THE EFFECTS OF ELECTROSHOCK ON NEUROPSYCHOLGICAL TEST PERFORMANCE

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ABSTRACT

The present study was designed to test the effects of electroconvulsive shock (ECS) on a battery of neuropsychological tests, the Halstead Battery. The Halstead Battery has been shown, in a number of studies, to be a reliable and valid indicator of brain damage. Since there is a high degree of similarity between the symptoms observed in patients following electroshock and the symptoms of brain damage, it has been hypothesized that Electroshock Therapy (ECT) treatments produce cerebral damage. However, existing neurohistological evidence, although supporting this hypothesis, is not entirely adequate. Methodological problems, including post-mortem artifacts, lack of suitable control groups, and the relative insensitivity of examination techniques, do not permit specific determination of organic consequences of ECS in either animals or humans. Little research has been done with behavioral tests of brain damage which eliminate the above methodological problems. Consequently, it was felt that the use of this approach would provide a behavioral examination of post ECS alterations of brain function.

In the present study, the Halstead Battery, Trail Making Test and the Wechsler Adult Intelligence Scale (WAIS) were administered to a control group of normal hospital personnel, a control group of depressed hospitalized patients not receiving ECT, and an experimental group of depressed patients receiving ECT. Control subjects were re-tested after one week, and ECT patients were re-tested after the sequence of ECT. Difference scores were computed between testings to

control for subject variables, and analyses of variance and t-tests were applied to these scores.

The results obtained showed generally poorer performance in the ECT group, with three of the neuropsychological tests and three of the WAIS subtests showing statistically significant declines in difference scores.

An analysis of the task requirements on the significant tests provided an interpretation of the obtained results in terms of information processing theory.

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INTRODUCTION

Electro-convulsive therapy (ECT) has become a widely used therapeutic technique because of its efficiency in treating certain psychiatric disorders, mainly the affective psychoses. However, patients often show marked confusion and memory loss after treatment, indicating cortical dysfunction and possible brain damage. As a consequence, a number of treatment variations have been introduced to minimize these symptoms, (Pacella, 1949; Friedman, 1949; Cannicott & Waggoner, 1967), and considerable research has been stimulated to determine the effects of ECT on brain structure and function (Alexander, 1953; Campbell, 1961; Slater & Walley, 1963).

Animal Studies

In order to investigate structural changes in the brain, produced by electroshock, a number of animal studies have been performed. Such studies allow for considerable experimental control, greater variations in treatment, and immediate post-mortem examination of structural alterations.

Neuberger et al. (1942) administered electro-convulsive shock (ECS) to 12 dogs, using a replicated clinical setting with AC current of 80 V and 200 in A with a duration of .15 seconds. The number of shocks ranged from 5-125. On examination, the brains of the animals showed vascular dilation, minute hemorrhages and cytoarchitectural changes. The investigators concluded that some degree of neuropathologic change is produced in animals given shocks in a replicated clinical

setting.

Alpers and Hughes (1947) gave 30 cats threshold current for inducing convulsions, alternating the total number of shocks given between groups. The investigators found that 18 of the 30 cats showed focal subarachnoid and punctate hemorrhages and concluded that "...it is probably fair to assume that there is some damage to the human brain, the difference being one of degree rather than kind." (Alpers & Hughes, 1947).

A similar study was performed by Heilbrunn and Weil, (1947). Twenty-eight rabbits and ten rats were given ECS in a replication of the standard clinical setting. The current was varied between 60 V and 150 V and 65-300 mA, and the number of treatments between six and thirteen. In only three of the animals was no neurohistological damage found. The investigators considered the damage observed to be a result of venous rupturing.

One of the chief problems of control in such studies is organic changes resulting from post-mortem artifacts. Siekert, Williams, and Windle (1950), developed a post-mortem technique which they considered would eliminate artifacts produced by such factors as rapid drop in blood pressure and anoxia. These investigators found no evidence of pathological change in the brains of five monkeys given varying amounts of convulsive shock, with varying numbers of treatments. However, Hartelius (1953), in a study using the same techniques, and employing fifty-seven cats, found that most animals showed sac-like dilation of the perivascular spaces.

The available evidence of organic changes in animals thus indicates that changes which do result may be due to post-mortem artifacts, vascular rupturing, or perhaps to cerebral anoxia resulting from apnea during convulsions. Heilbrunn (1943) has found that when ether narcosis is used, hemorrhages no longer occur. This further supports the view that the brain hemorrhages are produced by the sharp rise in arterial blood pressure during muscle contraction and vasospasm of the peripheral arteries. It should be noted that, with the exception of Heilbrunn's study, none of the above studies employed anaesthetics or muscle relaxants.

A certain amount of behavioral research has been performed with animals to test the effects of ECS. However, most of the studies performed have been concerned with tests of the neural consolidation hypothesis (Hebb, 1949). A great deal of methodological controversy surrounds studies in this area (e.g., Duncan, 1948; Corson, 1965; Chorover & Schiller, 1965; Tenen, 1965). However, the evidence does appear to suggest that short-term retrograde amnesia is a result of ECS.

Human Studies

With regard to evidence of organic brain changes in humans resulting from ECT, the problems of post-mortem artifacts, past neurological history, etc., become even more important. A longer delay generally exists between death and neurohistological examination, and it is also possible that the cause of the fatality may have caused the organic brain damage.

Madow (1956) has summarized existing evidence in the literature

of brain damage occurring in ECT fatalities. In the 38 cases reviewed, petechial hemorrhages were found in 17, subarachnoid hemorrhages in 4, and large intracerebral hemorrhages in 2. Twenty patients showed no neuronal change, and 29 patients showed no neurological changes. Of the cases, 16 fatalities could be considered due to, or markedly influenced by, cerebral complications. Madow, reporting on a further four cases, has found significant vascular changes in all, ranging from subarachnoid hemorrhages scattered throughout the cerebrum, to a massive intraventricular hemorrhage.

Holmberg (1963) has noted increased cerebrovascular permeability following ETC, which greatly resembles the results obtained following inhalation of CO_2 mixtures. Holmberg considers that an increase in cerebral CO_2 is responsible for plasma leakage occurring after seizures. This investigator also reports edema and distension of the perivascular spaces as common in autopsies following ECT fatalities.

To summarize, then, structural changes, mainly vascular, appear in conjunction with ECT. Methodological problems, however, preclude specific determination of damage.

A number of behavioral investigations of cerebral dysfunction following ECT have been performed with humans. Verbal memory deficits have been found in humans following ECT, dating from the introduction of the method (Alexander, 1953). Most treatment variations are attempts to minimize such distrubances (e.g., Gottlieb & Wilson, 1965; Cannicott & Waggoner, 1967), in accordance with the functional asymmetry of the brain (Cohen et al., 1968).

Stone, (1947), has found significant deficits in cognitive func-

tions resulting from ECT. Deficits were found in Wechsler Memory Scale, Form I scores. The investigator suggests that the deficits are due to cortical damage resulting from ECT. Pascal and Zeaman (1951), however, found that Wechsler-Bellevue scores improved during and after ECT. Joffe, Fink, and Kahn (1960) have found changes in speech patterns following ECT, e.g., non-aphasic mismanning. With regard to perceptual-motor changes, Erwin and Hampe (1966) did not find an expected deterioration in Bender-Gestalt performance, but found that scores actually improved over trials.

Thus, in humans, although memory deficits appear to be a common consequence of ECT, evidence concerning other changes in cognitive functioning is not clear-cut.

Electroencephalographic studies (e.g., Levy et al., 1942; Kane, 1963) show evidence of altered cortical function following ECT. Kane (1963) however, found that these changes were transient.

The Halstead Battery

A number of the objections raised to the neurohistological technique, such as post-mortem artifacts, may be overcome through the use of an indirect behavioral approach to the assessment of alterations in the brain. Such a technique allows evaluation of cerebral dysfunction in live human subjects following ECT, as well as allowing inference of structural changes involved. Halstead (1947) has developed a behavioral test battery sensitive to brain damage and standardized on patients with known brain lesions. Since this battery (The Halstead Battery) is a measure of the biological condition of the brain, it has been

termed a test of "biological intelligence" (Halstead, 1951). Because of the extreme complexity of the neural networks of the cortex, the effects of even the most minute changes are multiplied considerable. Thus, alterations not detectable by present neurohistological or neurological techniques may become manifest in the complex psychomotor tasks of the Halstead Battery. The battery also presents novel situations where transfer from previous learning is negligible. Memory deficits, therefore, have little effect on performance. The Halstead Battery, then, presents definite advantages as an instrument to detect alterations produced by ECT.

The initial test results presented by Halstead (1947) showed striking intergroup differences among mean test scores of control, non-frontal brain-damaged and frontal brain damaged subjects. Patients with predominantly frontal cortical damage did more poorly on the battery than patients with non-frontal damage, who in turn did more poorly than control patients with no known neural lesions.

Reitan (1955) attempted to validate Halstead's results, using the same tests, but with different patients sampled from different locales. This study employed 50 subjects with known cortical lesions as well as 50 control subjects with no neurological evidence of cortical damage or dysfunction. The subjects were matched on the basis of colour and sex, chronological age, and amount of formal education. All subjects were then given the Halstead Battery. Reitan found significant differences between the groups on all measures except two based on

critical flicker frequency.

In another study, Reitan (1959a) used an independent rater procedure to assess the extent of agreement between neurological and Halstead Battery evaluations of 112 patients. Inter-rater agreement was calculated for location of lesions, types of focal lesions and classification of lesions as focal or diffuse. As well as the Halstead Battery, the Wechsler-Bellevue Scale (Form I) (Wechsler, 1944), the Trail Making Test (Reitan, 1958), a modification of the Halstead-Wepman Aphasia Screening Test (Halstead & Wepman, 1949) and tests for tactile, auditory and visual perception and suppression were administered. Reitan found that on all measures, agreement between neurological and neuropsychological assessment far exceeded chance.

To provide added information regarding the efficiency of the Halstead Battery in determining the presence and nature of cortical damage, a number of studies have attempted to assess the adequacy of various component tests of the battery.

