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T.S.

(I: 3/22/57)

Electroencephalogram in Electroshock: Role of Delta Change in Behavioral Response

Following the original x observations that electroshock induces changes in the electroencephalogram, numerous studies correlating such changes with clinical improvement were undertaken. In an exhaustive review of these studies, Chusid and Pacella (1952) conclude their survey with "in our opinion, the slow wave formations after electric shock treatment bear no direct relationship to clinical improvement. The favorable therapeutic response depends primarily upon the administration of a certain number of treatments in each particular case, and since patients vary considerably in the degree of EEG abnormality noted with the same number of treatments, it follows that any relationship between EEG changes and clinical recovery is largely coincidental or secondarily related to other factors." In the course of a study of electro-shock induced changes in cerebral function, a relationship between the EEG changes in serial records and the clinical effect has been observed, and will be reported here.

(1)

In the course of a study of changes in cerebral function induced by electroshock, a relationship between changes in slow wave activity in serial records and the clinical effect has been observed, and will be reported here.

Yet, consistent electroencephalographic effects have been ascribed to electroshock. It is reasonable to assume that a relationship does indeed exist between such changes and behavioral response. Indeed, two studies do indicate that a relationship may exist ( )( ).

In contrast to most reports,
two studies, however, indicate a relationship between

~~Of the previous reports of work in this area, two demonstrate relationships between certain EEG findings and clinical behavior.~~ electroencephalographic changes and clinical effects.

In an early report, Hoagland et al (1946) noted a correlation between changes in the per cent time of more than 13 cps activity and independent clinical rating of behavioral change. As disturbed behavior became more manifest, the fast activity increased. With treatment induced behavioral improvement, this activity diminished; only to reappear with a recurrence of symptoms. Similar observations of changes in fast frequencies and treatment were reported by Kennard and Wilner (1948), without a clinical correlation.

Roth (1951), reporting the delta response as activated by intravenous thiopentone, elicited characteristic EEG changes in every subject. Early in the treatment course, there was random irregular slow wave activity which, after more treatment, increased to a highly rhythmic, bilaterally synchronous high amplitude runs and bursts. These were chiefly 2 to 3 cps, with voltages up to 200-350 microvolts and continuous duration of 30 to 80 seconds. When the resting record evinced rhythmic delta activity, thiopentone increased its voltage and duration, spread its area and decreased its basic frequency. Roth believed that these changes were related to the process of recovery, and concluded: "the development of a typical EEG change does not insure recovery and 10 of the 36 patients who obtained such change failed to remit for longer than two weeks. But transient improvement in clinical condition seemed to be related

to the EEG change even in these patients. If we are correct in connecting the EEG changes with the therapeutic effect, it would seem since most of the patients developed typical changes, that the physiological basis for improvement is acquired by the majority of cases; it may or may not prove effective in promoting recovery."

(5)

Most observers ( ) Reed

It is generally agreed that electroshock induces diffuse slowing and increased voltages in the electroencephalogram. There is ~~also~~ ~~some~~ considerable indication that fast activity, also decreases both in voltage and in per cent time, ~~also~~ ~~decreases~~; ~~as well as~~ and in ~~xxxxxx~~ patients who are intensively treated, there is a slowing of the persistent alpha frequencies. The degree, duration and extent of the delta activity is directly related to the frequency and the number of grand mal convulsions. Such activity is usually symmetric, and with anterior placed electrodes, appears maximal in anterior electroencephalographic leads. In patients who have received twelve to twenty treatments on a ~~twice~~ thrice a week schedule, the electroencephalographic effects usually disappear in 4 -8 weeks following the last treatment. Studies of the pre-treatment EEG characteristics have failed to demonstrate any relationship with the post seizure electroencephalogram or clinical response. Similarily, there ~~xxxx~~ has been no report of a relation between the post treatment record characteristics and the clinical response

(3)

~~characteristics and the clinical response.~~

~~Two studies, however, did demonstrate a relationship of electroencephalographic changes with clinical effects.~~

(1) Both of these reports emphasize a relation between the degree of electro-encpphalographic change and current behavioral response. ~~It is note worthy that~~ different aspects are emphasized, namely delta response to barbiturate activation and the beta response. Had other systematic studies been done, perhaps correlations of behavioral response of other changes ~~x~~ would have also been noted. Nevertheless, despite the agreement that a delta response is directly related to frequency and number of treatments, the consenses has been that no correlation between electroencephalographic changes and behavioral response of electroshock exists. Lack of such correlation, if indeed a report of such a relationship. a relationship does exist, may reflect ~~either a)choice of~~ failure to select appropriate measures of EEG change, or inappropriate (2) b) ~~time of sampling~~; or c) ~~methods~~ measures or time of evaluating behavioral response. ~~It is with regard~~ In an effort to further ~~an elucidation of~~ the relationship between EEG response and time of sampling. The following study was undertaken. is behavioral change, ~~that the following study was undertaken~~.

