MEMORY IN ORGANIC PATIENTS WITH DAMAGE INVOLVING THE DOMINANT TEMPORAL LOBE

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Thesis presented to the School of Psychology and Education of the University of Ottawa as partial fulfillment of the requirements for the degree of Doctor of Philosophy

Ottawa, Canada, 1963

ACKNOWLEDGMENTS

This thesis was prepared under the supervision of Professor Lawrence T. Dayhaw, Ph.D., of the School of Psychology and Education of the University of Ottawa.

The writer is indebted to R.H. Tavener, M.D., Superintendent of the Selkirk Mental Hospital, and to G. Bristow, M.D., Superintendent of the Brandon Mental Hospital, who offered the facilities of their hospitals so that this project could become a reality, and to Mr. R. Anderson, Electroencephalographer, who donated his valuable time and skill to aid in the selection of the sample population.

The writer is also grateful to J. French, Ph.D., and the Educational Testing Service, to H. Paul Kelley, Ph.D., Raymond Christal, Ph.D., for their permission to use and reproduce copies of their memory tests.

CURRICULUM STUDIORUM

Lloyd A. Shewchuk was born June 4, 1934, in Gilbert Plains, Manitoba. He received the Bachelor of Arts degree from the University of Manitoba in 1959 and the Master of Arts degree in Psychology from the same university in 1960. The title of his thesis was Tactual Sensitivity as Measured by a Technique of Intermittent Stimulation.

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INTRODUCTION

Clinical experience with brain damaged patients indicates that defective memory, especially for recent events, is a very common symptom. However, very few objective studies concerning the status of memory have been reported in the literature.

Most studies done to date have been concerned with differentiating heterogeneous groups of brain damaged patients from other diagnostic categories on the basis of global memory impairment. A few have focused attention on the effect of different types of brain injury or disease on memory ability. Others have attempted to relate memory impairment to the amount of cerebral damage, while others have been concerned with localising memory function within the brain.

With the advent of factor analysis, it has been possible to compose a battery of memory tests, each measuring some specific function of memory, in order to analyze memory in terms of factor concepts. The use of factorial data may be helpful in providing more accurate and meaningful assessment of memory losses in brain damaged patients.

This report is concerned with the nature of recent memory impairment, analyzed in terms of factor concepts, in dominant temporal lobe brain damaged patients as opposed to

these suffering damage in non-temporal areas.

The first portion of the thesis is concerned with a review of the literature on the various approaches used in studying memory defect in brain damaged individuals. Emphasizing quantitative studies, this review shows few previous attempts at assessing the nature of memory impairment. This is followed by the formulation of the hypotheses.

A description of the experimental design of the project is presented, emphasizing the nature of the tests utilized and the criteria for selecting the sample population. It describes the major characteristics of the brain damaged sample and the statistical operations employed.

The results obtained in this analysis of memory ability are then presented and discussed. This discussion evaluates the intergroup and intertest differences in memory impairment in terms of the existing conventional theories of brain functioning. A less dichotomous theory is then presented in which an hierarchical model of brain functioning is postulated.

Finally, the summary and conclusions of the investigation are presented along with suggestions for further research.

CHAPTER I

REVIEW OF THE LITERATURE

This chapter presents a review of the literature on the studies of memory disorders in brain damaged individuals. Historically, studies on memory defect in organic brain damaged persons can be divided into two basic approaches, the qualitative and quantitative studies. A brief review of the qualitative studies is presented, followed by a review of the quantitative studies outlining the major trends of research. A third section will introduce a multidimensional approach to the study of memory defects in brain damaged individuals in which Guilford's Structure of the Intellect Theory will be presented. Finally, the last section will present a summary and the statement of the hypotheses to be tested.

1. QUALITATIVE APPROACH IN STUDYING MEMORY DEFECTS

Typically, the qualitative approach to the study of memory defects utilized direct observation of a single individual, or a group of individuals, and any impairment was noted. The most obvious or gross impairments were then tabulated and described as coherently as possible.

Clinical observation of brain damaged individuals indicates that defective memory, especially for recent events, is a common symptom. Cameron, in observing cases with a permanent, progressive type of damage states:

> ...frequently the first sign of organicity is increasing forgetfulness. The patient cannot remember where he has left or hidden personal belongings, he does not recall having met recent acquaintances before, and he forgets engagements whether these are recreational or in the line of duty. He tends to repeat himself, often telling the same thing over and over with the same detail to the same person. He fails to retain new things that others tell him, he cannot learn new procedures, and he becomes easily confused in a new environment.[1]

Cameron's observations were based on individuals showing generalized deterioration of the brain, however, much information has been obtained about memory functioning resulting from damage to specific or localized regions of the brain. In the majority of studies, two regions of the brain seem primarily and most frequently studied. These are the frontal and temporal areas.

Klebanoff[2], in his review of the psychological changes in brain damage, notes that it was generally agreed that the

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1 Norman Cameron, The Psychology of Behaviour Disorders, a Biosocial Interpretation, Boston, Houghton Mifflin, 1947, p. 548.

2 S.G. Klebanoff, "Psychological changes in organic brain lesions and ablations", in the Psychological Bulletin, Vol. 42, No. 9, 1945, p. 585-623.

mental symptoms which occur from frontal and temporal lobe damage are generally the same. The majority of studies describe such symptoms as distractibility of attention, loss of spontaneity, general intellectual deterioration, changes in mood and psychomotor tempo, and memory loss. These symptoms, however, are not found in cases of parietal and occipital brain damage. In the former, defects are primarily psychophysical while in the latter they are visual.

With respect to memory loss with frontal cortex damage, Klebanoff[3] noted that out of 39 studies between 1870-1941 that he reviewed, only eight observed an impairment in recent memory ability. Three other authors found that memory defect was a generalized one affecting both recent and remote memory functions. One author found that remote memory remained intact, while recent memory was markedly impaired. The remaining studies failed to note the existence of any memory defect whatever. The confusion and disagreement with reference to the existence and nature of the memory loss can probably be attributed to the absence of any test techniques for it's more objective evaluation.

Much the same situation was observed with reference to memory loss in temporal lobe cases, however, there

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3 Idem., ibid., p. 588-589.

appeared to be more agreement among investigators as to the existence of a definite memory defect.

Kolodny[4] observed a definite memory loss in 19 of the 38 cases of temporal lobe tumors that he studied. The memory defect involved both recent and remote events and appeared to be more evident in cases of left-sided tumor than right-sided tumor.

Similarily, Minski[5] studied a number of left-sided temporal tumor cases and observed that recent memory was initially affected, but in the later stages of tumor growth, remote memory also became involved and impairment appeared to be more generalized. Minski believed this to be characteristic of the typical memory loss in organic brain disease.

Keschner et al[6] studied 110 cases with tumors in the temporal lobes and found that fifty percent showed some type of memory disturbance. Exploring the nature of the defect from a different point of view, they found that the defects

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4 A. Kolodny, "The symptomatology of tumors of the temporal lobe", in Brain, Vol. 51, No. 4, 1928, p. 385-417.

5 L. Minski, "The mental symptoms associated with 58 cases of cerebral tumor", in the Journal of Neurological Psychopathology, Vol. 13, 1933, p. 330-343.

6 M. Keschner, M.B. Bender and I. Strauss, "Mental symptoms in cases of tumor in the temporal lobe", in the Archives of Neurology and Psychiatry, Chicago, Vol. 35, 1936, p. 572-596.

were primarily in the spheres of retention and recollection while recognition was found to be least affected.

More recently, Penfield and Rasmussen[7], on the basis of electrical stimulation of the exposed cortex, attributed the role of perservation of memory traces to the temporal lobe as a whole. By stimulating the exposed temporal cortex they could elicit a variety of memories of past experience from the conscious patient. They concluded that the temporal lobe is concerned with memory functions and with judgments and assessments of current experience based on memory.

Although the qualitative observations concerning the nature of memory defect is vague and confused, there is general agreement among investigators that the temporal lobes are involved, in some capacity, with memory functioning. It is obvious that only gross estimates of memory loss could be evaluated on the basis of qualitative studies. In order to adequately evaluate the nature of memory deficit, strict controls and testing techniques are required. The following section will review the studies utilizing such quantitative techniques.

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7 W. Penfield and T. Rasmussen, The Cerebral Cortex of Man, a Clinical Study of Localization of Function, New York, Macmillan, 1950, xv-248 p.

2. QUANTITATIVE APPROACH IN STUDYING MEMORY DEFECTS

Very few studies using quantitative techniques have attempted to evaluate the nature of memory deficit in brain damaged individuals. The studies done to date follow one or more of five distinct trends. The first are studies utilizing global testing techniques to indirectly contribute knowledge on memory impairment. The second are studies concerned with differentiating heterogeneous groups of organic patients from those of other diagnostic categories using memory-type tests. The third are studies evaluating the effects of different types of brain damage on memory tests. The fourth are studies attempting to relate the amount or extent of brain damage to impairment of memory ability. The fifth are studies relating the effect of temporal lobe damage and memory dysfunction. Each of these trends will be reviewed.

1. Studies Utilizing Global Techniques - Although most global testing techniques, such as the Wechsler Adult Intelligence Scale[8], are heavily weighted with reference to test items of memory functioning, relatively few investigations of a systematic nature have evaluated memory impairment per se in cases of cortical damage. Most of the studies

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8 David Wechsler, The Measurement and Appraisal of Adult Intelligence, Baltimore, Williams and Wilkins, 1958, ix-297 p.

have been concerned with two basic problems. First, in evaluating general intellectual deterioration and second, in searching for a pattern of responses which would differentiate organic patients from those of other diagnostic groups. Extensive critical reviews of both these major problems are given by Klebanoff[9], Klebanoff et al[10], Wechsler[11], and Meyer[12].

Despite the controversy centered around the topics of general intellectual deterioration in organics and the presence or absence of a pattern of differentiating responses, most investigators are in agreement that the subtests of immediate memory ability are usually affected, to some degree, by cortical damage.

Because the Digit Span subtest is usually affected by brain damage and because this subtest is generally regarded

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9 S.G. Klebanoff, "Psychological changes in organic brain lesions and ablations", in the Psychological Bulletin, Vol. 42, No. 9, 1945, p. 585-623.

10 S.G. Klebanoff, J.L. Singer and H. Wilensky, "Psychological consequences of brain lesions and ablations", in the Psychological Bulletin, Vol. 51, No. 1, 1954, p. 1-41.

11 David Wechsler, "Changes in intelligence consequent to Brain damage", in David Wechsler, The Measurement and Appraisal of Adult Intelligence, 1958, p. 214-225.

12 V. Meyer, "Psychological effects of brain damage", in H.J. Eysenck, Ed., Handbook of Abnormal Psychology, New York, Basic Books, 1961, p. 529-565.

as a test of immediate memory span[13] it has found it's way into many of the specialized test batteries of memory ability. Studies utilizing these techniques will be reviewed in the following sections.

2. Memory in Heterogeneous Organic Groups - Although numerous studies have been concerned with memory functioning in heterogeneous groups of organic patients, few have been concerned with the evaluation of the nature of memory defect that has been evident. Most investigations have been carried out in the attempt to differentiate these groups of brain damaged patients from those of other diagnostic categories, on the basis of tests primarily measuring memory ability.

Hunt[14] devised the Hunt-Minnesota Test for Organic Brain Damage to differentiate brain damaged patients from non-brain damaged individuals using tests in which the subject must learn pairs of geometrical designs and pairs of words so that when he is presented with the design or word of one pair he can recall the corresponding design or word. The scores achieved on these were then compared to a vocabulary

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13 David Wechsler, "A standardized memory scale for clinical use", in the Journal of Psychology, Vol. 19, First half, 1945, p. 87-95.

14 H.F. Hunt, "A practical clinical test of organic brain damage", in the Journal of Applied Psychology, Vol. 27, No. 5, 1943, p. 375-386.

score and expressed in terms of a "T-score". Hunt tested a heterogeneous group of 33 organic patients and a control group of 41 neurotics, psychotics and normals. The results indicated that the organic patients scored significantly lower than the normal group on all trials of recall for designs and words. Organic patients consistently showed "T-scores" greater than 66 while the control group scored consistently below 66. Hunt used this score to differentiate between organic patients and those of other diagnostic groups. Unfortunately, most other investigators failed to confirm Hunt's findings.

Yates[15], in reviewing the literature on the validity of some psychological tests of brain damage, found that of the five studies he reviewed which utilized the Hunt-Minnesota, not one confirmed Hunt's findings. However, most of these studies were primarily concerned with differentiating between groups on the basis of the "T-score" and did not evaluate the significance of the differences on the memory for designs and memory for words pairs.

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15 Aubrey J. Yates, "The validity of some psychological tests of brain damage", in the Psychological Bulletin, Vol. 51, No. 4, 1954, p. 359-379.

Rappaport[16] administered the Word Pairs I and II from the Hunt-Minnesota, along with a Digit Span test, two recall of short stories tests, a memory for designs test, and other tests of general intelligence to 42 brain damaged and 85 schizophrenic patients. He found that the schizophrenic group scored significantly higher on all the memory tests except the memory for designs test. The organic group showed significantly higher scores on this test. The results from this investigation cannot be considered as conclusive, since there is some question of whether the groups were adequately matched for age. In part, the results seem to confirm Hunt's findings as well as other studies on memory dysfunction.

Armitage[17] administered a test of memory for short stories to a heterogeneous group of organic patients and a control group of normal and neurotic subjects. The test required the retention of dates, times, distances, directions, names, and other information. He found that the brain damaged group scored significantly lower than the controls. This finding was confirmed in Rappaport's study.

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16 S.R. Rappaport, "Intellectual deficit in organics and schizophrenics", in the Journal of Consulting Psychology, Vol. 17, No. 5, 1953, p. 389-395.

17 S.G. Armitage, "An analysis of certain psychological tests used for the evaluation of brain damage", in the Psychological Monographs, Vol. 60, Whole No. 277, 1946, p. 60-277.

With regard to the memory for designs test, Benton[18] developed the Visual Retention Test, composed of seven geometrical designs arranged in increasing order of complexity, to differentiate between organic and non-organic patients. He tested a group of 78 persons of which 22 percent were normal subjects, 27 percent neurotics, 26 percent psychopathic personalities, 13 percent mental defectives, 9 percent epileptics and related states and 3 percent concussion and head injury cases. He found that the organics generally completed less than three designs correctly, while the non-organics had no difficulty in completing three or more designs correctly. This finding was not evident in Rappaport's study, however, there were a number of serious flaws in this investigation which invalidate the results. First, there was no statistical analysis of the data. Second, the sample could hardly be considered representative of the brain damaged population. Third, variables such as age and intelligence were left uncontrolled. In any event, later studies seemed to confirm Benton's findings.

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18 Arthur L. Benton, A Visual Retention Test for Clinical Use, New York, Psychological Corporation, 54 p.

Graham and Kendall[19] devised a memory for designs test composed of fifteen designs and administered these to a heterogeneous group of brain damaged patients and a control group of psychotic, neurotic and normal medical patients. They found that the test could differentiate fifty percent of the organic group quite clearly. Some impairment in memory for designs was evident in most of the brain damaged group. However, the authors failed to analyze their results statistically making their conclusions difficult to evaluate.

In a more comprehensive study, Knott et al[20] devised a short battery of memory tests made up of the Benton Visual Retention Test, three tests of recall of pictures in which the subject must recall a series of pictures after various time intervals, a completion of matrices test in which the subject must remember the steps involved in completing the matrices, a symbol recall test in which the subject must draw symbols in an order presented previously, and a digits forward test. This battery was administered to a heterogeneous group of 102 hospital patients made up of neurotics,

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19 Francis K. Graham and Barbara S. Kendall, "Performance of brain damaged patients on a memory for designs test", in the Journal of Abnormal and Social Psychology, Vol. 41, No. 3, 1946, p. 303-314.

20 J.R. Knott, J.P. Umberger and I.M. Bilodeau, "The application of an experimental memory battery in the psychiatric clinic", in the Journal of Clinical Psychology, Vol. 8, No. 4, 1952, p. 355-361.

psychotics, personality and behaviour disorders, and organic psychotics. A control group of 50 freshmen nurses was used. The results indicated that the organic patients scored significantly lower on four of the tests: Picture Recall A and B (both involved short time intervals), Matrices, and the Benton Visual Retention Test. In addition, the Wechsler Memory Scale was administered to 48 patients. A positive correlation of 0.72 was obtained between the Wechsler Memory Scale and the four differentiating tests. However, it is not clear from which of the groups the 48 patients were selected for this part of the investigation. The authors also failed to supply data on the controlled variables, such as sex, age, education and intelligence, making the results difficult to evaluate objectively.

Other investigators have utilized the Wechsler Memory Scale in attempting to differentiate brain damaged patients from other diagnostic categories.

Cohen[21] administered the Wechsler Memory Scale to a heterogeneous group of 144 brain damaged patients and a control group of 144 neurotic and psychotic patients. The results indicated no significant differences between the organic,

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21 J. Cohen, "Wechsler memory scale performance of psychoneurotic, organic and schizophrenic groups", in the Journal of Consulting Psychology, Vol. 14, No. 5, 1950, p. 371-375.

neurotic, and psychotic groups on any of the memory items.