Reitan (1959b) has used the Halstead Category Test, one of the Halstead Battery tests, in an effort to determine if quantitative measures of brain damage may be obtained. This test is highly loaded with the Abstraction factor of "biological intelligence" (Halstead, 1947). In this study, the Halstead Category Test was administered to 52 subjects neurologically free from brain damage. The results obtained allowed a reliable quantitative differentiation of the groups, showing an impairment of abstraction ability associated with brain damage.

Reitan (1959c) has also examined the effectiveness of Halstead's

Tactual Performance Test in detecting brain damage. This test is a psychomotor task consisting of placing blocks in a formboard while blindfolded. This study employed 39 patients with clear evidence of brain damage, and 39 control Ss without any neurological evidence of brain damage. Subjects were matched between groups for colour, age, sex, and education. Highly significant intergroup differences were found in the time required to complete the task, the brain damaged group being much slower in the time required to complete trials, as well as the total time required to complete the test.

Reitan (1959d) has attempted to investigate the relationship between "psychometric" and "biological" intelligence. Fifty patients with known brain damage and 50 non-neurological control Ss were administered the Halstead Battery and the Wechsler-Bellevue (Form I). The Halstead Impairment Index (Halstead, 1947) was computed from the Halstead Battery scores for each group. This index provides a measure of cerebral dysfunction resulting from brain damage. The results obtained showed that differences in scores between groups were significantly greater on the Halstead Battery and, consequently, on the Halstead Impairment Index as well. These results indicated that the Halstead Battery appears to be more sensitive to brain damage than the Wechsler-Bellevue Scale, and that there does not appear to be a direct relationship between "biological intelligence" and "psychometric intelligence."

Trail Making Test

Reitan, in extending Halstead's initial work, has employed other behavioural tests of brain damage in conjunction with the Halstead

Battery. One test, which appears to be a reliable and valid indicator of brain damage is the Trail Making Test, one of the performance subtests of the Army Individual Test. Reitan (1955b) administered the Trail Making Test to 27 patients with brain damage, and 27 patients without brain damage. Patients in both groups were closely matched in pairs on the basis of sex, colour, age, and education. Highly significant intergroup differences were found in the time to complete both parts as well as the total time required on the test, with the brain damaged group being much slower in each case.

In a larger study, Reitan (1958) administered the Trail Making Test to 200 patients with verified brain damage and 84 subjects neurologically free from brain damage. The groups were comparable with respect to sex, chronological age, and years of formal education. Highly significant differences were found between the groups on Parts A and B of the test individually, as well as for the total time, between groups, required to complete the test.

Fitzhugh et al. (1963) have attempted to relate acuteness of cortical organicity to Trail Making Test performances. Four groups of 16 subjects each were administered the Trail Making Test. The four groups were selected neurologically as follows: control, acute, relatively static and chronic-static. The results obtained showed that the Trail Making Test not only differentiated significantly the brain damaged group from the brain damaged controls, but also differentiated the groups on the basis of severity of organicity. These investigators also found significant correlations between Trail Making performance

and Wechsler-Bellevue scores. This indicates that the Trail Making Test may be affected by intelligence, or that there may be a significant relationship between "biological" intelligence and "psychometric" intelligence, although not necessarily operating in an "all or none" manner.

Aphasia Screening Test

A common symptom of brain damage, especially with diffuse or left hemisphere damage, is aphasia. Heimburger and Reitan (1961) have modifed the Halstead-Wepman Aphasia Screening Test (Halstead & Wepman, 1949) to provide an instrument for detecting aphasia and lateralizing brain lesions. This test was administered to 239 patients with known brain lesions. The results obtained indicated that this test could effectively diagnose aphasia and could accurately localize lesions.

Wheeler and Reitan (1962) used this aphasia screening test to determine its ability to predict cerebral damage, and the type of lesion involved. These investigators administered the test to 47 Ss with damage in the left hemisphere, 57 Ss with right hemisphere damage, 54 Ss with diffuse or bilateral damage, and 104 Ss with no evidence of cerebral damage. Diagnoses were based on neurological examinations, electroencephalography, surgery and autopsy results. The results obtained indicated that a correct classification of presence or absence of brain damage could be made with $p = .78$ when one or more of the 26 indicators per subject were positive. Similarly, a high degree of accuracy of lesion lateralization was obtained using patterns of positive signs on the test. In another study (Heimburger, Demyer & Reitan,

1964), 456 patients were given the aphasia screening test, using a blind procedure in an investigation of Gerstmann's Syndrome (finger-agnosia, right-left disorientation, dysgraphia and dyscalculia). Of 111 patients showing this syndrome, as revealed by the test, all were found to have neurological disorders, following neurological examination.

Purpose of the Present Study

Thus, a number of behavioral instruments exist which may be used to test the hypothesis that alterations take place in the cerebrum as a result of electroshock. In the present study, an attempt was made to investigate such changes in patients receiving ECT, measured by testing with behavioral instruments, before and after a sequence of electroshock therapy. The prediction was made that electroshock patients would perform significantly poorer immediately after a sequence of ECT treatments than would control subjects tested at the same time intervals.

PROCEDURE

Experimental Design

In the present study, a repeated measurements design was employed. Three groups of subjects were compared on test-retest difference scores. The groups of equivalent size (n = 15), consisted of: depressed, hospitalized patients receiving ECT; depressed, hospitalized patients not receiving ECT; and a group of normal Ss composed of hospital staff volunteers. Since a problem existed in obtaining sufficient numbers of

depressed patients, particularly those receiving ECT, it was not possible in the time available to match Ss on the basis of age and I.Q. As a consequence, a difference score design was employed, in which the differences between test-retest scores were considered for each subtest, in order to minimize the effect of these subject variables. Such variables would thus affect only the absolute scores, not the difference scores, if the effects of the variables may be assumed to be constant in each case. Table I indicates the subjects in each age group, and Table II, the subjects in each I.Q. range for the three groups in the study.

Subject Selection

Subjects for the depressed control and depressed ECT groups were obtained from the staff and private psychiatric wards at Winnipeg General Hospital. The normal control group was formed of pre-existing test-retest data obtained from hospital staff volunteers. All of these subjects were normal in the sense that they were not receiving medical or psychiatric care. The depressed-control and depressed-ECT Ss were hospitalized patients diagnosed as depressed by the attending psychiatrists. As previously mentioned, because of the low admission rate of such subjects, particularly in the ECT groups, it was not possible to select or match subjects on the basis of age or I.Q. How-

TABLE I

AGE DISTRIBUTION OF SUBJECTS

AGE	NORMAL C	DEPRESSED C	ECT
15-20	5	6	1
21-25	2	5	1
26-30	2	1	1
31-35	0	1	3
36-40	1	1	1
41-45	1	0	1
46-50	4	0	1
51-55	0	1	4
56-60	0	0	2
61-65	0	0	0
	$\bar{X}$ = 31.17	$\bar{X}$ = 25.10	$\bar{X}$ = 42.10

TABLE II

I.Q. DISTRIBUTION OF SUBJECTS

AGE	NORMAL C	DEPRESSED C	ECT
80-85	1	2	4
86-90	0	1	2
91-95	0	3	4
96-100	1	0	0
101-105	1	3	0
106-110	7	2	1
111-115	5	1	3
116-120	0	0	0
121-125	0	2	0
126-130	0	1	0
131-135	0	0	0
	$\bar{X}$ = 107.43	$\bar{X}$ = 103.37	$\bar{X}$ = 88.67

ever, the following criteria were used, in selecting subjects:

1. No history or evidence of neurological damage or cranial injury.
2. No ECT treatments within the 12 months preceding testing.
3. I.Q. of 80 or above.
4. Age greater than 16 but less than 65 years.
5. Subjects to be of good physical health.

Of the total of 45 subjects participating in the study, all were residents of Manitoba, and fluent in the English language.

Test Battery

All subjects were administered the Wechsler Adult Intelligence Scale (WAIS), (Wechsler, 1955), the Memory for Designs Test (MFD) (Graham & Kendall, 1960) the Aphasia Screening Test (Heimburger & Reitan, 1961), the Trail Making Test (Reitan, 1958), and the Halstead Battery (Halstead, 1947). The Halstead Battery differs from that originally employed by Halstead (1957), with the critical flicker frequency and time sense subtests removed. Detailed descriptions of the Halstead Battery tests appear in both Halstead (1947) and Reitan (1966). Therefore, only a brief description of the tests will be presented here.

The Halstead Battery

The Category Test employs a projection apparatus for presentation of 208 stimulus slides to the subject. The slides presented involve abstraction of common principles in subtests, of which there are

seven. This test is highly loaded with Halstead's (1947) abstraction factor of biological intelligence. The subject is allowed four choices for each item and, if correct, hears a chime, or, conversely, a harsh buzzer. Although this test is not especially difficult for normal subjects, the requirement for competence in concept formation makes it difficult for brain-damaged subjects. The score consists of the number of errors made on the test.

The Tactual Performance Test is a modification of the Seguin-Goddard form board. The subject is blindfolded and not allowed at any time to see the board. He is asked to perform the task first with the dominant hand only, then the non-dominant hand, and finally, with both hands, the time being recorded for each trial. The subject is then required to draw the board from memory, and scores for location and memory of the blocks are obtained. This is a highly complex task, involving tactile form discrimination, psychomotor coordination and visualization of spatial configurations and interrelationships.

The Rhythm Test is a subtest of the Seashore Test of Musical Talent, requiring the subject to differentiate between 30 pairs of rhythmic beats, which are the same or different. This test requires sustained task attention, perception of rhythm and alertness. The score consists of the number of errors.

The Speech Sounds Perception Test is a tape-recorded series of 60 spoken nonsense words, each containing variants of the "ee" sound. The subject is required to underline the spoken word from among four similar alternatives on the answer sheet. The score on this task is

the number of errors made. This test, like the Rhythm Test, requires attention, alertness, and correct auditory perception.

The Finger Oscillation or "Tapping Test" consists of tapping speed, with the index finger, over five 10 second trials for each hand. An average of the best 5 trials with scores within a range of 5 points is computed for each hand. The test is performed using the dominant hand first. This task appears to be purely a measure of motor speed.

