SPECIFICITY OF IMMEDIATE MEMORY FUNCTION ASSOCIATED WITH CEREBRAL CORTEX DAMAGE*

By

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THE psychometric assessment of memory presents special problems in that inferences regarding this function seem to be markedly dependent upon the conditions under which it is measured. Thus, following exposure to experience X, it is problematic whether a single statement regarding a person's ability to remember X can be made. His ability would likely be a function of the time between exposure and reinstatement (Ebbinghaus, 1913; Luh, 1922; Postman and Rau, 1957) and whether assessment involved recognition, free recall, or relearning (Luh, 1922; Postman and Rau, 1957). Beyond these, the importance of the sensory channel involved in the initial experience or in reinstatement (Thurstone, 1938, p. 86) and the nature of the content to be retained (Benton, 1945) remains relatively unexplored. All of these considerations dictate against accepting differing psychological test measures of memory as equivalent and, conversely, suggest that any generalized statements regarding memory ability should be based upon several different measures.

When memory tests are used to aid in the detection of cerebral pathology or to assess the psychological effects of cerebral trauma, still another complicating feature is added. There is an increasing body of research suggesting differential and rather specific decline in psychological abilities associated with lesions of the left and the right cerebral hemispheres. Left hemisphere pathology in right-handed persons is characterized by differential impairment on verbal tasks (Anderson, 1951; Heilbrun, 1956; McFie and Piercy, 1952; Meyer and Jones, 1957; Reitan, 1955). There is considerable evidence that right hemisphere lesions in right-handed persons are associated with a disability on spatial tasks (Brain, 1941; Hécaen, de Ajuriaguerra and Massonnet, 1951; McFie, Piercy and Zangwill, 1950; Paterson and Zangwill, 1944; Paterson and Zangwill, 1945), and some evidence that right-sided pathology is differentially related to spatial impairment (Heilbrun, in press; McFie and Piercy, 1952). Accordingly, the nature of the content of any given memory test could assume a major role in assessment of brain-damaged patients since, for example, an examiner might make a far different inference regarding memory function of a patient with left hemisphere damage if he administered a "non-verbal" memory-for-designs test rather than a verbal retention test.

The view that clinical appraisal of memory in the brain-damaged should not be based on a single memory test was proposed some time ago by Benton (1945), but since that time there has been little evidence reported regarding the degree of relationship between various memory tests in either a brain-damaged or non-brain-damaged population. It is the purpose of this study to determine

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the inter-relationships between several immediate memory tests and to further evaluate whether these inter-relationships differ in a brain-damaged group based on the notion that specific disabilities in dealing with verbal and spatial test content following left and right hemisphere damage could produce specific decline on memory tests with these content characteristics. Such data will provide direct evidence as to whether a general statement regarding a brain-damaged patient's memory *ability* is permissible or whether several statements regarding memory *abilities* are in order (i.e. whether a single or multiple memory tests are necessary to appraise memory function).

PROCEDURE

Subjects

The 110 patients included in the brain-damaged group were judged to have lesions involving the cerebral hemispheres and were collected from the neurological services of the State University of Iowa Hospital and Veterans Administration Hospital, Iowa City. The 68 patients in the non-brain-damaged group were obtained from various non-neurologic wards of the same hospitals and included patients with no history or current suspicion of brain pathology. The groups were matched for mean age (brain-damaged, 41·8 years; controls, 41·1 years) and mean educational level (brain-damaged, 9·8 years; controls, 10·1 years).

Memory Tests

The four immediate memory tests selected for this study were chosen because they included divergent characteristics presumed to influence the ability to reinstate previous experiences. They were administered as part of a larger battery of tests, always appearing in the same order relative to each other. These were:

1. The Digit Span Test. This task, a subtest from the Wechsler-Bellevue Intelligence Scale (Wechsler, 1944), required the patient to *recall* series of numbers both forward and backwards. The sensory modality involved was *auditory*, the content *verbal-symbolic*, and the motor act was *vocal*.
2. Visual Retention Test, Form C (Benton, 1955). In this test the patient was *visually* presented *meaningful geometric designs* and was asked to *recall* the designs by *drawing* them.
3. Visual Retention Test, Form G (Benton, 1955). Form G involved the same *visual* presentation of *meaningful geometric designs* (which differed from those in Form C), but the patient was only required to *recognize* the correct design from a multiple choice of 4. Either a *verbal* or *pointing* response was accepted.
4. Serial Synthesis. This task included the *visual* presentation of parts of *meaningless geometric designs* one at a time, and the *recognition* of the combined design from a multiple choice of 4. Again either a *verbal* or *pointing* response from the patient was possible.

The 4 measures were all presented under immediate memory conditions so time between exposure and reinstatement of the stimulus was not a differential characteristic of the tasks.

