Electroencephalographic Correlates of the Electroshock Process

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and

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Electroencephalographic Correlates of the Electroshock Process

During the past few years, renewed attention has been given to the relation between changes in measures of cerebral function, and the behavioral changes induced by electroshock (1, 2). Alteration in various aspects of the electroencephalogram has been emphasized by various observers (3, 4) as a sensitive index of changes in cerebral function. In an initial study in this laboratory, a significant relationship between the degree and duration of induced delta activity and clinical evaluation of "improvement" was observed (6). Subsequent studies have focused on various parameters of the EEG changes including frequency of treatment, type of current, age of subject and pre-treatment record characteristics. It is the purpose of this report to assess the relation of these aspects of treatment to changes in the EEG and in clinical response; and to describe the role of serial electroencephalograms in the rational management and study of convulsive therapies.

METHOD:

One hundred and seventy-three consecutive electroshock referrals have been studied. Electroencephalograms were taken before treatment, and on a day after treatment at weekly intervals during and following the course of therapy until the record had achieved its pre-treatment characteristics. Patients in whom the pre-treatment electroencephalogram demonstrated slow wave or spike activity were excluded from the series.

All the EEG records were quantitatively measured for the amount of delta activity. On the basis of the per-cent time, slowest frequency, highest voltage and longest duration of bursts of slow waves, in selected lead combinations, the records were classified into "high," "moderate" and "low" degrees of delta activity, according to criteria previously published (6).

Three convulsive techniques were employed: suprathreshold alternating current, threshold alternating current and parathreshold unidirectional current methods. The alternating current suprathreshold (7) and unidirectional parathreshold (8) treatments followed established techniques. In the threshold alternating current method, patients without prior sedation received small amounts of current (90 volts for 0.2 second), usually sufficient for a petit mal response. At 20 second intervals voltage, and if necessary, duration was increased until a grand mal convulsion was induced. The minimal voltage and duration necessary to induce a grand mal was the threshold value.

In addition, a convulsive-subconvulsive control study was instituted during a period of these observations. Randomly selected patients referred

for electrotherapy received subconvulsive therapy instead of grand mal. In this technique, patients were given pentothal intravenously until asleep, and then either low voltage unidirectional current for 60 seconds (8) or alternating current of 80 to 120 volts for 0.2 second were administered for one to three applications, for a total of 24 to 36 petit mal responses.

Of the 173 electrotherapy referrals, 146 received grand mal therapy - 57 by threshold alternating current, 26 by suprathreshold alternating current and 63 by parathreshold unidirectional current methods. Twenty-seven subjects received a course of subconvulsive therapy.

All treatments were given three times a week, for 12-20 treatments. Patients who failed to develop a significant behavioral or clinical response, or middle or high degrees of delta activity in the EEG, were subsequently treated five to ten times per week.

Evaluations of clinical response were made by the supervising psychiatrist and resident therapists on two occasions. At the height of the treatment effect, the degree of behavioral change was scored as "marked," "moderate," "minimal" or "none." These ratings were estimates of the change in behavior in interviews and on the ward from the pre-treatment patterns. Ratings of "improvement" were also made by these physicians two to three weeks after treatment was terminated. These ratings were value judgments and were based on the four-fold classification of "recovered," "much improved," "improved" and "unimproved or worse" (2, 6).

RESULTS:

1. Variability in Delta Activity with Convulsive Therapy:

The wide variability in the degree of induced delta activity reported in the initial 24 patients (6) is confirmed in these series of convulsive therapy referrals (Table I). While the number of high degree records increases with treatment, 27% in the third week, and 18% in the fourth week, are still rated as "low" degrees of delta activity.

TABLE I

Degree of EEG Delta Activity with Convulsive Therapy

(Per-cent of Group)

	Treatment Period			
	1-3	4-6	7-9	10-12
High Degree	4	28	46	60
Moderate Degree	12	21	27	22
Low Degree	68	48	25	18
No Delta Activity	16	3	2	0

2. Role of Convulsion in EEG Response:

The significance of the convulsion per se in the EEG and behavioral response was assessed in the convulsive-subconvulsive study. Of the 47 subjects* who received convulsive therapy in this study, 9 had

* These included 28 subjects who received grand mal therapy on a random selection basis, plus 19 subconvulsive subjects referred for a "second course" of therapy.

high degree delta records in both second, third and fourth weeks of treatment, 12 during two of the three weeks, and 13 during one of the test periods. Thirteen of the 47 subjects failed to show a high degree delta record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none demonstrated middle or high degree delta activity records during any week of treatment. Low degrees of delta activity were noted in three subjects during both the second and third weeks of treatment, and in 8 subjects during the fourth week.

In concurrent behavioral ratings, 25 of initial 28 subjects in the convulsive group showed marked behavioral change; while of the subconvulsive group, 24 of the 27 showed minimal or no behavioral changes (Table II). Of the latter group, 19 were referred for a second course of therapy. In 14 of these, grand mal electroshock induced high degree delta activity and all showed a significant behavioral change. Of the five who failed to demonstrate high degree delta activity on convulsive electroshock, all showed middle degree records; and three of the five showed a behavioral change. Thus, of the 47 convulsive therapy subjects, 42 showed a significant behavioral change.

TABLE II

Ratings of Behavioral Change: Convulsive - Subconvulsive Therapies

(Fourth-Fifth Weeks of Treatment)

	Marked	Moderate	Minimal	None
Convulsive Therapy (47)	27	15	5	0
Subconvulsive Therapy (27)	0	3	8	16

In evaluations of the degree of "improvement" two weeks after treatment, 51% of the convulsive therapy group were rated as "much improved" or "recovered," and 32% as "improved" (Table III). On discharge, 51% were evaluated as sustaining the same degrees of improvement, while 42% were "improved," and only 7% were "unimproved." Of the subconvulsive group, however, 11% were rated in the first two categories, 19% in the "improved," but 70% were "unimproved," two weeks after treatment. As these were referred for a second course of therapy, hospital discharge evaluations do not reflect the effects of subconvulsive therapy.

TABLE III

Ratings of Improvement: Convulsive-Subconvulsive Therapies

(Two Weeks After Last Treatment)

	Recovered	Much Improved	Improved	Unimproved, Worse
Convulsive Therapy (47)	9	15	15	8
Subconvulsive Therapy (27)	2	1	5	19

Convulsive therapy induced significantly greater behavioral change and more favorable evaluations of improvement than did subconvulsive therapy. The clinical observations thus parallel the electroencephalographic data. Also, patients who showed neither an EEG or a behavioral response to subconvulsive therapy, showed both EEG and behavioral changes when placed on convulsive therapy.