In the present investigation, Granuketahine penal students of the delta response were undertaken, ~~The study was designed to answer the following questions were~~ to answer the following questions:

(1) What is the ~~state~~ relation of electroencephalogram response to behavioral response in electroshock?

(2) If a relationship exists, what significance may it have for an understanding of the electroshock therapy process?

b) In a second series of electroshock patients, electroencephalographic records were obtained during the second and third weeks of treatment, prior to treatment + two weeks after treatment. Using the method of analysis developed in the initial series of 16 records, the ~~abnormalities were verified by~~ initial observations were tested in a predictive study of therapeutic response.

but the dramatic change so evident in the first group was not apparent. Each patient continued to show some noticable disturbance such as obsessional thinking, paranoid ideas, or somatic preoccupation.

C. Minimally or Unimproved: In this group were placed seven patients in whom change was not clearly noticable or who showed only equivocal or transient improvement. Some showed fluctuations in behavior, at times appearing somewhat improved. But the changes were not sustained, so that by the end of treatment, they appeared much as they did before.

(14)

We are aware of the difficulties in evaluating improvement. Others might have differed in the estimates of change in these patients. In any case, by using this threefold classification, the differences between the first and third groups will be distinct.

EVALUATION OF EEG RECORDS: A total of 160 records were obtained in these subjects. Following the suggestion of Dr. Hans Strauss (Clinical and Electroencephalographic Studies - Correlations of Mental Electroencephalographic and Anatomic Changes in Cases with Organic Brain Diseas, Am. J. Psychiat. 101: 42-50, 1944), the delta index was determined for three lead combinations (frontal-parietal-ear lobe) for 180 seconds of recording for each lead.

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Simultaneously, the record was scanned for the slowest frequency ~~xxx~~ identified at least twice in any lead; the highest voltage of any delta wave; and the duration of the longest burst. Other aspects recorded, but not used in the final evaluation, were the regularity of burst activity, slowing of alpha activity; and the degree, frequencies, and amplitude of fast activities. These indices did not lend themselves to statistical study; and were not identifiable in all the records. Fast activities were readily altered by the clinical administration of barbiturates. As this

(9) Good-med electroshock therapy was ~~See treatments were~~ administered by the staff psychiatrists, using a Reiter C 47 electrostimulator. Treatment schedules were three times a week; and the number of treatments varied from 9 to 33. As patients showed a clinical ~~improvement~~ response, the psychiatrist tended to give fewer treatments, and more ~~orderly~~ widely spaced. There were 15 women and 9 men in the series, and the ages ranged from 24 to 68 with a median of 47.

EVALUATION OF CLINICAL RESPONSE: All the patients were observed for at least eight weeks after termination of therapy. The patient's response to electroshock was ~~made~~ determined on the basis of the resident psychiatrist's impression, staff opinion, the nurse's notes and the clinical evaluation of the ~~supervision~~ ones in charge of electroshock. The patients were divided into three groups - markedly improved, moderately improved and unimproved, ~~as to their short term (1-2 months) response to electroshock.~~

(13) A. Markedly Improved: The 11 cases in this group were regarded as showing recovery or marked improvement. These patients no longer showed the symptoms which brought them into the hospital; their doctors felt they were better; and the nurses' notes confirmed such aspects as being able to sleep without medication, better appetite, and improved capacity to get along with the other patients and participate in hospital activities.

B. Moderately Improved: The six patients in this group showed some improvement but continued to manifest indications of mental illness. These patients typically showed symptomatic relief, ie., acute depressive features might be gone, but the dramatic change so evident in the first group was not apparent. Each patient continued to show some noticable disturbance such as obsessional thinking, paranoid ideas, or somatic preoccupation.

medication could not be controlled our evaluations of fast activity following electroshock are not satisfactory, and the results of Hoagland ~~et~~al, have not been ~~subjected to study here.~~ studied.

On the basis of ~~the few~~ these five indices of slow wave activity ~~used, i.e.,~~ ~~the average delta index, the highest delta index, the slowest bursts~~ delta wave, the length of delta burst and the presence of beats the records were placed in a rank order from the greatest abnormality to the lowest. The 160 records were then divided into 3 groups - ie. upper third = high degree EEG abnormality and lowest third = Low degree abnormality. Figure I, II and III portray pre-treatment and treatment trends taken during the 10-12 treatment period to exemplify the three points of abnormality induced by electroshock.

RESULTS: Our results show a

~~1. What is the correlation between high degree EEG abnormality and clinical evaluation of short term (1-2 month) response to electroshock? There was a~~ positive correlation between early high degree EEG abnormality ~~after~~ and improvement. These relationships are demonstrated in Slide I. Of the much improved patients, 25% showed a high degree abnormality after one week of treatment; 80% after two weeks and over 90% after 3 weeks. In the unimproved patients, however, none had a high degree abnormality record during the first 3 weeks and only one had such a record by the fourth week of treatment. The records of the moderately improved patients fell in between these two groups. These relationships are demonstrated in Slide I.