RESULTS AND COMMENT

The relationships between the 4 memory tasks were analysed by means of product-moment correlations. These correlations for the non-brain-damaged group are presented in Table I. All of the correlations differed significantly

TABLE I

Correlations Between Performances of Non-Brain-Damaged Patients on Four Tests of Immediate Memory

	Visual Retention Test (C)	Visual Retention Test (G)	Serial Synthesis
Digit span	·42	·35	·50
Visual retention test (C)		·46	·62
Visual retention test (G)			·53

from zero at the 1 per cent. level of confidence. Two inferences may be made from these data. One is that since performance on each test is significantly related to performance on all others, a case can be made for a general memory ability which to some extent governs performance on memory measures of widely varying characteristics. The other inference would be that despite the possible general memory factor, attempts to predict how a patient will perform on one memory task based upon his performance on another will lead to considerable error. For example, the correlations* obtained with the control group suggest that only 12–38 per cent. of the variability in memory scores on any one test can be accounted for by the variability on any other.

The correlations between the memory tests for the brain-damaged group are given in Table II. All of these correlations were reliably greater than zero at

TABLE II

Correlations Between Performances of Brain-Damaged Patients on Four Tests of Immediate Memory

	Visual Retention Test (C)	Visual Retention Test (G)	Serial Synthesis
Digit span	·26	·35	·40
Visual retention test (C)		·61	·49
Visual retention test (G)			·47

the 1 per cent. confidence level except that between Digit Span and Visual Retention Test (C) which reached the 5 per cent. level. Each of these correlations was compared statistically with its counterpart obtained from the control group, and it was found that none of the comparisons provided a statistically significant difference. Thus these between-group comparisons give no support to the notion that *greater* caution is necessary in making test-based statements about general memory ability when dealing with brain-damaged patients than with non-brain-damaged patients. However, it is clear that the *same* limitations regarding any general statement of memory ability from a single test suggested with reference to the control group would hold for the organic group. That is, the correlations between performances of brain-damaged patients on several memory tests suggest that one can account for only between 7 per cent. and 37 per cent. of the variability in scores on any one test from the variability on any other.

* One of the ways in which a correlation can be interpreted is in terms of common variance between the 2 sets of scores which are correlated. Thus by squaring the obtained correlation, the per cent. of common variance can be estimated. As a perfect correlation of 1·00 is approached, the amount of variability in scores on one measure which can be accounted for by the variability on the other approaches 100 per cent. As an example from Table I, the Digit Span–Serial Synthesis correlation of ·50 suggests that there is a 25 per cent. common variance and 75 per cent. error variance.

Inspection of the magnitude of correlations when the *verbal* Digit Span performance of a patient was related to his own performance on the three tests with *geometric-spatial* content suggests that differences in the nature of the content may contribute substantially to the limited relationships between memory tests for *both* the brain-damaged and non-brain-damaged groups. The 3 correlations between Digit Span and the memory tests with spatial content for the brain-damaged group (r's = ·26, ·35, ·40) are considerably lower than the 3 correlations involving only tests with spatial content (r's = ·47, ·49, ·61). The same trend can be observed in the matrix of correlations based on non-brain-damaged patient performance though it is not so clear-cut (Digit Span *vs.* spatial; r's = ·35, ·42, ·50: spatial *vs.* spatial; r's = ·46, ·53, ·62). Caution is necessary in this type of inspectional comparison since no statistical safeguards are provided, but it is possible that the larger discrepancies for the brain-damaged group between the set of correlations relating tests with verbal and spatial content as opposed to correlations relating tests with only spatial content do reflect the effects of specific disabilities following laterally localized cerebral trauma. A large group made up of only cases with lesions restricted to a single hemisphere would be necessary to test the hypothesis in a precise fashion.

The importance of these findings to the neurologist would seem to be in the re-emphasis upon the limited statements regarding immediate memory function which can be made should the neurologic examination include a single test of that function. Two options present themselves: (1) increase and diversify the memory measures so that a more comprehensive estimate of memory potential is possible, or, (2) limit the estimate of retentive capacity to the particular operations involved in the single measure. Accepting the second option, the clinician using the Digit Span procedure, for example, might state that a given patient when presented numbers to remember performed at such-and-such a level. Thus any statements are confined to the recall of verbal symbols at most and the diagnostic or prognostic significance is rather limited. However, when performance on several tests of memory are available for a given patient along with useful norms, the clinician has a better opportunity to detect a pervasive, a well-circumscribed, or no disability in memory function. Such observations would more likely have important diagnostic or prognostic implications.

Summary

The measurement of immediate memory skills by psychological tests is complicated by the fact that such tests vary with respect to the nature of the content, sensory modality carrying the test stimuli, whether recall or recognition is demanded, and the type of response which is scored. The present study concerned itself with the degree of relationship between several immediate memory tests which varied with respect to these characteristics. More specifically, the study addressed itself to whether the specificity of loss observed in cases of cerebral cortex damage (e.g. loss in verbal skills following left hemisphere injury; loss in spatial skills following right hemisphere injury) might lead to a lower degree of relationship when memory testing is done with brain-damaged patients.

All intercorrelations between the four immediate memory tests were significant for both control and brain-damaged groups suggesting the operation of a general memory factor. However, they were of such restricted magnitudes as

to indicate considerable caution in drawing any conclusions about a patient's memory functioning from a single test. There were no significant differences in correlations when those for the brain-damaged group were compared with the correlations for controls suggesting that differential impaiıment on verbal and spatial tasks associated with left and right cerebral lesions does not produce any substantial specific decline in memory test scores when a large unselected group of brain-damaged patients is considered. Implications for the neurologic examination were discussed.

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