Additional Tests

The Trail Making Test consists of 2 parts: Trail A and Trail B. Trail A is comprised of 25 circles distributed on a sheet of paper and numbered 1-25. The subject, after attempting a sample of the test, is required to join up the circles with a pencil, in the correct numerical order, as quickly as possible. Trail B is similar, and also has 25 circles. However, these are alternately numbered 1-13 and lettered A-L. Therefore, the subject must proceed 1-A-2-B...L-13. The scores on both parts consist of the number of seconds required to complete each part.

The Aphasia Screening Test consists of a number of verbal, numerical and pictorial items which must be reproduced, identified or interpreted orally, in writing or graphically. The test surveys common aphasic deficits, e.g., dysnomia, dyscalculia, dysarthria, dyslexia, dysgraphia and constructional apraxia.

Testing Procedure

Prior to testing, the hospital charts were consulted to obtain neurological and psychiatric history, age, education, diagnosis, drug, and ECT information. The subjects were than tested with the Wechsler Adult Intelligence Scale, and verbal, performance and full-scale I.Q.'s calculated from the scaled scores according to the appropriate age norms. The Aphasia Screening Test and the Halstead Battery, as well as the Trail Making Test, Memory for Designs Test, and Minnesota Multiphasic Personality Inventory were than administered in random order. The tests were administered according to a standard set of instructions reproduced in Appendix A.

On re-tests, all tests were again re-administered except for the MMPI and MFD. The Aphasia Screening Test was omitted in the re-testing of the control groups of normal and depressed non-ECT patients. Since all subjects were screened as non-aphasic on the first test, it was felt that the only group which would subsequently manifest aphasia as a result of cortical dysfunction, would be the experimental, (ECT), group.

Subjects in both the experimental and depressed control groups were administered the WAIS at all testings. However, WAIS re-test data was not available for the group of normal control subjects, although on the Wechsler-Bellevue I, there has been found to be a test-retest F-S I.Q. improvement of 5-8 points, with the change in Verbal I.Q. approximately half that of Performance I.Q. (Wechsler, 1958). Thus, it was considered useful, in the present study, to compare test-retest I.Q.

changes obtained from the depressed control and ECT groups.

The MMPI and MFD were initially given to all patients as part of routine clinical evaluation. These tests were not considered part of the present study and hence were not used in retesting.

With regard to inter-test intervals, control subjects were tested and re-tested after seven days, which was approximately the time between testing and retesting of ECT patients, after a complete sequence of ECT treatments. With regard to the ECT group, it was necessary, because of the wishes of hospital staff and treatment scheduling, to wait until the completion of a sequence of ECT before re-testing. These patients were pre-tested on the day prior to the first treatment.

The time required for complete administration of tests (pre or post testing) was approximately six hours. The WAIS was administered first in all cases, with the other tests administered randomly to Ss. Due to the length of the testing session, Ss from the ECT and control groups often became fatigued and occasionally reluctant to continue, thus requiring considerable amounts of encouragement and occasional rest periods in the case of some subjects as indicated in the TPT directions, page 57.

Treatment Conditions

All ECT patients received ECT at the Winnipeg General Hospital. Pre-treatment preparation for these patients consisted of no breakfast as well as administration of atropine. The patients were then administered sodium pentathal and succinycholine chloride for general anaesthetic and muscle relaxant purposes respectively.

The treatment was administered using a Reiter Electrostimulator,

Model CW47. Electrode placement was bilateral in all but one case, where unilateral stimulation was attempted initially, but was later changed to bilateral stimulation.

Generally, a basal value of 120 volts with a stimulus duration of .5 seconds was used. However, if this proved insufficient to induce a grand mal seizure, the voltage and/or stimulus duration was increased. The mean stimulus voltage was 133.08V (range: 120V-140V) with mean stimulus duration of .53 seconds (range: .4-.6s). The mean number of treatments received by the patients was 7.67 (range: 7-11 treatments).

It should be noted that in this clinical setting, no control was possible for the treatment parameters of the ECT group or the drugs administered to either the ECT or the aggressed control group. It may be noted, however, that the ECT parameters fall within a fairly narrow range and in all cases represent individual threshold differences in grand mal seizure induction. The effects of the drugs administered to the ECT and depressed control groups may only be inferred from inter-group comparisons, especially with the group of normal subjects. At any rate, the difference score design tends to greatly reduce the effects of drugs on test performance, since in all cases both ECT and depressed control subjects were administered drugs before and throughout inter-test intervals.

RESULTS

The raw data obtained were tabulated for each subject, and error scores were calculated as the difference between pre and post testings.

Difference scores indicating improvement were positive and scores indicating poorer performance were negative with the exception of error scores, with which signs were reversed so as to maintain a consistent convention. Those tests employing error scores are the Halstead Category Test, Speech Perception, Rhythm, and Tactual Performance time tests. All data were then transfered to IBM cards to allow computer analysis of data.

Analyses of Variance

Initial data analysis consisted of the computation of one factor analyses of variance for each subtest, the three groups being considered to exist at different levels of the factor "treatment."

The factor "treatment" was found to produce significant intergroup differences on the following tests: Tactual Performance Left Hand ($p < .001$), Trail B ($p < .01$) and Tactual Performance Test Total Time ($p < .05$). The analysis of variance summary tables for these tests will be found in Tables IX-XVII. At this point pooled and unpooled means, standard deviations, and standard errors of the mean were also computed for each group. These statistics are presented in Table III.

To test the assumption of homogeneity of variance, Hartley's test (Meyers, 1966) was used. This test yields a statistic Fmax as the ratio of the largest to the smallest group variance. The homogeneity of variance assumption was found to be rejected on the following tests: Tactual Performance Test Total, Trail A, Seashore Rhythm Test, and Tactual Performance Test Both Hands. Consequently, it was felt

TABLE III

GROUP STATISTICS (DIFFERENCE SCORES)

Test	Normal Controls				Depressed Controls				ECT Group			
	Mean	Median	S.D.	S.E.	Mean	Median	S.D.	S.E.	Mean	Median	S.D.	S.E.
Category	20.53	19.00	20.28	5.24	17.87	14.00	11.93	3.08	7.13	12.00	20.13	5.20
Speech Per.	.40	0.0	2.53	.65	1.20	1.00	3.90	1.01	-.40	-1.00	3.14	.81
Rhythm	1.87	0.0	7.82	2.02	.47	0.0	4.50	1.16	-.53	0.0	2.70	.70
Trail A	.33	0.0	.82	.21	.13	0.0	1.64	.42	.27	0.0	2.81	.73
Trail B	1.80	1.00	2.18	.56	.80	1.00	1.26	.33	.33	0.0	1.91	.49
Trail Total	2.13	2.00	2.72	.70	1.13	1.00	2.13	.55	-.07	0.0	3.86	1.00
Tapping Dom	2.47	3.00	4.16	1.07	1.60	1.00	3.66	.95	4.47	1.00	10.00	2.58
Tapping N Dom	.80	0.0	5.05	1.30	.87	0.0	6.40	1.65	4.20	3.00	6.82	1.76
TPT Shape	1.13	1.00	1.60	.41	.73	1.00	1.71	.44	-.020	0.0	2.21	.57
TPT Location	1.53	2.00	1.77	.46	1.20	1.00	1.93	.50	.47	0.0	1.77	.46
TPT L Hand	112.33	100.00	92.76	23.95	171.54	140.00	132.74	34.27	34.53	0.0	189.37	48.89
TPT R Hand	91.60	31.00	102.42	26.45	103.00	120.00	182.32	47.07	69.67	60.00	157.87	40.76
TPT Both Hands	27.87	46.00	48.67	12.57	84.80	56.00	177.87	45.93	-18.07	21.00	157.17	40.58
TPT Total	179.73	133.00	173.90	44.90	360.33	354.00	373.95	96.55	-6.27	82.00	500.86	129.32

TABLE IV

TACTUAL PERFORMANCE TEST - LEFT HAND

Source of Variation	DF	SS	MS	F
ECT	2	337689.9375	168844.9375	8.16
Within Cells	42	869164.8750	20694.3984	
Error Due to Approx.		-0.8125		
Total	44	1206854.0000		

$p < .001$

TABLE V

TACTUAL PERFORMANCE TEST - TOTAL TIME

Source of Variation	DF	SS	MS	F
ECT	2	1008040.3125	504020.1250	3.59
Within Cells	42	5893125.0000	140312.5000	
Error Due to Approx.		-0.3125		
Total	44	6901165.0000		

$p < .05$

TABLE VI

TRAIL B

Source of Variation	DF	SS	MS	F
ECT	2	34.1778	17.0889	5.12
Within Cells	42	140.1333	3.3365	
Error Due to Approx.		0.0		
Total	44	174.3111		

$p < .01$

TABLE VII

TRAIL A

Source of Variation	DF	SS	MS	F
ECT	2	0.3111	0.1556	0.04
Within Cells	42	158.0000	3.7619	
Error Due to Approx.		0.0000		
Total	44	158.3111		

N.S.

TABLE VIII

TRAIL TOTAL

Source of Variation	DF	SS	MS	F
ECT	2	36.4000	18.2000	2.03
Within Cells	42	376.3997	8.9619	
Error Due to Approx.		0.0001		
Total	44	412.7998		

N.S.

TABLE IX

CATEGORY TEST

Source of Variation	DF	SS	MS	F
ECT	2	1509.3750	754.6875	2.36
Within Cells	42	13429.2070	319.7429	
Error Due to Approx.		-0.0039		
Total	44	14938.5781		

N.S.

TABLE X

TAPPING DOMINANT HAND

Source of Variation	DF	SS	MS	F
ECT	2	64.8443	32.4221	0.74
Within Cells	42	1829.0664	43.5492	
Error Due to Approx.		0.0004		
Total	44	1893.9111		

N.S.

TABLE XI

TAPPING NON-DOMINANT HAND

Source of Variation	DF	SS	MS	F
ECT	2	113.3775	56.6887	1.51
Within Cells	42	1580.5332	37.6317	
Error Due to Approx.		0.0002		
Total	44	1693.9109		

N.S.