By utilizing these quantifications of slow wave abnormality induced by electroshock, we conclude that such EEG abnormality induced in the first 3 weeks of treatment is an essential pre-requisite for the short term favorable clinical response.

2. What relationships ~~correlations~~ exist between each of the indices, first with the clinical response, and then among each other?

Mr Chairman, Members and Guests:

Quantitative Studies of Slow Wave Activity Following Electroshock

Despite repeated attempts, correlations between slow wave activity induced by electroshock and subsequent therapeutic outcome have been unsuccessful. However, certain conclusions from previous studies are warrented, ~~however.~~ All patients subjected to electroshock therapy suffer alterations in the electroencephalographic ~~patterns~~. Three patterns are generally described as 1) the slowing of the alpha frequencies; 2) the appearance of random, symmetric slow wave activity, generally of high voltage which progresses to burst activity; and ~~the~~ 3) diminution of beta frequencies in rate and amplitude. There is a direct relation between the degree of these changes, and the number and frequency of treatments. In many subjects a saturation point of change is described, which can be maintained by further treatment, but which, seemingly, is not increased. Also, such electroencephalographic changes are reversible. The rate of return of the cerebral patterns to the pre-treatment levels is generally 1 to 4 weeks, depending directly again on the number, frequency and the type of treatment.

Another area of agreement among the cited authors is the lack of direct relationship between degree of manifest memory loss and confusion and the degree of electroencephalographic abnormality. Cases are ~~cited~~ described of severe memory changes with few treatments and without significant electroencephalographic change; and also of severe changes in cerebral rhythms without manifest clinical confusion or memory impairment. In these reports, emphasis is frequently laid on such organic confusion also correlating poorly with clinical results.

Presented at E. EEG, Bethesda

Sep 30, 1955

Two studies, however, may be cited ~~which noted~~ as noting a correlation between Electroencephalographic changes and clinical improvement. Hoagland, Malamud, Kaufman and P~~e~~ecus in ~~this~~ their 1946 study of involutional women -(changes in the electroencephalogram and in the excretion of 17 ketosteroids accompanying electroshock therapy of agitated depression, Psychosom. Med. 8: 246-251, 1946) reported a relation between changes in their clinical rating scale and the per cent time 13 cps activity. As the disturbed behavior became more manifest, the 13 cps activity increased. ~~So~~ As treatment induced behavioural improvement, 13 cps activity diminished. With recurrence of symptoms, there was an increase in the % time 13 cps activity.

More recently, Roth (Changes in the EEG under Barbiturate Anesthesia Produced by Electroconvulsive Treatment and Their Significance for the Theory of ECT action, EEG and Clin. Neurophys. 3: 261-280, 1951) described ~~a series of studies in which~~ a relationship between thiopentone induced EEG changes and the recovery process ~~was elicited~~. Roth noted that slow wave activity as seen in a routine post-shock record was irregular in appearance, and he confirmed the reports that it could not be satisfactorily related to improvement. However, By administering an intravenous solution of the barbiturate thioperitone, ~~Roth~~ he elicited characteristic changes in the EEG after electroshock in every subject. Early there was random irregular slow wave activity, which, with more treatment, increased to a highly rhythmic, bilaterally synchronous, high amplitude delta runs and bursts. These were chiefly 2-3 cps, with voltages of 200-350 uv and continuous durations of 30-80 seconds. When the resting record evinced rhythmic delta activity, thiopentone increased its voltage and duration, spread its area, and decreased its basic frequency. Roth believed that these changes were related to the process of recovery, ~~although~~ and the concluded: ~~However~~, "the development of a typical EEG change does not ensure recovery and 10 of the 36 patients who attained such a change failed to remit for longer than two weeks. But

Similar analyses of the relation of each of the indices and clinical result showed identical curves to the group curve shown before. Slide 2 shows the relation of the delta index to improvement. The mean index in the much improved group jumps to 52% by the 7-9 treatment; while the moderately improved and unimproved groups show a gradual, slow increase to 10-20% by the 10-12 treatment.

A similar set of curves is demonstrated in slide 3 for the mean highest percent time delta in one lead.

In the next slide the mean slowest frequency is recorded, and this too shows the same significant relationships. While the much improved patients show delta waves down to 3 cps or less by the second week of treatment, the other two groups barely reach 4 cps by the fourth week of treatment.

Slide 5 shows the same correlations for the mean highest amplitude The much improved group show higher voltages by the second week and by the fourth week the differences are persistent for all three groups.

Finally, slide 6 shows the mean duration of bursts. The records of the much improved patients show longer bursts, averaging more than 7 seconds by the third week of treatment. Bursts are less frequent in the unimproved and moderately improved groups and are significantly shorter in duration. Not noted here, however, is the factor of regularity of bursts. In the longer bursts, wave forms frequently were more regular in frequency and amplitude, than in the other two groups.

These studies may be interpreted as demonstrating that each of these measures of slow wave activity arise from the same physiological process, and assume the same significance in relation to the disturbances in cerebral function induced by electroshock.

