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Diagnosis of brain damage through the use of three visual tests: retinal rivalry spiral after-imaage and stereoscopic figure tracings

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DIAGNOSIS OF BRAIN DAMAGE THROUGH THE USE OF THREE VISUAL TESTS: RETINAL RIVALRY, SPIRAL AFTER-IMAGE, AND STEREOSCOPIC FIGURE TRACINGS

by

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CHAPTER I

IDENTIFICATION OF ORGANIC BRAIN DAMAGE

The identification of that type of intellectual deterioration or impairment indicative of organic damage to the brain has long been a problem in psychological diagnosis. The ability of the brain to function in an effective and often "normal" manner despite such organic disturbances has made the problem of detection extremely difficult [17].

While perceptual, motor, thought, and emotional functions have known involvement concomitant to organic changes in the brain [10], The problem of identifying such changes by means of any one of these functions is often difficult [10, 17]. An evaluation of any one or all of these functions may reveal such damage.

In general, the rationale for constructing evaluative measures of brain damage is based on the rigidity of psychological functioning which has been found to be associated with such pathological conditions [5, 8, 21]. In the perceptual area, rigidity in visual modes of perception has been utilized as an index of brain damage. Ambiguity of results, when these visual evaluative measures were used to identify brain damage, suggests the need for further research in this area.

Three visual tests chosen to evaluate brain damage were used in this study to determine the possibility of diagnosing brain injury.

A. REVIEW OF LITERATURE

The Concept of Rigidity

The term "rigidity" has been used as a concept to relate various kinds of behavior in genetic, abnormal and comparative psychology. This term has been used in so many contexts and descriptions of behavior that no universal definition is apparent. An attempt has been made here to identify rigidity in general terms and relate it to organic pathology.

In theory, rigidity occurs when the organism fails to cope adequately with its environment and appears as a type of reaction to a situation to which the individual is inadequate.

Werner [20] has referred to functional rigidity. Functional rigidity as used by him refers to a slowness in response variation. It is characterized by a lack of variability in responding to the environment and has been found in organisms relatively low on the phylogenetic scale. In addition, this trait has been observed in brain-injured animals and humans as well as in organically unimpaired, frustrated individuals.

Fisher [6] has identified rigidity with the behavior of people under different circumstances. Behavior under different circumstances varies along a continuum from cautious guardedness, or limitation of reaction, to freedom of reaction or lack of defensive caution.

Goldstein [8] has done extensive work with rigidity as it concerns pathology. He emphasizes that rigidity is a normal phenomenon that is exaggerated in organic pathology.

In his studies of pathological conditions, he has found that the brain-injured display two kinds of rigidity identified as "primary" and "secondary."

Primary rigidity is characterized by an inability to change "set" and does not involve impairment of the higher mental processes. This deficiency is apparent if the brain-injured patient attempts to shift from one activity to a task not related to the first activity. The difficulty does not appear to lie in the task itself since the patient is quite capable of solving any of the required tasks even if a higher level of abstraction be demanded. This primary rigidity has been observed especially with subcortical lesions.

Secondary rigidity is an impairment of abstract thinking. This form of rigidity appears in brain-injured patients when a given task is too difficult. The patient will stay with a task which he has solved previously, repeating it over and over. Rigidity here is a secondary phenomenon in that it is a means of escape from a frustrating situation.

In his observations of surgical experiments, Goldstein found that in pathological conditions, rigidity can affect many performances, physical as well as mental. His observations of surgical experiments in animals and pathological processes in man have shown that rigidity appears when a part of the central nervous system is exposed to stimulation. Under the effects of stimulation of isolated parts of the central nervous system, the organism, it was found, may not react to "normal" stimuli, or, if it does react, the reaction may be abnormally strong. In addition, Goldstein found that the organism may react to one stimulus but is very easily diverted to another.

Among the psychological studies of brain-injured subjects, forms of rigidity have been identified similar to those mentioned above. These studies have included the areas of intellectual functioning, critical flicker frequency, spatial orientation, visual form and pattern vision, and figural after-image.

Intellectual Functioning

Rigidity in intellectual functioning has been found in brain-damaged subjects. In sorting tests of conceptual relationships, Strauss and Schtiner (17) found that brain-injured children, as compared with non-brain-injured normal and mentally deficient children, failed to elaborate effectively on the concepts they were using and exhibited pedantic and formalistic behavior in arranging objects.

Werner (19) has identified rigidity as a dominant trait in feeble-minded persons and has given statistical evidence that the rigidity of the brain-damaged defective is distinctly different from the rigidity of the familial type defective.

Measuring rigidity in terms of different kinds of perseverance, he found that the rigidity of the brain-injured is due to a tendency to break up concepts into unrelated parts with uncritical persistence in the use of these parts in meeting later situations. There was no comprehension of the inappropriateness of such parts when used out of context.

However, Werner found that the familial defective seems to be rigid because he has an uncritical tendency to grasp things as primitive wholes. That is, in meeting new situations, he fuses them into the mold of a former concept and consequently responds perseveringly to them in terms of older concepts to which they have been fused.

Studies of individuals with brain pathology have suggested that rigidity is more readily identified with non-verbal types of intellectual functioning.

Allen [1] studied patients with non-traumatic brain pathology and reported that intellectual functioning of a performance and manipulative kind was more impaired than were verbal abilities.

Similarly, in studies dealing with the removal of cerebral tissue, Hebb [9] found that following removal of portions of the right temporal lobe, disturbances were primarily in the non-language areas with good retention in the verbal abilities. He concluded, therefore, that normal intelligence is a complex whose components may be differently affected by cerebral lesions.

<u>Critical Flicker Frequency</u>

A lowering of critical flicker frequency has been found to be associated with brain damage.

Bender and Teuber [4] recorded definite lowering in critical flicker frequency after the occurrence of occipital lobe lesions. The impairment was detected under routine perimetric examination. Defects were found to be more striking when critical flicker frequency was tested in the periphery than when tested in the macular region.

Werner and Thuma [22] found that critical flicker frequency differentiated groups of feeble-minded subjects. They compared equated groups of exogenous feeble-minded and familial feeble-minded types on performance in critical flicker fusion perception. The results indicated that the exogenous feeble-minded fell below the familial groups in critical flicker frequency at all brightness levels. It was concluded that the time-space process of flicker fusion and apparent motion was similarly impaired by the occurrence of lesions of the central nervous system.

Evidence against critical flicker frequency as a means of identification of brain damage was obtained by Battersby [2] who found negative results in studies of veteran patients with frontal head wounds. The patients did not show any significant differences in the frequency level when compared with an equated control group. It was felt that differences in populations and test conditions may have accounted for the discrepancies in results.

Spatial Orientation

Rigidity has been observed in the spatial orientation of brain-damaged patients. It is identified as an inability to change "set."

Stengel [16] reported cases of brain lesions in which severe spatial reorganization difficulty was found. Also, Paterson and Zangwill (14) found that patients with right parieto-occipital lobe injuries have a tendency to overestimate the distance of very near objects and to underestimate the distance of far objects. However, in such patients, the ability to appreciate depth and distance remained and their awareness of space was not affected.