3. Role of Type of Convulsive Therapy:

In view of the variety of electroshock techniques employed, and the relationship between EEG delta activity and the behavioral response, an analysis of the effect of type of electroshock on EEG delta activity was undertaken. The results are graphically presented in Figures 1 and 2. The first figure relates the treatment type to the percentage of records demonstrating high degrees of EEG delta activity in each treatment group during the second, third and fourth weeks of treatment. In each period, treatment with alternating current at suprathreshold strength gave the highest percentage of high degree delta records. Treatment with unidirectional current and with alternating current at threshold strength was less effective than the suprathreshold alternating current technique in each period; the unidirectional current treatment being more effective than the threshold alternating current method only early in the course of therapy.* Subconvulsive techniques yielded no high degree delta activity records.

The second figure demonstrates the same relationship by measuring the per cent of each treatment group showing no delta activity or only low degrees

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* The differences between suprathreshold and threshold treatment methods are significant at .05 by chi square in the 4-6 and 7-9 treatment periods, but not in 10-12 period. Parathreshold treatment methods are not significantly different from the other two methods during any treatment period.

of such activity. Here, the subconvulsive group is 100% for each treatment period. Suprathreshold alternating current techniques show the least number of such records in each period, with threshold and parathreshold techniques in between.

4. Frequency of Treatment:

Another factor in the rate of development of delta activity is the frequency of treatment. While all patients were initially treated three times a week, a number who failed to develop high degrees of delta activity were treated more intensively. In nine such patients, treatments were given daily or twice daily, and in each instance middle or high degrees of delta activity were induced. Similar EEG correlates were previously demonstrated by Pacella et al. (9), and Callaway (10).

5. Factor of Age:

In the initial series of patients, it was noted that younger patients, under 45 years of age, developed greater degrees of delta activity during the first and second weeks of treatment; while older subjects developed such activity to a significant degree during the third week. By the fourth week of treatment, age no longer differentiated between the groups. Combining the data from all convulsive therapies supports this observation. During the second week, 43% of records are measured high degree delta in patients under the age of 40; but only 30% in patients from 40-60, and 18% in patients 61 and over. In the third and fourth weeks, the differences are no longer present and approximately 2/3rds of the subjects have high degree delta records when treated 3 times per week.

TABLE IV

Variation in Per Cent High Degree Delta EEG Records with Age *

		Treatment Period		
		Second Week	Third Week	Fourth Week
Age	(N)	4-6	7-9	10-12
To 40 years	(28)	43%	61%	69%
41-50 years	(28)	29%	40%	56%
51-60 years	(28)	32%	56%	55%
Over 61 years	(18)	18%	50%	80%

6. Pre-Treatment Record Characteristics:

Previous reports, summarized by Chusid and Pacella (3), noted a significant relationship between pre-treatment record characteristics and the degree of induced "abnormality." Predominant alpha rhythm, "abnormal" (3) or "borderline abnormal" (11) records were more liable to develop alterations in the EEG than those with predominantly low voltage fast activity patterns.

In these series of patients, subjects whose pre-treatment record demonstrated diffuse slow wave activity, spike or spike wave activity were not included in the statistical analyses. Eight such subjects were

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* The difference in incidence of high degree records is significant at .01 level of confidence between the second and fourth weeks and .05 between the second and third weeks of treatment in patients over 50 years of age; but is not significantly different for these periods in groups under 50 years.

treated with convulsive techniques, however, and seven of them developed high degrees of delta activity earlier, and for more sustained periods, than patients without such pre-treatment abnormality.

A specific analysis of the relation between pre-treatment alpha and the degree of induced delta activity was undertaken. Rank order correlations of the pre-treatment per cent time alpha in selected leads (anterior temporal-vertex) with the degree of delta activity during the third and fourth weeks of treatment in 43 patients demonstrated correlations of +.24 and +.35 respectively. The relationship in the fourth week is significant at the .05 level of confidence; while that in the third week fails of significance, although the trend is indicated.

DISCUSSION:

Two aspects of these studies warrant discussion: the significance of the convulsion in the electroshock process; and the role of serial electroencephalograms in the rational management and study of convulsive therapies.

In the early studies of convulsive therapy numerous authors, including Kalinowsky et al. (12) and Pacella et al. (9), emphasized both the clinical and electroencephalographic differences between grand mal and petit mal responses. While grand mal seizures induced clinical improvement in 60 to 80% of cases, petit mal induced changes in less than 25% of subjects. Similarly, electroencephalograms in grand mal therapy demonstrate delta activity, while in petit mal therapy, no delta activity is seen.

In subsequent years, various subconvulsive, brief stimulus, unidirectional stimulating, monopolar stimulating, and focal convulsive techniques have been described, and in each, in turn, discarded in routine therapy. Bergman et al. (13), for example, in describing the electroencephalographic effects of focal seizure techniques noted that 70% of patients had normal records at 15 such "seizures;" while 70-75% had "abnormal" records after grand mal seizures. Ulett et al. (14), in a careful convulsive-subconvulsive control study, reported a significant difference in the clinical response of patients receiving convulsive therapies (60-80%) and those receiving subconvulsive (33%), or controls (38%). He noted the discrepancy in the EEG response in the two groups, and emphasized the significance of the seizure for the therapeutic effect. Recent additional reports by various observers, based on a variety of data further emphasize the significance of the convulsion

in the therapeutic response (4, 15, 16). The evidence thus indicates that convulsions per se are, or reflect, the significant physiologic events which are the basis for therapeutic efficacy of convulsive therapies.

If the convulsion is the essential element both in the EEG and in the behavioral response, does the mode of induction of the seizure play any role in this response?. In the studies reported here, small differences in both the degree of EEG delta activity and the rate of its development were observed between different methods of induction of grand mal seizure.

Ulett et al. (14) reported an improvement rate of 57% for the alternating current convulsive technique, and 76% for the photo-metrazol technique. While the differences are small, the authors ascribe greater clinical efficacy to the convulsive photo-metrazol technique. In a discussion of this report, Kalinowsky noted that metrazol convulsions have impressed various workers as being more efficacious than electrically induced convulsions. More recently, Edwalds, (17) describing a new convulsant drug, PM 1090, ascribed to it clinical results slightly better than electroconvulsive techniques.

