Relation of Tests of Altered Brain Function to Behavioral Change Following Induced Convulsions

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Numerous studies have been reported assessing the type, duration and significance of mental changes following electroshock. These reports vary widely in their descriptions and it is difficult to arrive at a meaningful conclusion regarding the relation of such mental changes to clinical response. Basic to these differences in observation are the vexing problems of the definition and the ways of measurement of organic-type reactions; the time relation of the measurements to the treatment process; and the definition of improvement following therapy. Each of these factors bears an integral relationship to the final definition of the problem. In the present study, various tests of brain function were applied serially to patients in whom behavior was altered by repeated inductions of grand mal convulsions (Electroshock). The data comparing the serial changes in these indices are presented.

METHOD:

Definition of "organic mental changes": The conventional conception of organic mental changes includes such behavioral changes as impairment of memory and of the discrimination of differences on perceptual tasks; disorientation for time, date, or place; errors on calculation tests; distractibility and inability to handle more than one situation at a time; perserveration in speech and behavior; emotional lability; and loss of interest in one's appearance and in the environment. Most studies assess the relationship of memory loss or clinically manifest disorientation to improvement following electroshock. The memory loss is usually measured by tests of simple recall, information, personal events, digit memory span,

etc.: while disorientation is determined by questions relating to present place, date, name of the examiner, etc. Such tests of memory and of orientation, however, discriminate primarily only severe degrees of dysfunction.

In the present studies, cognizant of the difficulties inherent in simple clinical assessments, we measured changes in brain function by four different measures, hoping thereby to determine varying degrees, or even, types of dysfunction. The four measures selected as being sensitive to varying aspects and degrees of cerebral dysfunction were:

a) The degree of delta activity in the electroencephalogram (1).

b) Changes in language and orientation following the administration of amobarbital sodium - the "amytal test" for organic brain disease (2, 3).

c) Alteration in perception of multiple simultaneous tactile stimuli (4).

d) Changes in tests of recall of common words, both with and without the interpolation of reading lists of nonsense syllables (5).

Time of Testing: A second factor to be considered is the time of application of these tests in relation to the treatment program. Numerous observers have reported the development of organic changes in the few minutes of recovery following each treatment. Others noted the appearance of mental changes during the course of treatment, and reported that treatments at periods more frequent than the conventional three times per week induced earlier and more severe changes. The transient nature of the changes are frequently noted, so that by the second or third week following an extensive course of therapy the electroencephalogram is at pretreatment levels, memory changes have disappeared and orientation is re-instituted.

In the present studies, the electroshock treatment schedule was maintained at three times per week with all patients receiving conventional Reiter electroshock, during the initial three weeks. In the fourth week, treatment frequency was occasionally reduced to two times per week. All patients received a minimum of twelve treatments. All tests were carried out at weekly intervals on a day following a treatment during the course of therapy. Following termination of therapy, weekly testing was continued until the tests returned to their initial level.

Behavior Ratings: A third factor crucial to a study relating the significance of organic mental changes to electroshock results is the definition and evaluation of "improvement." The evaluation of clinical response to therapy is a subjective value judgment by the therapist or administrator which reflects a divergence of goals, judgments, and compromises. Significant variables in the evaluation of "improvement" are the type, severity and duration of the patient's illness, his premorbid personality, the sociologic (family) constellation to which he will return, and the expectations (both conscious and unconscious) of the therapist, of the institution, of the patient and of the family. Furthermore, the time of the evaluation of the treatment result is also a most significant variable.

The parameters of evaluation have not been satisfactorily delineated. In this study, the following compromises have been made. All evaluations are made by an independent qualified psychiatrist who has no responsibility for the selection of subjects or application of the treatments. Patients are seen weekly and conferences are held with the therapist to assess the

therapeutic goals before treatment and the therapist's estimate of the response after treatment. The final evaluation used here is the clinical state of the patient during the second and third weeks following the last treatment, and describe only changes in clinical behavior. We have used a three-fold classification of "much improved," "moderately improved" and "unimproved," with the intent that the "much improved" and "unimproved" categories respectively would describe patients at the extremes of the response continuum.

The patients rated as "much improved" were those who no longer showed the symptoms which brought them to the hospital, their physicians believed them to be better, and the nurses' notes confirmed such aspects as being able to sleep without medication, better appetite and improved capacity to participate in hospital activities.

The "unimproved" patients were those who manifested no clearly noticeable change in behavior or who became worse.