TABLE XII

TACTUAL PERFORMANCE TEST - RIGHT HAND

Source of Variation	DF	SS	MS	F
ECT	2	8610.8789	4305.4375	0.19
Within Cells	42	961157.0000	22884.6875	
Error Due to Approx.		-0.1914		
Total	44	969767.6875		

N.S.

TABLE XIII

TACTUAL PERFORMANCE TEST - BOTH HANDS

Source of Variation	DF	SS	MS	F
ECT	2	79664.0000	39832.0000	2.04
Within Cells	42	821921.0625	19569.5469	
Error Due to Approx.		0.1250		
Total	44	901585.1875		

N.S.

TABLE XIV

TACTUAL PERFORMANCE SHAPE

Source of Variation	DF	SS	MS	F
ECT	2	14.0445	7.0222	2.03
Within Cells	42	145.0667	3.4540	
Error Due to Approx.		-0.0000		
Total	44	159.1111		

N.S.

TABLE XV

TACTUAL PERFORMANCE LOCATION

Source of Variation	DF	SS	MS	F
ECT	2	8.9333	4.4667	1.34
Within Cells	42	139.8667	3.3302	
Error Due to Approx.		-0.0000		
Total	44	148.8000		

N.S.

TABLE XVI

SEASHORE RHYTHM

Source of Variation	DF	SS	MS	F
ECT	2	43.6000	21.8000	0.74
Within Cells	42	1241.1995	29.5524	
Error Due to Approx.		0.0004		
Total	44	1284.7998		

N.S.

TABLE XVII

SPEECH PERCEPTION

Source of Variation	DF	SS	MS	F
ECT	2	19.2000	9.6000	0.92
Within Cells	42	439.5996	10.4667	
Error Due to Approx.		0.0002		
Total	44	458.7998		

N.S.

advisable to transform the data to produce homogeneity of variance. A constant of 1,000 was added to each Tactual Performance Test time score, and a constant of 10 to scores on the other subtests; so as to eliminate negative values. The following transformations were then applied to the data, and the analyses of variance repeated: $\sqrt{X}$, $Log_{10}X$, and $\frac{1}{X}$.

As a result of these data transformations, homogeneity of variance was produced, but no differences in significance were found for any of the replications of the analyses of variance with transformed data. On both original and subsequent transformed analyses, the Halstead Category Test was found to approach significance ($p < .2$).

T- Tests:

It was felt that, incidental to observing changes between groups on the Halstead Battery, that it would be useful to test the null hypothesis of no change between mean WAIS I.Q. and subtest scores, between the depressed control and ECT groups. Consequently *t*-tests for independent means, with Ho: $\mu_1 = \mu_2$ were computed between WAIS I.Q. and subtest difference score means. The *t*-test results are presented in Tables XVIII-XXXI.

The null hypothesis was rejected for the following measures: WAIS Full Scale I.Q. ($p < .01$), Performance I.Q. ($p < .05$), Comprehension ($p < .05$), Digit Span ($p < .05$), and Digit Symbol ($p < .05$). It should be noted at this point, however, that the WAIS Full Scale I.Q. is dependent on Verbal and Performance I.Q. scores. Therefore, the

TABLE XVIII

WAIS VIQ

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	3.1333	4.9116	1.2682
ECT	1.6000	5.6543	1.4599

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = -.793 with 28 Degrees of Freedom

N.S.

TABLE XIX

WAIS PIQ

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	9.0000	5.5549	1.4343
ECT	3.8667	7.2296	1.8667

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 2.181 with 28 Degrees of Freedom

$p < .05$

TABLE XX

WAIS FSIQ

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	6.2000	3.7834	0.9769
ECT	2.1333	4.1553	1.0729

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 2.803 with 28 Degrees of Freedom

p <.01

TABLE XXI

WAIS INFORMATION

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	0.2667	0.9612	0.2482
ECT	0.0667	1.0998	0.2840

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 0.530 with 28 Degrees of Freedom

N.S.

TABLE XXII

WAIS COMPREHENSION

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	-2.1333	3.3566	0.8667
ECT	0.1333	1.8074	0.4667

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 2.303 with 28 Degrees of Freedom

p <.05

TABLE XXIII

WAIS ARITHMETIC

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	0.6667	1.2910	0.3333
ECT	1.3333	1.8772	0.4847

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 1.133 with 28 Degrees of Freedom

N.S.

TABLE XXIV

WAIS SIMILARITIES

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	0.6000	1.2983	0.3352
ECT	1.3333	1.9518	0.5040

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 1.212 with 28 Degrees of Freedom

N.S.

TABLE XXV

WAIS DIGIT SPAN

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	2.2000	2.8335	0.7316
ECT	-0.4667	2.6957	0.6960

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 2.641 with 28 Degrees of Freedom

$p < .05$

TABLE XXVI

WAIS VOCABULARY

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	0.5333	1.0601	0.2737
ECT	0.3333	0.9759	0.2520

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 0.538 with 28 Degrees of Freedom

N.S.

TABLE XXVII

WAIS DIGIT SYMBOL

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	11.3333	0.7238	0.1869
ECT	10.2667	1.3870	0.3581

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 2.641 with 28 Degrees of Freedom

$p < .05$

TABLE XXVIII

WAIS PICTURE COMPLETION

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	0.8000	1.0823	0.2795
ECT	0.2667	1.7512	0.4522

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 1.003 with 28 Degrees of Freedom

N.S.

TABLE XXIX

WAIS BLOCK DESIGN

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	1.7333	1.8696	0.4827
ECT	1.2667	1.5337	0.3960

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 0.747 with 28 Degrees of Freedom

N.S.

TABLE XXX

WAIS PICTURE ARRANGEMENT

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	1.3333	2.0587	0.5315
ECT	1.0667	2.6313	0.6794

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 0.309 with 28 Degrees of Freedom

N.S.

TABLE XXXI

WAIS OBJECT ASSEMBLY

Individual Means and Standard Errors

Group	Mean	Standard Deviation	Standard Error
DEP	1.8000	3.1214	0.8059
ECT	0.2667	1.8309	0.4727

Null Hypothesis - Difference = 0.0

Theoretical T 2.048 - 5% 2.763 - 1%

T = 1.641 with 28 Degrees of Freedom

N.S.

rejection of the null hypothesis for Full Scale I.Q. may be due to significant inter-group Performance I.Q. differences.

Overlap Analysis

In order to assess the degree of separation between groups on the significant test measures, it was decided to perform an overlap analysis. This analysis was applied to the Trail B, Tactual Performance Test Left Hand and Total Time scores between the depressed control and ECT experimental groups.

To compute the percentage of overlap of scores between the two groups, an optimal cut-off point which would give 0% overlap was calculated. The following formula was used to establish this optimum score:

$$C = \frac{\bar{X}_1\sigma_2 + \bar{X}_2\sigma_1}{\sigma_1 + \sigma_2}$$

where $\bar{X}_1$ and $\bar{X}_2$ are the respective means for the two groups, and σ_1 and σ_2 are the standard deviations. The deviation of the group means from this cut-off was then determined by making these means into standard scores, using the formula $\frac{\bar{X}-C}{\sigma}$, and obtaining the deviations of these standard scores from C. The degree of overlap between the ECT and depressed control group on a given task was obtained by looking up the area beyond the given Z score on a normal probability table. The degrees of overlap obtained were as follows: Trail B, 36%; Tactual Performance Left Hand, 36%; and Tactual Performance Total, 37%.

DISCUSSION

Organicity Hypothesis

In accordance with the hypothesis that cerebral dysfunction results from ECT, it was noted that, although only three of the brain damage indicators employed showed significant inter-group differences, that there was a general tendency for poorer performance in the ECT group on re-tests. Of the fourteen measures employed, eight measures showed declines in mean performance in the ECT group, whereas no mean declines were found for any measure in either of the other two groups. Only on both of the tapping tests did the ECT group means surpass the means of the other two groups. It seems apparent that ECT or its accompanying treatment conditions operated to produce decrements in performance. However, with the small numbers of subjects in each group, significance was not obtainable on several tests.

The nature of the results obtained thus does not allow either an acceptance or a rejection of the hypothesis that organic changes result from ECT. At the same time, there appears to be definite cerebral dysfunction resulting from ECT. Whether such dysfunction persists may be determined by a longitudinal extension of the present experimental design, where all groups are again re-tested after an appropriate time interval.

Task Analysis

At this point, it is profitable to speculate more closely as to

the precise nature of the deficits observed. As mentioned previously, the Halstead Battery and the Trail Tests assess cerebral function, but do so in a novel situation in which previous learning has little effect. However, it is possible for learning to occur in the test situation, and this learning is reflected in a positive difference score. In the results obtained, however, it may be noted that, although some learning effect is found on each test for the two control groups, that there is an acutal decline in performance on eight of the fourteen subtests for the ECT group. In other words, not only does no learning effect appear for the ECT subjects on these subtests, but they show inferior performance compared to the initial testing on eight subtests. As previously mentioned, on the six other subtests, these subjects also generally displayed poorer performance than the two control groups, with the exception of the Tapping Tests, which do not, however, show significantly better performance.

At this point, consideration will be given to factors operating on the groups. Essentially, the three groups differ in terms of presence of depression and/or ECT[1]. Since a difference score design is being used to control subject variables, then, test re-test differences will be a function of ECT, or learning effect for each group. Thus, the original rationale for such a design emerges. The effect of ECT may be inferred from comparison of the ECT group with the depressed control group, and the characteristics of depressive behavior may be in-

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[1]A consideration of the types and dosages of drugs administered to the ECT and depressed control group showed no systematic differences between the groups, either in type or dosages of drugs.

ferred from comparison of the depressed control group with the normal control group. Consequently, differences between the ECT group and the other groups appear to be due to the effects of ECT. Since the re-tests are replications of the original testings, ECT deficits are attributable to either memory deficits or to cortical dysfunction. Memory deficits appear to be common after ECT, as has been discussed previously in this paper. Indeed, in the present study, several of the ECT subjects did not recall the previous testing or the tests, when re-tested.