We have further noted that the convulsions induced by various techniques have varying characteristics of latency, duration, preponderance of clonic or tonic phase, apnea, etc. All grand mal seizures are seemingly not equivalent; and a seizure is not an "all or none" phenomenon. Different seizure patterns occur and these may reflect differences in the physiologic effect of different treatment methods. Further studies of this problem are in progress (18).

While this variability in clinical results is reported, it is clear that with repeated convulsions, no matter how induced, improvement rates of 60 to 80 per cent are observed. The differences between various types of treatment are small, and, for the most part, may be readily obviated by the simple expedient of increasing the frequency or number of treatments. We may conclude that convulsive therapy is non-specific with regard to the way the convulsion is induced. The significant element is the brain change subsequent to the convulsion, and not the agent used in bringing about this brain change. In previous reports (6, 19, 20) we have noted that convulsive therapy is also non-specific with regard to its application in mental illness, and in its clinical and behavioral effects. The present studies, amplify , therefore, the previous conclusion of the non-specificity of convulsive therapies.

We have applied methods of quantitative, serial EEG analyses in the studies reported here. While clinical estimates of behavioral change have yielded similar data, such evaluations are more dependent on the attitudes of the observer (21), and less amenable to quantification than the EEG. Application of EEG analyses to problems in convulsive therapies provides a rational basis for the comparison of different treatment techniques.

We have previously noted that EEG analyses may be applied in the clinical management of patients receiving convulsive therapy (6). In patients who fail to show a significant behavioral response on treatment regimens of three times per week, an electroencephalogram may serve as a

guide for further therapy. In those subjects in whom high degree delta activity has not been induced, increasing treatment frequency, withholding premedication, or shifting to a more effective convulsant method, may result in the neurophysiologic changes. If the degree of delta activity is high and sustained for a number of weeks, other factors as personality (22) or environmental (19) may be assumed to preclude a satisfactory behavioral response, even when the neurophysiologic substrate is assured; and further convulsive therapy may well be discontinued. A similar application has been suggested by Roth (5) for thiopental activated EEG records.

The successful application of quantitative EEG techniques to convulsive therapies, has led to their application to other physiodynamic therapies. Recent reports from these laboratories note a similar application for the rational management and understanding of psychopharmacologic agents (20).

SUMMARY AND CONCLUSIONS:

Serial quantitative analysis of the degree of induced EEG delta activity were made in 173 consecutive electrotherapy referrals. Patients were treated by three convulsive methods: suprathreshold alternating current, threshold alternating current and parathreshold unidirectional current. Random electrotherapy patients received a course of subconvulsive treatment instead of grand mal, in a convulsive-subconvulsive control study.

1. An induced grand mal convulsion is essential both for the electroencephalographic and the behavioral changes ascribed to "shock" therapy.

2. The rate and degree of induced EEG delta activity is dependent upon:

(a) Mode of seizure induction: suprathreshold alternating current techniques induce EEG changes earlier and to a higher degree than threshold techniques. The results of unidirectional current methods fall between these two techniques.

(b) Frequency of treatment: increasing frequency increases degree of EEG delta activity.

(c) Age of subject: Patients under 45 develop greater degrees of delta activity earlier than older patients, but by the fourth week of treatment, differences are insignificant.

(d) Pre-treatment record characteristics: Patients with dysrhythmic records or high per-cent time alpha activity develop greater degrees of delta activity earlier than patients with low per-cent time alpha activity.

3. It is suggested that serial quantitative electroencephalography provides a rational basis for the study and the clinical management of convulsive therapies.

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ELECTROENCEPHALOGRAPHIC CORRELATES OF THE ELECTRO-SHOCK PROCESS

MAX FINK, M.D., and MARTIN A. GREEN, M.D.

From the Department of Experimental Psychiatry, Hillside Hospital, Glen Oaks, N. Y.

Problem:

In the course of an evaluation of the role of altered brain function in the electroshock process, the relation between electroencephalographic change and behavioral response has been re-assessed.

Subjects and Method:

Eighty consecutive electroshock patients have been studied. All patients received electroencephalograms before treatment; on a day after a treatment at weekly intervals during, and following the course of therapy until the records had achieved their pre-treatment characteristics. Treatment procedures varied, including unidirectional and alternating current electroshock, and subconvulsive technics with Pentothal premedication. Treatment was usually instituted at three times per week for 12-20 treatments. Patients who failed to develop a clinical response, or EEG changes of significant degree, were subsequently treated at 5-10 times per week.

The EEG records were classified for degree of delta activity into "high," "middle" and "low" degree delta records using the following indices: the percent-time delta; highest percent-time delta in any lead; slowest wave in the record; highest amplitude of delta; and duration of burst activity. (Arch. Neurol. & Psychiat., 78: 516-525, 1957.)

Evaluations of change in behavior were made by the supervising psychiatrist at the height of the electroshock effect; and ratings of improvement were made two to three weeks following the termination of therapy.

Results:

1) The appearance of a high degree EEG delta activity during the second and third weeks of treatment was significantly correlated with change in behavior and ratings of improvement.

3) High EEG delta activity was induced in patients receiving convulsive electroshock only, and was not observed in subconvulsive therapy.

3) Alternating current instruments induced high degree EEG delta activity earlier than unidirectional instruments, but by the 4th week of treatment, the differences were eliminated.

4) There was a direct relation between the degree of EEG delta activity and the frequency of treatment; and an inverse relationship to age.

Conclusion:

1) There is a relationship between the degree of EEG delta activity in the EEG and clinical change in behavior.

2) The time of the appearance of EEG delta activity and its persistence is related to:

a) induction of grand mal seizures;
b) type of current employed;
c) frequency of treatment; and
d) age of the patient

3) Early and sustained high degree electroencephalographic delta activity is a necessary,, though not sufficient, pre-requisite for improvement in the electroshock process.