The "moderately improved" patients showed some change in behavior, but continued to manifest signs of mental illness. They typically showed some symptomatic relief, which was transient.

RESULTS:

Twenty-four consecutive electroshock patients were studied. Of these, eleven were rated as "much improved," seven as "unimproved," and six as "moderately improved."

(a) Electroencephalograms: EEG records, using conventional leads, were measured for the average per cent time delta activity, and highest per cent time delta in any one lead; the slowest frequency in the record; and the duration and amplitude of delta burst activity (1). Using these measurements, the 180 records in the series were placed in rank order according to the degree of delta activity. The upper 1/3 of the records were described as "high delta activity" and the lowest 1/3 as "low delta activity."

No pretreatment records showed delta activity. During the course of electroshock delta activity appeared in all records to varying degrees. It was apparent within the first week of treatment and usually reached a peak on the third week following the 7-9 treatments. The results for those with high EEG delta activity are seen in Table I.

TABLE I

EEG - % High Delta Activity

Treatment Period:	1-3	4-6	7-9	10-12
Much Improved (11)	25	80	91	88
Moderately Improved (6)	0	16	50	40
Unimproved (7)	0	0	0	20

(b) Amobarbital Test: In these tests (2, 3) the patients are asked a series of questions relating to their illness and to orientation. Sodium amytal is administered intravenously until nystagmus and slurred speech are observed. The questions are then repeated. Changes in orientation and awareness of illness are scored as "positive" amytal response, reflecting a change in brain function ascribed to "organic brain disease" (2). The results are noted in the next table.

TABLE II

Amytal Test - % Positive

Treatment Period:	1-3	4-6	7-9	10-12	13-15
Much Improved (11)	45	64	100	89	100
Moderately Improved (6)	20	33	67	20	25
Unimproved (7)	14	16	16	33	0

The data of Tables I and II have been graphically portrayed in Figure 1. The congruence of the observations of the degree of EEG delta activity and the per cent positive amytal test responses is demonstrated. (Fig. 1)

(c) Memory Tests: In this test (5) a list of three letter common words were presented to patients by flash cards. The cards were presented for 10 trials. After this, lists of 3 letter nonsense syllables were interpolated. The recall of the first list of words was then tested, and the number of words recalled in each session was scored.

An impairment in recall function was apparent in all subjects. This decrement was maximal in the second and third weeks of treatment, and was sustained as long as treatments were administered 3 times a week.

The decrease in ability to recall the word list is noted in the next table.

TABLE III

Impairment in Recall - % Marked Decrement

Treatment Period	1-3	4-6	7-9	10-12
Much Improved (9)	0	11	33	0
Moderately Improved (4)	0	50	50	0
Unimproved (7)	0	14	0	0

When the scores are compared with the improvement rating, there is no significant difference between groups. The rapid return of recall ability to pretreatment levels when treatment frequency was reduced to two times per week indicates that this test is a measure of only the more severe degrees of cerebral dysfunction.

(d) Tactile Perceptual Tests: In these tests the patient is touched by the examiner simultaneously on the cheek and the hand, and asked to localize the stimuli. The tests are repeated for 10 trials using varying combinations of cheek, hand, shoulder and thigh. Persistent failure to report one of the stimuli or to mislocalize a stimulus beyond the tenth trial is indicative, in adults, of altered cerebral function (4).

In all subjects, this test was negative before treatment. Positive responses were observed in 19 of the 24 patients. In nine patients, two consecutive responses were observed, and of these, six were in the much improved and three in the moderately improved groups.

In the next table the positive responses were charted with relation to the treatment period and the clinical evaluation. A high incidence of positive responses is to be noted in the first two groups, and many fewer such responses in the unimproved group.

TABLE IV

Face Hand Test - % Positive

Treatment Period	1-3	4-6	7-9	10-12	13-15
Much Improved (11)	16	40	47	43	60
Moderately Improved (6)	60	43	43	30	0
Unimproved (7)	0	16	12	11	0

DISCUSSION:

Three aspects of these observations warrant elaboration. The sensitivity and stability of these indices of altered brain function and the significence for a definition of altered cerebral function; the relation of these indices during and after treatment to the clinical evaluation; and the relation of these observations for the theory of electroshock action.

All tests showed changes during electroshock therapy, indicating that a state of altered cerebral function was induced. Certain tests, as the EEG and the amytal test, were altered after a few convulsions and remained persistently positive for one to three weeks following treatment. In this regard the electroencephalogram manifested the earliest and the most sustained changes. The recall and tactile perceptual tests also showed changes but these appeared late (in the 2nd week of treatment) and disappeared rapidly when treatment frequency was reduced.