3. Finally, can these alterations in the EEG be correlated with other aspects of cerebral function which may have been altered by electroshock? In these studies, three other indices of cerebral function were assayed- the amytal test of Weinstein and Kahn, tests of double simultaneous tactile stimulation, and tests of memory and recall. Of these three indices, only the amytal test showed a positive correlation with improvement and with the EEG. In this test, the subject is interviewed and questions of orientation of intravenous sodium amytal, the questions are repeated, errors in orientation, confabulation, denial of illness and reduplication are scored as "positive" amytal test, and are indicative of cerebral dysfunction. Correct responses to these questions after amytal are a "negative" amytal test.

In the next slide, #7, the percentage positive amytal tests are compared for each of the three groups, with the number of weeks of treatment. The difference between the much improved and the other two groups is striking. While every patient in the much improved group had a positive amytal by the third week of treatment, ~~once~~ the abnormality persisted; in the unimproved groups only one patient had a positive amytal and this was transient despite continued treatment.

~~In slide # 8~~, the correlation between the amytal testing and the high degree EEG abnormality, shows a distinct ~~correlation which is statistically significant.~~

What of the simultaneous tactile tests and the tests of memory and recall? These indices showed no correlation with improvement. In this respect, it can be concluded that there are various types of cerebral dysfunction and that one cannot speak in gross terms of a lack of correlation between the EEG and cerebral dysfunction or organic psychoses.

Secondly, these studies point to the ~~significance~~ validity of quantitative EEG studies for the elucidation of mechanisms of behavior.

V: 5/4/57

Electroencephalogram in Electroshock: Relation of Induced Delta Activity to Behavioral Response

Despite considerable study and speculation, the mode of action of electroshock therapy is unclear. Recent theories (Weinstein, et al, Roth, Aird) have emphasized the role of neurophysiologic changes as the basis for the electroshock effect. In previous studies, we have observed a relation between changes in measures of brain function and the behavioral response. We noted the relation between clinical improvement following electroshock with changes in orientation and confabulation following intravenous amobarbital ( ), syntactical changes in language ( ), and memory and recall ( ). The present study is an evaluation of changes in the electroencephalogram, as an index of altered cerebral function, and the behavioral response.

Following the observation b y various observers that electroshock induces changes in the electroencephalogram, numerous studies correlating such changes with clinical improvement were undertaken. In an exhaustive review of these reports, Chusid and Pacella (1952) concluded their survey with the comment: "In our opinion, the slow wave formations after electric shock treatment bear no direct relationship to clinical improvement. The favorable therapeutic response depends primarily upon the administration of a certain number of

treatments in each particular case, and since patients vary considerably in the degree of EEG abnormality noted with the same number of treatments, it follows that any relationship between EEG changes and clinical recovery is largely coincidental or secondarily related to other factors."

Yet, the electroencephalographic changes induced by electroshock are consistent. Most observers ( ) report that electroshock induces diffuse slowing and increased voltage in the electroencephalogram. There is considerable indication that fast activity decreases ( ), both in voltage and in percent time; and in patients who are intensively treated, there is a slowing of the persistent alpha frequencies ( ). The degree, duration and extent of delta activity is directly related to the frequency and the number of grand mal convulsions ( ). Such activity is usually symmetric, and with anterior placed treatment electrodes, appears maximal in anterior electroencephalographic leads. In patients who have received twelve to twenty treatments on a schedule of three treatments per week, the electroencephalographic effects usually disappear in 4-8 weeks following the last treatment ( ).

In view of the consistency of the electroencephalographic response to electroshock, it may be ~~xxxxxxx~~ reasonable to assume that a relationship does exist between electroencephalographic and behavioral changes. Two studies

do indicate such a relationship. In an early report, Hoagland et al (1946) noted a relation between changes in the per-cent time fast activity (more than 13 cps) and independent clinical ratings ofbehavioral change. As disturbed behavior became prominent, fast activity increased. With treatment-induced behavioral improvement, this activity diminished; only to reappear with a recurrence of symptoms.*

Roth (1951), reporting the delta response activated by intravenous thiopentone, elicited characteristic EEG changes in every subject. Early in the course of treatment random irregular slow wave activity appeared, which increased with continued treatment to rhythmic, bilaterally synchronous, high amplitude runs and bursts. These were chiefly 2 to 3 cps, with voltages up to 200-350 microvolts and continuous duration of 30 to 80 seconds. When the resting record evinced rhythmic delta activity, thiopentone increased its voltage and duration, spread its area and decreased its basic frequency. Roth believed that these changes were related to the process of recovery, and concluded: "the development of a typical EEG change does not insure recovery and 10 of the 36 patients who obtained such change failed to remit for longer

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* Similar changes in fast frequencies with treatment were reported by Kennard and Wilner (1948) without the behavioral correlation.

than two weeks. But transient improvement in clinical condition seemed to be related to the EEG change even in these patients. If we are correct in connecting the EEG changes with the therapeutic effect, it would seem, since most of the patients developed typical changes, that the physiological basis for improvement is acquired by the majority of cases; it may or may not prove effective in promoting recovery."