Treatment Group

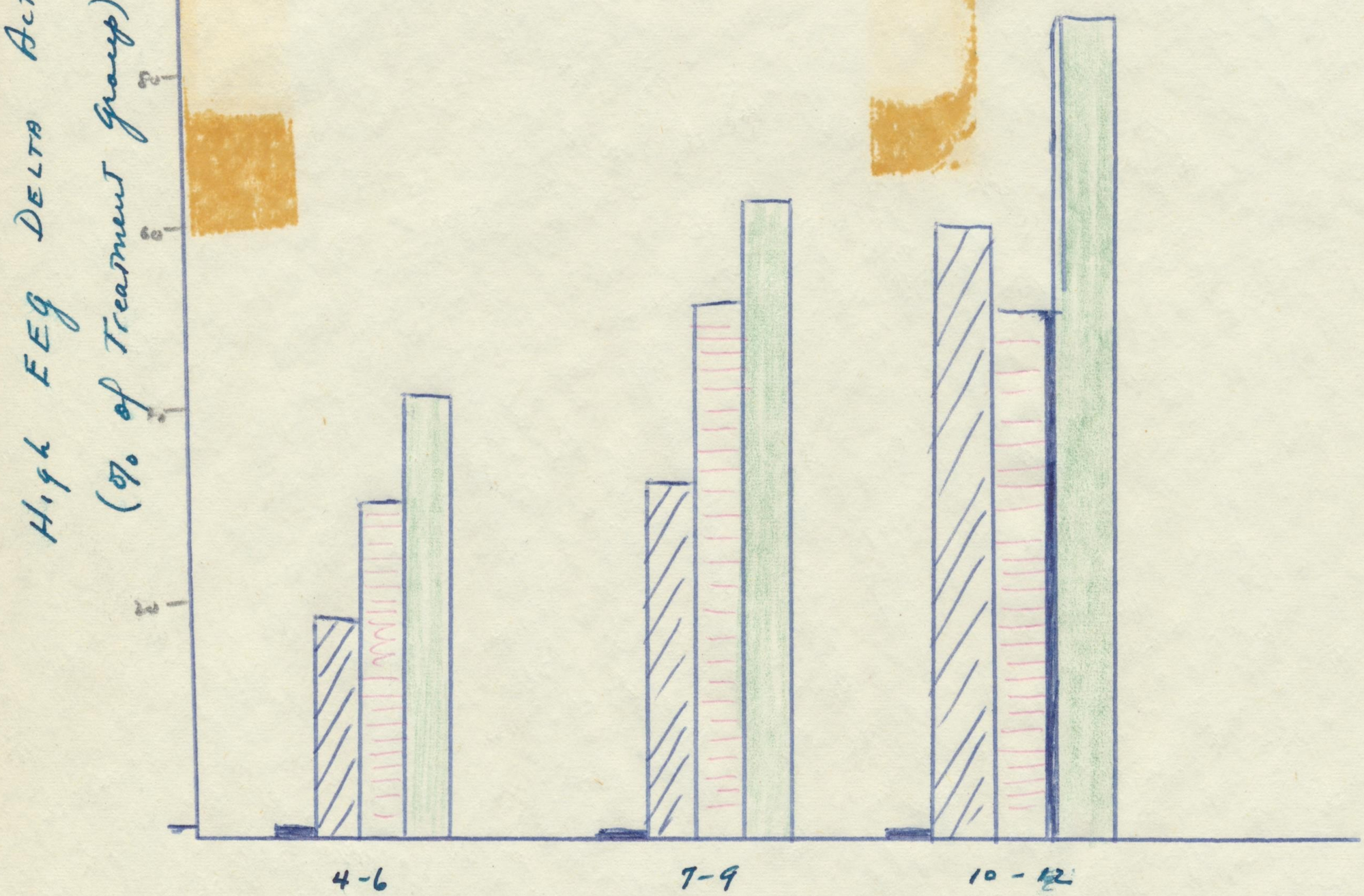
Subconvulsive - AC and UniDir.

Convulsive - Threshold - AC

" - ~~Glissando~~ Parathreshold - ~~UniDir.~~ UniDir.

