Perception of Embedded Figures after Induced Cerebral Trauma

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Studies of complex visual perception after cerebral damage in man are not always clear or consistent. The disagreements may be due, in part, to difficulties in evaluating the extent of the disease process or the degree of alteration in cerebral function. In contrast, conditions in which there is control of the degree of brain damage, as in electroconvulsive therapy (ECT), provide a unique opportunity for studying this problem.

While investigations of brain-injured populations have focused on the role of location of lesion on behavior, current studies of ECT have emphasized the factor of individual differences. Marked variability has been shown for perceptual (1), behavioral (2) and physiological[3] responses to ECT. In addition, various personality (4) and social factors (5) have

1. C. Landis, D. Dillon and S. Leopold, Changes in flicker-fusion threshold are in choice reaction time induced by electroconvulsive therapy, J. Psychol., 41, 1956, 61-80.

2. M. Fink, R.L. Kahn and M. A. Green, Experimental studies of the Electroshock process, J. Nerv. & Ment. Dis. (in press).

3. R.L. Kahn, M. Fink and E.A. Weinstein, Relation of amobarbital test to clinical improvement in electroshock, A.M.A. Arch. Neurol. & Psychiat., 76, 1956, 23-29;

   M. Fink and R.L. Kahn, Relation of EEG delta activity to behavioral response in electroshock; quantitative serial studies, A.M.A. Arch. Neurol. & Psychiat. 78, 1957, 516-525.

4. R. L. Kahn and M. Fink, Personality factors in behavioral response to Electroshock, Conf. Neurol. in press).

5. R. L. Kahn, M. Pollack and M. Fink, Social factors in the selection of therapy in a voluntary mental hospital, J. Hillside Hosp., 6, 1957, 216-228.

been related to differences in response to treatment.

In the course of an investigation of the perceptual and behavioral changes with ECT, a convulsive-subconvulsive control study was undertaken. In this report, performance on complex visual tasks is presented. Specifically, the aim was to determine whether perceptual change induced by ECT is related to the degree of altered brain function and clinical behavioral change; and whether the pretreatment perceptual pattern was related to physiologic changes with treatment.

The method used in the study was the perception of embedded geometric figures - a technique which has been widely employed in recent years in studies of perceptual changes accompanying cerebral dysfunction (6).

Method:

1) Population: Fifty-three consecutive patients referred for ECT were studied. These included 16 men and 37 women, with ages ranging from 22 to 66 with a median of 49 years. The patients were divided at random into two groups. An experimental group of 29 patients (Convulsive A) received grand mal electrotherapy with pentothal premedication three times a week, using either a Medcraft alternating current instrument or a Reiter C-47 electrostimulator. A minimum of 12 treatments were given. The number of treatments was determined by the supervising psychiatrist in charge of the treatment unit on the basis of clinical criteria. A control group of 24 patients was treated in similar fashion, except that only subconvulsive

6. W. S. Battersby, H.P. Krieger, M. Pollack and M. B. Bender, Figure ground discrimination and the "abstract attitude" in patients with cerebral neoplasms, A.M.A. Arch. Neurol. & Psychiat., 76, 1956, 369-379; H. L. Teuber and S. Weinstein, Ability to discover hidden figures after cerebral lesions, A.M.A. Arch. Neurol. & Psychiat., 76, 1956, 369-379; M. Pollack, W.S. Battersby and M. B. Bender, Figure-ground discrimination in patients with cerebral tumor, presented at Eastern Psychological Association, 1957.

stimulation was given following the pentothal. Fourteen patients in the control group were subsequently given a regular course of convulsive therapy (Convulsive B).

2) Perceptual task: In the week prior to treatment and on the day following the 12th treatment each patient was tested with a modification of Gottschaldt's hidden figures developed by Battersby et al.(7). The subject is presented with a page containing two forms - a simple geometric figure, and below it a complex figure in which the simple figure is embedded (fig. 1). The patient is asked to trace a specific geometric figure from the background by outlining it with a colored pencil. The discriminations ranged in complexity from relatively simple to more complex. There were 25 such discriminations. A maximum of two minutes was allowed for each. Performance was scored in terms of total number of errors. To minimize a practice effect two equivalent forms of the test were used.

3) Evaluation of physiologic change: Two tests of brain function - the electroencephalogram and the amobarbital test (8) - were given to each patient prior to, and at weekly intervals during treatment. The

7. Battersby, Krieger, Pollack and Bender, op. cit., 703-712.

8. E. A. Weinstein, R.L. Kahn, L.A. Sugarman and L. Linn, Diagnostic use of amobarbital sodium ("amytal sodium") in organic brain disease, Am. J. Psychiat., 112, 1953, 889-894.

electroencephalogram was evaluated as to the degree of delta activity induced according to criteria previously published (9). The amobarbital test for brain disease was noted as positive or negative according to the standardized criteria (10). The results of these tests obtained during the second, third and fourth weeks of treatment furnished the criteria for physiological change. A combined physiological index was obtained by ascribing to each high degree delta EEG record and each positive amobarbital test a score of one. The range of physiological alteration thus ranged from zero to six.