Tests of recall function and tactile perceptual tests, therefore, are less sensitive indicators of the state of cerebral function. In any evaluation of the relation of an induced change in brain function to another variable, it is important, therefore, to clearly define both the operation (or test) and the sensitivity of the operation which forms the basis for the estimation of altered cerebral function.

Because these tests have varying sensitivities, the frequency of treatment and the duration of the treatment regimen become important variables in any assessment. EEG changes are maintained by infrequent

treatment, while changes in recall function and simultaneous tactile perception are rapidly lost, when treatment frequency is reduced.

Of the many correlations possible with these tests of brain function, we have selected the relation of these test results to the clinical improvement rating. With the EEG and amytal tests significant relationships between the appearance of test changes and clinical improvement are clearly observed. In the much improved patients, positive amytal tests and high degree EEG abnormality appeared early, were more marked, and were sustained for longer periods (on the same treatment regimen) than in the unimproved patients. The moderately improved patients were in between.

This relation between altered brain function and clinical response is noted only with the data obtained during the course of therapy. There is no correlation of improvement ratings with post-treatment test results. This divergence is related to the timing of test applications, and may explain the discrepancies in the conclusions of other studies of this problem.

These observations can also be related to an understanding of the mode of action of electroshock. In 1952, Weinstein, Linn and Kahn (6) postulated that the function of electroshock therapy was to "initiate the production of a state of altered brain function in which the patient can deny his problems." These observations support the first part of this hypothesis, namely, that a state of altered cerebral function is induced by electroshock. Also, in patients who improved, the altered state is more prominent, appears earlier and is more persistent than in

those who fail to improve. Of the eleven much improved patients, all had positive amytal tests (while 5 of the 7 unimproved never had a positive test); and ten had high EEG abnormality records, while only one of the unimproved patients had such a record. It is our conclusion that early, sustained and significant degrees of altered cerebral function are a prerequisite - a necessary, though not a sufficient requirement - for improvement in electroshock therapy.

SUMMARY:

In a study of the relation of tests of altered brain function to improvement in electroshock, it was observed that while indicators of change in brain function vary in sensitivity, all tests indicate the development of organic mental changes during electroshock therapy.

The reason for the conflicting results reported by others can be accounted for by the variations in the tests used, the time of study and the difficulties in evaluating improvement.

It is our conclusion that clinical improvement in electroshock is dependent on early, sustained and marked changes in mental function; and that electroshock therapy may be described as the non-specific, traumatic induction of states of altered cerebral function in which the subject reacts with new patterns of adaptation.

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ROLE D'UNE ALTERATION FONCTIONNELLE CEREBRALE DANS LE CHANGEMENT DE COMPORTEMENT SUCCEDANT A DES CONVULSIONS PROVOQUEES

MAX FINK, ROBERT L. KAHN and HYMAN KORIN
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Time of Testing

A second factor to be considered is the time of application of these tests in relation to the treatment program. Numerous observers have reported the development of organic changes in the few minutes of recovery following each treatment. Others noted the appearance of mental changes during the course of treatment, and reported that treatments at periods more frequent than the conventional three times per week induced earlier and more severe changes. The transient nature of the changes are frequently noted, so that by the second or third week following an extensive course of therapy the electroencephalogram is at pretreatment levels, memory changes have disappeared and orientation is re-instituted.

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(c) Memory Tests:

In this test (5) a list of three letter common words were presented to patients by flash cards. The cards were presented for 10 trials. After this, lists of 3 letter nonsense syllables were interpolated. The recall of the first list of words was then tested, and the number of words recalled in each session was scored.

An impairment in recall function was apparent in all subjects. This decrement was maximal in the second and third weeks of treatment, and was sustained as long as treatments were administered 3 times a week. The decrease in ability to recall the word list is noted in the next table.

TABLE III

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Time of Testing: A second factor to be considered is the time of application of these tests in relation to the treatment program. Numerous observers have reported the development of organic changes in the few minutes of recovery following each treatment. Others noted the appearance of mental changes during the course of treatment, and reported that treatments at periods more frequent than the conventional three times per week induced earlier and more severe changes. The transient nature of the changes are frequently noted, so that by the second or third week following an extensive course of therapy the electroencephalogram is at pretreatment levels, memory changes have disappeared and orientation is re-instituted.