Both these reports emphasize a relation between the degree of electroencephalographic change and concurrent behavioral response. Different aspects are emphasized, namely delta response to barbiturate activation and beta activity. In the present investigation, quantitative serial studies of the delta response were undertaken to answer the following questions:

(1) What is the relation of the electroencephalographic response to behavioral response in electroshock?

(2) If a relationship exists, what significance may it have for an understanding of the process of electroshock therapy?

Subjects and Method: a) In the initial series, twenty-four consecutive patients referred for electroshock were studied. Electroencephalograms were done prior to treatment, and at weekly intervals during and after treatment using an 8 channel Medcraft electroencephalograph and needle electrodes. Recording was bipolar, and hyperventilation activation was utilized during each recording.

Concomitantly, the record was scanned for the slowest frequency identified at least twice in any lead; the highest voltage of any delta wave; and the duration of the longest period of delta burst activity.

On the basis of these five indices of slow wave activity the records were placed ~~xx~~ in rank order, from the greatest amount of delta activity to the lowest. The 160 records were divided into 3 groups. The upper third were classified as "high degree delt a records"; the middle third, as "moderate degree delta a records"; and the lowest third as "low degree delta ~~x~~records." Figures I, II, and III portray pre-treatment and treatment records taken during the 10-12 treatment period to exemplify the three ranges of delta activity induced by electroshock.

b) In a second series of fifty-four consecutive, unselected electroshock patients, electroencephalographic records were obtained prior to treatment, during the second and third weeks of treatment, and two weeks after treatment. Using the method of analysis developed in the first series of 160 records, the initial observations were tested in a predictive study of therapeutic response.

EVALUATION OF CLINICAL RESPONSE: All patients were observed for at least eight weeks after termination of therapy. The patient's response to electroshock was determined on the basis of the resident psychiatrist's impression, the staff

opinion, the nurse's notes and the clinical evaluation of the supervisor in charge of electroshock. The patients were diveded into three groups - much improved, moderately improved and unimproved - according to the following criteria.

A. Much Improved: The 11 cases in this group were regarded as showing recovery or marked improvement. These patients no longer showed the symptoms which brought them into the hospital; their doctors felt they were better; and the nurses' notes confirmed such aspects as being able to sleep without medication, better appetite, and improved capacity to get along with others and participate in hospital activities.

B. Moderately Improved: The six patients in this group showed some improvement but continued to manifest symptoms of mental illness. These patients trypically showed symptomatic relief, i.e., acute depressive features might be gone, but the dramatic change so evident in the first group was not apparent. Each patient continued to show some noticable disturbance such as obsessional thinking, paranoid ideas, or somatic preoccupation.

C. Minimally or Unimproved: In this group were placed seven patients in whom change was not clearly noticable, who showed equivocal or transient changes, or who became worse. They showed fluctuations in behavior, at times appearing less ill. The changes were not sustained, however, so that by the end of treatment, they appeared much as before.

Results

1. EEG Delta and Clinical Ratings:

The initial analyses of the relation between the degree of induced delta activity and clinical ratings, demonstrated a significant relationship between the early appearance of high degree delta activity and the "much improved" clinical ratings. Of the records in patients who were rated as much improved, 80% were classified as high degree delta in the second week; 91% in the third week and 88% in the fourth week of treatment. Of the records in patients who were rated as unimproved, none were high degree delta in the second or third weeks of treatment, and 20% were high degree delta in the fourth week. The ~~delta~~ data is expressed in Table I, and graphically in Figure 4.

EEG - % High Degree Delta Records

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

Similar analyses were undertaken for the relation between each of the measured indices of delta (average %-time delta, highest %-time delta, duration of bursts, highest voltage, and slowest frequency,) and the clinical ratings. In each instance, the relationship of degree of induced delta index and the clinical rating was sustained. This data will be presented in detail in a

subsequent report.

2. EEG Delta as an Index of Altered Brain Function:

Disorientation, confabulation and denial of illness in a structured interview after the administration of intravenous amobarbital in patients with brain lesions have been described as signs of organic cerebral dysfunction ( ). We had previously noted such patterns to be rare in patients hospitalized with mental illness, unless there was evidence of active cerebral dysfunction ( ). It seemed probable, therefore, that if electroshock induced cerebral dysfunction, persistently positive amobarbital tests would be produced. This was indeed ture in this group of subjects, and has been previously reported ( ). In that report, we noted, that sixteen (67%) of the 24 subjects, had positive amobarbital tests in the 7-9 treatment period, and fourteen (58%) in the 10-12 period.

In these twenty-four subjects, there were ninety-one test sessions during the course of therapy for which concurrent electroencephalograms and amobarbital tests are available. Pre and post treatment records are not included. Relating the amobaribtal test results to the degree of induced delta activity shows a high relationship, both for the tests to each other, and to clinical ratings of improvement during therapy. In Table II, the degree of induced delta activity is compared with the results of the concurrent amobarbital tests.