4) Behavior ratings: Each patient's behavior was evaluated at weekly intervals. After the 12th treatment, a rating for the degree of behavioral change was made according to four classes: marked, moderate, minimal or none. These ratings of change were not value judgments as to the quality of change, but rather quantitative estimates of differences in behavior patterns under similar conditions of observation. Thus such behavior patterns as euphoria, paranoia or withdrawal might all be rated as equivalent degrees of quantitative change, although the implications of each for qualitative evaluation of improvement were quite different.

9. Fink and Kahn, op. cit., ~~(in press)~~. 516-525.

10. Weinstein, Kahn, Sugarman and Linn, op. cit., 889-894.

Results:

The pre-treatment and treatment scores and the mean change in the number of errors with treatment is shown for each group in Table I. The intragroup analysis shows that the subconvulsive group made significantly fewer errors during treatment, while the combined convulsive patients made significantly more.

TABLE I

Intragroup Comparisons for Number of Errors Before and During ECT

Type of Treatment	N	Mean No. Errors: Before ECT	Mean No. Errors: During ECT	Difference	p *
Subconvulsive	24	9.96	7.67	-2.29	$<.02$
Convulsive A	29	10.59	12.62	+2.03	NS
Convulsive B **	14	7.36	10.14	+2.79	$<.05$
Combined Convulsive	43			+2.28	$<.02$

* Intragroup analyses in this and subsequent tables based on Wilcoxon's method of paired replicates.

** Patients originally in control group, then placed on convulsive treatment. The score obtained during treatment in the control group is used here as the pretreatment score for the convulsive period.

Prior to treatment, subconvulsive patients made approximately the same number of errors as the original convulsive group. During treatment, however, subconvulsive subjects made fewer errors (7.67), while the errors in convulsive patients increased to 12.62 errors - a difference significant at better than the 1% level of confidence.

When the data is analyzed with respect to physiologic change, significant increases in errors are found only in those patients with the greater degrees of physiologic change. This relationship is present in analysis of the amobarbital test and the EEG as separate indices, and when the two tests are combined (Table II).

TABLE II

Intragroup Comparisons for Number of Errors Before and After ECT in Relation to Degree of Physiological Change

Physiological Index	N	Mean Difference in Number of Errors during Treatment	p
Amobarbital Test.			
None or one positive	13	-0.23	NS
Two or three positive	28	+3.74	.01
Electroencephalogram			
None or one High Delta	23	+1.73	NS
Two or three High Delta	18	+3.33	.05
Combined Physiological			
0 to 3	21	+1.00	NS
4 to 6	20	+3.90	.01

The relationship between the degree of behavioral change and the change in number of errors during treatment is shown in Table III. Those patients with no, minimal or moderate behavior changes do not show an appreciable difference in number of errors. Those with marked behavior changes, however, made significantly more errors during treatment.

TABLE III

Intragroup Comparisons for Number of Errors Before and During ECT in Relation to Degree of Behavioral Change

Degree of Behavioral Change	N	Mean Difference Number Errors During Treatment	p
Marked	24	+3.58	$< .01$
Moderate	14	+1.00	NS
Minimal or None	5	-0.40	NS

Analysis of the pretreatment error scores in relation to the degree of physiological change is shown in Table IV. The results show that subjects with large pretreatment error scores manifest greater degrees of physiological change during treatment. Patients with little physiological change during convulsive therapy had a mean pretreatment score of 7.88, while those who developed marked physiological effects, had a mean pretreatment score of 13.25 errors. The triserial correlation is +.34, significant at the .05 level of confidence.

TABLE IV

Relation of Pretreatment errors to Eventual Degree of Physiological Change During Treatment

	N	Mean Number Errors Prestreatment
Physiologic Change:		
0 to 2#	16	7.88
3# and 4#	19	11.21
5# and 6#	8	13.25

Qualitative Data:

Alterations in size of figure or in minor aspects of form were common types of error during both testing periods. Certain qualitative patterns were frequently noted during treatment, however, which occurred only rarely or to a lesser extent in the pretreatment period. It was common for patients to make no attempt to trace the more complex figures. This response was often associated with a generalized withdrawal reaction in which the patient was unresponsive to any stimulus or procedure. Others became hostile and negativistic toward the testing.

Patients with the greatest amount of physiological change seemed to have difficulty following instructions. They would trace the lines indiscriminately without regard for the specific figure to be outlined, repeated a previous figure despite changes in the test figure, drew lines where none actually existed, and attempted to trace the stimulus figure while ignoring the more complex test figure. Such patients were likely to respond quickly and impulsively, and showed little concern about making an error even when they might spontaneously comment, "I know that's not right."