Similarly, Bender and Teuber (4) utilized a phenomenon tentatively labeled "extinction." They found that patients with brain lesions who were confronted with an object in their left-half field, reported that the object disappeared as another object was shown in their right-half field. Extinction occurred on simultaneous stimulation by targets placed on both sides of the fixation points.

It would seem that visual activity mediated by one hemisphere "inhibits" activity in the second, relatively more impaired hemisphere. This extinction also occurred in response to simultaneous stimulation on either side of the midline and on simultaneous stimulation of upper and lower quadrants in the homolateral half of the field. The target thus became extinct in the upper left quadrant as soon as an additional target was introduced into the left lower quadrant. Extinction occurred in monocular as well as in binocular testing. A weak stimulus was often sufficient to extinguish a stronger stimulus in another quadrant.

The time relationship between the stimuli was found to be important. Since there is simultaneous stimulation in many parts of the field in ordinary vision, it was thought that certain visual defects might be due to an ease of distraction in corresponding regions rather than to any actual loss of function caused by complete destruction of tissues.

An evaluation of the brain-damaged patient's rigidity of spatial orientation is made in the stereoscopic tracing test which is a part of this study. In this test, spatial orientation is important in reproducing figures viewed through a stereoscope.

Form and Pattern Vision

Exaggerated perceptual experiences appear in the form and pattern vision of brain-damaged subjects.

Werner and Carrison [19] investigated the adequacy of figure-ground formations in brain-injured children. They found that tactile kinesthetic ability and visual form perception were impaired in subjects with such injury. The subjects showed inability to grasp and retain visual patterns made up of discrete elements.

Werner [19] found that pattern vision lacked stability of visual contours after the occurrence of occipital injury. It was found that the formation of contours took more time in the defective fields of brain-damaged subjects than in the fields of normal subjects. Tachistoscopic exposure of simple outline patterns led to excessive gamma movements; the patients complained that the figures appeared with a vigorous illusory motion of approaching and expanding and disappeared with similarly pronounced movements of recession and contraction.

The phenomenon of completion has been studied by Bender and Teuber [4] using brain-damaged patients. They found that when a figure was shown simultaneously in a blind and non-blind area of an eye, the brain-damaged patient saw the total figure. He "completed" the figure in such cases although the perimetric findings indicated that only a part of the figure should have been visible to him.

An evaluation of form and pattern vision with brain-damaged patients is made through the retinal rivalry test which is a part of the present study.

Figural After-Images

An inability to react effectively to the figural after-effect appears as a characteristic of rigidity in brain-damaged subjects. By utilizing the spiral after-image, Price and Deabler [15] found that brain-damaged subjects reported significantly fewer after-images than either normal or non-organic psychiatric subjects. Subsequent to this experiment Gallese [7] also effectively identified brain-damaged patients by means of the spiral after-image. However, the findings of Page (13) failed to attribute any discriminatory ability to the spiral aftereffect such as that reported by Price and Deabler. A validation of the spiral aftereffect, with some variations, will be undertaken in the present study.

Klein and Krech [11] tested the hypothesis that both concreteness and figural aftereffects in brain-injured patients were functions of reduced "cortical conductivity." Their experiment compared brain-injured and controls on both degree and rate of satiation following exposure to a kinesthetic stimulus and on the extent of recovery. It was found that brain-damaged subjects reported a more pronounced figural aftereffect that appeared sooner and lasted longer than did the control group.

These psychological studies suggest that methods involving the use of tachistoscopic presentations, apparent movement thresholds, critical flicker fusion frequency testing, and psychophysical techniques of visual perception, in general, may be useful in examination of organic patients. Since the concept of rigidity in brain damage is not clearly understood, the following evaluation of brain damage will not refer to this concept.

B. STATEMENT OF THE PROBLEM

While visual perception appears to be related to brain damage, the nature of this relationship is not clear. The present study is an attempt to relate visual perception to brain damage and to develop additional techniques for the identification of brain-damaged patients.

Hypotheses

The general hypothesis of this study is that the visual perception of brain-damaged subjects differs significantly from that found in non-brain-damaged subjects. The following specific hypotheses were investigated:

1. That retinal rivalry, when quantified in terms of the number of visual changes reported over a period of time, will differentiate brain-damaged patients from non-brain-damaged psychotic and normal control groups.

2. That the spiral after-image, when quantified in terms of an inability to report sighting the aftereffect, will differentiate brain-damaged patients from non-brain-damaged psychotic and normal control groups.

3. That binocular tracings, when quantified in terms of reduced ability to accurately trace figures which are

binocularly presented, will differentiate brain damaged patients from non-brain-damaged psychotic and normal control groups.

CHAPTER II

METHOD AND PROCEDURE

A. APPARATUS

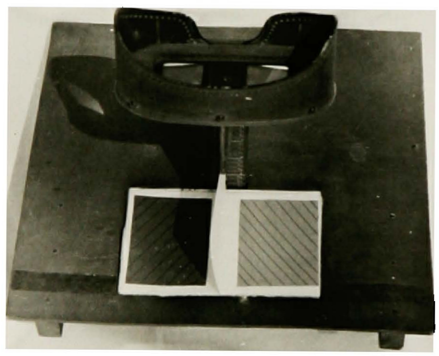
Retinal Rivalry

The apparatus used to produce the retinal rivalry consisted of a stereoscope and a viewing card. The stereoscope was mounted five inches above the vieing card. The viewing card consisted of two colored squares, each having an area of eight and three-quarter square inches. One square was colored red, the other, green. Each had diagonal lines running in opposite direction to those drawn on the other square. The apparatus used is shown in Photograph I and Illustration I.

Spiral After Image

To produce the spiral after-image a 78 RPM phonograph turntable was used together with three eight-inch Archimedes spiral discs of 920 degrees. Disc A was yellow with a green spiral; disc B, black with a brown spiral; and disc C, blue with a red spiral.

Spirals A and C produced contracting aftereffects while spiral B produced an expanding aftereffect. The discs were rotated at 78 RPM. The apparatus used is shown in Photograph II and miniature examples in Illustration II.