TABLE II

EEG Delta - Amobarbital Test *

	# EEG Delta Activity Records		
	High	Middle	Low
Amobarbital Test			
Positive (45)	29	8	8
Negative (46)	10	16	20

The relation between the test data and clinical ratings of improvement are also significant. In Table II, the EEG and amobarbital test results are analyzed according to the evenual clinical rating. The much improved group had a higher number of positive amobarbital test reactions; and that the cluster of positive amobarbital, high EEG delta activity and markedly improved rating is a significant one. Equally significant is the cluster of negative amobarbital test, low and middle EEG delta activity and clinical rating of unimproved. /TABLE III\

Clinical Ratings Compared to EEG and Amobarbital Test Results **

	Much Improved	Moderately Improved	Unimproved
High Delta and Positive Amobarbital (29)	25	3	1
Either High Delta or Positive Amobarbital (26)	10	11	5
Neither High Delta nor Positive Amobarbital (36)	5	10	21

The data in Tables II and III relate the total number of observations during

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* Statistical analysis by chi-square is significant at better than 1% level of confidence.

** Significant by chi-square at better than 2% level of confidence.

the course of therapy in the initial twenty-four patients. Patients who eventually are rated as much improved tend to develop high degree EEG delta activity early in the course of treatment, and sustain it throughout the period. (Figure 4 and Table I) Similar observations, made for the amobarbital test results, are graphically portrayed in Figure 5. A composite of figures 4 and 5 is presented in figure 6, which shows a remarkable congruence of the two test data.

3. EEG Delta Activity as Index of Clinical Outcome:

Following the observations in this group, that the much improved patients had developed a high degree delta activity early and had sustained such activity, electroencephalograms were obtained during the second and third weeks of treatment in 54 consecutive electroshock patients. This study was undertaken to determine whether or not the degree of delta response is predictive of the short-term therapeutic outcome.

The records were scored as to whether high degree delta activity was achieved during both, one or neither of the 4-6 and 7-9 treatment periods, and the data was related to the clinical evaluations (Table IV).

TABLE IV

Patients with High Delta Activity During Second, Third Weeks of Treatment ***

	Clinical Rating		
EEG Delta	Much Improved	Moderately Improved	Unimproved
Both High (18)	12 (67%)	4 (22%)	2 (11%)

One High (16)	4 (25%)	8 (50%)	4 (25%)
None High (20)	6 (30%)	7 (35%)	7 (35%)
Total (54)	22	19	13

*** Significant at the 2% level of confidence.

Of the patients who manifest high delta activity during the second and third weeks of treatment, 67% are rated as much improved, while only 30% of patients without high delta are so rated. The early induction and persistence of high degree delta activity is related to the short term clinical evaluation.

The arbitrary selection of the second and third weeks of treatment was based upon an electroshock series in which the average treatment course was 12-15 treatments. Further analysis of this data demonstrates that the development of high degree delta activity, and its maintenance at this level for a number of weeks, is related to evaluation of improvement regardless of the time in the course of therapy xx the delta achnges are first manifest. Thus, continued treatment in some subjects resulting in high EEG delta activity after 15-20 treatments, is associated with a marked behavioral response at this later period. Patients given many treatments at the rate of three times per week, without the induction of high degree delta activity, demonstrate a limited behavioral response - one that is not significantly different than the ~~expected~~ placebo response ( ). Intensive treatment at a frequency of 5-10 times per week, however, with the resultant induction of high degree delta activity, will demonstrate a concurrent significant behavioral response.

Discussion: These studies demonstrate a consistent relationship between the degree and duration of induced electroencephalographic delta activity and clinical

evaluations of behavioral change. Symmetric and dysrhythmic delta activity has been interpreted as evidence of dysfunction of the midline hypothalamic and thalamic centers (~~electroce~~CENTRENcephalic system) (Ostrow and Strauss).. Such activity is also indicative of an alteration in the state of consciousness, with more marked alteration being directly related to the duration, amplitude and frequency of the slow wave activity (Strauss et al, Jung, Davis and Davis).

The demonstrated relationship between induced delta activity and behavioral response after electroshock permits the further conclusion that changes in the centrencephalic system with attendant alteration in consciousness are the physiologic basis of the electroshock process. * Two aspects of the electroshock process thus warrant elaboration: the relation of the induced neurophysiologic changes to the behavioral response and the significance of these observations for a theory of the mode of action of electroshock therapy.

(a) Relation of Neuro-Physiologic Change to Behavior:

Behavioral change is a consistent accompaniment of alteration in cerebral function. Changes in mood, language, attitude, judgment, thought process, perception, and insight attending changes in cerebral function, from whatever cause, are extnesively documented in the neurologic literature.