Discussion:

The results of this study clearly demonstrate a relationship between the degree of cerebral dysfunction and perceptual alteration. Patients with subconvulsive stimulation make fewer errors on retesting. A slight decrease or no change in errors occurred in those patients receiving convulsive therapy who showed only minimal physiological changes. The convulsive patients, however, with the most marked physiological alteration, showed a significant increase in number of errors. This interrelationship of brain function and perception is in accord with studies of patients with altered brain function due to head injury and brain tumor. Teuber and Weinstein (11), applying a similar technique in cases with penetrating brain wounds, concluded that performance was unrelated to locus of lesion but that aphasic patients made significantly more errors than a non-aphasic brain-injured group. Pollack et al. (12), using the identical test as in this study, reported no relationship between perceptual errors and the location of lesion in tumor patients. They reported, instead, that defective perception was related to the severity of other mental changes, such as disorientation.

It should be pointed out that the total pretreatment mean score for all patients referred for ECT was 10.35 errors, a score almost identical to that found by Pollack et al. (13) in their brain tumor patients. Since

11. Teuber and Weinstein, op. cit., 369-379.

12. Pollack, Battersby and Bender, op. cit.

13. Ibid.

the two populations are comparable in terms of other parameters as age and education. The defects in figure ground discrimination cannot be regarded as reflective of cerebral dysfunction as an isolated entity abstracted from the totality of behavior. Rather than being in a one to one relationship, poor performance on such tasks may be due to the interaction of many factors, brain dysfunction being only one. Thus there are many cases with cerebral damage who do not show defects. Conversely, the present findings indicate that the inability to perceive embedded figures may be related as much to certain types of mental illness as it is to brain disease.

The relationship of perceptual alteration to behavioral change during treatment is clearly demonstrated. The patients who showed the greatest increase in errors during treatment were those who also showed the most pronounced change in clinical behavior. They manifested such behavior patterns as euphoria, hypomania, withdrawal, somatization or paranoia. Comparable to these are the qualitative aspects of performance on the embedded figures test during treatment. Failure to attempt the task was related to an evasion or withdrawal reaction in some cases, and to a paranoid hostility in orders. The lack of concern in correcting errors was associated with clinical patterns of euphoria and hypomania. The increase in errors may as well be attributed to change in motivation or attitude toward the task or examiner as it is to any specific aspect of the altered brain function. Changes in performance on this complex perceptual task can thus be understood as one manifestation of changes in the patterns of interaction with the environment.

The relation between behavioral and perceptual patterns, using this type of task, has been noted by Witkin to be true of persons without demonstrable cerebral dysfunction as well. He found that the wide individual differences in the perception of embedded figures (14) may be related to personality factors (15). The finding in the present study of the prognostic significance of the pretreatment score to the eventual physiological response is in accord with his observations. Personality factors may thus be related to the degree of changes in brain function with trauma. In a previous study (16) certain personality patterns were associated with the short term behavioral improvement following ECT. The basic characteristics of persons with a favorable prognosis defined in that study were an inability to think critically or sensitively about their own or other's needs or feelings, and response patterns characterized by oversimplified generalizations, stereotypy and conventionality. The present data that persons with greater difficulty in making the necessary analysis and figure-ground discriminations on embedded figures show a greater alteration in behavior with treatment, is consistent with the previous observations.

14. H. A. Witkin, Individual differences in case of perception of embedded figures, J. Pers., 19: 1950, 1-15.

15. H. A. Witkin, Nature and importance of individual differences in perception, J. Pers., 18, 1949, 145-170.

16. Kahn and Fink, op. cit.

Summary and Conclusion:

1. Fifty-three consecutive patients referred for electrotherapy were studied before and after treatment on their ability to perceive embedded geometric figures. An experimental group of 29 patients received regular grand mal therapy with pentothal premedication. A control group of 24 patients received subconvulsive stimulation only.

2. The experimental group made significantly more errors following treatment than did the controls.

3. Within the experimental group, however, there was considerable variability. Increase in errors was found to be significantly related to the degree of altered brain function, and the degree of behavioral change.

4. The pretreatment error scores were significantly related to the degree of altered brain function developed during treatment. The significance of this in terms of personality factors is indicated.

5. Performance in this complex visual task mirrors the pattern of behavioral change observed clinically.

6. It is concluded that performance on a complex visual task is one manifestation of a generalized pattern of interaction with the environment.

Legend:

Fig. 1. Illustrations of test figures. The preliminary sample used to acquaint the subjects with the task is shown in a. In d the task is complicated by having the subject determine which of the two simple figures can be found in the complex figure.