Howard[22] administered the Wechsler Memory Scale to a group of 43 brain damaged patients and a control group of 43 psychotic patients. In addition, the scale was administered to a group of 35 paretics and a group of 35 psychotic controls matched for age, education, occupational level, and length of hospitalization. The results indicated that there were no significant differences between the heterogeneous group of organics and the group of psychotics. This finding confirmed Cohen's results. However, the scale differentiated between the paretics and their matched controls on Tests I (personal and current information), II (orientation), III (mental control), and VI (memory for designs) at the .01 level of confidence and Tests IV (recall of logical material) and V (memory span) at the .05 level. There was no significant difference on Test VII (associate learning) of the scale. This finding points to the possibility that different homogeneous types of brain injury or disease may show memory defects while other types do not. A few investigators have explored this possibility.

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22 Alvin R. Howard, "Diagnostic value of the Wechsler memory scale with selected groups of institutionalized patients", in the Journal of Consulting Psychology, Vol. 14, No. 5, 1950, p. 376-380.

3. Memory in Different Types of Brain Damage - Some investigators have shown interest in studying memory deficit resulting from different types of brain injury or disease. Most have attempted to evaluate impairment from generalized damage to the brain as opposed to focal damage.

Zangwill[23] studied memory deficit in different cases of neuropsychiatric patients with verbal memory tasks. His battery included a Digit Span test, two rote learning tasks, and a substance recall task made up of two short stories. He found that cases of generalized brain damage displayed intact verbal memory span but grossly impaired verbal learning. Substance recall was also defective in these cases. Cases showing focal lesions of the speech areas showed impairment of memory span and severe difficulties in rote learning. The results, however, are not conclusive since the data was not subjected to statistical analysis.

Similarily, Winfield[24] studied three groups of epileptic conditions and a control group of normal subjects. Among other tests of general intellectual functioning, he administered the associate learning tasks from the Wechsler

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23 O.L. Zangwill, "Some qualitative observations on verbal memory in cases of cerebral lesion", in the British Journal of Psychology, Vol. 37, Part 1, 1946, p. 8-18.

24 D.L. Winfield, "Intellectual performance of cryptogenic epileptics, symptomatic epileptics and post-traumatic encephalopaths", in the Journal of Abnormal and Social Psychology, Vol. 46, No. 3, 1951, p. 336-343.

Memory Scale. He found that only those patients showing localized lesions were impaired on the associate learning tasks. The remaining patients were not significantly different from the control group.

On the other hand, Sharp[25] found that general paretics and senile patients showed poor performance on a memory for visual designs test. However, the author used an 84 point scoring scale made up of many items of graphic analysis so that the nature of the memory deficit was hard to evaluate.

One of the main criticisms to be directed toward studies on different types of brain damage and memory impairment is that little attention was paid to the amount of damage each group suffered. It is possible that memory differences could appear between groups simply because each suffered a different amount of damage.

4. Memory and Extent of Brain Damage - The possibility that the amount of damage suffered could influence test performance was explored by Aita and his co-workers[26].

Aita et al studied groups of organic patients showing a combination of focal and diffuse brain injury divided on

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25 A.A. Sharp, "The diagnostic significance of a visual memory drawing test", in the Journal of Abnormal and Social Psychology, Vol. 44, No. 4, 1949, p. 517-527.

26 J.A. Aita, S.G. Armitage, R.M. Reitan and A. Rabinowitz, "The use of certain psychological tests in the evaluation of brain injury", in the Journal of General Psychology, Vol. 37, First half, 1947, p. 25-44.

the basis of mild, moderate, or severe damage. The results indicated no significant differences between any of the groups on a digit span test. The Hunt-Minnesota could only differentiate those cases showing severe damage. Unfortunately, differentiation was made on the basis of the "T-score" and little attention was paid to memory impairment on specific items of the test.

Studies evaluating the effects of extent of injury on test performance have been criticized for disregarding areas of the brain important for certain psychological functions. Deficits in memory may appear in any one group, not only because they suffer more damage, but merely because a certain area of the brain is damaged. From qualitative studies, it was generally agreed that the temporal lobe is important to memory functioning.

5. Memory in Temporal Lobe Organic Patients - Many investigators have attempted to evaluate the effects which damage at various foci of the brain may have on certain psychological functions[27]. A number of these have attempted to study the effects of temporal lobe damage on memory ability.

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27 V. Meyer, "Psychological effects of brain damage", in H.J. Eysenck, Ed., Handbook of Abnormal Psychology, New York, Basic Books, 1961, p. 529-565.

Milner[28] studied the intellectual functions of 25 temporal lobe organic patients, 13 with damage to the right lobe and 12 with damage to the left, and a control group of 13 frontal and parietal lobe injuries on a battery of sixteen tests. She found that there were no significant differences between the temporal lobe groups and the control group on the Benton Visual Retention Test, but that the temporal lobe groups showed greater impairment on other visual tasks.

Meyer and Yates[29] studied a group of 18 temporal lobe brain damaged patients, divided into two equal groups on the basis of dominant and non-dominant lobe injuries, on the ability to retain new words and the ability to remember word associations. They found that the group with dominant lobe injuries showed severe impairment on both tests. Furthermore, this disability was present a year after their operations for temporal lobe epilepsy and appeared to be of a permanent nature.

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28 Brenda Milner, "Psychological functions of the temporal lobe", in the Psychological Bulletin, Vol. 51, No. 1, 1954, p. 42-62.

29 V. Meyer and A.J. Yates, "Intellectual changes following temporal lobectomy for psychomotor epilepsy, preliminary communication", in the Journal of Neurology and Psychiatry, Vol. 18, No. 1, 1955, p. 44-52.

Quadfasel and Pruyser[30] studied a group of epileptics with psychomotor seizures and EEG anterior temporal lobe spike foci, a group of epileptics exhibiting "Grand Mal" seizures and generalized EEG abnormalities and a group of normal controls on a battery of cognitive tests. The temporal lobe group produced a memory deficit on test items involving verbal material presented auditorily, but no such deficit was present on non-verbal items requiring the visual modality. The group with generalized abnormalities did not differ significantly from the normal controls. The authors, however, failed to control for dominance of injury.

Meyer[31] administered a battery of memory tests to a group of 25 temporal lobe organic patients matched for age, age of onset of illness, duration of illness, extent of damage, and dominance. The battery included a word learning test and tests of Auditory-Verbal-Recall, Auditory-Verbal-Recognition, Visual-Verbal-Recognition, Visual-Design-Recognition, Visual-Design-Recall, and Tactile-Design-Recall. The group was tested pre- and post-operatively. The results indicated that patients with non-dominant injuries showed no

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30 A.F. Quadfasel and P. Pruyser, "Cognitive deficit in patients with psychomotor epilepsy", Epilepsia, Vol. 4, no No., 1955, p. 80-90.

31 V. Meyer, "Cognitive changes following temporal lobectomy for the relief of temporal lobe epilepsy", in the Archives of Neurology and Psychiatry, Chicago, Vol. 81, no No., 1959, p. 299-309.

significant change, pre- and post-operatively, on any of the tests, while those with dominant lobe injuries showed significant impairment on tests of Auditory-Verbal-Recall and Recognition. The visual and tactual modalities were relatively unchanged. No relationship was found between extent of damage and performance on any of the tests. Unfortunately, the author was mainly interested in the effects of the operation and did not compare those cases with dominant lobe injuries to those with non-dominant lobe damage.

Most of the investigations studying memory deficit in temporal lobe brain damaged patients can be criticized on one or more points. First, many have failed to control for the degree of damage in their groups. Second, some have failed to control for dominance of injuries.

From the foregoing review of the literature, it was evident that most studies suffered from several defects which undermine the value of the conclusions which can be drawn with respect to the nature of memory deficits in brain damaged individuals. Aside from the various defects in design which have been mentioned, most studies employed tests of a complex nature measuring many functions at one time. When test performance depends upon a number of different functions, any lesion may lead to a significant test impairment through disturbance of any of the functions involved in a test and for different reasons.

To adequately analyze memory impairment in any meaningful manner a battery of memory tests, each of which measure some specific aspect of memory, is needed. With the advent of factor analysis it has been possible to describe more fully the functions which tests measure. The next section will introduce Guilford's theory of the structure of the intellect in which he proposed the use of factorial data in providing more accurate and meaningful assessment of intellectual losses in pathological groups. Particular attention will be paid to the matrix of memory factors which he proposed.

3. GUILFORD'S THEORY OF THE STRUCTURE OF THE INTELLECT

In 1956 Guilford published an article in which he proposed his hierarchical theory of the structure of the intellect. He stated that "It is the purpose of this report to describe a developing picture of the structure of the human adult intellect, as seen in terms of factors"[32]. Later publications[33,34] showed that by means of factor analysis, 46 factors of the intellect had been identified. These factors

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32 J.P. Guilford, "The structure of intellect", in the Psychological Bulletin, Vol. 53, No. 4, 1956, p. 267-293.

33 --------, "A revised structure of intellect", in the Reports from the Psychological Laboratory, University of Southern California, No. 19, 1957, 27 p.

34 --------, Personality, Toronto, McGraw Hill, 1959, xiii-562 p.

were divided into two broad categories, memory and thinking abilities. Within the group of thinking factors, a three-fold division is made into segments called cognitive factors, productive factors and evaluative factors. One further sub-division was made with respect to the productive factors. It was separated into two classes of thinking abilities labelled convergent and divergent thinking abilities. The memory abilities were not broken down into further divisions. Figure 1 is a schematic representation of the main categories of intellectual abilities.

Within each of the five main categories of abilities there were two principles for classifying the factors. One principle subdivided them according to the kind of product involved. Thus in memory, the kind of thing remembered; in cognition, the kind of thing known; in production, the kind of thing produced; and in evaluation, the kind of decision reached. A second principle of classification cut across the first. It had to do with the kinds of material or content upon which the functions of memory and thinking operate. There were three classes of content known to apply in this way; figural, symbolic, and semantic.

Figural content may be in visual form, the units of which have shape, color, size, and so on as properties. There are also figures in auditory form, such as melody, rhythm, and speech sounds. Symbolic content is best

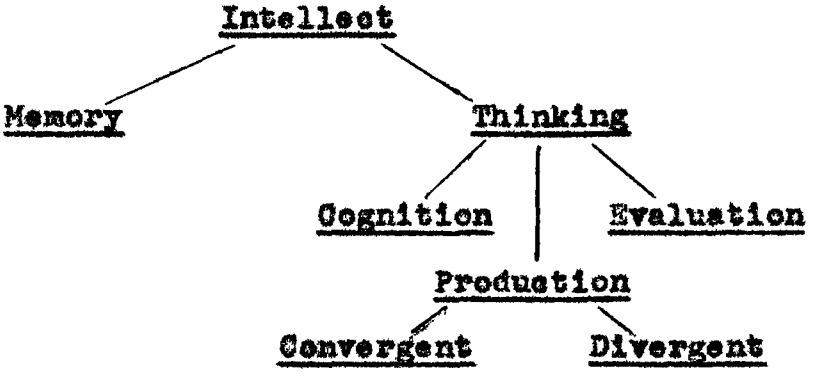

Figure 1. General plan of the relationships among the main categories of intellectual ability.[a]

a J.P. Guilford, Personality, Toronto, McGraw Hill, 1959, p. 360.

represented by such elements as letters or digits and such units as syllables, words, and sentences, where meaning does not matter. Semantic content is in the form of meanings or abstract ideas, tested by means of meaningful material. On the basis of these principles, Guilford drew up a matrix of factors for each of the five main categories of intellectual ability.

The tests from which the memory factors had been discovered usually involved giving the examinee some material that he was to inspect or some material composed of paired units that he was to learn. All examinees were given the same amount of time for learning. There was usually a fairly prompt testing of how much was retained, which involved reproduction or recognition of the material by the examinee or recall of one member of a pair of units in response to the presentation of the other member. Thus these factors represent the ability to memorize, ability to retain, or ability to use learned material in recall and recognition, or any combination of these abilities. The known memory factors are presented in Table I.

The rows represent the kind of thing remembered by the subject and the columns indicate the kind of content with which the subject must work. There are three general kinds of things remembered; substances or concrete things, associations or relations and systems or units in the form

Table I. - Matrix of Memory Factors.[a]

Kind of Thing Remembered	Kind of Content		
	Figural	Symbolic	Semantic
Substance	Visual and Auditory Memory	Memory Span	Memory for Ideas
Associations		Rote Memory	Meaningful Memory
Systems	Spatial Order		Temporal Order

a J.P. Guilford, Personality, Toronto, McGraw Hill, 1959, p. 362.

of order. The three kinds of content are figural, symbolic, and semantic, as defined earlier.

Within the figural-substance cell there are two known memory abilities. First is visual memory which is defined as the ability to recall, recognize, or reproduce material presented visually. Second is auditory memory which is defined as the ability to recall or recognize patterns in perceived sequences of auditory stimuli.

The symbolic-substance cell contains memory span which is defined as the ability to recall immediately a series of symbolic elements in correct order after a single exposure.

The semantic-substance cell contains memory for ideas which is defined as the ability to reproduce previously presented ideas, not verbatim.

There are no known figural-associative memory abilities as yet since this type of test has not been fully analyzed. In the symbolic-associative cell there is rote memory which is defined as the ability to remember units of material in naturally meaningless connections.

The semantic-associative cell contains meaningful memory which is defined as the ability to remember meaningful connections between units of material.

There are two factors of memory for systems. In the figural cell there is memory for spatial order which is defined as the ability to remember locations of objects. There

are no known symbolic-system memory abilities. The semantic-system cell contains memory for temporal order which is defined as the ability to remember the order in which events occurred.

Guilford made some speculations regarding the effect of pathology on his factors. He stated:

> There are many possible relationships of the intellectual factors to pathology. Defects in memory and thinking are common occurrences in connection with the intellectual losses that are associated with organic and functional pathologies. If we find by observation and experimental study that defects tend to be along the lines of intellectual factors, we have another source of evidence for the validity of the factors as functional unities. In practise, the use of measures of the factors may be helpful in providing more accurate and meaningful assessment of intellectual losses. Losses described in terms of factor concepts may help in understanding the types of pathology, and in providing better definitions and diagnostic criteria.[35]

To the present, only one study has been done applying Guilford's Theory of the Structure of Intellect to pathological groups. Sperazzo[36] studied convergent thinking abilities in schizophrenic and normal subjects. He found that schizophrenics showed a marked generalized impairment on all these abilities.

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35 J.P. Guilford, "The structure of intellect", in the Psychological Bulletin, Vol. 53, No. 4, 1956, p. 290.

36 G. Sperazzo, Convergent Thinking in Schizophrenics, unpublished Doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1960, viii – 102 p.

4. SUMMARY AND BASIC HYPOTHESIS

Numerous clinical studies on memory ability in brain damaged individuals have been reviewed. None of these have adequately dealt with the nature of memory loss in organic brain damaged patients. Most have been concerned with differentiating heterogeneous groups of brain damaged patients from other diagnostic categories on the basis of global memory impairment. A few have focused attention on the effect of different types of brain injury or disease on memory ability. Others have attempted to relate the amount of cerebral damage to memory impairment, while others have been concerned with localizing memory function within the brain. It is now generally agreed that damage to the temporal lobe results in memory loss for recent events, but the nature of this loss has rarely been explored. The question of whether there is a general loss of recent memory ability following temporal lobe damage or whether this loss involves only certain types of recent memory ability has never been resolved. This is mainly due to the complexity of the tests that have been used. When test performance depends upon a number of different functions, any lesion may lead to significant test impairment through disturbances of any of the functions involved in a test.

To provide more accurate and meaningful assessments of memory loss in brain damaged patients, a multidimensional theory of memory functions in terms of factor concepts was then presented along with the applicability of such concepts in the study of pathological losses.

This investigation attempted to analyze memory activity in dominant temporal lobe organic patients in terms of factor concepts. The writer sought to find an answer to two specific questions. First, do dominant temporal lobe organic patients show a greater loss of recent memory ability than non-temporal lobe organic patients and second, what is the nature of this loss, that is, do temporal lobe organics perform better on certain types of memory tests than on others? Stated in null form, the hypotheses will read: First, there are no significant differences between the performance of the dominant temporal lobe organic and non-temporal lobe organic patients on any of the memory tests. Second, there are no significant differences in the performance between any two tests in the dominant temporal lobe organic patients.

The following chapter presents the experimental design employed to test the hypotheses.

CHAPTER II

EXPERIMENTAL DESIGN

The experimental design begins with a description of the memory tests used, along with a description of the factors which they represent. This is followed by a description of the method of administration. The sample population is then described, with emphasis given to the criteria of selecting each subject. Finally, the statistical procedure for handling the data is presented.