If memory deficits are considered to operate to lower difference scores in the ECT group, then some inferences as to their effects may be made by examining subtests on which memory and recall factors may differentially act. The Tapping Test and the Speech Perception and Rhythm Tests may be considered to be fairly "pure" motor and perceptual tasks respectively, in which there is little opportunity for learning, especially in the present situation, where the subjects gain no knowledge of results.

Conversely, such tests as the Tactual Performance Test and the Category Test do provide opportunities for learned strategies to be applied, as well as allowing knowledge of results. Therefore, learning, and hence memory and recall factors become more important.

On examination of the test results, it may be seen that the Tapping, Speech Perception and Rhythm Tests do not show significant declines in performance, thus supporting the notion that memory deficits have not differentially affected these scores. On the other hand,

Tactual Performance Total and Left Hand do show significant declines, thus supporting the memory deficit hypothesis. However, the Tactual Performance Total Time is not a separate measure, but is affected by the significance of Tactual Performance Test Left Hand, one of its components. If one then considers only Tactual Performance Left Hand as being significantly worse in the ECT group, it is difficult to understand why the other components of the Tactual Performance Test, as well as the Category Test, do not also differ significantly from the other groups. Therefore, the memory deficit explanation is not entirely satisfactory to account for the phenomena observed here.

WAIS Evidence

Some insights regarding the nature of the deficits observed may be gained by a consideration of WAIS I.Q. and subtest changes in the depressed control and ECT groups. As outlined in the results section, the following WAIS I.Q.'s and subtests were found to be significantly different between the depressed control and ECT groups: Performance I.Q., Full Scale I.Q., Comprehension, Digit Span and Digit Symbol. Wechsler (1958) reports from his review of a number of studies of brain damaged patients, than an "organic test-syndrome" exists for the WAIS. He has found in these studies that the organic patients were consistently poor on the following subtests: Digit Symbol, Digit Span, Block Design, Arithmetic and Similarities, as well as showing lower Performance than Full Scale and Verbal I.Q.'s. It is interesting to note here that, with the exception of Comprehension, the other WAIS subtests showing significant declines, as well as Performance I.Q., all fall into this

"organic indicator" group of tests. However, in the present study, significant declines were not obtained on the Block Design, Arithmetic and Similarities subtests.

An examination of the significant *t*-test results performed on WAIS subtests shows that the significant difference obtained on Comprehension is actually due to improvement in the ECT group. At the same time, the significant difference due to the ECT group's decline in performance on the Full Scale I.Q. measure is likely largely due to the fact that the decline on the Performance I.Q. score is significant. Therefore, the only WAIS non-composite measures providing meaningful significant declines are Digit Span and Digit Symbol.

Comparison of WAIS and Halstead Battery Results

At this point, comparison will be made of WAIS and Halstead Battery results. The following non-composite measures have been seen to show significant difference score declines: Trail B, Tactual Performance Left Hand, WAIS Digit Span and Digit Symbol. If these tests can be found to possess characteristics not common to the other tests, then ECT may be considered to operate selectively on these characteristics.

Consideration of the nature of the tasks involved in these tests reveals that all of these tests include a memory factor. In Trail B, the subject is required to connect alternate numbers and letters as quickly as possible. This requires remembering the preceding number or letter alternate in the series. Tactual Performance Left Hand performance is dependent on learning of correct spatial recognition and

and relationship on the initial trial with the right hand. WAIS Digit Span requires retention and recall of digits, and WAIS Digit Symbol speed is partly dependent on recall of certain symbol substitutions.

However, it should also be noted that in each of these tests, with the exception of WAIS Digit Span, that subjects have been given a "speed" performance set. Therefore, the results seem to indicate that the subjects in the ECT condition show poorer performance in tasks with timed performance.

Information Processing Model

A consideration of the results obtained in this study suggests an information processing interpretation. If the nervous system, and, in particular, the cortex, is considered to function as an information processing system, then relatively small change, structurally or functionally, becomes greatly multiplied in effect. Therefore, changes in any aspect of encoding and decoding of information as well as storage and retrieval become important to the overall efficiency of this highly integrated system.

In this context, the results obtained in the present study appear as breakdowns of information processing on certain of the tests. Memory deficits may thus be regarded as deficits in information retrieval from storage. During timed performance, then, the capacities of the system are exceeded and there is a breakdown in performance, particularly when information must be relatively quickly retrieved from storage. Future research on the effects of ECT could profitably, then be performed in

terms of examining changes in information processing ability.

Limitations of the Present Study and Suggestions for Future Research

A number of problems were encountered in the execution of the present study. Difficulties were encountered in obtaining representative ECT subjects. These subjects, as seen in Tables I and II were generally older, and showed a lower mean Full Scale I.Q. Because the testing was done in a clinical setting, and since most patients were being treated by private psychiatrists, it was not possible to exercise control over treatment parameters or drugs. The time for testing a subject was also found to be too long, especially on initial testing sessions. Despite encouragement and rest periods, subjects often refused to continue, or refused to return for re-tests. Admission diagnoses of depression by psychiatrists were used in selecting patients. The validity of these provisional diagnoses in some cases is doubtful especially with comparison to final discharge diagnoses. It was originally intended to use a depression inventory in selecting patients. However, with the existing heavy load of testing per subject as well as the difficulties in obtaining adequate numbers of subjects, this was not considered to be practible.

It is felt that future research of this type would be highly valuable. However, such research could be more effectively undertaken in a university hospital type of situation, where stricter control could be exercised over subject selection and availability, as well as treatment parameters. With sufficient time and numbers of suitable patients available, a matched subject design could be employed, with a possible

longitudinal extension in which there is a second re-test after a suitable time interval to investigate the possibility of permanent vs. reversible changes in brain function.

As mentioned previously, it would also be useful to examine changes in cortical function after ECT with specific reference to an information processing model of control nervous system functioning.

SUMMARY AND CONCLUSIONS

The present study was undertaken to assess the effects of electroconvulsive shock on a group of neuropsychological tests - the Halstead Battery and the Trail Making Test. The similarity of the behavioral changes resulting from ECT and those of organic brain damage has led to much neurohistological research to determine the existence and/or nature of structural changes resulting from ECT. The present study attempted to investigate dysfunction following ECT by using behavioral measures, specifically, by using behavioral tests of brain damage.

Three groups of fifteen subjects each were selected and tested with both the Halstead Battery and the Trail Making Test. These subjects comprised three groups - a control group of normal hospital personnel, a control group of depressed in-patients not receiving ECT, and an experimental group of depressed patients receiving ECT. Subjects in the control groups were tested and re-tested at a one week interval, and subjects in the ECT experimental group were tested before and after the sequence of ECT. Difference scores were computed between first and second testings and analyses of variance and *t*-tests were performed between the means of these difference scores between the three groups.

The results obtained indicate that ECT does appear to produce cortical dysfunction. Significant declines were found on three of the neuropsychological measures and on three of the WAIS subtests in the ECT group.

Consideration of the nature of the tasks involved in those tests showing significant declines indicates that complex tasks requiring fast retrieval from memory storage appear to be affected greatest. Therefore, it is suggested that the results obtained may be interpreted by an information processing model of the brain in which the effects of ECT may be considered to produce a breakdown of the information processing model in test situations where there is a high informational loading of the system.

APPENDIX A

HALSTEAD CATEGORY TEST

ON THIS SCREEN YOU ARE GOING TO SEE DIFFERENT GEOMETRICAL FIGURES AND DESIGNS. SOMETHING ABOUT THE PATTERN ON THE SCREEN WILL REMIND YOU OF A NUMBER BETWEEN ONE AND FOUR. ON THE KEYBOARD IN FRONT OF YOU (pointing) THE KEYS ARE NUMBERED 1, 2, 3, and 4. YOU ARE TO PRESS DOWN ON THE KEY WHICH IS THE SAME NUMBER AS THE NUMBER THE PATTERN ON THE SCREEN REMINDS YOU OF. FOR EXAMPLE, WHAT NUMBER DOES THIS REMIND YOU OF? (Put on first picture. If the subject says, "one", ask him which key he should press. After he has pressed the number 1 key, say:) THE BELL YOU JUST HEARD TELLS YOU THAT YOU GOT THE RIGHT ANSWER. EVERY-TIME YOU HAVE THE RIGHT ANSWER YOU WILL HEAR THE BELL RING. (Instruct the subject to try one of the other keys in order to find out what happens when an incorrect key is pressed.) THE BUZZER IS WHAT YOU HEAR WHEN YOU HAVE THE WRONG ANSWER. IN THIS WAY YOU WILL KNOW EACH TIME WHETHER YOU HAVE THE RIGHT OR WRONG ANSWER. HOWEVER, FOR EACH PICTURE ON THE SCREEN YOU GET ONLY ONE CHOICE. IF YOU MAKE A MISTAKE WE JUST GO RIGHT ON TO THE NEXT PICTURE.

(Proceed with subtest one.) NOW, WHICH KEY WOULD YOU PICK FOR THIS PICTURE?

After subtest one say: THAT WAS THE END OF THE FIRST SUBTEST. THIS TEST IS DIVIDED INTO SEVEN SUBTESTS. IN EACH SUBTEST THERE IS ONE IDEA OR PRINCIPLE THAT RUNS THROUGHOUT THE SUBTEST. ONCE YOU HAVE FIGURED OUT WHAT THE IDEA OR PRINCIPLE IN THE SUBTEST IS, BY USING THIS IDEA YOU WILL GET THE RIGHT ANSWER EACH TIME. NOW WE ARE GOING TO BEGIN

THE SECOND SUBTEST AND THE IDEA IN IT MAY BE THE SAME AS THE LAST ONE OR IT MAY BE DIFFERENT. WE WANT YOU TO FIGURE IT OUT. (Proceed with subtest 2.)

When you reach the first slide with circles, say: YOU WILL NOTICE THAT WE FIRST SAW SQUARES, THEN LINES, AND NOW CIRCLES. EVEN THOUGH THE PATTERNS CHANGE, YOU SHOULD CONTINUE TO USE THE SAME IDEA TO GET THE RIGHT ANSWER.

