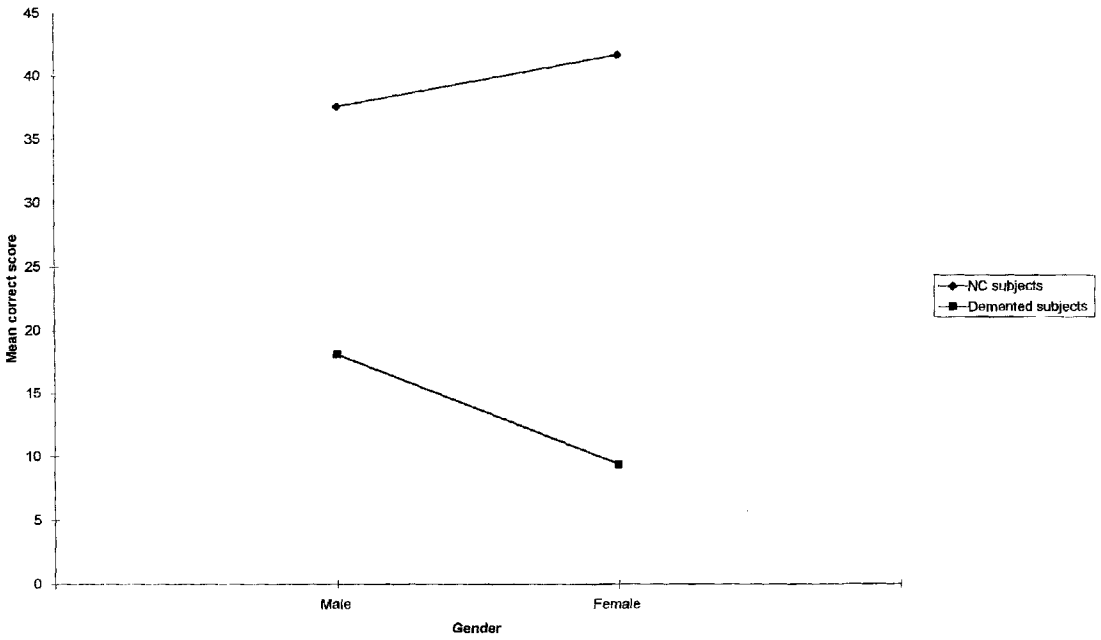

Fig. 5. Mean PIC:SUM scores (total correct pictures in correct locations) for subjects with dementia and normal controls by gender.

the individual cannot name the item as long as he/she can correctly place it. The LLT includes a delayed-recall trial.

Results support the discriminatory validity of the test. The LLT correlates well with the MMSE (59% of the variance explained) but is also sensitive to learning. There were no significant differences between those with AD and those with VAD on the LLT, although there was a suggestion that patients with VAD may be more vulnerable to difficulties with this task. This finding is consistent with recent evidence suggesting that patients with white matter low attenuation (WMLA: areas of hypo-dense tissue in the subcortical regions commonly found in patients with vascular pathology) perform significantly worse on tests of visuo-spatial functioning than do matched patients with dementia but without WMLA (Amar, Bucks, Lewis, Scott, & Wilcock, 1996). However, because of the small samples used, the cut-off score and delayed recall results require cross-validation on a larger sample of subjects.

More than half of the subjects with dementia (whether AD or VAD) were able to benefit from the learning trials. The remaining subjects seemed to be approaching the test as if each presentation were a new experience. This division of subjects with dementia into those who did and those who did not learn was not explained by degree of cognitive deficit. Not only is this finding important because it suggests that learning ability may vary with severity of dementia, but also because this is essential information for care givers. In particular, it will be of benefit when suggesting strategies for managing memory loss. In those patients who show learning, repeated repetition of a name or a request may be of benefit; in those who do not show learning over trials this repeated recognition may lead only to frustration or distress. In these circumstances alternative strategies must be recommended.

The LLT also showed sensitivity to differences in the performance of male and female subjects with dementia and this difference was not explained by degree of cognitive impairment

or previous premorbid IQ. Other researchers have reported gender differences in the performance of patients with AD on tests of language (Henderson & Buckwalter, 1994; Ripich, Petrill, Whitehouse, & Ziol, 1995), delayed verbal recall (Henderson & Buckwalter, 1994), semantic memory (Buckwalter et al., 1996), naming (Padovani, Magni, Cappa, & Binetti, 1996), denial of deficits (Sevush & Leve, 1993), and behavioural problems (Ott, Tate, Gordon, & Heindel, 1996). As with the LLT, these differences could not be explained by education, premorbid ability, or the duration or severity of the disease. These findings (learning and gender differences) may be a function of the relatively small samples used, or could suggest that the LLT taps into an aspect of cognitive functioning which dissociates in some way from generalised measures of cognitive ability such as the MMSE. Further studies of the performance of patients with AD and VAD, and male and female subjects are planned.

In order to validate the LLT further it would be interesting to establish whether there is a relationship between ability to remember spatial information and measures of the ability to perform activities of daily living. One could posit a relationship between carrying out such tasks as cleaning the house, ironing, cooking, or carpentry with visuo-spatial memory ability. It may also be useful to validate the LLT against complaints of losing items measured in such scales as the MAC-Q (Crook, Feher, & Larrabee, 1992). Finally, the LLT may be a useful means of assessing the effect of treatment trials for AD. A relationship has been postulated between visuospatial memory decline and cholinergic neurotransmitter deficits (Meador et al.,1993) and spatial abilities have been shown to correlate well with environmental knowledge both in a nursing home (Norris & Krauss, 1993) and in community – living older adults (Walsh, Krauss, & Regnier, 1981). Further information is required about the relationship between the LLT and other measures of memory, cognitive ability, and functional skills. Finally, if the test is to be used clinically, normative data on the performance of older adults is also required. This data is currently being collected.

Whether visuospatial memory is truly distinct from verbal memory is a controversial question. Recent functional imaging studies using PET have demonstrated differential activation of right and left temporal regions in verbal and spatial working memory tasks (Jonides et al., 1993; Smith, Jonides, & Koeppe, 1996). However, studies of epilepsy patients with right and left temporal lobectomy are less clear cut in the dissociations that they have endeavoured to show between verbal and spatial working memory tasks (Helmstaedter, Pohl, & Elger, 1995). One reason for the confusion is that subjects often verbalise even seemingly abstract stimuli. For example, subjects completing the Benton Visual Retention Test often use verbal strategies which can confound their results (Helmstaedter, Pohl, & Elger, 1992). It is true that subjects can verbalise the names of the objects used in the LLT. What is less clear is the extent to which this helps them to remember the locations of those items. Clinical experience with the test suggests that even agnosic subjects can correctly locate the items because of their ability, borne out by the good recognition scores achieved in this study, to distinguish between the stimuli. This study, however, has not attempted to demonstrate the existence of a separable visuo-spatial memory system; rather it has sought to establish the clinical utility of the LLT, as a valuable test of memory because it requires simple, nonverbal responses and is diagnostically valid. Further study is needed to establish the nature of the memory system or systems which support performance on this task.

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