1. TOOLS OF THE EXPERIMENT

Eight tests, each measuring a "pure" memory ability in accordance with Guilford's matrix of memory factors[1], were used in this investigation. All the memory tests involved giving the examinee some material that he was to inspect, either visually or auditorily, or some material composed of paired units that he was to learn to associate. All the examinees were given the same amount of time for learning. There was always a prompt testing of how much was retained, which involved reproduction or recognition of the material by the examinee or recall of one member of a pair of units in response to the presentation of the other member. Here

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1 J.P. Guilford, Personality, Toronto, McGraw Hill, 1959, p. 361-365.

is a brief description of the tests used.

1. Reproduction of Visual Designs[2] - The examinee, after seeing an outline geometric design, had to reproduce the design by drawing. Ten designs, arranged in increasing order of difficulty, were included in the test. A display time of five seconds was allowed for each design with ample time for reproduction. Each correct design received two points, and one point for each design with only minor deviations from the correct design. This test loaded heavily on visual memory, which was defined as the ability to recall, recognize, or reproduce material presented visually.

2. Sentence Completion Test[3] - In this test the examinee had to learn a group of unrelated sentences so that when presented with a sentence with one word omitted he could reproduce the missing word. When studying the sentence, the examinee did not know which word would be omitted. There were forty sentences included in the test, with the sentences arranged in random order in the performance part. A study time of four minutes was allowed with ample time for completing all the sentences during recall. The total score was the number of sentences completed correctly. This test

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2 H. Paul Kelley, "A factor analysis of memory ability", in the Research Bulletin, Princeton, Educational Testing Service, issue of April 1954, xiii-187 p.

3 Idem., ibid.

loaded heavily on meaningful memory, which was defined as the ability to remember meaningful connections between units of material.

3. Number Span Test I[4] - The examinee, after hearing a sequence of digits, had to reproduce the sequence. The sequences ranged in length from three to eleven digits. There were two sequences of each length, making eighteen sequences in all. Approximately one second per digit reading time was allowed with approximately one minute for recording each sequence of digits. The total score was the number of sequences completely correct. This test loaded heavily on memory span, which was defined as the ability to recall immediately a series of symbolic elements in correct order after a single exposure.

4. Picture Recall I[5] - The examinee was required to learn the details of a sketch representing a Venetian scene so that when he was presented with a sketch of another similar Venetian scene he could answer true-false questions about the similarities and differences of the two pictures. Thirty such true-false items were included in the test. A study time of five minutes was allowed to inspect the first picture and approximately five minutes was allowed to inspect the second picture and answer the true-false items. The

4 Idem., ibid.

5 Idem., ibid.

total score was the number of true-false items answered correctly. This test loaded heavily on memory for ideas, which was defined as the ability to reproduce previously presented ideas, not verbatim.

5. Memory for Numbers Test[6] - The examinee was required to learn pairs of words and numbers so that when he was presented with the word of a pair he could reproduce the number. Two parts, administered consecutively, made up this test with twelve word-number pairs in each part. A study time of one minute was allowed for each part with sufficient time to complete each pair in testing. The total score was the number of correct pairs. This test loaded heavily on rote memory, which was defined as the ability to remember units of material in naturally meaningless connections.

6. Tonal Memory Test[7] - The examinee, after hearing a short series of musical tones, indicated in a second similar short series which one tone had been changed. The test was made up of thirty tonal tasks. The second series was presented immediately after the first with approximately five seconds allowed for recording the correct response. Since the normative sample scores were pro-rated to a possible

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6 Idem., ibid.

7 J.E. Karlin, "A factorial study of auditory function", in the Psychometrika, Vol. 7, No. 4, 1942, p. 251-279.

score of 100, the total score was the number of correct responses multiplied by ten-thirds. This test loaded heavily on auditory memory, which was defined as the ability to recall, or recognize, patterns in perceived sequences of auditory stimuli.

7. Position Recall II[8] - The examinee was presented with four pages, each containing twelve drawings. The drawings were arranged on each page in four rows with three drawings in each row. He was later shown the same pictures, in random order, and asked to recall on which of the original study pages they were located. Thirty-six of the forty-eight pictures were used in testing. Exactly one and one-half minutes was allowed to study each page. The total score was the number of pictures correctly located. This test loaded heavily on memory for temporal order, which was defined as the ability to remember the order in which events occurred.

8. Space Memory Test[9] - The examinee was presented with five squares, each of which had been divided into five spaces containing a symbol. The examinee was required to learn the location of each symbol in each space of each square. A list of symbols was supplied during testing so

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8 Raymond E. Christal, "Factor analytic study of visual memory", in the Psychological Monograph, Vol. 72, No. 13, 1958, p. 1-24.

9 Idem., ibid.

that the examinee merely indicated which symbol belonged in each space. A list of twenty-seven symbols was given of which only twenty-five were the correct symbols. A study time of five minutes was allowed to inspect the five squares with ample time allowed for testing. The total score was the number of symbols correctly located. This test loaded heavily on memory for spatial position, which was defined as the ability to remember locations of objects.

The Tonal Memory test was a copywrited test and was purchased from the publisher. Test-copies and permission to use and reproduce copies of the remaining seven tests were secured from the original test constructors.

2. METHOD OF ADMINISTRATION

All the testing in this investigation was conducted by the writer. Since all the patients of the two hospitals utilized in this study were undergoing tests to determine rehabilitation and resocialization procedures, each examinee was told that the testing was part of this overall program. It was hoped that this statement at the outset of testing would provide sufficient motivation for each subject to perform as well as possible.

All the memory tests used in this investigation were administered as group tests. Each group contained five examinees; at times two from the experimental group and three

from the control group and at other times, three from the experimental and two from the control group. Once assigned to a group, the examinee remained in that group for the entire test situation. Six groups were tested. The order of testing was identical for each group.

Each examinee was completely tested in a single day; there were two testing sessions, one in the morning and one in the afternoon. In the morning session, the Reproduction of Visual Designs test was administered first. Following a two to three minute break, the Sentence Completion test was administered. A ten minute break, during which the examinees were allowed to leave the room, was given. After the break, they were administered the Memory Span Test I, followed by another two to three minute break. The Picture Recall I test was then administered; following which, the examinees were allowed to return to their wards for lunch. Similarily, the afternoon session began with the administration of the Memory for Numbers Test, followed by the Tonal Memory, Position Recall II, and Space Memory tests.

As a direct measurement of reliability, each group was retested on the entire memory battery on the third day after the initial testing. The test procedure on this day was identical in every respect to the initial testing session.

3. SAMPLE POPULATION

The population used in this investigation was composed of thirty hospitalized patients, both male and female, from the two Manitoba Provincial Hospitals for Mental Diseases. Two criteria were employed in the selection of the population. First, each subject had to be diagnosed as organic brain damaged or diseased in the usual hospital diagnostic conferences. In such case conferences, the staff of Medical Director, Clinical Director, psychiatrists, psychologists, and social workers use all means avaible to arrive at an accurate diagnosis in which the majority of the staff members must agree. If agreement cannot be reached, diagnosis is postponed until more information is avaible or until such time as unanimous agreement can be reached. Second, each subject had to show the same localized lesion on the two latest electroencephalographic records. The earliest of the two EEG records had to be within one and one-half years of the final EEG record. The final record had to be within a six month period prior to testing. Those subjects who did not have the latest record within this period were given electroencephalographic examinations prior to being selected for this investigation. The selected subjects were then divided into two groups, an experimental and a control group on the basis of the location of damage.

In selecting the experimental group, fifteen subjects of the two provinical hospitals meeting the above two criteria and showing EEG-localized lesions in the dominant temporal lobe, were given the Wechsler Adult Intelligence Scale[10] Vocabulary subtest to estimate their level of intellectual functioning. The Vocabulary subtest was chosen for three reasons. First, it shows a high correlation with the Full Scale I.Q. Second, it has been well established that organicity shows little or no interference with performance on this subtest. Third, the subtest is relatively free from any recent memory factors. This subtest was administered individually to each subject. The age, to the closest birthday, of each subject was recorded, as well as the type and amount of medication each subject was receiving. Dominance was evaluated on the basis of right or left handedness. Ideally, such a measure of dominance is admittedly very crude since lobe dominance is not necessarily identical with hand dominance. Theoretically, a measure of memory dominance would be needed for this investigation, but due to practical considerations a lesser measure was felt to be sufficient. All the dominant temporal lobe organics in the two hospitals who could read and write were included in the experimental group. Thus, in effect, the universe of such cases in Manitoba

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10 David Wechsler, The Measurement and Appraisal of Adult Intelligence, Baltimore, Williams and Wilkins, 1958, p. 61-144.

Mental Hospitals was included.

In selecting the control group, all the patients of the two hospitals meeting the two criteria mentioned earlier and showing EEG-localized lesions in any area but the dominant temporal lobe were given the WAIS Vocabulary subtest. Ages, to the closest birthday, were recorded as well as the type and amount of medication each subject was receiving. A control group of fifteen subjects was then selected to match the experimental group in terms of estimated I.Q., age and amount of medication. The groups were not controlled for sex, although each group contained approximately the same number of males and females.

All thirty subjects were on anti-convulsive medication, that is, Diphenylhydantoin (Dilantin) and/or Phenobarbital. The amount of medication taken by any one subject was never more than one and one-half grains three times a day. The average dosage of the two groups was fairly equal. Some subjects were on ataractic drugs, such as Trifluoperazine (Stelazine) and Chlorpromazine (Largactil), but these were only given periodically and in minimum dosages and should have no direct bearing on the results of this investigation.

The frequency distribution of estimated intelligence in scaled score units for both groups is presented in Table II.

Table II. - Frequency Distribution of Estimated Intelligence in Scaled Score Units for the Experimental and Control Groups.

Estimated Intelligence (Scaled Scores)	Experimental Group N =15	Control Group N =15
15	0	1
14	1	0
13	1	0
12	1	2
11	1	1
10	1	1
9	2	3
8	4	3
7	0	0
6	3	2
5	0	1
4	1	1
Mean	8.8	8.8

The estimated intelligence of the examinees ranged from 4 to 14 scaled score units in the experimental group and from 4 to 15 in the control group, with a mean of 8.8 scaled score units in both groups. This mean was slightly below the average mean of 10 scaled score units for the universe. The standard deviation for the experimental and control groups were 2.71 and 2.81, respectively. There was no significant difference between the mean estimated intelligence of both groups (t=0).

The ages of the examinees ranged from 17 to 57 years in the experimental group and from 16 to 56 years in the control group. The mean age of the experimental group was 38.53 years and of the control group 38.06 years. The standard deviations were 12.87 and 12.46, respectively. There were no significant differences between the ages of both groups (t=0.098). The frequency distribution of ages of the two groups is presented in Table III.

Although the degree of brain damage in each subject was difficult to evaluate, there were a number of reasons to assume that the groups were relatively equal in the amount of damaged suffered. First, all the subjects were ambulatory. Second, each subject had been, or could be, out of hospital for short periods of time and had been able to control his behaviour adequately. Third, the amount and kind of medication given to both groups was relatively equal. Fourth, all

Table III. - Frequency Distribution of Age for the Experimental and Control Groups.

Age Group	Experimental Group N =15	Control Group N =15
56 - 60	1	1
51 - 55	3	3
46 - 50	1	1
41 - 45	2	2
36 - 40	2	2
31 - 35	2	2
26 - 30	1	1
21 - 25	1	1
15 - 20	2	2
Mean	38.53	38.06

EEG records contained adjectives, such as slight or gross damage, to partially describe the amount of damage evident. Such adjectives were fairly well divided among the two groups. Tables IX and X in Appendix 1 present estimates of the degree of damage in both groups.

There are a number of reasons to suggest that the sample population selected for this investigation were representative of the universe of people with localized lesions. First, since the universe, or the majority of the universe, of both groups in Manitoba hospitals were tested it can be assumed that these groups would also be representative of the general population of Manitoba's EEG-localized organic patients not in hospitals. Second, Manitoba hospitals admit relatively the same percentage of organic patients as hospitals anywhere else in Canada. Third, Manitoba offers treatment services that are comparable to any other hospital in Canada, with the possible exception of the Neurological Clinic in Montreal. However, a few of the subjects in the sample population had received surgical treatment from this institution. Fourth, the population in Manitoba hospitals originate from all parts of Canada. In the sample population tested, subjects originated from points as far west as British Columbia and as far east as Nova Scotia.

4. STATISTICAL PROCEDURE

All the eight memory tests were scored twice in both the initial test and in the retest; any discrepancy in score was eliminated by a third scoring of that test. All scoring was done by the writer using the scoring methods called for by each test.

To provide comparable measures of each individual's performance on the eight memory tests, the raw scores were transformed into standard scores with reference to the distribution of scores obtained by the original standardization sample of each memory test. In order to rule out many of the negative values of the sample population scores, a mean of five and a standard deviation of two was arbitarily chosen to represent the transformed mean and standard deviation of the normative sample. Such transformed scores make it possible to indicate the individual's relative standing in the normative sample and thus permit an evaluation of his performance in reference to a "normal" population. This was done by substituting the normative sample means and standard deviations of each memory test into the following formula[11]:

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11 Quinn McNemar, Psychological Statistics, New York, Wiley and Sons, 1955, p. 38.

$$Z = \frac{S}{\sigma}(X) - \frac{M}{\sigma}(S) + K$$

where Z = the transformed score.
S = desired standard deviation, that is, 2.
σ = standard deviation of normative sample.
X = raw score of each individual in the sample population.
M = mean score of the normative sample.
K = desired mean score, that is, 5.

To estimate the reliability of each memory test, a test-retest reliability coefficient was computed using the Pearson Product Moment Coefficient of Correlation of raw scores[12]:

$$r = \frac{N\Sigma XY - \Sigma X \Sigma Y}{\sqrt{N\Sigma X^2 - (\Sigma X)^2}\ \sqrt{N\Sigma Y^2 - (\Sigma Y)^2}}$$

where r = coefficient of correlation.
N = number of individuals.
X = raw score on one test.
Y = raw score on another test.

To test the hypotheses outlined in the preceding chapter, the data was submitted to an analysis of variance using a mixed model, with a pseudo three-way classification[13]:

$$(X_{igt} - \overline{X}) = a_i + D_g + G_t + (DG)_{gt} + h_{igt}.$$

where $(X_{igt} - \overline{X})$ = an individual's score as a deviation from the total mean.
a_i = individual difference effects.
D_g = group effect.
G_t = test effect.
$(DG)_{gt}$ = group by test interaction effect.
h_{igt} = remainder effect.
igt = subscripts denoting individual, group, and test scores.

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12 Idem., ibid., p. 118.

13 Idem., ibid., P. 332-335.

Using this model, estimates of differences between individuals, between groups, and between tests may be achieved. The group by test interaction indicates differences among the profiles for the two groups. The remainder estimate is an indication of error variance.

In order to determine on which of the eight memory tests the groups differ, a *t* test of significance was calculated between the means of each test of the two groups:

$$t = \frac{M_1 - M_2}{\sigma_D}$$

where $M_1 - M_2$ = difference between the two means.
σ_D = standard error of the difference between two correlated means.

The standard error of the difference between two correlated means was calculated since the two groups were matched for age and estimated intelligence:

$$\sigma_D = \sqrt{\frac{2(\text{error variance})}{n}(1 - R^2_{1.23})}$$

where error variance = remainder variance estimate from analysis of variance.
n = number of subjects in each group.
$R_{1.23}$ = multiple correlation coefficient between test score, estimated intelligence and age.

The multiple correlation coefficient was computed by calculating the Pearson Product Moment Coefficient of Correlation between age and estimated intelligence; test score and estimated intelligence; and test score and age and

substituting these values into the following formula[14]:

$$R^2_{1.23} = \frac{r^2_{12} + r^2_{13} - 2r_{12}\, r_{13}\, r_{23}}{1 - r^2_{23}}$$

where r_{12} = coefficient of correlation between test score and estimated intelligence.
r_{13} = coefficient of correlation between test score and age.
r_{23} = coefficient of correlation between estimated intelligence and age.

In order to determine on which tests the experimental group showed the greatest loss, a *t* test of significance was calculated between the means of each test. Since the same individuals were measured on each test, the standard error of the difference between two correlated means was calculated in which the Pearson Product Moment Coefficient of Correlation was computed between scores of each test:

$$\sigma_D = \sqrt{\frac{2(\text{error variance})}{n}(1 - r^2_{12})}$$

where r^2_{12} = squared correlation coefficient between one test and another.

The following chapter will present the results of this investigation along with a discussion of their implications.

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14 Lawrence-T. Dayhaw, Manuel de Statistique, Ottawa, Éditions de l'Université d'Ottawa, 1958, p. 234.

CHAPTER III

PRESENTATION OF RESULTS

This chapter presents the results of this investigation in four sections. The first deals with the test-retest reliability of the memory battery. The second is a presentation of the intergroup and intratest differences in memory ability. The third section is concerned with the effects of age and estimated intelligence on memory ability. Finally, the fourth section presents a discussion of the results.

1. RELIABILITY OF THE MEMORY BATTERY

In order to test the reliability of each of the eight memory tests utilized in the battery, a test-retest reliability coefficient was established by the Pearson Product Moment Coefficient of Correlation of raw scores. The reliability coefficients for both groups on each of the eight memory tests are presented in Table IV.