After subtest 2 say: THAT WAS THE END OF THE SECOND SUBTEST AND AS YOU PROBABLY NOTICED, YOU DON'T NECESSARILY HAVE TO SEE A NUMBER TO HAVE A NUMBER SUGGESTED TO YOU. YOU SAW SQUARES, CIRCLES, AND OTHER FIGURES. ALSO, YOU PROBABLY NOTICED IN EACH OF THESE SUB-TESTS, THERE WAS ONLY ONE IDEA OR PRINCIPLE WHICH RAN THROUGHOUT. ONCE YOU FIGURED OUT THE IDEA YOU CONTINUED TO APPLY IT TO GET THE RIGHT ANSWER. NOW WE ARE GOING TO START THE THIRD SUBTEST AND THE IDEA IN IT MAY BE THE SAME AS THE LAST ONE OR IT MAY BE DIFFERENT. I WANT TO SEE IF YOU CAN FIGURE OUT WHAT THE IDEA IS AND THEN USE IT TO GET THE RIGHT ANSWER. REMEMBER, THE IDEA REMAINS THE SAME THROUGHOUT THE SUBTEST. I WILL TELL YOU WHEN WE COMPLETE ONE SUBTEST AND ARE READY TO BEGIN A NEW ONE (Proceed with subtest 3.) After subtests 3, 4, and 5 say: THAT WAS THE END OF THAT SUBTEST, NOW WE ARE GOING TO BEGIN THE NEXT ONE. THE IDEA IN IT MAY BE THE SAME AS THE LAST ONE OR IT MAY BE DIFFERENT. WE WANT YOU TO FIGURE IT OUT.

In subtest 4, after slide #6, (first slide without numbers) say: THIS IS STILL THE SAME GROUP, BUT NOW THE NUMBERS ARE MISSING. THE PRINCIPLE IS STILL THE SAME.

After subtest 6, say: IN THIS LAST SUBTEST THERE IS NO ONE IDEA OR PRINCIPLE THAT RUNS THROUGHOUT THE GROUP BECAUSE IT IS MADE UP OF ITEMS YOU HAVE ALREADY SEEN IN PRECEDING SUBTESTS. TRY TO REMEMBER WHAT THE RIGHT ANSWER WAS THE LAST TIME YOU SAW THE PATTERN AND GIVE THAT SAME ANSWER AGAIN.

SCORING - CATEGORY TEST

The slides are arranged in order according to the score sheet. The examiner should carefully follow the score sheet in setting lever #2 for the next correct response. A check (✓) in the right side of a column indicates a correct response and an (X) in the extreme left indicates an error. A star (*) may be placed on the score sheet next to an item where any special help is given.

The score on the test is the total number of errors on all seven tests. The criterion score on this test is more than 50 errors. At the bottom of the test sheet, write in a description of any unusual behaviour observed, or help that is given if this is more than usual, or any other comments which will be of assistance in clarifying the test performance.

TACTUAL PERFORMANCE TEST

Blindfold the subject as the first step in preparing to administer this test. While putting out block and board say: ON THE TABLE IN FRONT OF YOU I AM PUTTING OUT A BOARD. THE BOARD IS SITTING ON A STAND SO THAT IT WILL BE UPRIGHT AND WILL NOT FALL OVER. ON THE BOARD ARE SPACES OF VARIOUS SIZES AND SHAPES. ON THE TABLE I AM PUTTING OUT BLOCKS OF VARIOUS SIZES AND SHAPES. THE BLOCKS WILL FIT INTO THE SPACES ON THE BOARD. THERE IS A BLOCK FOR EACH SPACE AND A SPACE FOR EACH BLOCK. WHEN YOU HAVE PLACED THE BLOCK IN ITS PROPER SPACE, IT WILL FIT AND WILL NOT FALL OUT.

After the board and block are out, say: THIS IS WHAT THE BOARD FEELS LIKE. While running subject's preferred hand around board say: HERE IS ONE SIDE, HERE IS THE TOP, AND HERE IS THE OTHER SIDE. THIS IS THE STAND THAT YOU FEEL OUT HERE AT THE SIDES (guide patient's hand to the two sides of the stand.) AS YOU RUN YOUR HAND OVER THE BOARD, YOU CAN FEEL THE VARIOUS SPACES (run patient's hand quickly over entire board). NOW USING ONLY YOUR RIGHT HAND (or left hand if subject is left-handed - always have subject use preferred hand on the first trial) I WANT YOU TO FIT THE BLOCKS INTO THEIR PROPER SPACES ON THE BOARD. DO YOU HAVE ANY QUESTIONS? (pause) REMEMBER TO DO IT AS QUICKLY AS YOU CAN. ALRIGHT - READY? BEGIN! (Start timing).

After subject has finished the task with his preferred hand, say: THAT WAS THE LAST BLOCK THAT YOU JUST PUT IN. NOW I WOULD LIKE YOU TO DO THE SAME THING OVER AGAIN, BUT THIS TIME USING ONLY YOUR LEFT

HAND (or right hand if the subject is left-handed). Quickly show the patient the shape of the board again and remind him that it is the same board and the same blocks; that he is to do the same task again as quickly as possible but using only his left hand.

After he has completed it with his left hand, say: THAT WAS THE LAST BLOCK YOU JUST PUT IN. NOW KEEP THE BLINDFOLD ON BECAUSE I WANT YOU TO DO THIS STILL ANOTHER TIME. THIS TIME YOU GET TO USE BOTH HANDS. REMEMBER, PUT THE BLOCKS IN THEIR PROPER PLACES AS QUICKLY AS YOU CAN USING BOTH HANDS. READY, BEGIN!

After the third trial be watchful that the subject does not remove his blindfold before you have removed the blocks and board. Then unblindfold the subject and say: NOW I WOULD LIKE YOU TO DRAW A PICTURE OF THE BOARD THAT YOU WERE JUST WORKING WITH. FIRST DRAW AN OUTLINE OF THE SHAPE OF THE BOARD AND THEN FILL THE BLOCKS IN. In case the subject is confused, point out that the outside shape should represent the board but not the stand. DRAW IN AS MANY OF THE BLOCKS AS YOU CAN REMEMBER AND TRY TO PUT THEM IN THEIR PROPER PLACES AS WELL AS YOU CAN REMEMBER. IF YOU REMEMBER A CERTAIN BLOCK BUT DON'T REMEMBER WHERE IT GOES, PUT IT IN AS BEST YOU CAN. THINK CAREFULLY, AND PUT DOWN ALL OF THE BLOCKS YOU CAN REMEMBER AND ALSO TRY TO PUT THEM IN THEIR CORRECT LOCATIONS.

SCORING - TACTUAL PERFORMANCE TEST

This test is scored by determining the total time for the three trials, by counting the number of the blocks correctly reproduced, and by counting the number of blocks properly located in the drawing. For the total time, the seconds should be expressed to the nearest tenth of a minute. In counting the blocks correctly reproduced, count only those which are fairly accurately drawn and indicated that the subject had a true concept of the block. A star of four or five points is accepted as correct. The localization score is obtained by counting the numbers of correctly drawn shapes which have been located approximately in the right place on the drawing and in relation to the other blocks. For example, if the circle were drawn near the top of the board and the cross and diamond placed to each side of it, but another shape drawn in above the circle, then the circle would not count as correctly localized. The time score, the memory score, and the localization score on this test each contribute to the Halstead Impairment Index. The criterion score for the total time required to do the test is 15.6 minutes. The normal subject usually takes about ten to twelve minutes for three trials; the brain damaged subject may take as long as an hour and a half. Therefore, if a subject takes more than 15.6 minutes, he is performing as do most subjects with known brain damage. A normal subject is expected to remember correctly six or more of the blocks, and to have five or more of them properly located on his drawing. A memory score of 6 and localization score of 5 are the criterion scores.

Scores lower than these each contribute one point to the Impairment Index. Usually a normal person will recall eight to ten and have seven to nine shapes located correctly. When a patient cannot remember as many as six, or localize five of the shapes, then his performance is in the range characteristic of cerebral damage.

Once a block is properly placed by the subject it is the duty of the examiner to keep it there. When a block is accidentally knocked out, the examiner replaces it and informs the subject that this is being done for him.

Although it rarely happens, sometimes a subject forces a block into an incorrect space. When this happens, the examiner should have him feel the block and space and explain to the subject that the block was not correctly placed and must be taken out.

Some patients seem to forget the size of the board and tend to omit the top row of spaces. When this occurs (after most of the other blocks have been placed) remind him to feel the entire board. It may become necessary to have him run his hand around the board again as he did at the beginning of the trial. Always tell the subject when he is working off the board. Some subjects would spend much time feeling the sections of the stand if the examiner did not direct their attention to the board.

Some patients could spend hours in trying to complete this test. It is permissible to discontinue each trial after 15 minutes of working time if the patient seems to be getting discouraged and is making very

slow sprogress. The trial should not be discontinued if the patient appears capable of completing it. Particularly if most of the blocks have been placed, the trial should continue until it is completed. The second trial then should not be discontinued until the same time has been reached. The same is true with the third trial unless of course the patient completes it before this time is reached. An important part of the information derived from this test concerns the comparative performances of the two hands. The procedure described above permits collection of data relevant to such comparisons even though the test is not completed. Although we always try to obtain at least a 15 minute sample on each trial, it would be better to limit each trial to 10 minutes than to deplete the patient's resources on the first trial for continuing with the rest of the task.

In cases where only one hand can be used, all three trials should be done with the one useable arm. Such an instance would occur, for example, in patients with a complete right or left hemiplegia. With partial paralysis the patient may be able to handle the blocks and feel the board well enough to go ahead with it. Even though the patient has some impairment of an upper extremity, it is advisable to have him try the test in the usual way in order to get an actual comparison of the performances with the two hands. If a patient has used only <u>one</u> extremity for the first two trials, this same extremity <u>only</u> should be used on the third trial.

Subjects may get extremely tired while working and need rest

periods. The watch is stopped during these periods and they should be noted on the test form. An occasional patient (such as ones with extreme intracranial hypertension) may become dizzy or nauseated during the test. If it is necessary to remove the blindfold, be sure that the board and blocks are first put out of sight. A note stating the time stopped, length of rest and number of blocks in place should be recorded.