PHOTOGRAPH I

APPARATUS USED IN RETINAL RIVALRY TEST

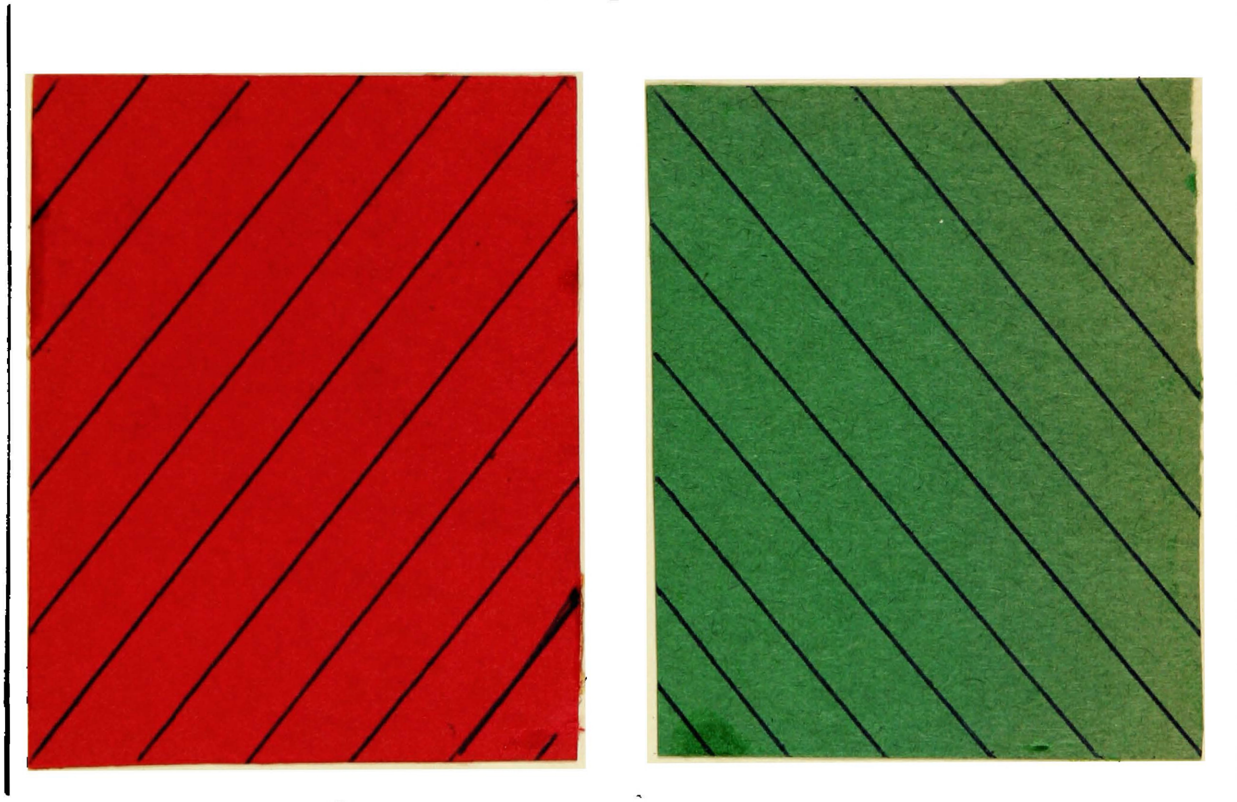
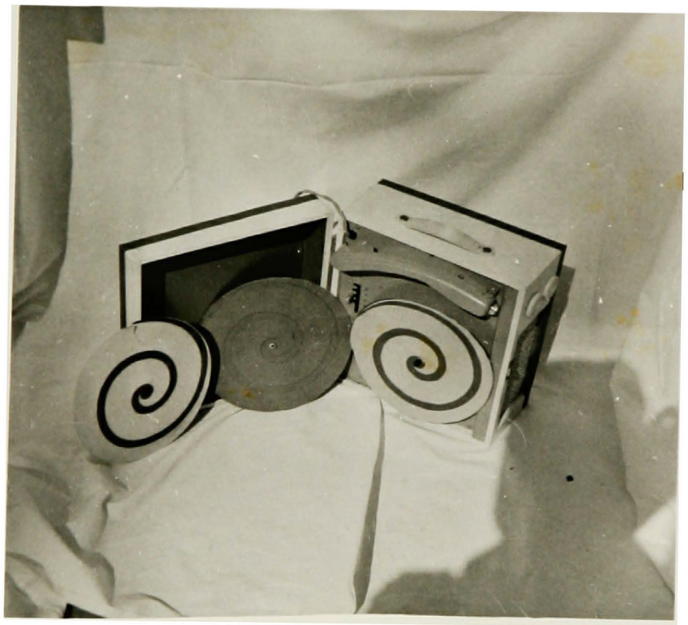


ILLUSTRATION I

VIEWING CARD FOR RETINAL RIVALRY TEST



PHOTOGRAPH II

APPARATUS USED IN SPIRAL AFTER-IMAGE TEST

ILLUSTRATION II

SPIRALS FOR PRODUCING SPIRAL AFTER-IMAGE

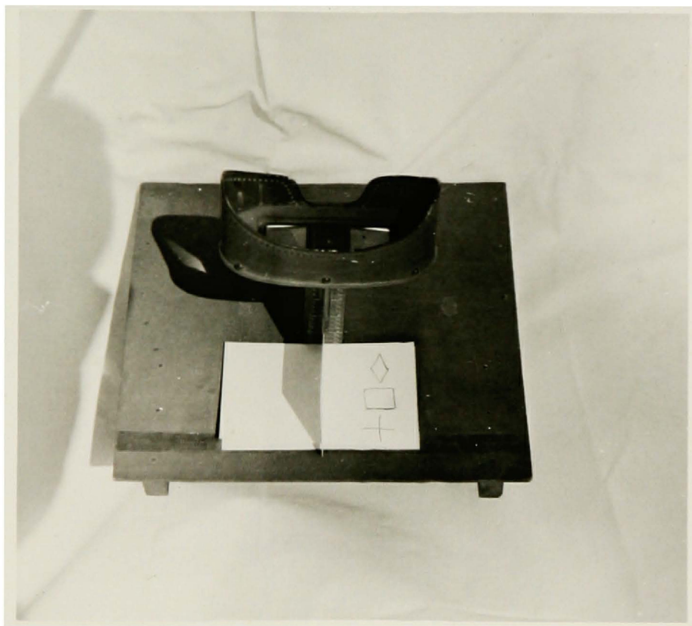
<u>Stereoscopic Tracings</u>

The apparatus used in the tracings consisted of a stereoscope mounted on a viewing platform. The stereoscope was mounted five inches above the viewing platform. Two identical cards were utilized. An outline of a cross, a square, and a diamond was drawn on each card. These figures were drawn off-center in such a manner that they were visible only to one eye when the card was seen through the stereoscope. The figures were exposed to the eye which corresponded to handedness. This apparatus is shown in Photograph III and Illustration III.

<u>Subjects</u>

The groups used in this study consisted of thirty organic, thirty non-organic psychotic, and thirty normal subjects. Each subject chosen for the organic group was matched with a similar subject in the other two groups with respect to age, sex, and education. Age matching was within a two-year differential and education attainment matching was within a five-year differential. Tables I and II present a comparison of the organic, non-organic psychotic and normal groups on the variables of age, sex, and education.

No patients subjected to electro-shock treatment within a two-week period preceding the time of the test were used in this study.