The reliability coefficients for both groups range from 0.60 to 0.94, statistically significant correlations at P=.05 and at P=.01 being o.51 and 0.64, respectively. Although the test-retest coefficient values are relatively low, greater meaning can be attributed to these values since the tests making up the battery were relatively "pure" measures of memory. Ideally, a pure test is an univocal one, having

Table IV. - Test-Retest Reliability Coefficients on Eight Memory Tests for Experimental and Control Groups.

Memory Test	Experimental N=15	Control N=15
1. Reproduction of Designs	0.63	0.74
2. Sentence Completion	0.85	0.94
3. Number Span I	0.60	0.80
4. Picture Recall I	0.64	0.62
5. Memory for Numbers	0.65	0.69
6. Tonal Memory	0.61	0.92
7. Position Recall II	0.90	0.73
8. Space Memory	0.72	0.68

only one common factor. Correlations between such measures are less ambiguous than between tests measuring a complexity of factors where the coefficients could be raised by any one or a combination of factors. Furthermore, Guilford[1] stated that a high reliability coefficient can sometimes give the test user a false sense of security especially when the proportion of variance in the factor one wishes to measure is very low.

The reliability coefficients found in this investigation were in agreement with those of other investigators. Christal[2] reported split-half reliability coefficients of 0.80 for the Position Recall II, 0.92 for the Space Memory, and 0.85 for the Memory for Numbers tests. Karlin[3] obtained a communality of 0.50 for the Tonal Memory test on normal subjects, while Larson[4] obtained a split-half coefficient of 0.92 for this same test on a group of 1248 normal subjects.

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1 J.P. Guilford, Psychometric Methods, Toronto, McGraw Hill, 1954, p. 388.

2 Raymond E. Christal, "Factor analytic study of visual memory", in the Psychological Monograph, Vol. 72, No. 13, 1958, p. 1-24.

3 J.E. Karlin, "A factorial study of auditory function", in the Psychometrika, Vol. 7, No. 4, 1942, p. 251-279.

4 Ruth Crewdson Larson, "Studies on Seashore's measures of musical talent", in the University of Iowa Studies, Series on Aims and Progress Research, The University, Iowa, Vol. 2, No. 6, 1930, p. 1-24.

Kelley[5] obtained communalities of 0.51 for the Memory for Numbers test, 0.58 for the Sentence Completion test, 0.56 for the Number Span I test, 0.52 for the Reproduction of Visual Designs test, and 0.24 for the Picture Recall I test. From these communalities, to which specific variance should be added, one can estimate the square of the reliability coefficient.

2. INTERGROUP AND INTERTEST DIFFERENCES IN MEMORY ABILITY

Two hypotheses were presented in Chapter I. These were: First, there are no significant differences between the performance of the dominant temporal lobe organic and non-temporal lobe organic patients on any of the eight memory tests. Second, there are no significant differences in the performance between any two tests in the dominant temporal lobe organic patients. In order to test these hypotheses, the data was submitted to an analysis of variance in a mixed model with a pseudo three-way classification using the transformed scores of all eight memory tests for both groups. In this model, estimates of differences between individuals, between groups and between tests were achieved. The group by test interaction indicated differences among

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5 H. Paul Kelley, "A factor analysis of memory ability", in the Research Bulletin, Princeton, Educational Testing Service, 1954, xiii-187 p.

the profiles for each group. The remainder estimate was an indication of the error variance to be used for testing the significance of the test and group by test components. The results are presented in Table V.

From the table, it can be seen that the three F ratios are significant, two at the .001 level of confidence and one at the .01 level. An F ratio of 27.24 was obtained as an estimate of differences in test performance between the two groups, thus the first hypothesis, that there are no significant differences between the performance of the dominant temporal lobe organic and non-temporal lobe organic patients on any of the eight memory tests, is rejected. However, this merely points to a significant difference between the two groups on test performance and does not indicate which group scored significantly higher and on which tests they differed.

In order to determine on which of the eight memory tests the groups differed, a *t* test of significance was calculated between the transformed mean scores of each group for each test. The results are presented in Table VI.

Table V. - Summary of Analysis of Variance for Eight Memory Tests Among the Experimental and Control Subjects in a Pseudo Three-Way Model.

Source	Sum of Squares	df	Variance Estimate	F	P
Individuals	199.91	28	7.14		
Groups	194.49	1	194.49	27.24	.001
Tests	869.73	7	124.25	47.97	.001
Group by Test	70.89	7	10.13	3.91	.01
Remainder	508.90	196	2.59		
Total	1843.92	239			

Table VI. - Statistical Differences Between Groups on Eight Memory Tests.

Test	Stat.	Group Expt.	Group Cont.	Diff.	σ_D [a]	t	p
Reproduction of Designs	M	1.78	3.01	1.23	.53	2.32	.05
	σ	1.92	1.95				
Sentence Completion	M	-0.16	1.89	2.05	.53	3.87	.01
	σ	1.89	2.34				
Memory Span I	M	3.47	3.71	0.24	.57	0.42	-
	σ	1.75	1.75				
Picture Recall I	M	-2.75	-0.64	2.11	.55	3.84	.01
	σ	1.46	2.75				
Memory for Numbers	M	1.19	2.00	0.81	.56	1.45	-
	σ	0.74	1.00				
Tonal Memory	M	-2.31	1.95	4.26	.58	7.34	.001
	σ	0.93	2.25				
Position Recall II	M	3.08	5.33	2.25	.54	4.17	.001
	σ	1.86	1.46				
Space Memory	M	2.56	4.01	1.45	.55	2.64	.02
	σ	0.95	1.80				

a where $\sigma_D = \sqrt{\frac{2(\text{error variance})}{n}(1 - R^2_{1.23})}$

Significant differences of test performance between the two groups were evident on all but two of the memory tests. Performance on the Memory Span I and the Memory for Numbers tests were not significantly different between the two groups (t=0.42 and 1.45, respectively). However, the differences on the Tonal Memory and Position Recall II tests were significant at the .001 level, while the differences on the Picture Recall I and Sentence Completion tests were significant at the .01 level of confidence. The difference between the two groups on the Space Memory test was significant at the .02 level, and at the .05 level on the Reproduction of Visual Designs test.

The experimental group scored lower than the control group on all of the eight memory tests. The scores on the Tonal Memory test were most outstanding. The experimental group received a mean transformed score of -2.31, standard deviation of 0.93, and the control group received a mean transformed score of 1.95, standard deviation of 2.25, making a mean difference of 4.26. The F ratio between the two standard deviations is 2.42 which is not significant at the .05 level of confidence, indicating that the variability in the one group was not significantly different from the variability in the other group. The least amount of difference between the two groups occurred on the Memory Span I and Memory for Numbers tests. Although the control group scored higher on

these tests than the experimental group, the differences were not significant.

The difference between the two groups on the Tonal Memory test confirmed the findings of other investigations using different tests of auditory memory. Meyer[6] found that dominant temporal lobe organics showed a significant loss on tests of Auditory-Verbal-Recall and Auditory-Verbal-Recognition after lobectomy while such losses were not evident in non-dominant cases. Similarily, Quadfasel and Pruyser[7] found that temporal lobe organics showed a significant deficit on test items involving verbal material presented auditorily.

Studies conducted independently by the above authors and by Milner[8] indicated no significant losses or differences on visual memory tests which contradict the findings of the present investigation. However, each of these studies contained serious flaws which undermine the value of their conclusions. Meyer was interested only in changes resulting

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6 V. Meyer, "Cognitive changes following temporal lobectomy for the relief of temporal lobe epilepsy", in the Archives of Neurology and Psychiatry, Chicago, Vol. 81, no No., 1959, p. 299-309.

7 A.F. Quadfasel and P. Pruyser, "Cognitive deficit in patients with psychomotor epilepsy", in Epilepsia, Vol. 4, no No., 1955, p. 80-90.

8 Brenda Milner, "Psychological functions of the temporal lobe", in the Psychological Bulletin, Vol. 51, No. 1, 1954, p. 42-62.

from lobectomy and failed to compare dominant and non-dominant cases with each other. Quadfasel and Pruyser neglected to control for dominance and the extent of damage. Similarily, Milner failed to control for the extent of damage in each group. Since the difference between the two groups for the Reproduction of Visual Designs test in the present investigation was only significant at the .05 level, further research is indicated to validate this finding.

Meyer and Yates[9] found significant differences between dominant and non-dominant temporal lobe cases on a word association test but this type of test, although measuring a similar function, was not identical to the Memory for Numbers test used in the present investigation. The remaining tests in the present study had not been utilized in previous studies dealing with temporal lobe damage.

An F ratio of 47.97 was obtained as an estimate of difference in test performance among the eight memory tests for both groups. Thus the second hypothesis, that there are no significant differences between the performance on any two memory tests in the temporal lobe group, is also rejected. However, this merely indicated that both groups perform differently but does not indicate on which tests they do so.

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9 V.Meyer and A.J. Yates, "Intellectual changes following temporal lobectomy for psychomotor epilepsy, preliminary communication", in the Journal of Neurology and Psychiatry, Vol. 18, No. 1, 1955, p. 44-52.

In order to determine on which tests the experimental group showed the greatest loss and on which tests the least loss, a *t* test of significance was calculated between the mean transformed scores of each test. The results are presented in Table VII.

The lowest scores for the experimental group were obtained on the Picture Recall I ($M = -2.75$, $\sigma = 1.46$), Tonal Memory ($M = -2.31$, $\sigma = 0.93$) and Sentence Completion ($M = -0.16$, $\sigma = 0.92$) tests. From Table VII, it can be seen that the mean score on the Picture Recall I test does not differ significantly from the Tonal Memory mean score ($t = 0.73$). However, both are significantly lower than the Sentence Completion test ($t = 4.39$ and 3.64, respectively). Similarily, the Sentence Completion mean score is significantly lower than the remaining test scores (*t* ranges from 2.33 to 6.72). The fourth lowest score was obtained on the Memory for Numbers test ($M = 1.19$, $\sigma = 0.74$) which differs significantly from all other tests (*t* ranges from 2.33 to 7.03) except the Reproduction of Visual Designs test ($t = 1.29$). The Reproduction of Visual Designs test ($M = 1.78$, $\sigma = 1.92$) is significantly lower than the Memory Span I test ($t = 3.13$) but is not significantly different from the remaining tests (*t* ranges from 1.29 to 1.37). The three highest scores were obtained on the Memory Span I, Position Recall II, and Space Memory tests.

Table VII. - Tests of Significant Differences, Expressed in t-values, Among Eight Memory Tests in the Experimental Group[a].

Tests	Memory Test						
	Sent.	Span	Pict.	Numb.	Tonal	Posit.	Space
Rep.Designs	3.34	3.13	7.81	1.29	7.86	2.50	1.37
Sentence		6.72	4.39	2.33	3.64	5.90	4.61
Span			11.11	3.93	10.32	5.72	1.54
Picture				7.03	0.73	10.41	9.65
Number					7.00	3.20	3.81
Tonal						10.78	9.36
Position							1.00

a where t=2.15 at $P_{.05}$, 2.98 at $P_{.01}$, 4.14 at $P_{.001}$

The experimental group, therefore, scored lowest on the Picture Recall I, Tonal Memory and Sentence Completion tests, followed by the Memory for Numbers test. The degree of memory deficit on specific memory tests had not been explored in previous studies of memory functioning in patients with temporal lobe damage, therefore, no comparisons are possible.

The Group by Test Interaction in the analysis of variance indicated a significant difference among the profiles for the two groups at the .01 level of confidence ($F = 3.50$). However, this does not indicate whether the difference is one of degree or one of a different pattern of responses to the memory battery. Figure 2, a graphic representation of the mean transformed scores for both groups indicates that the pattern of responses was similar for both groups. A Rho of 0.91 was obtained between the rank order of mean scores for each test for both groups indicating that the control group scored lowest (or highest) on the same tests as the experimental group. Thus the difference among the profiles for the two groups is one of degree and not one of a different pattern of memory deficit.

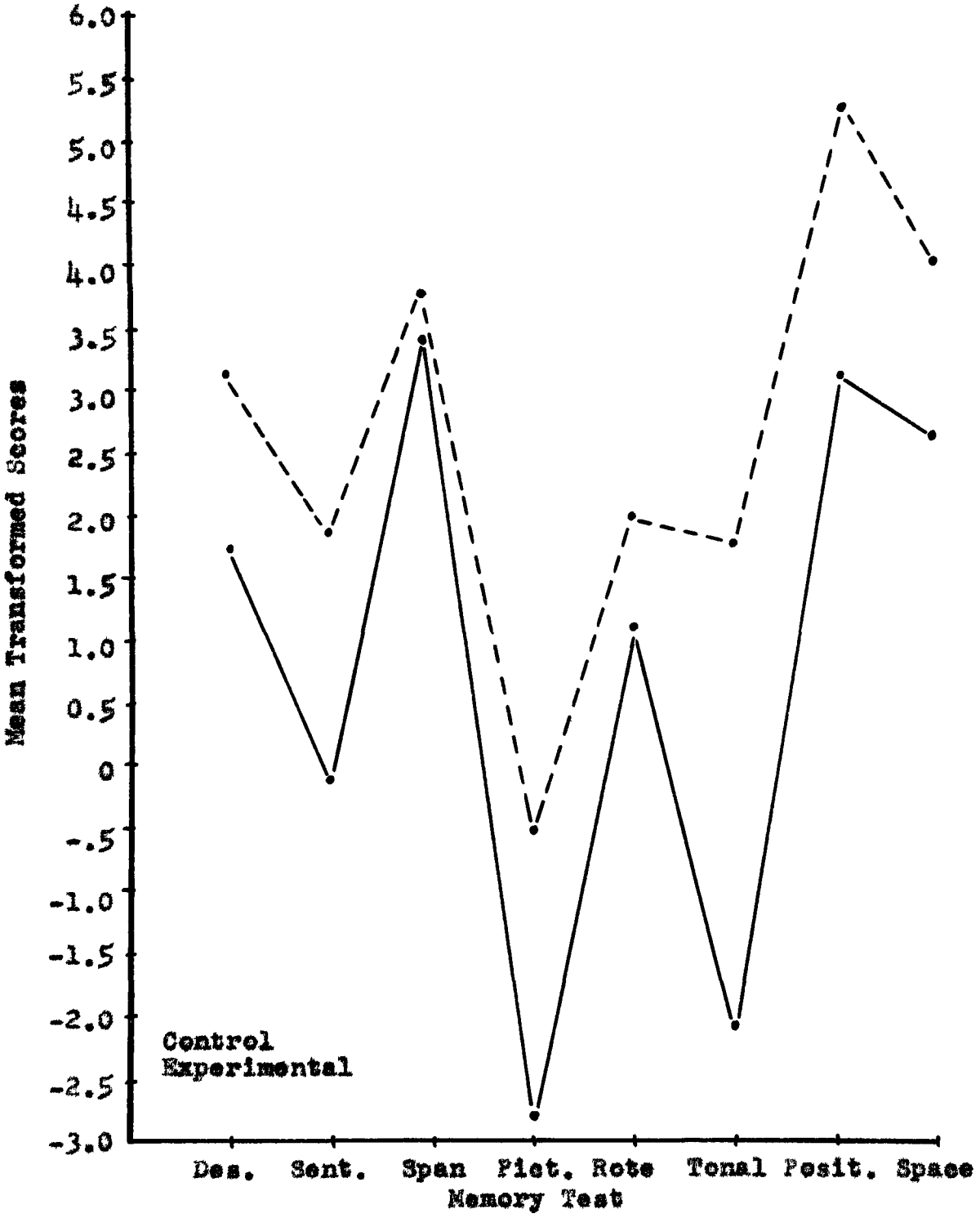

Figure 2. Mean Transformed Scores of the Experimental and Control Groups.

3. INFLUENCE OF AGE AND INTELLIGENCE ON MEMORY ABILITY

To evaluate the influence of age and intelligence on memory ability in brain damaged individuals, a multiple correlation coefficient was obtained between performance on each test and age and estimated I.Q. The Pearson Product Moment Correlation Coefficient of raw scores was obtained between test performance and age, test performance and estimated I.Q., and between age and estimated I.Q., for both groups combined. The results are presented in Table VIII.

The multiple correlation coefficients between test performance and age and estimated I.Q. for all eight tests are very small, ranging from 0.078 to 0.406. Only two memory tests, Reproduction of Designs and Sentence Completion, show significant correlations with age and estimated I.Q. at the .05 level of confidence. Similarily, the Pearson Product Moment Correlation coefficients between test performance and estimated I.Q. are very small ranging from 0.093 to 0.422. Only the Reproduction of Designs and Sentence Completion tests show significant correlations at the .05 level. Correlations between test performance and age range from -0.313 to 0.077, however, none are significantly different from zero at the .05 level of confidence. The correlation between age and estimated I.Q. is 0.006 and, of course, is not significantly different from zero.