In this study, electroshock has been shown to consistently alter two independent test situations, in a fashion which we have come to associate with

* The biochemical substrate of this process has received limited study. Emphasis has been placed on the acetylcholine-cholinesterase changes (Bernstein, ORV Tower and McEachern), the alteration in blood-brain barrier (Aird), changes in ionic and protein equilibria (Spiegel and Spiegel - Adolf), by different investigators without definite conclusions.

states of altered cerebral function. In an extensive experience with orientation tests after amobarbital, Weinstein and his co-workers ( ) ( ) ( ) have demonstrated the predictive value of this test for organic cerebral dysfunction. Likewise, extensive experience by numerous workers as Davis and Davis ( ), ( ), Ostow and Strauss ( ), Ostow and Ostow ( ) and Jung ( ) has affirmed the significance of diffuse delta activity as an index of altered brain function. Had other tests of cerebral function been applied in a similar serial fashion, it is anticipated that these, too, would demonstrate consistent changes during treatment and a relation to behavioral response, within the limits of the sensitivity of the test to reflect changes in cerebral function.

In this context, electroshock may be said to be a method of inducing a state of altered brain function for extended periods in order to achieve a behavioral response. The range of behavioral patterns induced under these conditions is wide. "Improvement" is a special case of behavioral response, being a subjective evaluation on the part of the observer that the patient is "better." Electroshock does not induce "improvement"; it induces a milieu of cerebral activity in which behavior is different than before electroshock. To the extent that the induced behavior in depressed patients is perceived as less complaining, depressed, agitated or anxious, or in schizophrenic patients,

less delusional, hallucinatory or excited, the patient is evaluated as "improved". When behavior, however, is perceived as anxious, agitated, paranoid, complaining, or withdrawan, it is evaluated as "unimproved." The particular type of behavioral pattern induced by electroshock, is dependent on a number of factors, of which ther personality of the subject ( ) is the most prominent.

Another example of the relation of electroencephalographic delta to behavior is to be seen on the occasional reports of epileptic patients. Landolt ( ) ( ) describes a young epileptic who was ordinarily pleasant, friendly and cooperative for his clinic visits. At these times, records were consistently dysrhythmic. On one occasion he was surxly, irritable and withdrawn, and his EEG was without delta activity. On the subsequent visit, the EEG was again dysrhythmic and z a behavioral "improvement" was noted. Similar observations were reported by Ulett ( ) and Alexander ( ).

(b) Theory of Electroshock Action:

Our studies of the electroshock process have demonstrated the following. Alteration in brain function is induced early and sustained in patients in whom the greatest degrees of behavioral change are noted. We have emphasized high degree delta activity in the electroencephalogram and positive amobarbital tests as indices of altered cerebral function, with the knowledge that other indices of altered brain function, applied in the same serial fashion, may

also show significant alterations and a relation to behavioral change.

We have been impressed that the ratings of improvement are value judgments of the behavioral response. All patients in whom cerebral changes are induced by electroshock manifest changes in behavior. Only certain patterns are evaluated as improved, however, while others are regarded as "unimproved" Improvement is seen as a special case of the behavioral response of the subject under the conditions of altered brain function.

Our more recent studies have noted a relation of the induced behavioral response to specific personality aspects ( ). Patients who most closely approximate the "explicit verbal denial" personality type ( ), manifest greater degrees of denial, displacement, euphoria and ludic behavior during electroshock therapy. Such adaptations are frequently rated as "much improved", so that the relationship between personality, behavioral response and clinical rating is most clear. The relation of other aspects of personality to the behavioral response are now under investigation.

Another factor in the rating of improvement is the environmental response to the induced behaviora. The modification of mutism, withdrawal and negativism to excitement, overactivity and irritability may be considered a positive movement by the therapist but a disorganization by the ward physician or family. The goals of the therapist and the family, and their expectations

Such altered cerebral function provides the physiologic milieu for an alteration of the organism's adaptive interpersonal behavior. Changes are induced in perception, language, mood, recall, and judgment which permit new adaptive interactions with the environment to unfold. The type of adaptive behavior induced under these conditions is dependent upon the personality of the subject; the environment in which the interaction occurs; and the duration of the state of altered cerebral function.

A similar view of the electroshock process was initially expressed by Weinstein, Linn and Kahn ( ), who emphasized the interrelationship of neurophysiologic changes and behavioral response. These studies amplify their observations to include another index of altered brain function - the electroencephlographic delta and also broaden their initial emphasis on the denial process as the only successful adaptative response, to include a wide variety of induced behaviors under the conditions of altered brain function. The description of the electroshock process is also consistent with the observations of Ulett et al ( ), Roth ( ) and Aird et al( ).

This neurophysiologic-adaptive interpretation of electroshock provides an operational definition of the process which has promise of further elaboration and observations. Such an hypothesis also has application to an understanding of therapeutic process in insulin coma therapy ( ), lobotomy and tranquillizing agents ( ).

transient improvement in clinical condition seemed to be related to the EEG change even in these patients. If we are correct in connecting the EEG changes with the therapeutic effect it would seem, since most of the patients develop typical changes, that the physiological basis for improvement is acquired by the majority of cases; it may or may not prove effective in promoting recovery."