PHOTOGRAPH III

APPARATUS USED IN STEREOSCOPIC FIGURE TRACING TEST

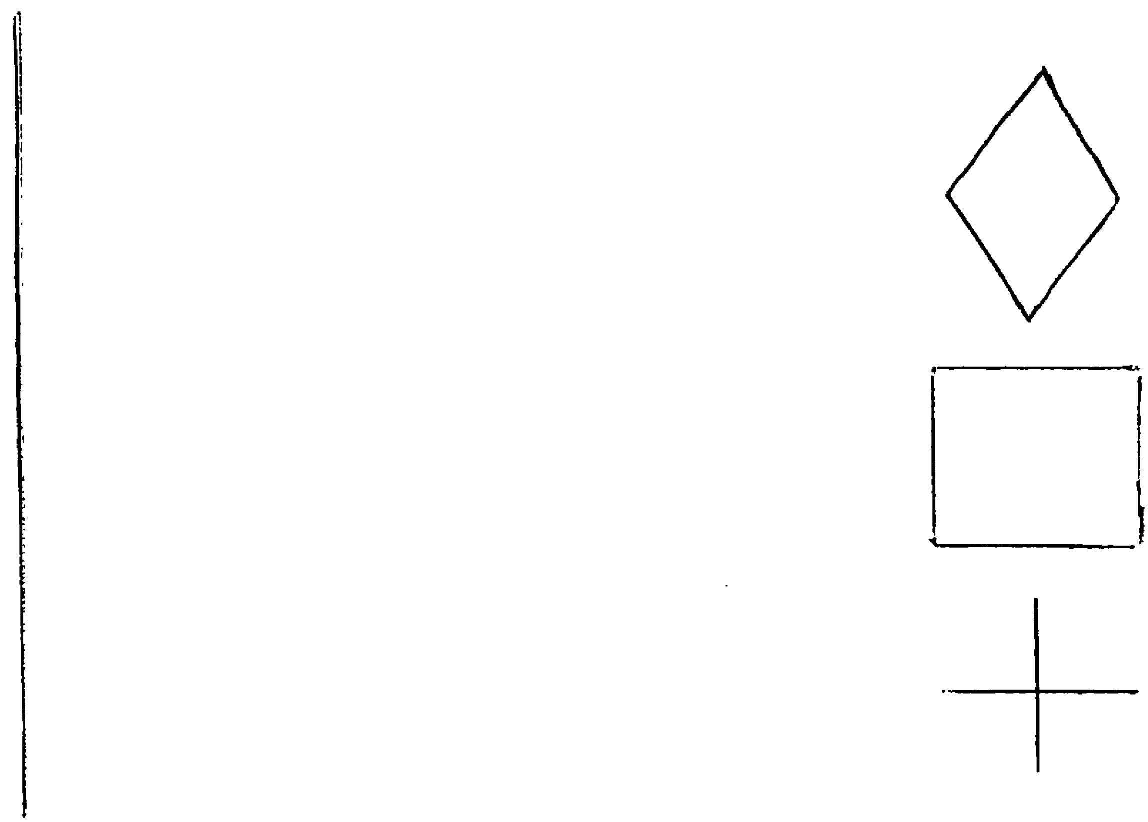


ILLUSTRATION III

VIEWING CARD FOR STEREOSCOPIC
FIGURE TRACING TEST

TABLE I

COMPARISON OF ORGANIC, PSYCHOTIC AND NORMAL GROUPS ON MATCHING VARIABLES OF AGE, SEX AND EDUCATION

ORGANIC					PSYCHOTIC					NORMAL				
Subject	Age	Education	Color Blind	Sex	Subject	Age	Education	Color Blind	Sex	Subject	Age	Education	Color Blind	Sex
1	51	8	No	M	1	55	7	No	M	1	50	8	No	M
2	59	8	No	M	2	55	8	No	M	2	56	8	No	M
3	46	8	No	M	3	43	10	No	M	3	50	10	No	M
4	22	8	No	M	4	26	10	Yes	M	4	21	7	No	M
5	37	15	No	F	5	39	13	No	F	5	43	13	No	F
6	58	4	Yes	M	6	57	4	No	M	6	53	6	No	M
7	51	8	Yes	M	7	47	8	Yes	M	7	53	8	No	M
8	68	8	Yes	M	8	63	9	No	M	8	68	8	No	M
9	69	u/k*	Yes	F	9	68	8	No	F	9	69	8	No	F
10	37	u/k*	No	M	10	33	u/k*	No	M	10	34	6	No	M
11	41	8	No	M	11	38	6	No	M	11	40	8	No	M
12	70	10	No	M	12	68	10	Yes	M	12	67	12	No	M
13	69	8	No	M	13	65	10	No	M	13	70	9	No	M
14	57	8	No	M	14	54	6	No	M	14	54	7	No	M
15	44	12	Yes	M	15	44	12	No	M	15	42	10	No	M
16	59	1	No	M	16	59	3	No	M	16	63	3	No	M
17	66	7	No	M	17	64	9	Yes	M	17	62	8	No	M
18	52	12	No	M	18	53	10	No	M	18	52	10	No	M
19	53	12	No	M	19	56	12	No	M	19	51	11	No	M
20	65	8	No	M	20	66	10	Yes	M	20	63	8	No	M
21	22	14	No	F	21	20	12	No	F	21	23	15	No	F
22	43	12	No	F	22	44	11	No	F	22	42	10	No	F
23	51	u/k*	No	F	23	55	11	No	F	23	52	8	No	F
24	60	u/k*	No	F	24	61	11	No	F	24	58	11	No	F
25	60	8	No	F	25	58	7	Yes	F	25	56	9	No	F
26	55	6	No	F	26	55	8	No	F	26	50	8	No	F
27	22	7	Yes	F	27	26	7	No	F	27	18	9	No	F
28	46	7	Yes	M	28	44	5	No	M	28	50	8	No	M
29	51	10	No	M	29	48	12	No	M	29	50	8	No	M
30	53	u/k*	No	M	30	52	7	No	M	30	53	8	No	M

*Unknown.

TABLE II

COMPARISON OF ORGANIC, PSYCHOTIC AND NORMAL GROUPS ON MATCHING VARIABLES

	AGE		EDUCATION	
	t	Probability	t	Probability
Organic vs. Normal	.052	N.S	.222	N.S
Psychotic vs. Normal	.025	N.S	.133	N.S
Psychotic vs. Organic	.025	N.S	.105	N.S

The organic group consisted of subjects having a medical diagnosis of chronic brain syndrome without mental deficiency and without psychosis. A list of such subjects was obtained from hospital IBM cards. To eliminate the most seriously deteriorated cases, the following criteria were met by those selected for the testing group:

1. Ability to speak the English language.

2. Adequate muscular coordination and sensory acuity to perform the test.

3. Adequate ability to cooperate and sustain the effort and attention necessary to perform the tasks required by the tests, including voluntary submission to the testing.

4. Within the age range of 16 to 70.

From the resulting list of subjects, thirty were chosen at random to serve as the organic group. Among the organics, were eight cases of convulsive disorders, six cases of syphilitic infection, three cases of Korsakoff's syndrome, three cases of cerebral arteriosclerosis, one case of senility, one case of traumatic brain damage, one case of pre-natal influence, one case involving other cranial infection, and six cases of unknown or unspecified causes.