Table VIII. - Coefficients of Correlation Between Test Performance, Age and Estimated I.Q. and Multiple Correlation for Combined Groups.

Test	Coefficient of Correlation[a]			
	r_{12}	r_{13}	r_{23}	$R_{1.23}$
Rep. Designs	.390	-.101	.006	.403
Sentence Comp.	.422	-.185	.006	.406
Memory Span	.132	-.125	.006	.182
Picture Recall	.093	-.313	.006	.327
Memory Numbers	.245	-.159	.006	.291
Tonal Memory	.006	.077	.006	.078
Position Recall	.229	-.266	.006	.352
Space Memory	.203	-.261	.006	.331

[a] where subscript 1 denotes test performance, 2 denotes estimated I.Q. and 3 denotes age.

The criticism, formulated by Eysenck and Halstead[10], that the practise of testing memory by the usual clinical tests was unsound, and that most tests measured intelligence rather than memory, was not upheld in this investigation. However, intelligence was assessed on the basis of a Vocabulary score in the present investigation and Meyer[11] and Meyer and Yates[12] compel caution in drawing conclusions if assessment was restricted to a single measure of intelligence. More intensive studies on the effect of intelligence on memory ability is indicated before definite conclusions could be drawn.

The same recommendation could be applied to the variable of age. Although the majority of investigations control for the factor of age, the effect of this variable on memory ability in cases of temporal or other localized brain damaged groups has rarely been explored. The present investigation pointed to the possibility that age does not influence

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10 H.J. Eysenck and B.A. Halstead, "The memory function, I, a factorial study of fifteen clinical tests", in the American Journal of Psychiatry, Vol. 102, 1945, p. 174-180.

11 V. Meyer, "Cognitive changes following temporal lobectomy for the relief of temporal lobe epilepsy", in the Archives of Neurology and Psychiatry, Chicago, p. 299-309.

12 V. Meyer and A.J. Yates, "Intellectual changes following temporal lobectomy for psychomotor epilepsy, preliminary communication", in the Journal of Neurology and Psychiatry, p. 44-52.

memory ability, however, this finding should be subjected to verification in larger groups of patients, with greater numbers in each age group.

The following section presents a discussion of the results and the significance of their implications.

4. DISCUSSION OF RESULTS

Three important findings have emerged from the results of this investigation. The first was that there were significant differences between dominant temporal lobe and non-temporal lobe brain damaged patients on all but two of the memory tests. Second, there were significant differences between memory tests in the temporal lobe brain damaged group in that certain memory abilities were more affected by brain damage than other memory abilities. Third, there were significant differences between the two groups in degree of memory loss, but not in the type of memory which was impaired.

These findings imply that the degree of immediate memory loss i dependent upon the locus of damage in the brain, but that the type of memory which is impaired is not related to any specific region of the brain. The three conventional theories on brain functioning[13] cannot adequately explain these results.

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13 V. Meyer, "Psychological effects of brain damage", in H.J. Eysenck, Editor, Handbook of Abnormal Psychology, An Experimental Approach, New York, Basic Books, 1961, p. 529-565.

The Associationism or Anatomical theory of brain functioning claimed that certain parts of the cerebral cortex are associated with specific types of function and that specific cells have the property of receiving only specific impressions. This theory could well explain the finding that certain types of memory were more impaired than others, however, it cannot explain the finding that this type of loss was similar in both groups. Furthermore, it cannot account for the degree of loss evident in the temporal lobe group.

The Field theory or the Theory of Equipotentiality claimed that the entire brain is responsible for all functions and any loss of function would depend upon the extent of damage to the brain. This theory could only explain part of the results of the present investigation. Since both groups were matched for extent of damage to the brain, this theory could only explain why certain types of memory ability were impaired in both groups alike, however, it cannot explain why one group showed a greater degree of memory loss than the other group.

The theory of Regional Equipotentiality or Functional Equivalence claimed that certain functions are dependent upon certain structural areas of the brain and damage to any given area would result in loss of function that is dependent upon that area. This theory could adequately explain the differences in degree of memory loss in both groups, but it could

not explain why certain types of memory were more impaired than others in both groups alike.

In order to explain the results of this investigation, a less dichotomous view of brain functioning is necessary. Guilford[14] presented evidence based on factorial analysis supporting an hierarchical view of cognitive and personality factors. It is plausible to postulate then that the functioning of the brain is also arranged in an hierarchical way. This view was supported by results, presented by Tueber and Weinstein[15], which presented an hierarchical finding for visual performance in the brain. They found that lesions which produced focal changes within the visual system also affected certain functions throughout this system, and the latter alterations were accompanied by more general deficits which occurred irrespective of the locus of injury.

In terms of the present study, an hierarchical view of brain functioning with respect to memory ability is possible. It would appear that any lesion in the brain produces a memory deficit, however, certain regions produce a greater degree of specific deficit than other regions. Thus

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14 J.P. Guilford, Personality, Toronto, McGraw Hill, 1959, xiii-562 p.

15 Hans-Lukas Tueber and Sidney Weinstein, "General and specific effects of cerebral lesions", in the American Psychologist, Vol. 10, No. 8, 1955, p. 408-409.

temporal lobe damage results in a large degree of memory loss for ideas, auditory stimuli, meaningful material, and a lesser degree of loss on other memory functions. The fact that the non-temporal lobe group showed a similar pattern of loss, but to a lesser degree, indicates that any alteration in the brain is accompanied by memory deficits irrespective of the locus of injury.

Further investigation, exploring the possibility of loss in similar non-memory functions in temporal lobe organics, should prove fruitful and would add greater weight to an hierarchical model of brain functioning.

A summary of this investigation and the conclusions drawn are presented in the following section.

SUMMARY AND CONCLUSIONS

This investigation attempted to analyze memory impairment in dominant temporal lobe brain damaged patients using "pure" measures of memory ability. The purpose was two-fold. The first was to evaluate the importance of localization of injury on memory impairment. The second, was to evaluate the nature of the memory loss in such brain damaged individuals.

The hypothesis that no significant differences existed between dominant temporal lobe and non-temporal lobe brain damaged patients on any of the memory tests was rejected. It was found that dominant temporal lobe damage resulted in greater impairment in auditory memory, memory for ideas, meaningful memory, memory for spatial position, memory for temporal order and visual memory, but not in memory span and rote memory.

The second hypothesis that no significant differences existed between different memory abilities following dominant temporal lobe damage was also rejected. It was found that damage to the temporal lobe resulted in greatest impairment to auditory memory, meaningful memory and memory for ideas. However, this pattern of memory deficit was similar in patients with damage to other areas of the brain and only differed in the degree of impairment.

A theory postulating that the functioning of the brain is arranged in an hierarchical fashion was presented to explain the results of this investigation. It was postulated that lesions which produce specific changes within a sensory system also affect certain other functions throughout the entire system, and these alterations in turn are accompanied by still more general deficits which occur with injury in any region of the brain.

These findings suggest other areas of exploration. Attempts should be made to determine if other functions of the intellectual domain, such as convergent, divergent, cognitive, and evaluative thinking abilities, are also ordered in an hierarchical manner within the brain. Once this is done, investigations could be carried out to determine whether the various intellectual functions could be brought into a single hierarchy. This could be expanded to determine whether or not an hierarchical model could apply to other areas of personality.

BIBLIOGRAPHY

Christal, Raymond E., "Factor analytic study of visual memory", in the Psychological Monograph, Vol. 72, No. 13, 1958, p. 1-24.

Presented factorial evidence that memory is not a unitary trait, but rather is composed of many specific types of memory. Two of the purest tests were utilized in this project.

Guilford, J.P., Personality, Toronto, McGraw Hill, 1959, xiii-562 p.

The culmination of two earlier works dealing with the structure of personality and especially of the adult human intellect in terms of factor concepts. Many tests of intellectual functioning in terms of factor models are suggested from which the memory battery utilized in this project was incorporated.

Kelley, H. Paul, "A factor analysis of memory ability", in the Research Bulletin, Princeton, Educational Testing Service, 1954, xiii-187 p.

Presented factorial evidence for differentiation of memory ability into many specific types of memory. Five of the purest tests, one for each specific memory ability, were utilized in the present project.

Klebanoff, S.G., "Psychological changes in organic brain lesions and ablations", in the Psychological Bulletin, Vol. 42, No. 9, 1945, p. 585-623.

Presented an extensive critical review of the literature up to 1945, outlining areas which lack experimentation.

--------, Singer, J.L. and Wilensky, H., "Psychological consequences of brain lesions and ablations", in the Psychological Bulletin, Vol. 51, No. 1, p. 1-41.

A continuation of the previous review up to 1954.

Meyer, V., "Psychological effects of brain damage", in H.J. Eysenck, Editor, Handbook of Abnormal Psychology, An Experimental Approach, New York, Basic Books, 1961, p. 529-565.

An extensive critical review of the literature relating experimental findings to theories on brain functioning. It outlines the many pitfalls of research work in this area with practical suggestions for overcoming these. It was used extensively in setting up the experimental design of the present project. It is strongly recommended for anyone

contemplating research with brain damaged individuals.

Tueber, Hans-Lukas and Weinstein, Sidney, "General and specific effects of cerebral lesions", in the American Psychologist, Vol. 10, No. 8, 1955, p. 408-409.

Although an extremely short article, it was the first study to present experimental evidence for an hierarchical theory of brain functioning.

APPENDIX 1

CHARACTERISTICS OF THE SAMPLE POPULATION

The localized area and estimated degree of brain damage for each subject in the experimental group is presented in Table IX. The same information for the control group is presented in Table X.

Table IX. - Localized Area and Estimated Degree of Damage in the Experimental Group.

Subj.	Localized Area of Damage	Estimated Degree of Damage
1	Left Temporal	Moderate
2	Left Temporal	Mild
3	Left Posterior Temporal	Moderate
4	Left Temporal	Mild
5	Left Temporal	Moderate
6	Left Temporal	Moderate
7	Left Temporal	Severe
8	Right Temporal	Moderate
9	Left Temporal	Severe
10	Left Temporal	Moderate
11	Left Temporal	Mild
12	Right Temporal	Mild
13	Left Posterior Temporal	Moderate
14	Left Temporal	Moderate
15	Left Temporal	Moderate

Table X. - Localized Area and Estimated Degree of Damage in the Control Group.

Subj.	Localized Area of Damage	Estimated Degree of Damage
1	Left Frontal	Severe
2	Left Parieto-Midline	Moderate
3	Right Fronto-Central	Moderate
4	Left Occipital	Severe
5	Left Parieto-Occipital	Mild
6	Left Parieto-Midline	Mild
7	Right Frontal	Moderate
8	Left Inferior Frontal	Moderate
9	Left Frontal	Moderate
10	Left Frontal	Moderate
11	Right Cerebrum	Moderate
12	Left Frontal	Severe
13	Left Frontal	Mild
14	Left Frontal	Mild
15	Left Frontal	Moderate

APPENDIX 2

CHARACTERISTICS OF THE MEMORY BATTERY

The standardization data on the normative sample for each memory test is presented in Table XI. This is followed by a presentation of the test intercorrelations for the experimental group in Table XII. Following this, each of the tests utilized in this investigation are presented.

Table XI. - Standardization Data on the Normative Sample for Each Memory Test.

Test	N	M	σ	Factor Load.	r_{tt}	Author
Rep. Designs	442	17.21	2.08	.55	.52[b]	Kelley[d]
Sentence Compl.	442	19.64	6.64	.53	.58[b]	Kelley
Number Span I	442	7.40	2.23	.57	.56[b]	Kelley
Picture Recall	442	23.18	3.27	.22	.24[b]	Kelley
Memory Numbers	442	10.60	4.75	.53	.51[b]	Kelley
Tonal Memory	200	72.43[a]	15.15[a]	.36	.50[b]	Karlin[e]
Position Recall	367	13.50	5.80	.34	.80[c]	Christal[f]
Space Position	353	11.10	6.60	.64	.92[c]	Christal

a As reported by Ruth Crewdson Larson, "Studies on Seashore's measures of musical talent", in the University of Iowa, Series on Aims and Progress of Research, The University, Iowa, Vol. 2, No. 6, 1930, p. 1-84.

b Communalities.

c Split-half reliability coefficients.

d H. Paul Kelley, "A factor analysis of memory ability", in the Research Bulletin, Princeton, Educational Testing Service, 1954, xiii-167 p.

e J.E. Karlin, "A factorial study of auditory function", in Psychometrika, Vol. 7, No. 4, 1942, p. 251-279.

f Raymond E. Christal, "Factor analytic study of visual memory", in the Psychological Monograph, Vol. 72, No. 13, 1958, p. 1-24.

Table XII. - Test Intercorrelations for Eight Memory Tests for the Experimental Group.

Tests	Memory Test						
	Sent.	Span	Pict.	Numb.	Tonal	Posit.	Space
Rep.Designs	-.10	-.36	.08	.61	-.42	.43	.19
Sentence		-.34	.01	-.14	.02	-.30	-.06
Span			.29	.10	.28	-.07	.04
Picture				.28	.05	.29	.31
Numbers					-.50	.07	.79
Tonal						-.50	-.43
Position							.43

NAME:_____
(print) Last First Middle

This book contains 8 tests. The examiner will tell you when to begin and end each test. During the time allowed for one test you are to work only on it. Do not turn back to a test after the time for that test is over.

For all the tests in this book you are to mark your answers in the spaces provided in the book.

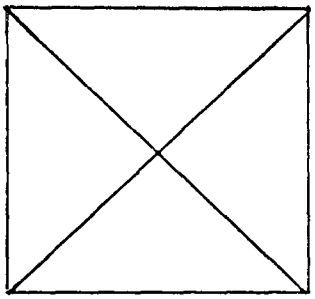
There are several types of tests. You will find special directions for each type. Be sure you understand the directions before attempting to answer any questions.

Do Not turn this page until you are told to do so.

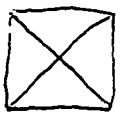
APPENDIX 2

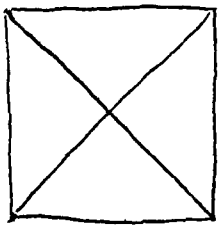
REPRODUCTION OF VISUAL DESIGNS TEST

This test is intended to measure your ability to remember designs. The examiner will hold up a card on which there will be a simple design. You are to study this design so that when it is removed, you can draw a copy of it. For example, one design might be like this:

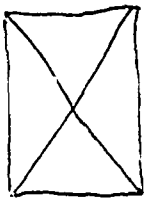


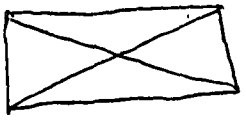
When the examiner removes the card containing the design, draw a copy of the design on the answer page. Only one design is to be drawn on each answer page. You may make the drawing any size you want, but try to reproduce the proportions and parts of the original design as well as possible. For example, these would be good copies:





These would be poor copies:





There will be ten designs. After each design has been removed, draw a copy of it. You will be allowed to study each design for only 5 seconds. It is important that you do not begin drawing until the examiner has removed the card.

Are there any questions?

SENTENCE COMPLETION TEST

This test is a sentence completion memory test. You will be given 4 minutes to study a group of 40 sentences. The sentences will then be presented to you in a different order with one word left out of each sentence. Your task is to write in the word which has been omitted.

The following two sentences are examples of the type of sentence you may expect.

George's barn is red.

The sun causes the trees to grow.

The answer page would look like this:

The _____ causes the trees to grow.

George's barn is _____.

You would write the word "sun" in the blank space in the first sentence and the word "red" in the blank in the second sentence.

DO NOT TRUN THIS PAGE UNTIL TOLD TO DO SO.

Study the following sentences.

The farm was all but deserted.

In spite of the darkness the progress continued.

All the blouses on sale were silk.

In increasing one's education one benefits.

A flood had prevented their arrival.

Much training is required to be a musician.

The maroon sedan crashed into the school bus.

Every week there is a change.

The lawyer's dog has brown spots.

The invasion was far from welcome.

The rumor was beginning to grow.

Lost buttons must be found.

The new car is ready to be delivered.

The library is the coolest place in town.

Wealthy people have plenty of spare clothes.

The perfume left him feeling dizzy.

Some outstanding engineers make large salaries.

The failure was very expensive.

In making a costume, one must be careful.

The round vase was placed on the table.

GO ON TO THE NEXT PAGE.

The fire last night burned the hospital.

He was pleased when his hat was returned.

The little lambs had just been born.

The key was found on the sidewalk.

This book on fishing is very good.

The crime was not an important one.

After the game they all went to the zoo.

The aluminum ring was hard to see.

Seeing his sweetheart, he jumped for joy.

Mary's sister ran away from home.

When it rains the brook usually overflows.

When the need arises, he can be aroused.

On hearing the bell he started running.

Everyone in the area was growing corn.

The exclamation was followed by silence.

His vacation was completely wasted.

He didn't receive the notice until too late.

When the police arrived, he had already finished.

Occasionally John goes to the opera.

According to the dictionary it was not so.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO.

The sentences below are the ones you studied just a few minutes ago. Fill in the blank in each sentence with the word which was in it before.