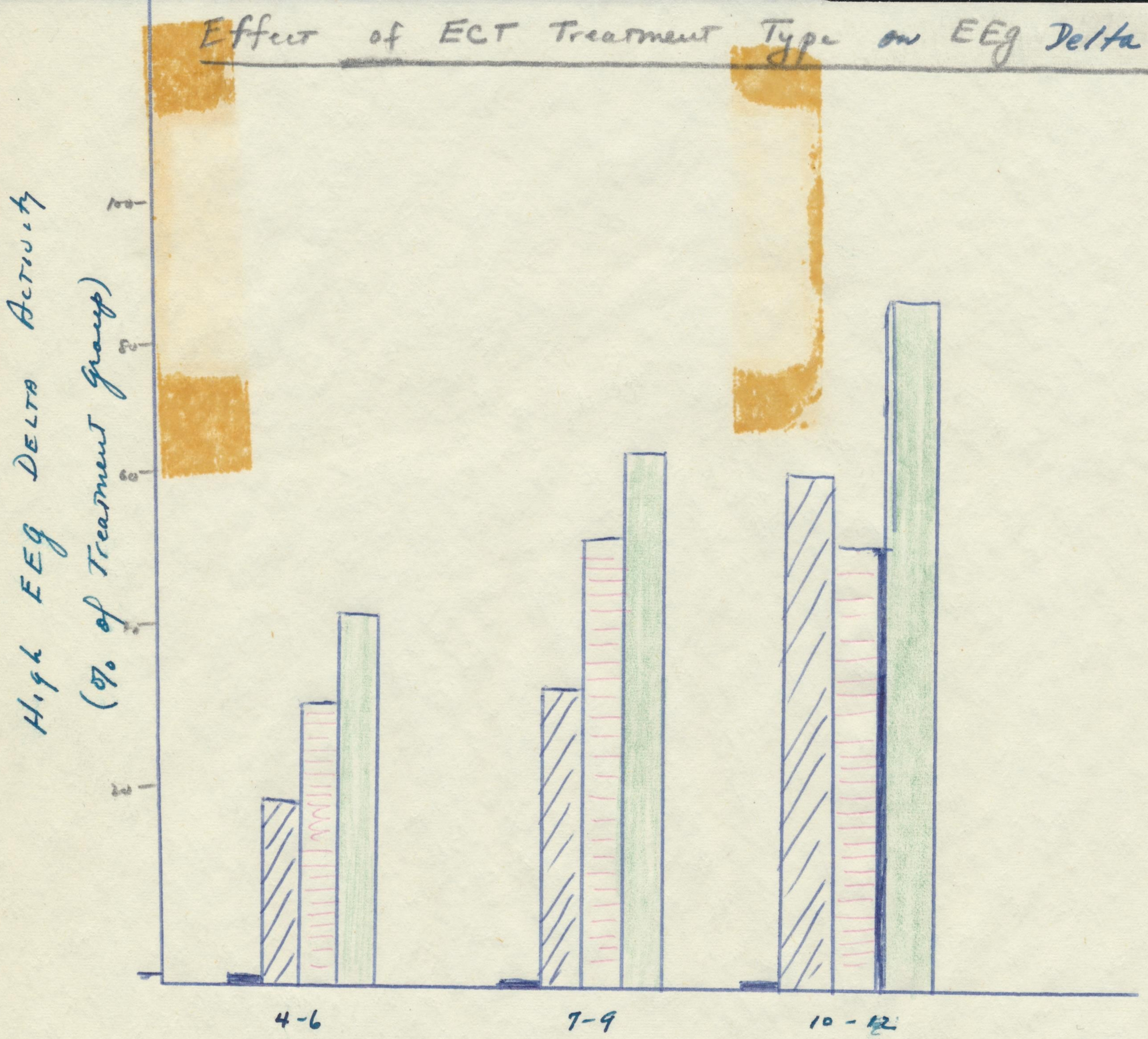
" - Suprathreshold - AC

Type on EEG Delta Activity



Percents:	0	20	31	44	0	34	51	60	0	59	50	78

Effect of ECT Treatment Type on EEg Delta Activity



ECT Treatment Period

Percents:	0 20 31 44	0 34 51 60	0 59 50 78	

Effect of ECT Treatment Type on EEG Δ Activity

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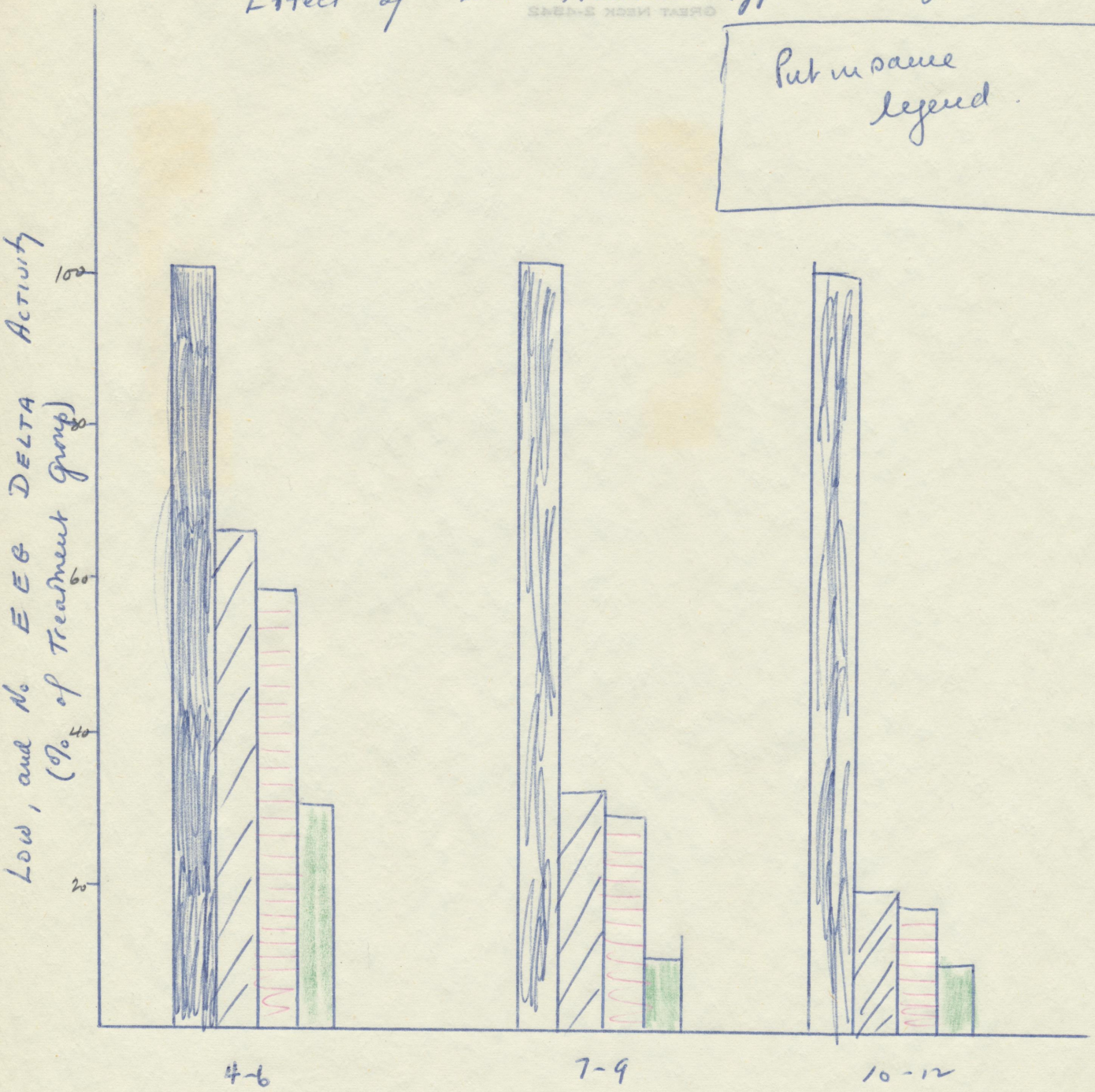