The standard position of the board in this test requires the cross to be in the upper right-hand corner.

SPEECH PERCEPTION TEST

(Use tape recorder) THIS IS A HEARING TEST. YOU ARE GOING TO HEAR A MAN'S VOICE SAYING, "THE FIRST WORD IS _____" AND THEN HE WILL SAY ONE OF THE FOUR NONSENSE WORDS OPPOSITE NUMBER ONE ON YOUR ANSWER SHEET. (point out to subject). THEN HE WILL SAY "THE SECOND WORD IS _____" AND GIVE ONE OF THE FOUR WORDS LISTED OPPOSITE NUMBER TWO. WE ARE GOING TO START WITH A SAMPLE, SO THAT YOU CAN SEE WHAT THE TEST WILL BE LIKE, AND SO THAT YOU CAN TELL ME HOW LOUD YOU WANT THE RECORDING TO BE. YOU JUST SIT BACK AND LISTEN, DON'T WRITE, AND TELL ME IF THIS IS LOUD ENOUGH OR IF IT IS TOO LOUD. DURING THE SAMPLE DO NOT WRITE DOWN ANY ANSWERS, BUT LOOK AT EACH WORD CAREFULLY AND POINT TO THE WORD YOU THINK IS SAID. (play sample).

NOW WE ARE GOING TO BEGIN THE TEST. THE VOICE ON THE RECORDING WILL SAY ONE OF THE FOUR WORDS EACH TIME, AND YOU ARE TO UNDER-LINE THE WORD THAT YOU THINK HE SAYS. IF YOU ARE NOT SURE OF WHAT HE SAYS, THEN MAKE A GUESS. UNDERLINE 1 WORD EVERY TIME. IF YOU MAKE A MISTAKE DON'T BOTHER TO ERASE IT; JUST CIRCLE YOUR MISTAKE AND UNDERLINE THE RIGHT ONE. WORK DOWN COLUMN "A" FROM ONE TO TEN, THEN START COLUMN "B" OVER HERE, (show subject) THEN "C" AND THEN DO "D", "E", AND "F" DOWN HERE.

GENERAL INSTRUCTIONS

This test measures the ability to match a spoken sound to the correct alternative among a group of similar printed sounds. The double

vowel, ee, is the middle part of every syllable spoken. An accurate performance is thus determined by discrimination and matching of the consonant or combination of consonants at the beginning and end of each syllable.

The subject should be seated comfortably at the opposite end of the table from the tape recorder. Care should be taken that the subject faces the speaker and does not move his head excessively. This is done so that the sound comes equally to both ears of the subject.

The first three items of the test are samples. As the subject listens to these items, have him point to the word he selects. Wrong selections are not corrected by the examiner. However, this procedure permits the examiner to be certain that the subject understands the instructions.

The sample can be re-run as many times as the examiner feels necessary when subject does not grasp the instructions. However, once the test begins no further help can be given. Examiner can only give help in making sure subject proceeds in the correct column.

Make certain the recorder is adjusted in tone and volume for the subject, and also that the room is as free from distractable noises as possible.

Criterion score on this test is more than seven errors.

RHYTHM TEST

(Use tape-recorder) YOU WILL HEAR TWO RHYTHMIC PATTERNS, ONE AFTER THE OTHER. THE SECOND PATTERN IS EITHER THE SAME AS THE FIRST OR DIFFERENT FROM IT. NOW I AM GOING TO PLAY THE SAMPLE. DON'T WRITE ANYTHING ON YOUR PAPER BUT LISTEN CLOSELY AND TELL ME WHETHER THE TWO PATTERNS SOUND THE SAME OR DIFFERENT. LISTEN CAREFULLY SO YOU WILL BE SURE TO UNDERSTAND WHAT TO DO. (Present sample).

(After presenting sample say:) IF THE TWO PATTERNS ARE THE SAME, PRINT "S" IN THE PROPER PLACE ON YOUR TEST BLANK (show patient proper space). IF THEY ARE DIFFERENT PRINT "D". (Write S = same and D = different on side of paper, explaining that this shows the type of responses to give.) REMEMBER "S" IF THEY ARE THE SAME, AND "D" IF THEY ARE DIFFERENT. PUT YOUR FIRST ANSWER IN THE SQUARE OPPOSITE NO. 1 AND GO DOWN COLUMN A. REMEMBER TO LISTEN FOR TWO PATTERNS EACH TIME BEFORE PUTTING DOWN AN ANSWER. A VOICE WILL TELL YOU WHEN TO START COLUMN B AND COLUMN C, BUT HE WILL NOT SAY ANY NUMBERS TO LET YOU KNOW WHAT SQUARE YOU SHOULD BE WORKING IN. THE TEST MOVES RAPIDLY SO BE SURE TO PUT YOUR ANSWER DOWN RIGHT AWAY.

TAPPING TEST

NOW WE ARE GOING TO DO A TEST TO SEE HOW FAST YOU CAN TAP. WE WILL USE THIS LITTLE KEY HERE (show it to the patient) AND I WANT YOU TO TAP JUST AS FAST AS YOU CAN, USING THE FOREFINGER (point to the finger of patient) OF YOUR RIGHT (or left, if the subject is left-handed) HAND. WHEN YOU DO IT, BE SURE TO USE A FINGER MOVEMENT: DO NOT MOVE YOUR WHOLE HAND OR YOUR ARM. WHEN YOU TAP THIS KEY, YOU WILL HAVE TO REMEMBER TO LET THE KEY COME ALL THE WAY UP AND CLICK EACH TIME OR ELSE THE NUMBER ON THE DIAL WON'T CHANGE. (Show the patient how the key works and how it should be allowed to click, etc.) NOW YOU MOVE THE BOARD TO A COMFORTABLE POSITION FOR YOUR HAND AND TRY IT FOR PRACTICE. After brief practice, say: REMEMBER TO TAP AS RAPIDLY AS YOU POSSIBLY CAN. READY, GO! The patient may rest his hand after any trial but always suggest that he rest after the third trial for each hand. After completing the test with the preferred hand, finger tapping speed for the index finger of the non-preferred hand is determined.

GENERAL INSTRUCTIONS

It is best for the examiner to place his fingers over the dial so the subject cannot see his score as he is working. Some subjects will stop tapping when the preceding score is reached, or he tries so hard to get a higher score that arm movement begins.

The subject taps with each hand until he receives five consecutive scores which are within five points of each other for a single

hand. Therefore, it is possible for the subject to have more than five trials. Add up the five consecutive scores and divide the total by five to find the average number of taps per ten seconds. The criterion score is less than 51. If the examiner notices that fatigue is developing, require the subject to rest between trials. A rest of a minute or two is always given after the third trial. Do not let the subject practice so much before the test that he becomes fatigued before the first trial.

APHASIA SCREENING TEST

In this test language abilities and a number of related perceptual abilities that are sometimes impaired by organic brain damage are tested in a systematic manner. Record patient's responses completely and carefully. Since this test is designed to determine whether or not a patient can perform some simple tasks, the examiner should not hesitate to repeat or amplify instructions in the attempt to elicit the patient's best possible performances. However, one should be careful to avoid giving the patient actual help with any item.

I HAVE A NUMBER OF THINGS THAT I WANT TO ASK YOU TO DO. SOME OF THEM ARE VERY SIMPLE, BUT EVEN IF THEY ARE EASY FOR YOU I WANT YOU TO DO THEM CAREFULLY AND BE SURE TO DO YOUR BEST.

1. FIRST, DRAW THIS (point to square) ON YOUR PAPER. I WANT YOU TO DO IT WITHOUT LIFTING YOUR PENCIL FROM THE PAPER. MAKE IT ABOUT THIS SAME SIZE (pointing to square). Elaborate on the requirement for a continuous line if necessary. If the subject is concerned about making a heavy or double line, point out that only a reproduction of the shape is required.

2. WHAT IS THAT SHAPE CALLED? or WHAT IS THE NAME FOR THAT FIGURE?

3. WOULD YOU SPELL THAT WORD FOR ME?

4. DRAW THIS (point to cross) ON YOUR PAPER. GO AROUND THE OUTSIDE LIKE THIS (examiner draws a finger-line around the edge of the stimulus

figure) UNTIL YOU GET BACK TO WHERE YOU STARTED. MAKE IT ABOUT THIS SAME SIZE (point to cross). Additional instructions, if necessary, should be similar to those used with the square.

5. (similar to 2 above)

6. (similar to 3 above)

7. (similar to 1 and 4 above)

8. (similar to 2 above)

9. (similar to 3 above)

If the subject has obvious difficulty in drawing any of the above figures, encourage him to proceed until it is clear that he can make no further progress. If he has not accomplished the task reasonably well on his first try, ask him to try again, and instruct him to be particularly careful to do it as well as he can.

10. (Baby) WHAT IS THIS?

11. (Clock) NOW I AM GOING TO SHOW YOU ANOTHER PICTURE BUT DO NOT TELL ME THE NAME OF IT. I DON'T WANT YOU TO SAY ANYTHING OUT LOUD. JUST WRITE THE NAME OF THE PICTURE ON YOUR PAPER.

12. (Fork) WHAT IS THIS?

13. (7 SIX 2) I WANT YOU TO READ THIS. If the subject has difficulty, attempt to determine whether he can read any part of the stimulus-figure.

14. (M G W) READ THIS.

15. (See the black dog) NOW I WANT YOU TO READ THIS.

16. (He is a friendly animal a famous winner of dog shows) CAN YOU READ THIS?

17. and 17a. These items relate to tactile perception and customarily are left to the end of the test. Instructions will be given at that point.

18. NOW I AM GOING TO SAY SOME WORDS. I WANT YOU TO LISTEN CAREFULLY AND SAY THEM AFTER ME AS CAREFULLY AS YOU CAN. SAY THIS WORD: TRIANGLE.