DO NOT TURN BACK TO THE PREVIOUS STUDY MATERIAL IN ANSWERING THESE QUESTIONS.

1. This book on _____ is very good.
2. A _____ had prevented their arrival.
3. When the need arises, he can be _____.
4. When the _____ arrived, he had already finished.
5. Occasionally John goes to the _____.
6. In spite of the _____, the progress continued.
7. The _____ was very expensive.
8. All the blouses on sale were _____.
9. The _____ was all but deserted.
10. The _____ sedan crashed into the school bus.
11. Much training is required to be a _____.
12. The _____ ring was hard to see.
13. Every week there is a _____.
14. The _____ was beginning to grow.
15. Some outstanding _____ make large salaries.
16. The _____ left him feeling dizzy.
17. The _____ is the coolest place in town.
18. Lost _____ must be found.
19. After the game they all went to the _____.
20. The _____ was far from welcome.

GO ON TO THE NEXT PAGE.

21. The _____ was not an important one.
22. Wealthy people have plenty of spare _____.
23. The _____ was followed by silence.
24. The fire last night burned the _____.
25. The key was found on the _____.
26. He didn't receive the _____ until too late.
27. Seeing his _____, he jumped for joy.
28. On hearing the _____ he started running.
29. His _____ was completely wasted.
30. The little _____ had just been born.
31. The new _____ is ready to be delivered.
32. Everyone in the area was growing _____.
33. In making a _____ , one must be careful.
34. The round _____ was placed on the table.
35. According to the _____ it was not so.
36. The _____ dog has brown spots.
37. He was pleased when his _____ was returned.
38. In increasing one's _____ one benefits.
39. Mary's _____ ran away from home.
40. When it rains the _____ usually overflows.

STOP. DO NOT GO ON TO THE NEXT TEST UNTIL TOLD TO DO SO.

NUMBER SPAN TEST

In this test, the examiner will call out a series of numbers. After he finishes, you are to write down the numbers in the exact order in which they were called out. Do not write any numbers until the examiner has finished the whole series.

For example, the examiner might call out, "Series One. 7 2 4 Now"

When he says "Now" showing that the series is complete, write the numbers on the answer page in this manner:

1. 7 2 4

Some of the series will be too long for you to remember all of the numbers. If you do not remember some of them, leave a blank space for them and write down all the numbers you do remember. Try to remember all the numbers if possible, and be sure to write them down in the exact order in which they were called out.

It is very important that no numbers be written while the examiner is calling the numbers out, since the test is intended to measure memory for numbers.

Now turn to the next page, the answer page, and wait for the numbers to be called out.

14

NUMBER SPAN TEST

Answer Page

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____

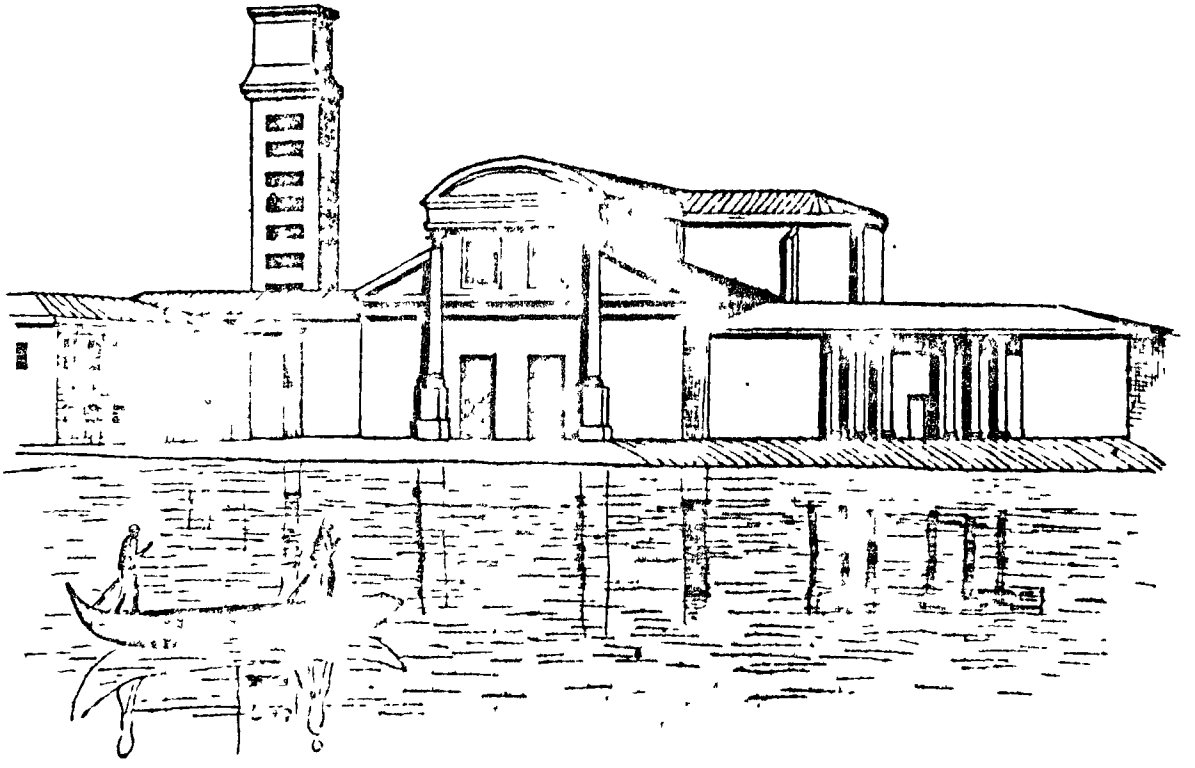
STOP. DO NOT GO ON TO THE NEXT TEST UNTIL YOU ARE TOLD TO DO SO.

MEANINGFUL MEMORY TEST

Part 1A

Time—5 minutes

Directions: Study the picture below. Later you will be shown a picture which is similar to this one but which differs from it in several respects, and you will be asked to compare the two. You will not be allowed to look back at the picture below when you are shown the second picture.



Picture 1

STOP. DO NOT GO ON TO PART 2A UNTIL YOU ARE TOLD TO DO SO.

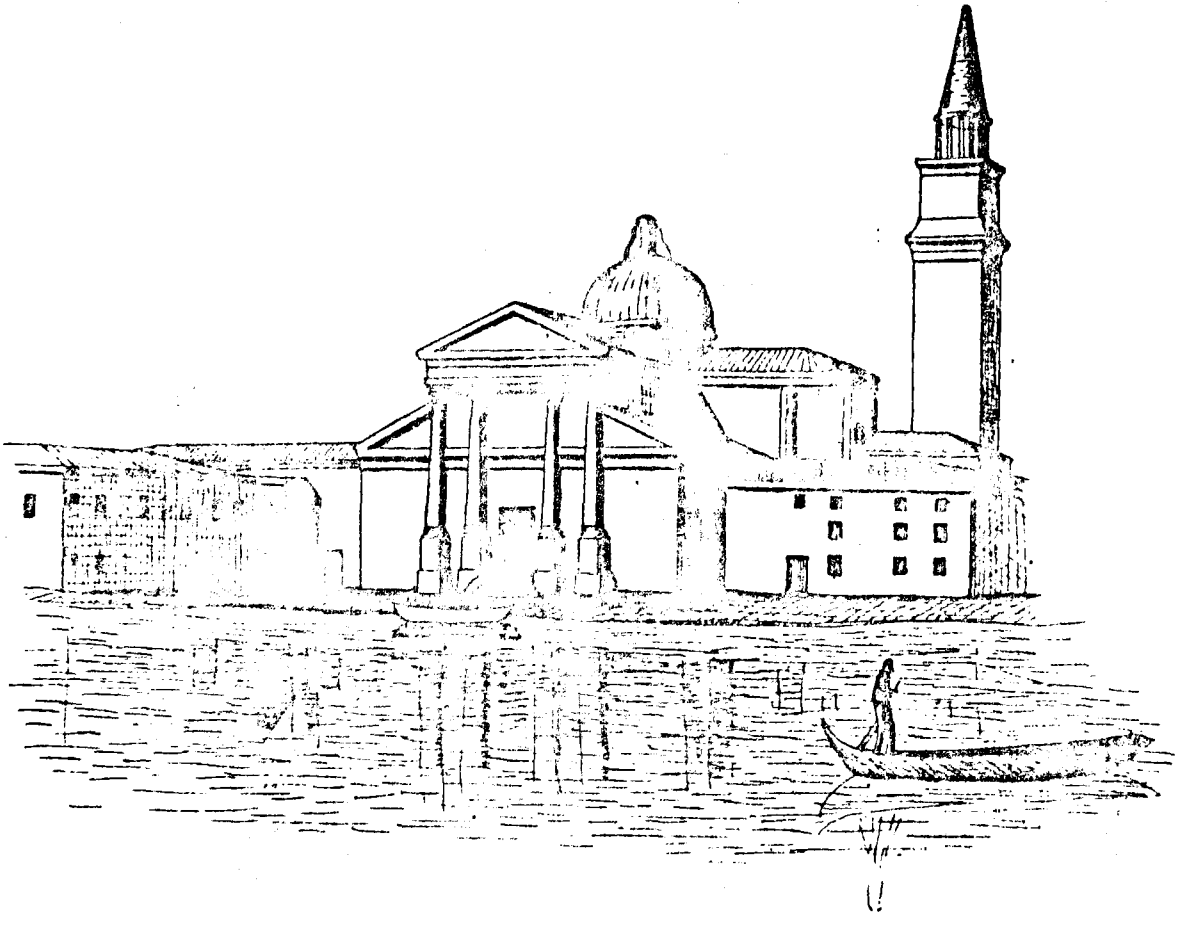
APPENDIX 2

MEANINGFUL MEMORY TEST

Part 1B

Time—5 minutes

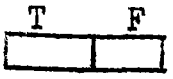
Directions: The picture below (picture 2) is similar to the one which you saw earlier (picture 1), but you will observe that a number of changes have been made. Study picture 2 and then indicate whether each of the following statements is true or false. If you think the statement is true, mark the space beneath the T; if you think it is false, mark the space beneath the F.



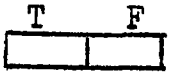
Picture 2

T	F		
		1.	There were two doorways at the main entrance of the palace in picture 1.
		2.	There was no circular dome in picture 1.
		3.	The roof over the main entrance came to a peak in picture 1.
		4.	The tower appeared on the opposite side in picture 1.
		5.	There were no steps leading to the main entrance in picture 1.
		6.	A conical dome has been added to the tower in picture 2.

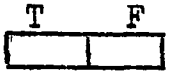
GO ON TO THE NEXT PAGE.



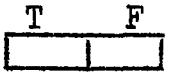
7. There were four pillars at the main entrance in picture1



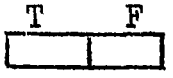
8. The right wing of the palace(i.e., the wing to your right) had no windows in picture 1.



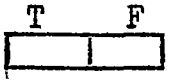
9. There were two boatmen in the gondola in picture 1.



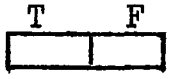
10. Several windows were visible in the tower in picture 1.



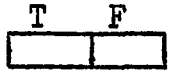
11. There was a passenger sitting in the gondola in picture 1.



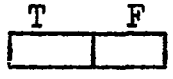
12. The portico in the right wing of the palace in picture 1 had exactly four pillars.



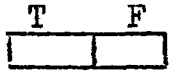
13. The shadows in picture 1 were cast in the opposite direction from those in picture 2.



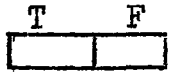
14. An inscription appeared over the entrance in picture 1.



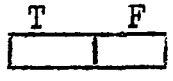
15. The front of the right wing in picture 1 was wider than the front of the same wing in picture 2.



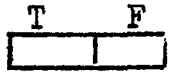
16. Several steps led to the portico shown in the right wing of picture 1.



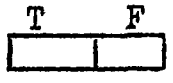
17. There was an empty gondola near the shore in picture 1.



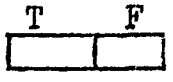
18. There were two windows above the main entrance in picture 1.



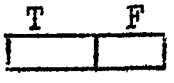
19. The door in the right wing of picture 1 was in the same position as the door in the right wing of picture 2.



20. Exactly twelve windows were visible in the left wing of the palace in picture 1.



21. Two doors were visible through which to enter the left wing of the palace in picture 1.



22. The columns at the center of picture 1 had the same design as the columns appearing in picture 2.

GO ON TO THE NEXT PAGE.

You may refer to picture 2 in answering these questions. 18

T F

23. The rooftop which appears closest to the base of the tower in picture 2 was not visible in picture 1.

T F

24. There was a large knocker on one of the doors in picture 1.

T F

25. There was a small circular window near the top of the tower in picture 1.

T F

26. The gondola shown in picture 1 was not in the same position as the one in picture 2.

T F

27. The pointed end of the gondola in the foreground faced in the same direction in picture 1 as in picture 2.

T F

28. There was a first-floor window on each side of the main entrance in picture 1.

T F

29. There was a crack in the base of one of the columns at the center of picture 1.

T F

30. The cornice about two thirds of the way up the tower was not present in picture 1.

STOP. DO NOT GO ON TO THE NEXT TEST UNTIL YOU ARE TOLD TO DO SO.

MEMORY FOR NUMBERS TEST

In this test you will be given 1 minute to study 12 pairs of words and numbers. Each pair will consist of a word followed by a number. You are to memorize the pairs so that when the word is given you can answer with the number which correctly completes the pair.

For example, the following pairs are like the ones you will study:

bird - 49

core - 17

time - 83

After studying the pairs for 1 minute you will be told to turn to the answer page. On it you will be given the word in each pair. In the blank space after each word you are to write from memory the number which completes the pair.

The answer page for the pairs given above might look like this:

core - _____

time - _____

bird - _____

In the first blank you would write the number "17", in the second blank the number "83", and in the third blank the number "49". Notice that the pairs on the answer page will not be in the same order as the pairs on the study page.

This test will have two parts. The directions for each part are exactly the same -- study the pairs, then fill in the blanks on the answer page.

Are there any questions?

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

Study the following pairs:

tone - 72

band - 39

team - 45

past - 81

crab - 13

salt - 74

case - 42

pool - 26

dish - 63

song - 58

twin - 96

lamb - 17

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

ANSWER PAGE

DO NOT TURN BACK TO THE PREVIOUS PAGE IN ANSWERING QUESTIONS.

1. case - _____
2. band - _____
3. fire - _____
4. song - _____
5. past - _____
6. tone - _____
7. dish - _____
8. team - _____
9. salt - _____
10. pool - _____
11. lamb - _____
12. hair - _____

STOP. DO NOT GO ON TO PART 2 UNTIL YOU ARE TOLD TO DO SO.

Part II

Study the following pairs:

wind - 15

door - 97

silk - 28

plan - 32

west - 76

mail - 52

scar - 44

loaf - 89

fish - 61

tree - 85

corn - 47

tent - 93

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

Part II

Answer Page

DO NOT TURN BACK TO THE PREVIOUS PAGE IN ANSWERING QUESTIONS.

1. plan - _____
2. tree - _____
3. door - _____
4. west - _____
5. silk - _____
6. fish - _____
7. tent - _____
8. scar - _____
9. wind - _____
10. corn - _____
11. mail - _____
12. loaf - _____

STOP. DO NOT GO ON TO THE NEXT TEST UNTIL YOU ARE TOLD TO DO SO.

APPENDIX 2

25

MUSICAL MEMORY

Answer Page

Listen to the instructions on the tape recording before you answer.

	A	B	C
Series One			
Series Two			
Series Three			
Series Four			
Series Five			
Series Six			
Series Seven			
Series Eight			
Series Nine			
Series Ten			

Stop. DO NOT GO ON TO THE NEXT TEST UNTIL YOU ARE TOLD TO DO SO.

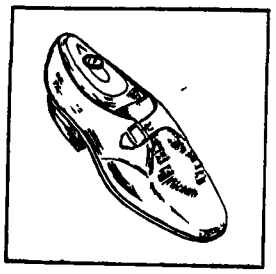
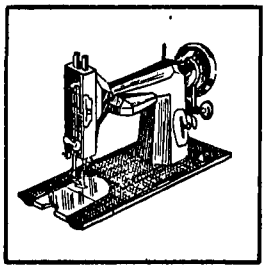
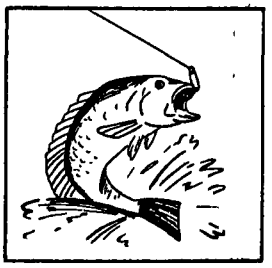
POSITION RECALL II

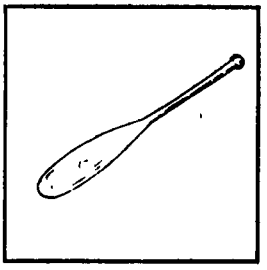
In this test you will study four pages of figures in succession. Study one page until you are told to turn to the next page, then study that page until you are told to turn to the next and so on. Try to remember what figures are shown on each page. Later you will be asked to indicate the page number for each figure you have seen.