Percent 100 65 48 32 100 32 29 8 100 18 17 11

Ellen – These numbers are for your information →

MAX FINK, M. D.
275 MIDDLE NECK ROAD
GREAT NECK, N. Y.
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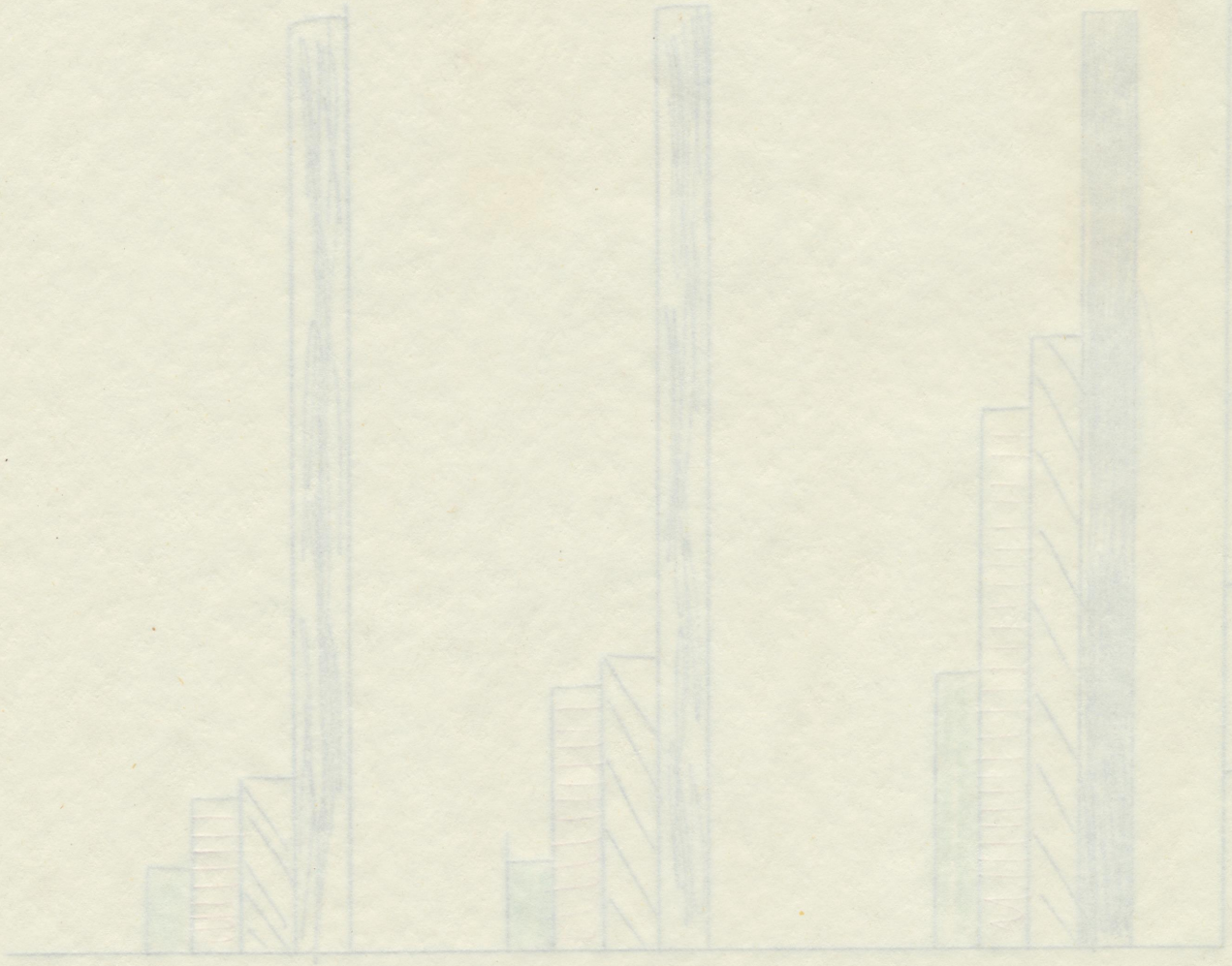
GREAT NECK 2-4542



11-16-56

ESRA

In 1952, D. B. & I. summarized the exp. & Recks EST to that time & concluded —

"The type, degree & persistence of abnormality are not related to dx, age, clinical result & no of Rx, or the pre treatment characteristics of the EEG."

The statement is generally true, a detailed analysis of EEG records using quantitative measures does show a relationship between degree of EEG abnorm., & term of induced (early & sustained) convulsive change; ① & difference in rate of induction and degree of EEG abnormality depending on the instrument used for EST (as well as the frequency of EST).

and 3) that ~~the re-evaluation of the EST literature with regard~~ the approach for the general problem of SC, unlike SC to EST

~~Impedance is measured~~

and other "portal" EST methods to be found a

Key feature of endemic SES abnormality.

11-26-56

Previous studies of the relation of EEG changes and electroshock therapy have shown no consistent relationship between EEG changes and improvement. In a report to the association in 1952, B, G, I + W summarized the existing experience with Reiter electroshock with the conclusion:

"The type, degree or persistence of the abnormality [in the EEG] was not related to the diagnosis, the age of the patient, the clinical results, the number of treatments or the pre-treatment characteristics of the EEG, and were, in the main, similar to those occurring after standard A.C. electroshock therapy."

In a report a year later, Bergman et al reported on the EEG findings following unilateral electroshock, which a number of observers have described the minimal to no EEG abnormality following subconvulsive electroshock.

~~Studies at the laboratory for the past 3 years have confirmed the general reliability of per~~

A detailed analysis of EEG records in this laboratory during the past 3 yr. has

11-26-56

EEG Paper

ESRA.

Problem:

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Subjects and Method:

Eighty electroshock patients referred for treatment by the supervising psychiatrist, have been studied. All patients received electroencephalograms before treatment; at weekly intervals during treatment, and at weekly intervals after therapy _____ until the records had achieved their pre-treatment characteristics. Conventional Reiter indirectional electroshock was used in 2/3 of the cases, while 1/3 received Medcraft AC therapy. In addition, a control group is now in progress, utilizing Reiter subconvulsive or Medcraft Pdht mal with pentothal medication. Anectine___ was not used in this series, while pentothal was used in 20 of the Reiter electroshock patients. While treatment was always instituted at three times per week for 12-20 treatments, a number of patients failed to develop a clinical response, or EEG changes of significant degree, were treated at five times per week.

The EEG records were analyzed for delta abnormality. The percent time delta; slowest wave in the second; amplitude of delta; and duration of burst activity. Using these indices, a classification of degree of abnormality was developed (based on the ~~maximum~~ initial seizure of 24 patients.) into high, middle and low abnormal records.

The ~~improvement~~ improvement ratings were made by the supposed_____ during the few weeks following the termination of therapy ~~X~~

Results:

1) A positive correlation was established between the development of a high degree EEG abnormality during the second and third week of treatment and clinical improvement.

2) High EEG abnormality was induced in patients receiving convulsive

electroshock only; and was not observed in subconvulsive or petit- mal therapy.