In the present studies, the electroshock treatment schedule was maintained at three times per week with all patients receiving conventional Reiter electroshock, during the initial three weeks. In the fourth week, treatment frequency was occasionally reduced to two times per week. All patients received a minimum of twelve treatments. All tests were carried out at weekly intervals on a day following a treatment during the course of therapy. Following termination of therapy, weekly testing was continued until the tests returned to their initial level.

Behavior Ratings: A third factor crucial to a study relating the significance of organic mental changes to electroshock results is the definition and evaluation of "improvement." The evaluation of clinical response to therapy is a subjective value judgment by the therapist or administrator which reflects a divergence of goals, judgments, and compromises. Significant variables in the evaluation of "improvement" are the type, severity and duration of the patient's illness, his premorbid personality, the sociologic (family) constellation to which he will return, and the expectations (both conscious and unconscious) of the therapist, of the institution, of the patient and of the family. Furthermore, the time of the evaluation of the treatment result is also a most significant variable.

The parameters of evaluation have not been satisfactorily delineated. In this study, the following compromises have been made. All evaluations are made by an independent qualified psychiatrist who has no responsibility for the selection of subjects or application of the treatments. Patients are seen weekly and conferences are held with the therapist to assess the

therapeutic goals before treatment and the therapist's estimate of the response after treatment. The final evaluation used here is the clinical state of the patient during the second and third weeks following the last treatment, and describe only changes in clinical behavior. We have used a three-fold classification of "much improved," "moderately improved" and "unimproved," with the intent that the "much improved" and "unimproved" categories respectively would describe patients at the extremes of the response continuum.

The patients rated as "much improved" were those who no longer showed the symptoms which brought them to the hospital, their physicians believed them to be better, and the nurses' notes confirmed such aspects as being able to sleep without medication, better appetite and improved capacity to participate in hospital activities.

The "unimproved" patients were those who manifested no clearly noticeable change in behavior or who became worse.

The "moderately improved" patients showed some change in behavior, but continued to manifest signs of mental illness. They typically showed some symptomatic relief, which was transient.

RESULTS:

Twenty-four consecutive electroshock patients were studied. Of these, eleven were rated as "much improved," seven as "unimproved," and six as "moderately improved."

(a) Electroencephalograms: EEG records, using conventional leads, were measured for the average per cent time delta activity, and highest per cent time delta in any one lead; the slowest frequency in the record; and the duration and amplitude of delta burst activity (1). Using these measurements, the 180 records in the series were placed in rank order according to the degree of delta activity. The upper 1/3 of the records were described as "high delta activity" and the lowest 1/3 as "low delta activity."

No pretreatment records showed delta activity. During the course of electroshock delta activity appeared in all records to varying degrees. It was apparent within the first week of treatment and usually reached a peak on the third week following the 7-9 treatments. The results for those with high EEG delta activity are seen in Table I.

TABLE I

EEG - % High Delta Activity

Treatment Period:	1-3	4-6	7-9	10-12
Much Improved (11)	25	80	91	88
Moderately Improved (6)	0	16	50	40
Unimproved (7)	0	0	0	20

(b) Amobarbital Test: In these tests (2, 3) the patients are asked a series of questions relating to their illness and to orientation. Sodium amytal is administered intravenously until nystagmus and slurred speech are observed. The questions are then repeated. Changes in orientation and awareness of illness are scored as "positive" amytal response, reflecting a change in brain function ascribed to "organic brain disease" (2). The results are noted in the next table.

TABLE II

Amytal Test - % Positive

Treatment Period:	1-3	4-6	7-9	10-12	13-15
Much Improved (11)	45	64	100	89	100
Moderately Improved (6)	20	33	67	20	25
Unimproved (7)	14	16	16	33	0

The data of Tables I and II have been graphically portrayed in Figure 1. The congruence of the observations of the degree of EEG delta activity and the per cent positive amytal test responses is demonstrated. (Fig. 1)

(c) Memory Tests: In this test (5) a list of three letter common words were presented to patients by flash cards. The cards were presented for 10 trials. After this, lists of 3 letter nonsense syllables were interpolated. The recall of the first list of words was then tested, and the number of words recalled in each session was scored.

An impairment in recall function was apparent in all subjects. This decrement was maximal in the second and third weeks of treatment, and was sustained as long as treatments were administered 3 times a week.

The decrease in ability to recall the word list is noted in the next table.