The non-organic psychotic group consisted of subjects diagnosed as schizophrenic by hospital staff action. A listing of these schizophrenic subjects was obtained from hospital IBM files. As with the organic population these psychotic subjects were seen and elimination of the most seriously deteriorated cases was made in terms of the same criteria used with the organic patients.

The normal group consisted of hospital employees and others having no known organic involvement. The criteria utilized for selection of subjects in the organic and psychotic groups were used to eliminate unacceptable subjects for the normal group.

Procedure

For purposes of illumination two 60-watt lamps were placed one foot from the viewing cards and approximately three feet from the disc. A constant illumination, as measured by an incidental light meter reading at the viewing platform and from the phonograph turntable, was thus obtained regardless of exterior lighting conditions.

Subjects were given the following instructions prior to testing: "This is a special eye test. Keep both eyes open." As an additional means of obtaining cooperation and attention (as well as for determining the presence of color blindness) the Dvorine test of color blindness was administered. In presenting the cards to be viewed through the stereoscope, Card A (retinal rivalry) and Card B (stereoscopic tracing) were presented in the order AB-BA.

Retinal Rivalry

While the subjects looked through the stereoscope the retinal rivalry card was presented with the instructions: "Tell me when the card you are viewing changes."

Scoring was made on the basis of the number of color and/or line changes verbalized by the subject over the two 30-second periods spent in viewing the card.

Spiral After-Image

Subjects in the test for spiral after-image were instructed to sit approximately four feet from the vertical phonograph to which spirals A, B, and C, in that order, were attached. The subject was then instructed: "Look at the center of the spiral (with experimenter pointing) and don't take your eyes away until you are told to do so."

The spiral was then rotated and the subject asked, "What do you see?" If the answer was ambiguous or if no answer was given, the subject was asked, "Which way is the line moving?"

When the subject had spoken or shown a response, the experimenter then said, "Now watch closely; when I turn the machine off, I want you to tell me what the line does."

After thirty seconds the machine was turned off and the disc stopped with the finger. The experimenter then asked the subject, "Now what is the line doing?"

This procedure was followed with spirals A, B, and C. In scoring, a positive response was designated as one in which the subject clearly reported perceiving the aftereffect; a negative response as one in which the subject reported no aftereffect.

Stereoscopic Tracings

The stereoscopic tracing card was presented while the subject was looking through the stereoscope. The subject was instructed: "Trace over these figures."

Scoring of the tracing card was made on the basis of the number of figures (out of a total of six) correctly reproduced. The success or failure of the subject on this part of the testing was determined by the quality of the reproductions relative to the requirements set by the Stanford-Binet Intelligence Scale from which the figures were chosen. Independent scoring of these figures was made by three judges. The correctness of each figure was determined by a ruling of two of the three judges.

B. STATISTICAL METHODS

The data obtained from the evaluation of the three tests involved the enumeration of cases in different categories. These categories were as follows: (1) cases above and below a combined median for the compared groups in the retinal rivalry test; (2) sighting or not sighting the aftereffect in the spiral after-image test; and (3) correctly or incorrectly tracing the figures of the stereoscopic figure tracing test.

The Chi Square technique was used to evaluate the significance with which the scores obtained on the various tests discriminated between the groups. The Yates correction for continuity was required in the calculations since certain of the theoretical frequencies were found to be below ten.

CHAPTER III

RESULTS

Since seven organic and six psychotic subjects were found to be color-blind, separate analyses were made which both included and excluded color-blind subjects from the retinal rivalry and spiral after-image tests. These separate analyses were used to control the effect color-blindness might have upon these two tests involving colored stimuli.

A. RETINAL RIVALRY

The analysis of the retinal rivalry test was made in terms of the number of subjects in each group falling above and below the combined median for the compared groups. Analysis was made both including and excluding color-blind subjects.

Total Sample

The relationship between the total organic and normal groups is presented in Table III. The normal groups reported more rivalry changes within the two 30-second periods than did the organic group. The chi square value for the difference between these groups was 45.27 with a p beyond the 0.01 level of confidence.

Table IV presents a comparison between the total psychotic and normal groups in reporting the rivalry changes. As shown by this comparison the normal group reported the changes more frequently than did the psychotic group. A chi square value of 6.70 and significance beyond the 0.01 level of confidence were found when these groups were compared.

The psychotic group reported the changes in greater number than the organic group. When these groups were compared, a chi square value of 35.31 was found with a p beyond the 0.01 level of confidence. These findings are shown in Table V.

A comparison between the groups in terms of performance on the retinal rivalry test indicates that the psychotic and normal groups reported these rivalry changes in significantly greater frequency than did the organic group. In addition, the normal group reported significantly more rivalry changes than did the psychotic group. With cut-off points at the median scores, false diagnosis would have occurred in 6.7% of the cases if the test had been used to separate organic from normals and in 11.7% of the cases if the test had been used to separate organics from psychotics.

TABLE III

A COMPARISON OF RETINAL RIVALRY CHANGES BETWEEN TOTAL ORGANIC AND NORMAL GROUPS

	Number Above Median	Number Below Median	Median Score*	Chi Square	p Beyond
Organic	3	27	-	-	-
Normal	29	1	10.5	45.27	0.01

*Median score of organic and normal groups combined.

TABLE IV

A COMPARISON OF RETINAL RIVALRY CHANGES BETWEEN TOTAL PSYCHOTIC AND NORMAL GROUPS

	Number Above Median	Number Below Median	Median Score*	Chi Square	p Beyond
Psychotic	11	19	-	-	-
Normal	21	9	17.3	6.70	0.01

*Median score of psychotic and normal groups combined.

Non-Color-Blind Sample

A comparison of rivalry changes for non-color-blind organic and normal groups is presented in Table VI.

As shown in this comparison, the normal group reported the changes with greater frequency than did the organic group. The test of significance between these groups resulted in a chi square value of 34.30 and a p beyond the 0.01 level of confidence.

The comparison between the non-color-blind psychotic and the normal groups is presented in Table VII. The normal group observed the rivalry changes more frequently than did the psychotic group. However, a chi square value of 3.68, found when these groups were compared, did not prove statistically significant.

Table VIII presents a comparison of rivalry changes between the non-color-blind psychotic and organic groups. Psychotic subjects visualized the changes with greater frequency than did the organic subjects. This comparison resulted in a chi square value of 28.94 with a p beyond the 0.01 level of confidence.

These comparisons between non-color-blind groups reveal that the psychotic and normal groups reported rivalry changes with significantly greater frequency than

TABLE V

A COMPARISON OF RETINAL RIVALRY CHANGES BETWEEN TOTAL PSYCHOTIC AND ORGANIC GROUPS

	Number Above Median	Number Below Median	Median Score*	Chi Square	p Beyond
Psychotic	27	3	-	-	-
Organic	4	26	10.0	35.31	0.01

*Median score of psychotic and organic groups combined.