3) Alternating current instruments induced high degree EEG abnormality earlier than the undirectional instrument, but by the 4th week of treatment, the differences were gone.

4) There was a direct relation between the dgreee of EEG abnormality and the frequency of treatment; and on _____ relationship to age.

Conclusion:

1) There is a relationship between the degree of delta abnormality in the EEG and clinical change in behavior.

2) The time of the indication of delta abnormality and its persistence is related to a) the induction of grand mal seizures.

b) the type of electrical current employed

c) the frequency of treatment

d) age of the patient

3) Modifications in electroshock therapy as m electroshock, subconculsive electroshock, electrostimulation therapy - which do not develop delta abnormality in the EEG, fail to achieve the therapeutic results of grand mal electroshock. The limited efficacy of these procedures is probably due to this placebo effect.

Electroencephalographic Correlates of the Electroshock Therapy Process *

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* From the Department of Experimental Psychiatry, Hillside Hospital, Glen Oaks, New York.

November 26, 1956

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The EEG records were classified for degree of delta abnormality with "high" "middle" and "low" abnormality record/xxsing the following indices. The percent time delta; highest percent time delta at any one lead; slowest wave in the record; highest amplitude of delta; and duration of burst activity.

The improvement ratings were made by the supervising psychiatrist during the few weeks following the termination of therapy, using a three-point scale.

Results:

1) A positive correlation was established between the development of

a high degree EEG abnormality during the second and third week of treatment and clinical improvement.

2) High EEG abnormality was induced in patients receiving convulsive electroshock only; and was not observed in subconvulsive or petit-mal therapy.

3) Alternating current instruments induced high degree EEG abnormality earlier than the undirectional instrument, but by the 4th week of treatment, the differences were eliminated.

4) There were a direct relation between the degree of EEG abnormality and the frequency of treatment; and an inverse relationship to age.

Conclusion:

1) There is a relationship between the degree of delta abnormality in the EEG and clinical change in behavior.

2) The time of the appearance of delta abnormality and its persistence is related to the: a) induction of grand mal seizures;

b) type of current employed;

c) frequency of treatment; and

d) age of the patient

3) Modifications in electroshock therapy as unilateral electroshock, subconvulsive electroshock, electrostimulation therapy - which do not develop delta abnormality in the EEG, fail to achieve the therapeutic results of grand mal electroshock. The limited efficacy of these procedures is probably due to their placebo effect.

Electroencephalographic Correlates of the Electroshock Process *

Max Fink, M.D., Martin A. Green, M.D., and
Robert L. Kahn, Ph.D.

Problem:

In the course of an evaluation of the role of altered brain function in the electroshock process, the relation between electroencephalographic change and behavioral response has been re-assessed.

Subjects and Method:

Eighty consecutive electroshock patients have been studied. All patients received electroencephalograms before treatment; on a day after a treatment at weekly intervals during, and following the course of therapy until the records had achieved their pre-treatment characteristics. Treatment procedures varied, including unidirectional and alternating current electroshock, and subconvulsive technics with pentothal premedication. Treatment was usually instituted at three times per week for 12-20 treatments. Patients who failed to develop a clinical response, or EEG changes of significant degree, were subsequently treated at 5-10 times per week.

The EEG records were classified for degree of delta abnormality into "high" "middle" and "low" degree delta records using the following indices: the percent-time delta; highest percent-time delta in any lead; slowest

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* From the Department of Experimental Psychiatry, Hillside Hospital, Glen Oaks, New York.

Submitted to the Section of Neurology and Psychiatry, New York Academy of Medicine.

June 19, 1957.

wave in the record; highest amplitude of delta; and duration of burst activity.

Evaluations of change in behavior were made by the supervising psychiatrist at the height of the electroshock effect; and ratings of improvement were made two to three weeks following the termination of therapy.

Results:

1) A positive correlation was established between the development of a high degree EEG abnormality during the second and third weeks of treatment, change in behavior and ratings of improvement.

2) High EEG abnormality was induced in patients receiving convulsive electroshock only; and was not observed in subconvulsive therapy.

3) Alternating current instruments induced high degree EEG abnormality earlier than unidirectional instruments, but by the 4th week of treatment, the differences were eliminated.

4) There was a direct relation between the degree of EEG abnormality and the frequency of treatment; and an inverse relationship to age.

Conclusion:

1) There is a relationship between the degree of delta abnormality in the EEG and clinical change in behavior.

2) The time of the appearance of delta abnormality and its persistence is related to the: a) induction of grand mal seizures;

b) type of current employed;

c) frequency of treatment; and

d) age of the patient

3) Early and sustained high degree electroencephalographic abnormality is a necessary, though not sufficient, pre-requisite for improvement in the electroshock process.

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Electroencephalographic Correlates of the Electroshock

~~Therapy~~ Process *

Max Fink, M.D., ~~Robert L. Kahn and~~ M. Green, M.D., and

Robert L. Kahn Ph.D.

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* From the Department of Experimental Psychiatry, Hillside Hospital, Glen Oaks, New York.

~~To the Electroshock Research Assoc. 11/56.~~

Submitted to the Section of Neurology and Psychiatry, New York Academy of Medicine.

June 19, 1957

~~November 26, 1956~~

Problem:

In the course of an evaluation of the role of altered brain function in the electroshock process, the relation between electroencephalographic change and behavioral response has been re-assessed.

Subjects and Method:

Eighty consecutive electroshock patients have been studied. All patients received electroencephalograms before treatment, on a day after a treatment at weekly intervals during, and following ~~treatment~~ the course of therapy; until the records had achieved their pre-treatment characteristics. Treatment procedures ~~Conventional Reiter undirectional electroshock was used in 2/3 of the cases, while 1/3 receiving Medcraft AC therapy.~~ varied, including unidirectional and alternating current electroshock, and subconvulsive techniques with pentothal premedication. ~~In addition, a control group is now in progress, utilizing Reiter subconvulsive or Medcraft petit-mal treatment with pentothal medication. Anectine was not used in this series.~~ Treatment was usually instituted at three times per week for 12-20 treatments. ~~A number of~~ Patients who failed to develop a clinical response, or EEG changes of significant degree, were subsequently treated ~~at five times per week~~ at 5-10 times per week.