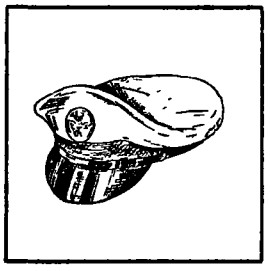
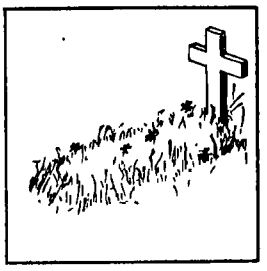
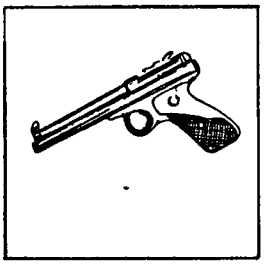
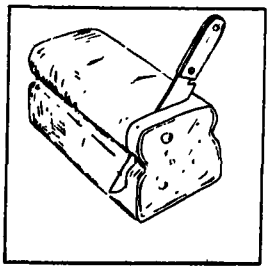
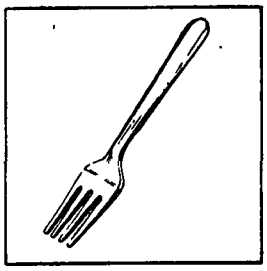
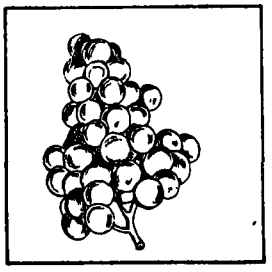
Remember, you study one page at a time. Try to remember what figures belong to each page.

STOP. DO NOT TURN THE PAGE UNTIL YOU ARE TOLD TO DO SO.

Page 1



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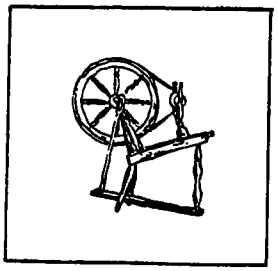
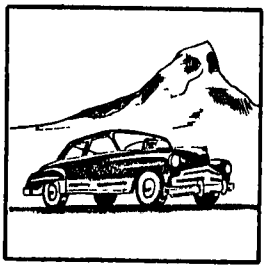
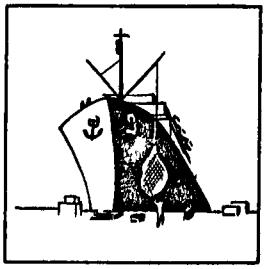
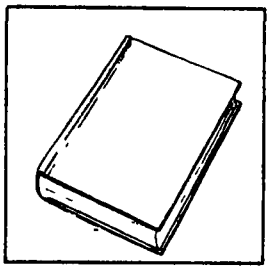
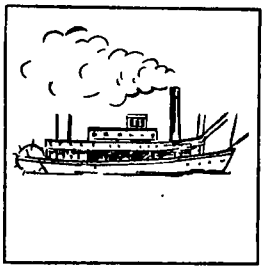
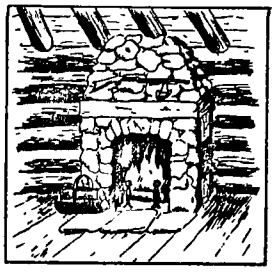
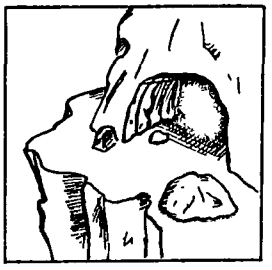
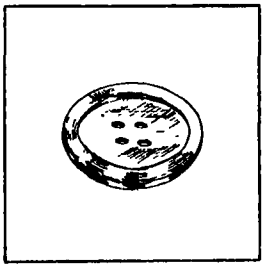

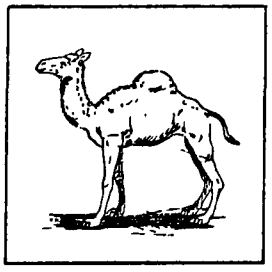
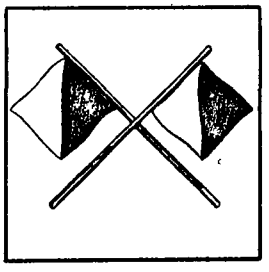
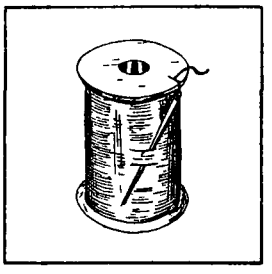

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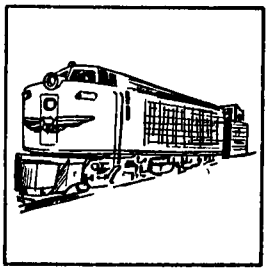
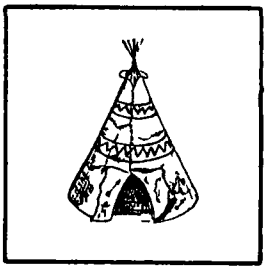
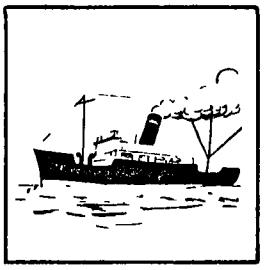

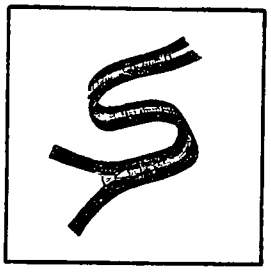
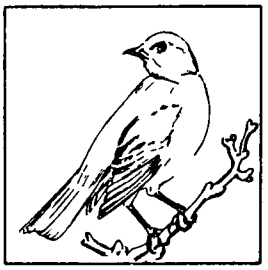
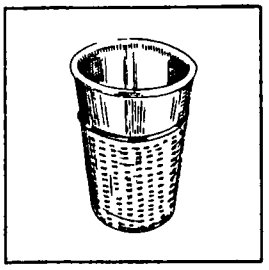
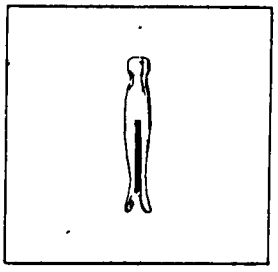
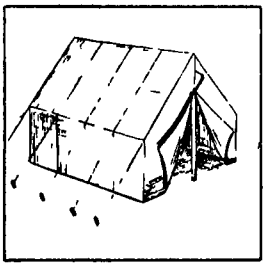
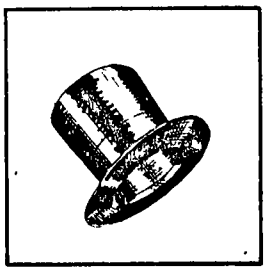

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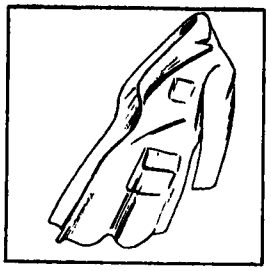

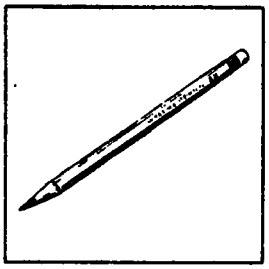
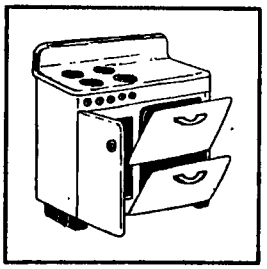
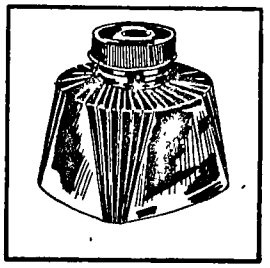
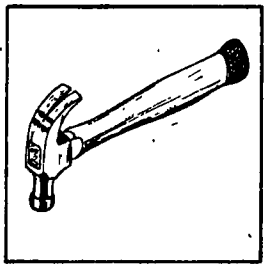
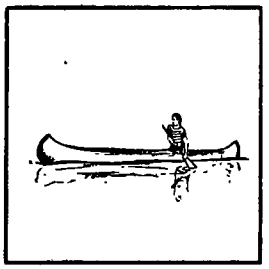
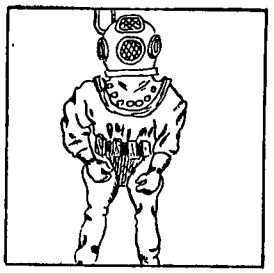
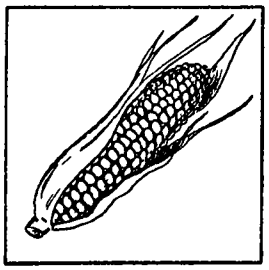
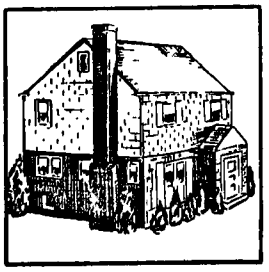


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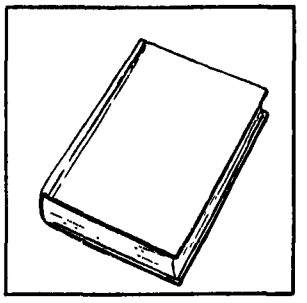

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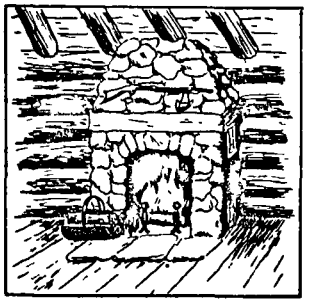

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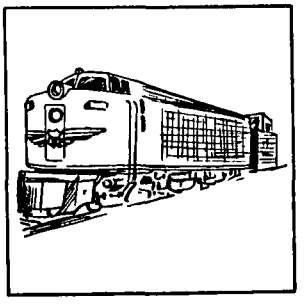

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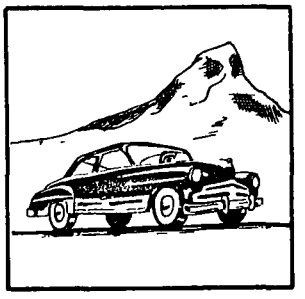

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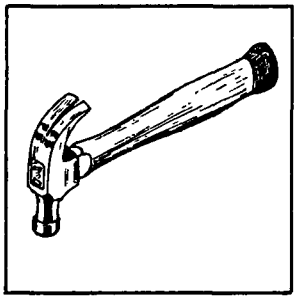

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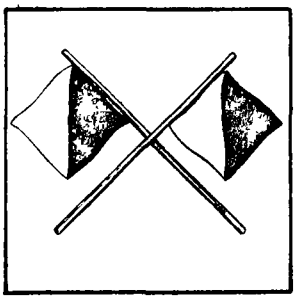

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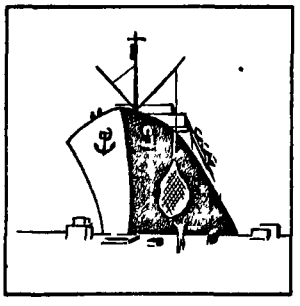

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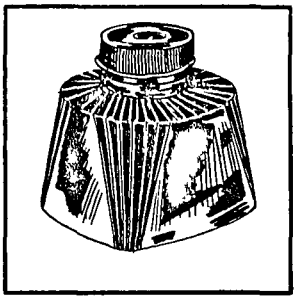

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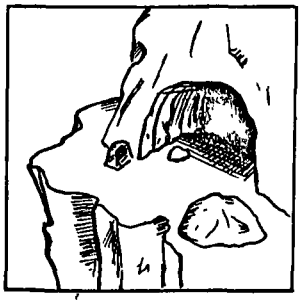

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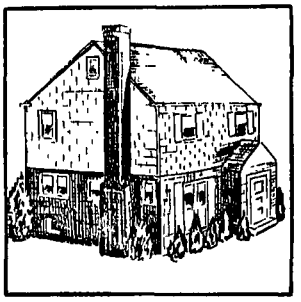

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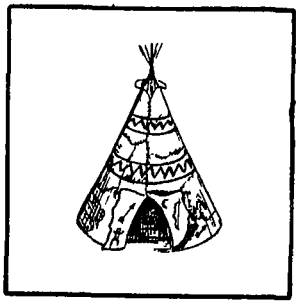

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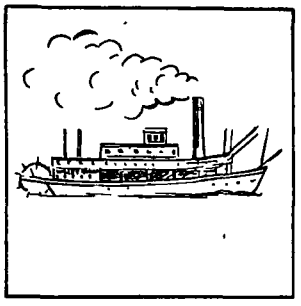

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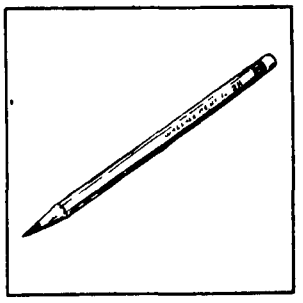

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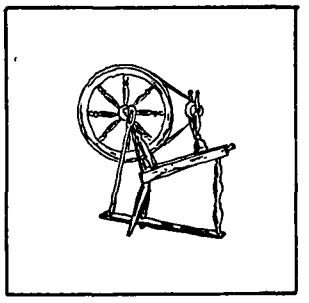

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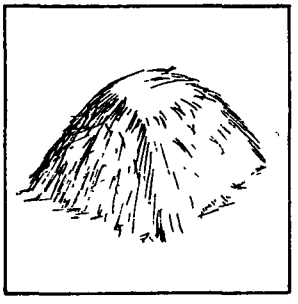

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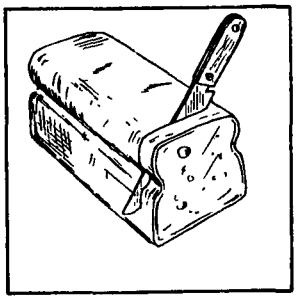

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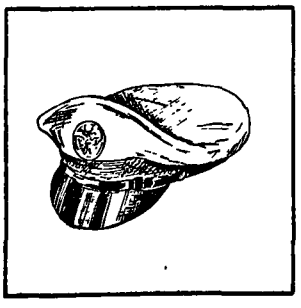

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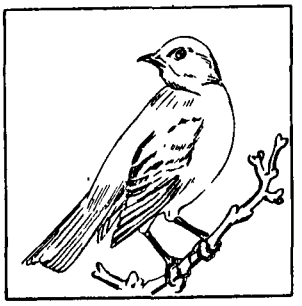

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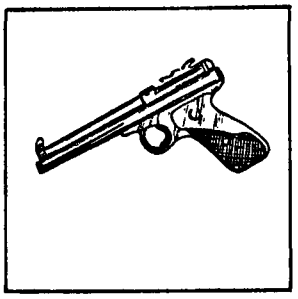

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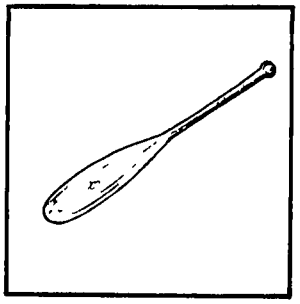

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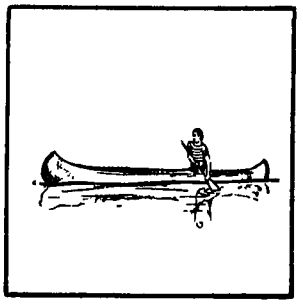

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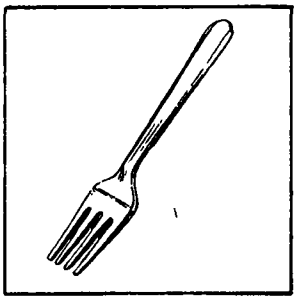

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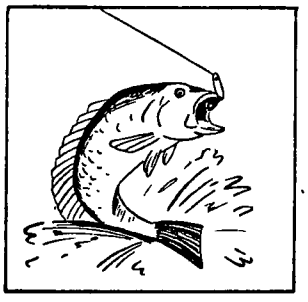

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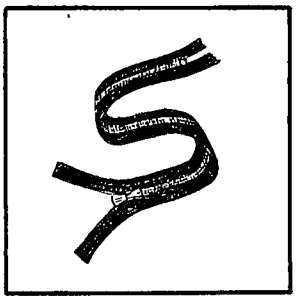

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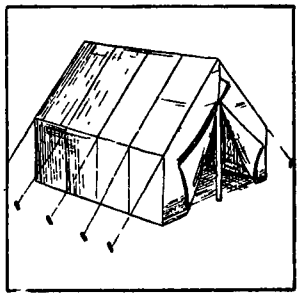

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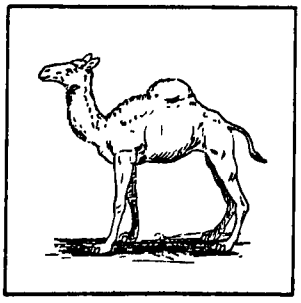