In the course of studies of altered brain function induced by electroshock at the Hillside Hospital in New York, further data on the relationships between EEG changes and clinical effects of electroshock were collected. The general results of previous investigations on the alterations in the EEG with electroshock were confirmed, but also, a definite relationship between EEG effects and the clinical result was demonstrated. Three foci are presented today:

(1) The EEG patterns following electroshock and their relation to improvement.

(2) The intercorrelations of different quantifications of delta activity.

(3) The relation of these observations to a theory of electroshock action.

SUBJECTS AND METHOD: In the initial series, Twenty-four consecutive patients referred for electroshock were studied. Electroencephalograms were done at weekly intervals during ~~treatment~~ end of the treatment. prior to treatment. An 8 channel Medcraft instrument , needle electrodes, and bipolar recording was used. Hyperventilation ~~was the only~~ activation was utilized during each recording. technic ~~used~~. During treatment, records were taken ~~on the~~ on a day ~~after a~~ following a ~~treatment~~, generally 25 to 31 hours ~~after~~ following a treatment.

At this point I should like to summarize our findings and express some thoughts as to their significance for a theory of electroshock action. There is little doubt that electroshock induces delta abnormality in the EEG. It is symmetric, chiefly frontal, but with increasing treatment, spreads to all leads. With increasing treatment the frequencies became slower, the amplitudes higher, the burst activity longer and more regular. While delta abnormality is present in every report after electroshock, its degree is variable. Roth's experiment's inducing increasing delta abnormality with barbiturate are significant in predicting the later changes induced by further electroshock. In some subjects however, a high degree delta abnormality is not induced despite extensive treatment.

Our correlations of degree of delta abnormality with improvement are also significant for the theory of the mechanism of electroshock ~~therapy.~~ An early, sustained alteration in cerebral function as measured by the EEG, and also by the amytal test, appears to be a necessary pre-requisite for improvement. Where such changes fail to occur in the EEG (and in the amytal test), there ~~this is~~ a significant clinical improvement will fail to occur in the patient's behavior. The fact that the correlations were not ~~a~~ evident with memory loss, points to the possibility that this is not a significant factor in improvement.

In conclusion, these studies lend support to a theory of EST action recently enumerated by Weinstein and one of us (Kahn). These authors postulated that improvement following electroshock is the result of the creation in the patient of a milieu of altered brain function in which new patterns of adaptation, particularly those of denial, may be maintained. These EEG studies demonstrate that an altered milieu of cerebral function as measured by delta abnormality is a pre-requisite for improvement. To this extent the first part of the Weinstein-Kahn hypothesis is supported.

During the treatment period, records were taken on the day following a treatment, generally 25 to 31 hours later. Concurrently, patients were studied by other neurophysiologic technics. The amobarbital test for organic brain dysfunction ( ) was employed at weekly intervals, before, during and after therapy, until the result achieved the pre-treatment level. The results of this study have been reported previously ( ).

Grand-mal electroshock therapy was administered by the staff psychiatrists, using a Reiter C 47 electrostimulator. Treatment schedules were three times a week; and the number of treatments varied from 9 to 33. As patients showed a clinical response, the psychiatrist tended to give fewer and more widely spaced treatments. There were 15 women and 9 men in the series, and the ages ranged from 24 to 68 with a median of 47.

EVALUATION OF EEG RECORDS: A total of 160 records were obtained in these subjects. Following the suggestion of Strauss ( ) the delta index was determined for three lead combinations (frontal-parietal, anterior temporal - vertex, and parietal-ear lobe) for 180 seconds of recording for each lead. The delta index is defined as the per-cent time occupied by waves of 7 cps or slower. The average delta-index for the three lead combinations, and the highest delta index in any one lead combination were the indices used in the final tabulation.

and tolerances, are significant factors in the behavioral response of the patient to therapy, and also, in the ratings of improvement.

These same factors are significant in the duration of the electroshock effect. The induced changes in cerebral function persist for 2-4 weeks only following even intensive courses of therapy. In many cases, the behavioral response is limited to this period of altered brain physiology. The changed patterns of behavior are not adaptive in the milieu of the patient, and the behavior "regresses" to pre-treatment patterns. In other instances, the induced behavior is adaptive to the environment, and, we assume, sustained thereafter not by the initial change in brain function, but b y the newly developed interaction of subject with environment. That this is indeed true is seen by the frequent successful adaptation of the patient to the hospital milieu after electroshock, only to have a recurrence of symptoms when discharge planning is discussed or discharge is consummated. Altered cerebral function provides the physiologic milieu in which the subject's adaptive (personality) processes may utilize devices not otherwise available to how, and permit a different interaction with the environment - the doctor, family or society.

These observations have led to the conclusion that electroshock therapy is a non-specific induction of persistent states of altered cerebral function.