19. THE NEXT ONE IS A LITTLE HARDER BUT DO YOUR BEST. SAY THIS WORD: MASSACHUSETTS.

20. NOW REPEAT THIS ONE: METHODIST EPISCOPAL.

21. (Square) DON'T SAY THIS WORD OUT LOUD. (Pointing to stimulus word "square") JUST WRITE IT ON YOUR PAPER. If the patient prints the word, ask him to write it.

22a. (Seven) CAN YOU READ THIS WORD?

22. NOW, I WANT YOU TO SAY THIS AFTER ME: SEVEN

23. I AM GOING TO SAY SOMETHING THAT I WANT YOU TO SAY AFTER ME, SO LISTEN CAREFULLY: HE SHOUTED THE WARNING. NOW YOU SAY IT.

WOULD YOU EXPLAIN WHAT THAT MEANS? Sometimes it is necessary to amplify by asking the kind of situation to which the sentence would refer. The patient's understanding is adequately demonstrated when he brings the concept of impending danger into the explanation or illustration given.

24. NOW I WANT YOU TO WRITE THAT SENTENCE ON THE PAPER. Sometimes it is necessary to repeat the sentence so that the patient understands what he is to write.

25. (85-27) HERE IS AN ARITHMETIC PROBLEM. COPY IT DOWN ON YOUR PAPER ANY WAY YOU LIKE AND TRY TO WORK IT OUT.

26. NOW DO THIS ONE IS YOUR HEAD: 17 x 3.

27. (Key) WHAT IS THIS?

28. (Still showing the picture of the key) IF YOU HAD ONE OF THESE IN YOUR HAND, SHOW ME HOW YOU WOULD USE IT.

29. (Key) NOW I WANT YOU TO DRAW A PICTURE THAT LOOKS JUST LIKE THIS. TRY TO MAKE YOUR KEY LOOK ENOUGH LIKE THIS ONE (pointing to the picture) SO THAT I WOULD KNOW IT WAS THE SAME KEY FROM YOUR DRAWING.

30. (Place left hand to right ear) WOULD YOU READ THIS?

31. (Place left hand to right ear) NOW, WOULD YOU DO WHAT IT SAID?

32. NOW I WANT YOU TO PUT YOUR LEFT HAND TO YOUR LEFT ELBOW.

EXAMINATION FOR PERCEPTUAL DISTURBANCES

Sensory Imperception

a) Tactile: PUT YOUR HANDS ON THE TABLE LIKE THIS (palms down). I AM GOING TO TOUCH YOUR RIGHT HAND (touch) OR YOUR LEFT HAND (touch). I WANT YOU TO CLOSE YOUR EYES SINCE I WANT YOU TO DEPEND ONLY ON YOUR FEELING TO TELL ME WHICH HAND I TOUCH. IF I TOUCH YOUR RIGHT HAND (touch right hand) YOU SAY "RIGHT". THAT WAY I WILL KNOW YOU FELT IT. IF I TOUCH YOUR LEFT HAND (touch left hand) YOU SAY "LEFT". BE SURE YOU DO NOT MAKE A MISTAKE IN TELLING ME WHICH HAND I TOUCHED. DO YOU HAVE ANY QUESTIONS?

Repeat or amplify the instructions as may be necessary to be sure that the patient understands the procedure.

First, touch the right hand or left hand in random sequence approximately four times each in order to determine the pressure needed to obtain consistent and correct responses to unilateral stimulation. Then, touch right hand, left hand, or both hands simultaneously in random sequence until each has been tried at least four times. If the patient has more difficulty feeling the stimulus on one side or the other, this should be recorded. The important point of this test, however, is to determine whether or not the patient fails to respond on one side consistently with bilateral simultaneous stimulation even though he responds correctly on the same side with unilateral stimulation. Never warn patient that you will touch both hands simultaneously on some trials. Some patients have so much difficulty keeping their

eyes closed that it may be necessary to blindfold them. Be sure that the responses are based upon tactile perception alone. Record only errors on the form.

Using the above procedure as a model, proceed with:

NOW I'M GOING TO TOUCH EITHER YOUR HAND OR YOUR FACE, AND I WANT YOU TO TELL ME WHICH ONE I'M TOUCHING. JUST SAY HAND OR FACE. ALL RIGHT, CLOSE YOUR EYES.

Touch right hand, left face, and both randomly until each has been done at least four times. Then repeat with left hand, right face, and both.

b) Auditory: NOW I'M GOING TO STAND BEHIND YOU AND MAKE A NOISE LIKE THIS (a barely audible finger snap -- just rubbing two fingers together should be sufficient). I WANT YOU TO TELL ME IF THE SOUND IS BY THIS EAR (touch right ear) OR THIS EAR (touch left ear). YOU CAN TELL ME WHICH EAR JUST BY SAYING "RIGHT" OR "LEFT". BE SURE TO KEEP YOUR EYES CLOSED. Proceed as above.

c) Visual: I'M GOING TO SIT IN FRONT OF YOU AND HOLD MY HANDS OUT LIKE THIS. (Place yourself about 3 feet in front of patient.) I WANT YOU TO LOOK DIRECTLY AT MY NOSE AND TELL ME IF I AM MOVING THIS HAND (move fingers of right hand obviously) OR THIS HAND (move fingers of left hand obviously). TELL ME WHICH HAND I MOVE BY SAYING "RIGHT" IF IT IS OVER TO YOUR RIGHT SIDE OR BY SAYING "LEFT" IF IT IS OVER TO YOUR LEFT SIDE. BUT BE SURE TO LOOK DIRECTLY AT MY NOSE ALL THE TIME -- DON'T LOOK AT MY HANDS.

It is difficult for some patients to fixate vision on one point.

However, the test is invalidated if the patient's vision is not fixated in the center of his visual field. The examiner must be alert to give the stimulus only when the subject's vision is properly fixated. First proceed with unilateral stimuli because correct responses to unilateral movement must be determined before possible failure to respond on one side or the other with bilateral simultaneous stimulation has any special significance. If the examiner suspects a possible limitation of visual fields, gross confrontation procedures may be used to map roughly the visual fields. In the event of homonymous hemianopsia, bilateral simultaneous visual stimulation is meaningless. However, homonymous quadrantanopsia may not invalidate the test provided that the intact quadrants are used for presenting the stimulus.

17a. Finger Agnosia: I'M GOING TO TOUCH YOUR FINGERS, AND I WANT YOU TO TELL ME WHICH ONE I TOUCH.

Examiner should hold test blank over patient's forearm to block his vision and touch one finger or another. Immediately after a finger has been touched the examiner should ask: NOW WHICH FINGER DID I TOUCH?

The examiner must work out a system with the patient for reporting which finger was touched. Customarily the patient will report by number, but sometimes patients prefer to identify their fingers in other verbal terms. The patient should be permitted to use whatever method of verbal identification he prefers. Sometimes it is necessary to give the patient practice with his eyes open in order to be sure that he is able to report reliably.

25. Finger-Tip Number Writing: I AM GOING TO WRITE SOME NUMBERS ON YOUR FINGER-TIPS. I WANT YOU TO PAY CLOSE ATTENTION SO THAT YOU WILL BE ABLE TO TELL ME THE NUMBERS THAT I WRITE.

Illustrate on subject's palm how the numbers will be written, as follows: THIS IS THE WAY I WILL MAKE A 3; THIS IS THE WAY I WILL MAKE A 4; THIS IS THE WAY I WILL MAKE A 5; AND I WILL MAKE A 6 LIKE THIS. If the subject gives any indication that he makes the numbers differently from the examiner, the examiner's method should be adapted to the subject's method for writing the numbers. In some instances it may be worthwhile to have the subject write the numbers 3, 4, 5 and 6 on paper before the illustrations are given on the subject's palm, so that the numbers can be made in the way most familiar to the subject.

BE SURE TO KEEP YOUR EYES CLOSED BUT PAY CLOSE ATTENTION SO THAT YOU WILL BE ABLE TO TELL WHAT NUMBERS I WRITE. SINCE I AM FACING YOU, REMEMBER THAT I WILL BE WRITING THE NUMBERS UPSIDE DOWN.

Shield the patient's finger as you write each number so that he will not be able to see what is written even if he should open his eyes. Use a different finger for each trial (proceeding from finger 1 through 5) until four trials have been given (using the numbers indicated on the test form) for each finger of the right hand. Duplicate the procedure for the left hand. Record errors only.

TACTILE FORM RECOGNITION TEST

Have subject place right hand into hole of board. I AM GOING TO PLACE AN OBJECT IN YOUR HAND. FEEL IT CAREFULLY, THEN POINT WITH YOUR LEFT HAND TO THE FIGURE ON THE BOARD (examiner points to the row of figures on the front of the board) WHICH IS JUST LIKE THE ONE IN YOUR HAND. Examiner places first figure (circle) in the subject's right hand. If the subject responds correctly, remove that figure from the hand and place the next figure (square) in the same hand. Whenever the subject's response is not correct, remove figure from hand, indicate on form subject's response, then go on to the next figure.

Proceed in order as indicated on form. Use all four figures first with the right hand. When this is completed, say: YOU MAY TAKE THAT HAND OUT AND NOW PUT IN YOUR LEFT HAND. WE WILL DO THE SAME THING USING THE LEFT HAND. FEEL THE OBJECT WITH YOUR LEFT HAND AND POINT TO THE CORRECT FIGURE WITH YOUR RIGHT HAND. Place figure (triangle) in hand and proceed as above. When all four figures have been tried, again have the subject change hands and do it again with the right hand. Following this, the left hand is used again.

GENERAL INSTRUCTIONS

The purpose of this examination is to test tactile form discrimination in the two hands. The four figures used in this test are first placed in the right hand, then the left, the right again, and finally the left. The hand not being tested is used to indicate the response by pointing to one of the four figures displayed on the face of the board.

There is no time limit. The subject may feel the figure as long as necessary.

Place the figure more on the finger tips than in the palm.

Do not allow subject to remove the hand being used from the board. Do not let the subject see the figure being felt.

ORDER OF PRESENTATION: Right hand: circle, square, triangle, cross. Left hand: triangle, cross, circle, square. Right hand: cross, circle, square, triangle. Left hand: square, triangle, cross, circle.

SCORING: Number of errors.

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