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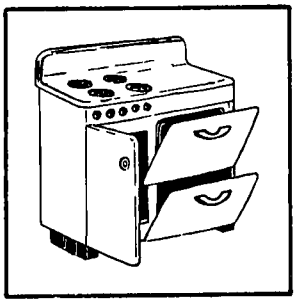

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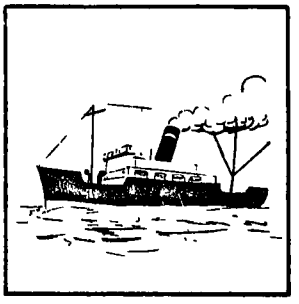

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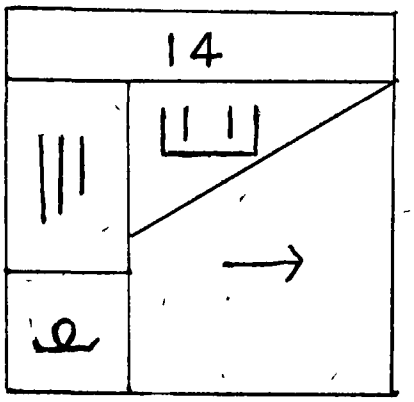
SPACE MEMORY

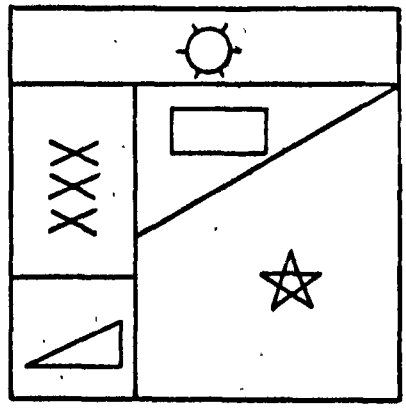
This test will test your ability to remember locations of objects. On the next page you will find five squares like the one below:

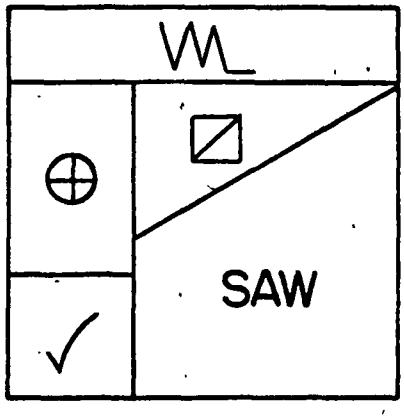


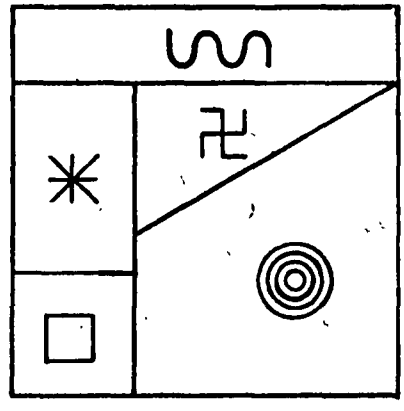
You will notice that this square has been divided into five spaces. Each of these spaces contains a symbol. You are to study each of the symbols on the next page so that you will be able to remember where it was located. In each case you will need to remember in which of the five squares it appeared and also in which of the five spaces in that square it appeared. After you have studied the page you will be asked to remember the location of each of the symbols.

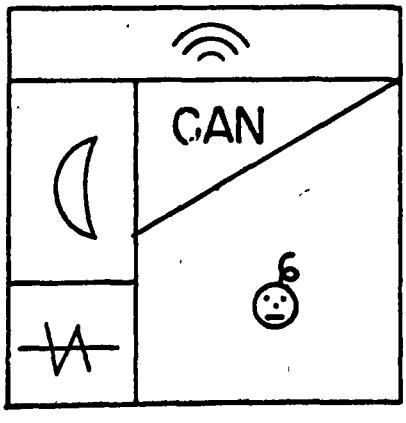
Are there any questions?

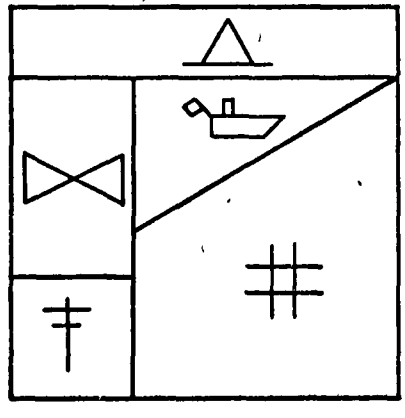
DO NOT TURN THE PAGE UNTIL YOU ARE TOLD TO DO SO.











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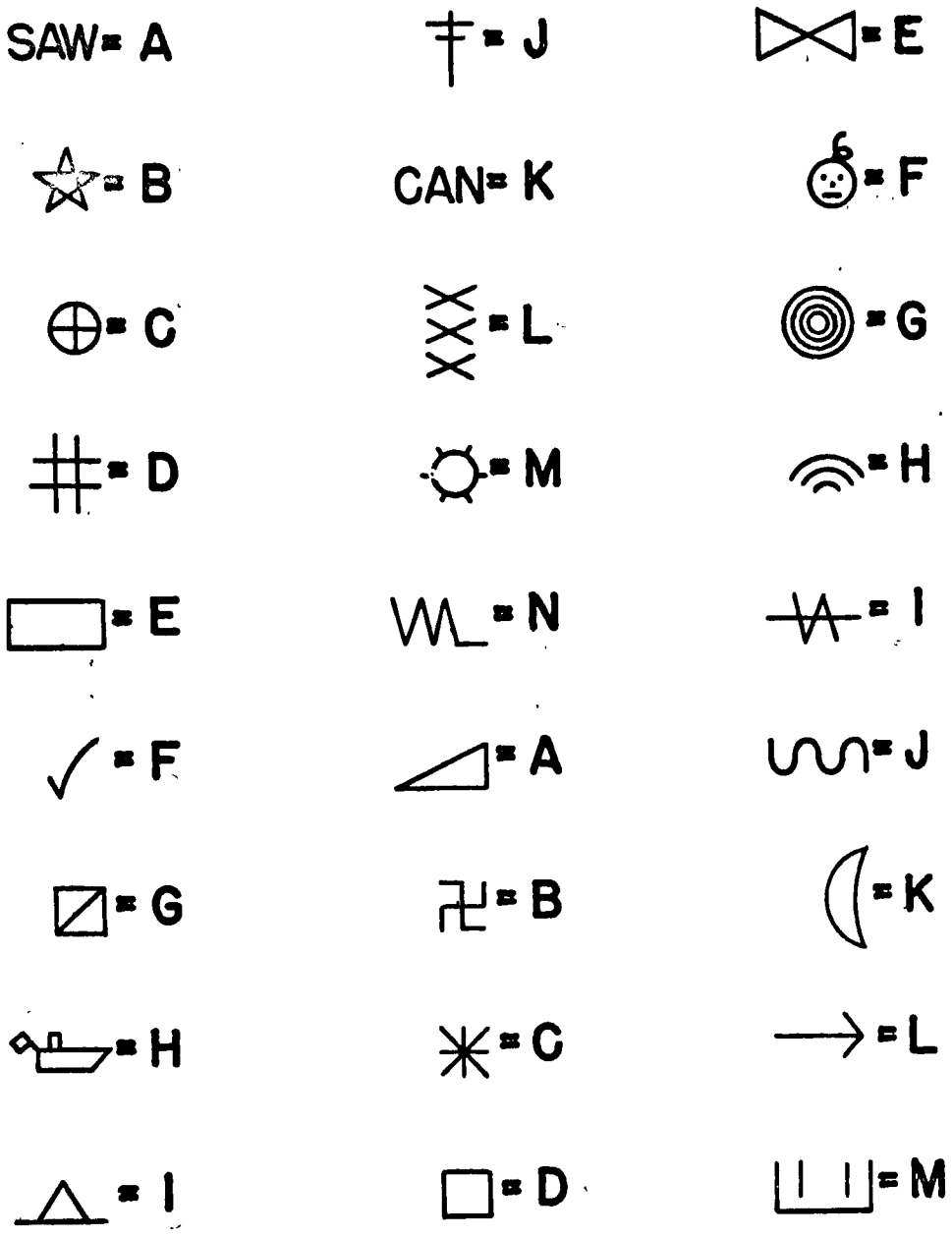
SAW= A
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CAN= K
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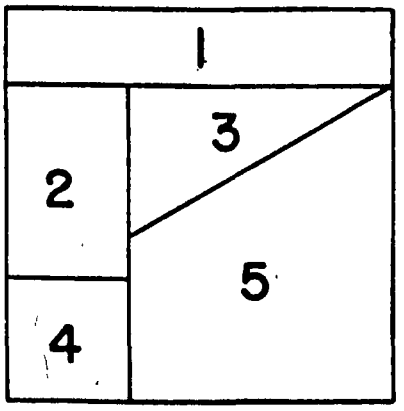

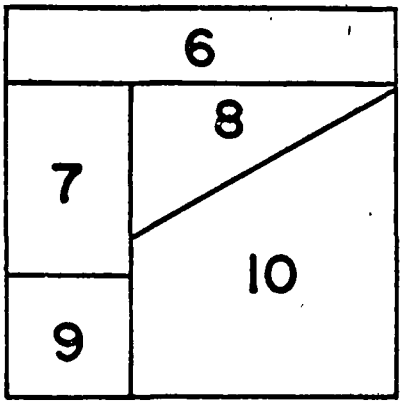

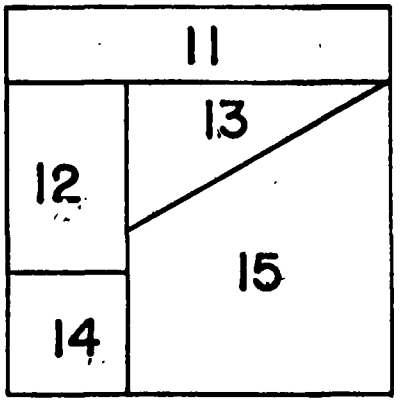

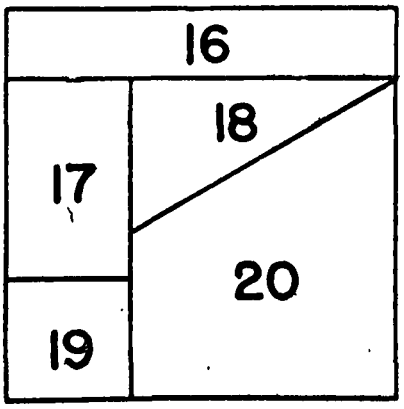

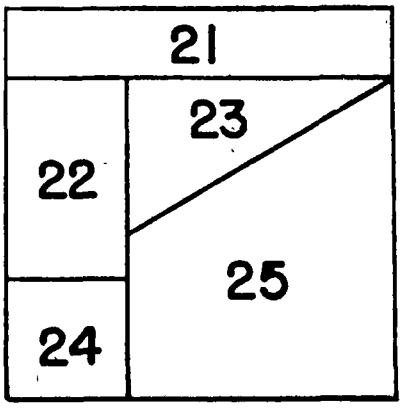

Air Force - Scott AFB, Il/82-2746

APPENDIX 3

PRESENTATION OF THE RAW DATA

Raw scores during the initial test session on the eight memory tests for the experimental group are presented in Table XIII. The retest scores are presented in Table XIV. Similar data for the control group are presented in Tables XV and XVI, respectively.

Table XIII. - Initial Test Raw Scores on Eight Memory Tests for the Experimental Group.

	Memory Test							
N	Rep. Designs	Sent. Comp.	Numb. Span	Pict. Recall	Mem. Numb.	Tonal Mem.	Posit. Recall	Space Mem.
1	12	2	7	12	2	17	10	3
2	9	1	5	10	0	10	4	1
3	17	4	6	9	4	13	5	4
4	12	1	6	8	4	27	10	4
5	14	0	4	10	2	20	7	3
6	9	2	4	11	0	17	10	4
7	14	0	4	9	0	20	16	5
8	9	1	5	9	0	20	16	0
9	17	3	4	10	2	20	5	0
10	4	0	8	5	0	20	2	3
11	4	0	10	14	0	3	0	0
12	12	3	7	17	6	27	16	13
13	12	4	8	15	0	13	14	1
14	6	13	3	11	0	17	0	1
15	6	3	5	8	2	3	5	3
Mean	10.47	2.46	5.73	10.53	1.46	16.46	8.00	3.0

Table XIV. - Retest Raw Scores on Eight Memory Tests for the Experimental Group.

	Memory Test							
N	Rep. Designs	Sent. Comp.	Numb. Span	Plst. Recall	Mem. Numb.	Tonal Mem.	Posit. Recall	Space Mem.
1	17	3	5	13	3	17	8	2
2	12	4	4	9	0	13	4	3
3	20	5	7	9	2	13	9	5
4	12	3	6	12	4	25	12	4
5	12	1	5	6	0	17	5	4
6	14	2	3	11	1	20	9	3
7	12	0	4	12	0	17	10	3
8	17	3	4	8	0	20	16	2
9	9	0	6	10	2	20	4	3
10	4	1	6	8	0	17	4	3
11	6	0	6	10	1	10	0	1
12	14	2	5	15	4	25	16	13
13	12	5	7	16	1	17	16	0
14	6	10	3	10	2	13	2	0
15	4	4	4	10	4	3	7	2
Mean	11.40	2.86	5.00	10.60	1.60	16.73	8.13	3.20

Table XV. - Initial Test Raw Scores on Eight Memory Tests for the Control Group.

	Memory Test							
N	Rep. Designs	Sent. Comp.	Numb. Span	Plct. Recall	Mem. Numb.	Tonal Mem.	Posit. Recall	Space Mem.
1	14	15	8	16	4	30	20	10
2	17	18	6	17	4	27	14	15
3	17	15	7	20	6	33	16	8
4	12	9	5	15	2	40	13	13
5	17	27	8	14	6	70	10	8
6	12	19	7	19	2	50	18	6
7	9	5	4	14	0	80	16	1
8	4	7	7	17	12	70	16	4
9	17	10	5	17	0	50	16	8
10	14	6	4	12	6	70	22	4
11	17	1	4	4	0	50	10	5
12	9	1	5	12	0	50	10	1
13	14	4	5	16	4	47	16	10
14	17	1	10	15	4	47	16	24
15	6	1	5	5	2	20	5	1
Mean	13.07	9.26	6.00	14.20	3.46	48.93	14.53	7.86

Table XVI. - Retest Raw Scores on Eight Memory Tests for the Control Group.

	Memory Test							
N	Rep. Designs	Sent. Comp.	Numb. Span	Pict. Recall	Mem. Numb.	Tonal Mem.	Posit. Recall	Space Mem.
1	17	14	7	18	5	27	18	8
2	14	20	6	20	4	30	16	10
3	17	17	7	17	3	30	14	10
4	12	9	5	16	5	50	14	15
5	19	28	6	20	6	70	12	10
6	17	15	6	18	0	50	16	10
7	12	10	3	12	1	70	16	2
8	6	6	4	10	6	80	12	3
9	14	12	4	15	3	60	16	6
10	17	10	4	15	5	70	20	6
11	12	5	5	6	1	60	18	4
12	12	6	4	14	2	60	8	0
13	12	6	6	15	3	50	14	13
14	17	3	9	15	5	50	18	15
15	12	4	4	8	2	27	10	8
Mean	14.00	11.00	5.33	14.60	3.40	52.40	14.80	8.00

APPENDIX 4

ABSTRACT OF

Memory in Organic Patients with Damage Involving the Dominant Temporal Lobe[1]

Clinical experience with brain damaged patients indicates that defective memory, especially for recent events, is a common symptom. However, very few objective studies concerning the nature of memory impairment have been reported in the literature.

This project was concerned with the nature of recent memory impairment, analyzed in terms of factor concepts, in dominant temporal lobe brain damaged patients as opposed to those suffering damage in non-temporal areas. Eight "pure" tests of memory ability corresponding to Guilford's matrix of memory factors were utilized. Two groups of fifteen patients, matched for age, intelligence and extent of damage, were tested. The hypothesis that no significant differences existed between dominant temporal lobe and non-temporal lobe brain damaged patients on any of the eight memory tests was rejected. It was found that dominant temporal lobe damage resulted in greater impairment in auditory memory, memory

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1 Lloyd A. Shewchuk, doctoral thesis presented to the School of Psychology of the University of Ottawa, Ontario, May 1963, viii-116 p.

for ideas, meaningful memory, memory for spatial position, memory for temporal order and visual memory, but not in memory span and rote memory.

The second hypothesis that no significant differences existed between different memory abilities following temporal lobe damage was also rejected. It was found that damage to the temporal lobe resulted in greatest impairment to auditory memory, meaningful memory and memory for ideas. However, this pattern of memory deficit was similar in patients with damage to other areas of the brain and only differed in the degree of impairment.

A theory postulating that the functioning of the brain is arranged in an hierarchical fashion was presented to explain the results of this investigation. It was postulated that lesions which produce specific changes within a sensory system also affect certain other functions throughout the entire system, and these alterations in turn are accompanied by still more general deficits which occur with injury in any region of the brain.