TABLE VI

A COMPARISON OF RETINAL RIVALRY CHANGES BETWEEN NON-COLOR BLIND ORGANIC AND NORMAL GROUPS

	Number Above Median	Number Below Median	Median Score*	Chi Square	p Beyond
Organic	1	22	-	-	-
Normal	26	4	14.3	34.30	0.01

*Median score of organic and normal groups combined.

TABLE VII

A COMPARISON OF RETINAL RIVALRY CHANGES BETWEEN NON-COLOR BLIND PSYCHOTIC AND NORMAL GROUPS

	Number Above Median	Number Below Median	Median Score*	Chi Square	p Beyond
Psychotic	9	15	-	-	-
Normal	19	11	18.0	3.68	N.S

*Median score of psychotic and normal groups combined.

TABLE VIII

A COMPARISON OF RETINAL RIVALRY CHANGES BETWEEN NON-COLOR BLIND PSYCHOTIC AND ORGANIC GROUPS

	Number Above Median	Number Below Median	Median Score*	Chi Square	p Beyond
Psychotic	22	2	-	-	-
Organic	3	20	10.4	28.94	0.01

*Median score of psychotic and organic groups combined.

the organic group. With the cut-off points at the median scores, false diagnosis would have occurred in 9.4% of the cases if the test had been used to separate organic from normals and in 10.6% of the cases if the test had been used to separate organics from psychotics.

The results obtained from the retinal rivalry test indicate that when the color-blind subjects were used in the comparison of psychotic and normal groups, significant differences were obtained. However, upon removing these color-blind subjects from the samples, significant differences were no longer obtained. This was the only major change noted upon eliminating the color-blind subjects from the samples.

B. SPIRAL AFTER-IMAGE

The analysis of results with the spiral after-image test was made in terms of the number of subjects reporting the aftereffect in the organic, psychotic, and normal groups for each of the three spirals. In addition, the number of subjects reporting the aftereffect on any one trial was considered.

Groups were compared on the basis of the frequency of subjects within each group reporting the aftereffect.

Analysis was made both including and excluding color-blind subjects.

Total Sample

A comparison between the total organic and normal goups in observing the aftereffect is presented in Table IX. The normal group reported the aftereffect with greater frequency than did the organic group. As shown by this comparison of groups, a p value beyond the 0.01 level of confidence was obtained for all three spirals.

Spiral A had a chi square value of 8.84; spiral B, a value of 17.86; and spiral C, a value of 6.94. A chi square value of 8.44 was obtained in the total score comparison between organics and normals with a p value beyond the 0.01 level of confidence. False diagnosis would have occurred in 31.6% of the cases if spiral A had been used to separate organics from normals. Spiral B would have falsely diagnosed 23.3% of the cases and spiral C would have falsely diagnosed 33.3% of the cases in this separation of organics and normals.

Table X presents the comparison between the total psychotic and normal groups in reporting the aftereffect. No significant differences were found in the performances of these groups on any of the three spirals. The chi square

TABLE IX

FREQUENCY OF REPORTED FIGURAL AFTEREFFECT IN TOTAL ORGANIC AND NORMAL GROUPS

Spiral	Organic	Normal	Chi Square	p Beyond
A	14	25	8.84	0.01
B	13	29	17.86	0.01
C	13	23	6.94	0.01
Total (Reported on at least one trial.)	19	29	8.44	0.01

TABLE X

FREQUENCY OF REPORTED FIGURAL AFTEREFFECT IN TOTAL PSYCHOTIC AND NORMAL GROUPS

Spiral	Psychotic	Normal	Chi Square	p Beyond
A	21	25	0.59	N.S
B	28	29	0.36	N.S
C	21	23	0.85	N.S
Total (Reported on at least one trial.)	28	29	0.36	N.S

value using spiral A was 0.59; for spiral B, this value was 0.36; and for spiral C, this value was 0.85.

The comparison between the total psychotic and organic groups is presented in Table XI. The psychotic subjects observed the aftereffect with greater frequency than did the organic subjects. Spiral A with a chi square value of 3.36 failed to differentiate significantly between these groups. Spiral B resulted in a chi square value of 15.07, which was significant at the 0.01 level of confidence while spiral C produced significance at the 0.02 level of confidence with a chi square value of 6.28. If the test had been used to separate organics from psychotics, false diagnosis would have occurred in 25% of the cases using spiral B and in 36.7% of the cases using spiral C.

In general, these results show that the normal and psychotic groups reported observing the aftereffect with significantly greater frequency than the organic group. Some differences are noted in the effectiveness with which the different spirals differentiated between groups.

<u>Non-Color-Blind Sample</u>

Table XII presents a comparison of the non-color-blind

TABLE XI

FREQUENCY OF REPORTED FIGURAL AFTEREFFECT IN TOTAL PSYCHOTIC AND ORGANIC GROUPS

Spiral	Psychotic	Organic	Chi Square	p Beyond
A	21	14	3.36	N.S
B	28	13	15.07	0.01
C	21	13	4.34	0.05
Total (Reported on at least one trial.)	28	19	6.28	0.02

TABLE XII

FREQUENCY OF REPORTED FIGURAL AFTEREFFECT IN NON-COLOR BLIND ORGANIC AND NORMAL GROUPS

Spiral	Organic	Normal	Chi Square	p Beyond
A	10	25	7.53	0.01
B	11	29	14.25	0.01
C	9	23	5.22	0.05
Total (Reported on at least one trial.)	14	29	8.69	0.01

organic and normal groups in observing the spiral aftereffect.

The frequency of reported aftereffect was greatest for the normal group. As shown by this comparison, a p value beyond the 0.01 level of confidence was obtained in comparing these groups with spirals A and B. A chi square value of 7.53 was found using spiral A, while a chi square value of 14.25 was found using spiral B. Significant difference at the 0.05 level of confidence was found between the organic and normal groups with use of spiral C. Significant difference at the 0.01 level of confidence was found between the performances of these groups for the total score.

If the test had been used to separate organics from normals, false diagnosis would have occurred in 28.3% of the cases using spiral A; in 22.6% of the cases using spiral B; and in 30.1% of the cases using spiral C.

The comparison between the non-color-blind psychotic and normal groups on observing the aftereffect is presented in Table XIII. None of the spirals differentiated significantly between these groups. The chi square values were 1.22 for spiral A; 0.02 for spiral B; and 0.25, for spiral C.

In the comparison between the non-color-blind psychotics and organics, spiral A again failed to differentiate between the groups. The psychotic group reportthe aftereffect with greater frequency than the organic group in using spirals B and C.

Spiral B differentiated the psychotic and organic groups successfully at the 0.01 level of confidence while spiral C proved successful in differentiating these groups at the 0.05 level of confidence. The chi square values were 1.70 for spiral A; 11.24 for spiral B; and 4.77 for spiral C. The total score chi square value was 6.62 which is significant at the 0.02 level of confidence. The results are shown in Table XIV.

If the spiral aftereffect test had been used to separate organics from psychotics, false diagnosis would have occurred in 25.5% of the cases using spiral B and in 34.4% of the cases using spiral C.