TABLE III

Impairment in Recall - % Marked Decrement

Treatment Period	1-3	4-6	7-9	10-12
Much Improved (9)	0	11	33	0
Moderately Improved (4)	0	50	50	0
Unimproved (7)	0	14	0	0

When the scores are compared with the improvement rating, there is no significant difference between groups. The rapid return of recall ability to pretreatment levels when treatment frequency was reduced to two times per week indicates that this test is a measure of only the more severe degrees of cerebral dysfunction.

(d) Tactile Perceptual Tests: In these tests the patient is touched by the examiner simultaneously on the cheek and the hand, and asked to localize the stimuli. The tests are repeated for 10 trials using varying combinations of cheek, hand, shoulder and thigh. Persistent failure to report one of the stimuli or to mislocalize a stimulus beyond the tenth trial is indicative, in adults, of altered cerebral function (4).

In all subjects, this test was negative before treatment. Positive responses were observed in 19 of the 24 patients. In nine patients, two consecutive responses were observed, and of these, six were in the much improved and three in the moderately improved groups.

In the next table the positive responses were charted with relation to the treatment period and the clinical evaluation. A high incidence of positive responses is to be noted in the first two groups, and many fewer such responses in the unimproved group.

TABLE IV

Face Hand Test - % Positive

Treatment Period	1-3	4-6	7-9	10-12	13-15
Much Improved (11)	16	40	47	43	60
Moderately Improved (6)	60	43	43	30	0
Unimproved (7)	0	16	12	11	0

DISCUSSION:

Three aspects of these observations warrant elaboration. The sensitivity and stability of these indices of altered brain function and the significance for a definition of altered cerebral function; the relation of these indices during and after treatment to the clinical evaluation; and the relation of these observations for the theory of electroshock action.

All tests showed changes during electroshock therapy, indicating that a state of altered cerebral function was induced. Certain tests, as the EEG and the amytal test, were altered after a few convulsions and remained persistently positive for one to three weeks following treatment. In this regard the electroencephalogram manifested the earliest and the most sustained changes. The recall and tactile perceptual tests also showed changes but these appeared late (in the 2nd week of treatment) and disappeared rapidly when treatment frequency was reduced.

Tests of recall function and tactile perceptual tests, therefore, are less sensitive indicators of the state of cerebral function. In any evaluation of the relation of an induced change in brain function to another variable, it is important, therefore, to clearly define both the operation (or test) and the sensitivity of the operation which forms the basis for the estimation of altered cerebral function.

Because these tests have varying sensitivities, the frequency of treatment and the duration of the treatment regimen become important variables in any assessment. EEG changes are maintained by infrequent

treatment, while changes in recall function and simultaneous tactile perception are rapidly lost, when treatment frequency is reduced.

Of the many correlations possible with these tests of brain function, we have selected the relation of these test results to the clinical improvement rating. With the EEG and amytal tests significant relationships between the appearance of test changes and clinical improvement are clearly observed. In the much improved patients, positive amytal tests and high degree EEG abnormality appeared early, were more marked, and were sustained for longer periods (on the same treatment regimen) than in the unimproved patients. The moderately improved patients were in between.

This relation between altered brain function and clinical response is noted only with the data obtained during the course of therapy. There is no correlation of improvement ratings with post-treatment test results. This divergence is related to the timing of test applications, and may explain the discrepancies in the conclusions of other studies of this problem.

These observations can also be related to an understanding of the mode of action of electroshock. In 1952, Weinstein, Linn and Kahn (6) postulated that the function of electroshock therapy was to "initiate the production of a state of altered brain function in which the patient can deny his problems." These observations support the first part of this hypothesis, namely, that a state of altered cerebral function is induced by electroshock. Also, in patients who improved, the altered state is more prominent, appears earlier and is more persistent than in

those who fail to improve. Of the eleven much improved patients, all had positive amytal tests (while 5 of the 7 unimproved never had a positive test); and ten had high EEG abnormality records, while only one of the unimproved patients had such a record. It is our conclusion that early, sustained and significant degrees of altered cerebral function are a prerequisite - a necessary, though not a sufficient requirement - for improvement in electroshock therapy.

SUMMARY:

In a study of the relation of tests of altered brain function to improvement in electroshock, it was observed that while indicators of change in brain function vary in sensitivity, all tests indicate the development of organic mental changes during electroshock therapy.

The reason for the conflicting results reported by others can be accounted for by the variations in the tests used, the time of study and the difficulties in evaluating improvement.

It is our conclusion that clinical improvement in electroshock is dependent on early, sustained and marked changes in mental function; and that electroshock therapy may be described as the non-specific, traumatic induction of states of altered cerebral function in which the subject reacts with new patterns of adaptation.

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