The non-color-blind organic group reported the aftereffect significantly less frequently than either the non-color-blind normal or psychotic groups. Spiral A again failed to differentiate between the organic and normal groups. No significant discrimination occurred between the non-color-blind psychotic and normal subjects.

TABLE XIII

FREQUENCY OF REPORTED FIGURAL AFTEREFFECT IN NON-COLOR BLIND PSYCHOTIC AND NORMAL GROUPS

Spiral	Psychotic	Normal	Chi Square	p Beyond
A	16	25	1.22	N.S
B	23	29	0.02	N.S
C	17	23	0.25	N.S
Total (Reported on at least one trial.)	23	29	0.20	N.S

TABLE XIV

FREQUENCY OF REPORTED FIGURAL AFTEREFFECT IN NON-COLOR BLIND PSYCHOTIC AND ORGANIC GROUPS

Spiral	Psychotic	Organic	Chi Square	p Beyond
A	16	10	1.70	N.S
B	23	11	11.24	0.01
C	17	9	4.77	0.05
Total (Reported on at least one trial.)	23	14	6.62	0.02

C. STEREOSCOPIC FIGURE TRACINGS

The analysis of the stereoscopic tracings was made in terms of the frequency of correctly reproducing figures.

The tracings were randomized and independently scored by three judges. The reliability of the judgments made by the judges is presented in Table XV. In recording the correctness or incorrectness of the figures, the judgment of two of the three judges was considered. The percentages of all the tracings for each figure on which all judges agreed were as follows: 94% for Figure 1; 66% for Figure 2; and 69% for Figure 3.

Table XVI presents a comparison between the organic and normal groups in correctly reproducing the figures. These groups approximate each other in frequency of tracing correctly Figure 1. However, the normal group did significantly better than the organic group in tracing Figures 2 and 3. A comparison between these groups resulted in chi square values of 2.48 for Figure 2 and 20.83 for Figure 3. These values proved significant at the 0.01 level of confidence. If the test had been used to separate organics from normals, false diagnosis would have occurred in 39.1% of the cases using Figure 2 and in 30.8% of the cases using Figure 3.

TABLE XV

RELIABILITY OF JUDGMENTS OF FIGURES
FOR THE STEREOSCOPIC TRACINGS

Figure	Total Figures	Number of Figures on Which 3 Judges Agree	Percentage of Total Figures on Which 3 Judges Agree
1	180	169	94%
2	180	118	66%
3	180	125	69%

None of the figures produced significant differences between the psychotic and normal groups. The chi square values were as follows: 1.58 for Figure 1; 0.96 for Figure 2; and 1.20 for Figure 3. These results are presented in Table XVII.

Figure 1 failed significantly to differentiate between the organic and psychotic groups. The psychotic group did significantly better than the organic group in tracing Figures 2 and 3. These group comparisons gave chi square values of 0.83 using Figure 1; 13.53 using Figure 2; and 11.66 using Figure 3. Figures 2 and 3 differentiated the groups effectively at the 0.01 level of confidence. These results are presented in Table XVIII.

If the test had been used to separate organics from psychotics, false diagnosis would have been made in 33.3% of the cases using Figure 2 and in 35.8% of the cases using Figure 3.

These results reveal that the psychotic and normal groups did significantly better than the organic group in correctly tracing Figures 2 and 3. The normal group did somewhat better than the psychotic group in successfully tracing Figures 2 and 3. Figure 1 failed to differentiate among any of the groups.

TABLE XVI

FREQUENCY OF CORRECT STEREOSCOPIC FIGURE TRACINGS BETWEEN ORGANIC AND NORMAL GROUPS

Figure	Organic	Normal	Chi Square	p Beyond
1	52	58	2.48	N.S
2	18	43	20.83	0.01
3	9	32	19.60	0.01

TABLE XVII

FREQUENCY OF CORRECT STEREOSCOPIC FIGURE TRACINGS BETWEEN PSYCHOTIC AND NORMAL GROUPS

Figure	Psychotic	Normal	Chi Square	p Beyond
1	56	58	1.58	N.S
2	38	43	0.96	N.S
3	26	32	1.20	N.S

TABLE XVIII

FREQUENCY OF CORRECT STEREOSCOPIC FIGURE TRACINGS BETWEEN ORGANIC AND PSYCHOTIC GROUPS

Figure	Organic	Psychotic	Chi Square	p Beyond
1	52	56	0.83	N.S
2	18	38	13.53	0.01
3	9	26	11.66	0.01

CHAPTER IV

DISCUSSION

The significance of the results is discussed in terms of a comparison of the brain-damaged and non-brain-damaged subjects in response to the three tests.

A. RETINAL RIVALRY

It was hypothesized that the retinal rivalry test, when quantified in terms of number of visual changes reported over a period of time, would differentiate brain-damaged subjects from non-brain-damaged psychotic and normal control groups. This hypothesis was confirmed. The organic group was significantly differentiated from the normal and psychotic groups through use of the retinal rivalry test.

The retinal rivalry test also discriminated between the normal and psychotic groups when color-blind subjects were included, but did not discriminate when the color-blind subjects were removed from these groups.

It will be noted that there was a general reduction in the extent of significance between groups when the color-blind were removed. The reason for this reduction is not clear. From the data reported here, it is not possible to specify the exact nature of the variables associated with color blindness which reduced the extent of significance between groups. Further research using non-color-blind subjects from comparable normal, psychotic, and organic groups is needed to clarify the discrepancies found in this study.

The percentage of falsely diagnosed subjects that would be obtained by use of the retinal rivalry test would limit its use for purposed of individual diagnosis.

B. SPIRAL AFTER-IMAGE

It was hypothesized that the brain-damaged subjects would differ from the non-brain-damaged subjects in ability to visualize the spiral aftereffect. This hypothesis was also confirmed.

The normal and psychotic groups reported the spiral aftereffect with greater frequency than the organic group. The spiral after-image did not significantly differentiate the normal group from the psychotic group.

Of the spirals utilized, spiral A was somewhat less discriminating than either spirals B or C. Spiral A failed to differentiate the organic group from the psychotic group. The fact that this spiral was presented first may explain this difference. A similar difference in discriminating power, as a function of order of presentation, was found in a previous study [13].

Spiral B, with its expanding aftereffect, showed greater discriminating power between the organic and non-organic groups than did spirals A or C with their contracting aftereffect. Removing color-blind subjects from the groups did not effect the results significantly.

These findings in the effectiveness of the spiral aftereffect for identifying brain damage, support those of Page [13]. While substantiating Price and Deabler's [15] findings, the present study failed to demonstrate as great a discriminatory ability for the spiral aftereffect as that suggested by their findings.

As with the retinal rivalry test, the spiral after-image would not be adequate for individual diagnostic purposes. The number of falsely diagnosed subjects indicates that the test is not sufficiently sensitive for purposes of individual diagnosis.

C. STEREOSCOPIC TRACINGS

It was hypothesized that the non-brain-damaged subjects would differ significantly from brain-damaged subjects in accuracy of stereoscopically tracing the cross, the square, and the diamond. This hypothesis was confirmed in the tracings of the square and diamond but not confirmed in the tracings of the cross.

The organic group differed significantly from the psychotic and normal groups in tracings of the square and diamond. No significant differences were found between these groups in tracing the cross. Since the scoring criteria for the cross are somewhat more lenient than for the other figures, this may account for its inability to discriminate as well as the square and diamond. In addition, it is noted that as the figures become more complex, they become relatively more difficult for organics than for the non-organics.

The square and diamond did not differentiate significantly between the psychotic and the normal group.

The relatively low reliability in scoring the figures throws doubt upon the validity of these test findings. The instructions for scoring these figures do no appear detailed enough for reliable judgments of the stereoscopic tracings to be made.

The results point to the need for more research in stereoscopic figure tracing. Further research might utilize more complex figures and more detailed scoring criteria. The results of this study suggest the possibility that discrimination of brain-damaged subjects from non-brain-damaged subjects may be possible through the use of stereoscopic tracing of figures. However, the figures used in the tracings produced false diagnoses in too great a number to make the test effective for individual diagnostic purposes.

CHAPTER V

SUMMARY

This study was designed to evaluate the use of three visual tests in diagnosing brain damage. The tests were chosen to evaluate the visual perception of brain-damaged and non-brain-damaged subjects.

The population used for the study consisted of thirty organic, thirty psychotic, and thirty normal subjects equated with respect to the variables of sex, education, and age. Tests of retinal rivalry, spiral aftereffect, and binocular tracings were administered to these subjects.

The results confirmed all hypotheses as follows:

1. A reduction in retinal rivalry changes as seen by brain-damaged patients differentiated them from control groups.

2. A reduction in ability to see the spiral after-image by brain-damaged patients differentiated them from control groups.

3. A reduction in ability to produce accurate tracings of binocularly presented figures by brain-damaged subjects differentiated brain-damaged patients from control groups in two of the three figures.

While the tests were generally effective in differentiating between the organic and non-organic groups, they did not give evidence of sufficient sensitivity to be used for purposes of individual diagnosis.

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APPENDIX

APPENDIX A

PERFORMANCE OF NORMAL SUBJECTS ON THE THREE TESTS

SUBJECT	Spiral After Image			Retinal Rivalry Changes Per Minute	Stereoscopic Figure Tracings		
	Spiral A	Spiral B	Spiral C		Figure 1	Figure 2	Figure 3
1	S	S	S	23	1	2	1
2	S	S	S	17	2	0	2
3	S	S	S	19	2	2	0
4	S	S	S	24	2	0	0
5	S	S	S	21	2	2	1
6	S	S	S	15	2	2	0
7	S	S	N.S	12	1	2	2
8	S	S	S	18	2	1	1
9	N.S	N.S	N.S	14	2	1	1
10	S	S	S	19	2	1	2
11	S	S	S	24	2	1	1
12	S	S	S	9	2	1	0
13	S	S	S	20	2	1	2
14	N.S	S	N.S	27	2	2	1
15	S	S	S	15	2	2	1
16	S	S	S	20	2	2	0
17	N.S	S	N.S	17	2	2	2
18	N.S	S	S	20	2	0	0
19	S	S	S	19	2	2	1
20	S	S	S	14	2	2	1
21	S	S	S	28	2	2	2
22	S	S	S	28	2	2	2
23	S	S	S	20	2	1	2
24	S	S	S	17	2	0	0
25	S	S	N.S	21	2	1	2
26	S	S	S	11	2	2	1
27	S	S	S	29	2	1	1
28	S	S	S	31	2	2	0
29	S	S	N.S	20	2	1	0
30	N.S	S	S	15	2	2	1

APPENDIX B

PERFORMANCE OF ORGANIC SUBJECTS ON THE THREE TESTS

SUBJECT	Spiral After Image			Retinal Rivalry Changes Per Minute	Stereoscopic Figure Tracings		
	Spiral A	Spiral B	Spiral C		Figure 1	Figure 2	Figure 3
1	S	S	S	7	2	0	0
2	N.S	N.S	N.S	4	2	1	2
3	N.S	S	S	8	2	0	0
4	S	N.S	N.S	6	2	0	0
5	S	S	S	15	2	0	1
6	S	N.S	S	5	2	0	0
7	N.S	N.S	N.S	2	2	0	0
8	N.S	N.S	N.S	9	2	1	0
9	N.S	N.S	S	8	2	1	1
10	N.S	N.S	N.S	4	2	1	1
11	N.S	N.S	N.S	10	1	1	0
12	S	N.S	N.S	0	0	0	0
13	S	S	N.S	10	2	0	0
14	N.S	N.S	N.S	5	2	1	0
15	S	S	S	8	2	0	0
16	N.S	S	N.S	5	2	0	0
17	N.S	N.S	N.S	6	2	2	0
18	N.S	N.S	N.S	5	1	2	1
19	N.S	S	S	10	1	0	1
20	S	S	N.S	3	2	1	1
21	N.S	N.S	N.S	4	2	1	0
22	S	S	S	3	2	2	0
23	S	N.S	S	7	2	0	0
24	N.S	N.S	N.S	3	2	0	0
25	N.S	N.S	N.S	0	2	0	0
26	S	S	S	3	2	0	0
27	S	N.S	N.S	1	2	0	0
28	S	S	S	8	0	1	0
29	S	S	S	7	2	2	1
30	N.S	S	S	6	2	1	1

APPENDIX C

PERFORMANCE OF PSYCHOTIC SUBJECTS ON THE THREE TESTS

SUBJECT	Spiral After Image			Retinal Rivalry Changes Per Minute	Stereoscopic Figure Tracings		
	Spiral A	Spiral B	Spiral C		Figure 1	Figure 2	Figure 3
1	S	S	S	13	1	0	0
2	S	S	S	14	1	1	0
3	S	S	S	19	2	1	1
4	S	S	N.S	9	2	2	2
5	S	S	S	13	2	0	0
6	N.S	S	N.S	12	2	2	0
7	N.S	N.S	N.S	20	2	2	2
8	S	S	S	15	2	1	2
9	N.S	S	N.S	11	1	0	0
10	S	S	S	22	2	0	0
11	S	S	S	13	2	0	0
12	S	S	S	11	2	0	0
13	S	S	S	18	2	2	2
14	N.S	N.S	N.S	4	2	1	1
15	S	S	S	22	2	1	1
16	N.S	S	S	11	2	1	0
17	S	S	S	12	2	0	0
18	S	S	S	15	2	0	1
19	S	S	N.S	16	2	2	0
20	S	S	S	17	2	2	0
21	S	S	S	20	2	0	0
22	N.S	S	N.S	15	2	1	1
23	S	S	S	22	2	1	2
24	S	S	S	12	2	2	2
25	S	S	S	11	2	2	0
26	S	S	S	20	2	2	2
27	N.S	S	N.S	19	2	2	2
28	S	S	S	10	2	2	1
29	N.S	S	S	24	2	2	2
30	N.S	S	N.S	12	0	1	1