The EEG records were classified for degree of delta abnormality ~~with~~ into "high" "middle" and "low" ~~abnormality~~ degree delta record/~~rising~~ using the following indices: The percent-time delta; highest percent-time delta ~~at~~ in any ~~one~~ lead; slowest wave in the record; highest amplitude of delta; and duration of burst activity.

~~The improvement ratings were made~~ Evaluations of change in behavior were made by the supervising psychiatrist ~~during the few weeks following the termination of therapy, using a three-point scale.~~ at the height of the Electroshock effect, and ratings of improvement were made two to three weeks following the termination of therapy.

Results:

1) A positive correlation was established between the development of

a high degree EEG abnormality during the second and third weeks of treatment, ~~and clinical improvement.~~ change in behavior and rating of improvement.

2) High EEG abnormality was induced in patients receiving convulsive electroshock only; and was not observed in subconvulsive ~~or petit mal~~ therapy.

3) Alternating current instruments induced high degree EEG abnormality earlier than ~~the~~ undirectional instruments, but by the 4th week of treatment, the differences were eliminated.

4) There ~~were~~ was a direct relation between the degree of EEG abnormality and the frequency of treatment; and an inverse relationship to age.

Conclusion:

1) There is a relationship between the degree of delta abnormality in the EEG and clinical change in behavior.

2) The time of the appearance of delta abnormality and its persistence is related to the: a) induction of grand mal seizures;

b) type of current employed;

c) frequency of treatment; and

d) age of the patient

43) Modifications in electroshock therapy as unilateral electroshock, subconvulsive electroshock, and electrostimulation therapy - which do not develop delta abnormality in the EEG, fail to achieve the therapeutic results of grand-mal electroshock. The limited efficacy of these procedures is probably due to their placebo effect.

34) Early and sustained high degree electroencephalographic abnormality is a necessary, though not sufficient, pre-requisite for improvement in the electroshock process.

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DS.

Electroencephalographic Correlates of the Electroshock Process *

Max Fink, M.D., and Martin A. Green, M.D.

Problem:

In the course of an evaluation of the role of altered brain function in the electroshock process, the relation between electroencephalographic change and behavioral response has been re-assessed.

Subjects and Method:

Eighty consecutive electroshock patients have been studied. All patients received electroencephalograms before treatment; on a day after a treatment at weekly intervals during, and following the course of therapy until the records had achieved their pre-treatment characteristics. Treatment procedures varied, including unidirectional and alternating current electroshock, and subconvulsive technics with pentothal premedication. Treatment was usually instituted at three times per week for 12-20 treatments. Patients who failed to develop a clinical response, or EEG changes of significant degree, were subsequently treated at 5-10 times per week.

The EEG records were classified for degree of delta activity into "high" "middle" and "low" degree delta records using the following indices: the percent-time delta; highest percent-time delta in any lead; slowest

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* From the Department of Experimental Psychiatry, Hillside Hospital, Glen Oaks, New York.

EPRA: 1/8/58

wave in the record; highest amplitude of delta; and duration of burst activity (A.M.A. Arch. Neurol. & Psychiat. 78: 516-525, 1957)

Evaluations of change in behavior were made by the supervising psychiatrist at the height of the electroshock effect; and ratings of improvement were made two to three weeks following the termination of therapy.

Results:

1) ~~A positive correlation was established between the development of~~ the appearance of a high degree EEG ~~abnormality~~ delta activity during the second and third weeks of treatment was significantly correlated with change in behavior and ratings of improvement.

2) High EEG ~~abnormality~~ delta activity was induced in patients receiving convulsive electroshock only, and was not observed in subconvulsive therapy.

3) Alternating current instruments induced high degree EEG ~~abnormality~~ delta activity earlier than unidirectional instruments, but by the 4th week of treatment, the differences were eliminated.

4) There was a direct relation between the degree of EEG ~~abnormality~~ delta activity and the frequency of treatment; and an inverse relationship to age.

Conclusion:

1) There is a relationship between the degree of delta ~~abnormality~~ EEG activity in the EEG and clinical change in behavior.

2) The time of the appearance of delta ~~abnormality~~ EEG activity and its persistence is related to the: a) induction of grand mal seizures;

b) type of current employed;

c) frequency of treatment; and

d) age of the patient

3) Early and sustained high degree electroencephalographic ~~abnormality~~ delta activity is a necessary, though not sufficient, pre-requisite for improvement in the electroshock process.

EEG
w Bridges.

11-14-57

Combine report of EST (3 #4 5) + EEG consel. of
Electroshock Proces.

c Biochem aspects (?)

Points to be made:

(A) (1) Gr essential - control group.

(C+A) (2) Factor of machine

(A+B) (3) Biochem. - ECT as Trauma

(4)

(5) Reference to personality changes Reaction (Reports two Observers)

Concl.: (1) Rec. for EEG as guide - index

(2) Rational use of ECT

Note: Diff in EEG Response of to Rate + Med may explain, by analogy, diff in Meth comparisons
Ewald's differences (
Diff quoted diff betw. metrazole - EST.

Neurophysiologic and Biochemical Aspects of EEG Effects of Electroshock

EEG Correlates of Electroshock Process

During the past few years, increasing attention has been given to the relation between changes in the electroencephalogic and the behavioral change induced by electroshock. The initial application of EEG techniques to the electroshock problem in the period 1940-1950, was summarized in an excellent review by Chusid and Pacella in 1952, who noted that the number of treatments rather than the degree of induced neurophysiologic change (reflected in the EEG) was the primary factor related to favorable therapeutic outcome. These studies, largely based on descriptive analyses of pre and post-treatment records, were followed by serial quantitative analyses.

In 1951 and 1952, Roth analyzed the EEG activated by thiopental in patients during a course of ECT and noted that induced delta activity was related to the process of recovery. He concluded that "

In 1953, in the laboratories at Hillside Hospital, we undertook an analysis of neurophysiologic bases of electroshock, based on a hypothesis expressed by Weinstein and his co-workers in which they related improvement in electroshock to persistent states of altered cerebral function. Our

first studies utilized the amobarbital test and these, parenthetically, did show a relationship between changes in language and ratings of improvement. Our second index was the delta index of the electroencephalogram.

In our original review of patients, recently reported, we noted a significant relationship between the degree and duration of the induced delta activity and clinical evaluation of behavioral change and "improvement." It is our purpose tonight to review these findings; to describe subsequent studies in which various aspects of the treatment process were related to the degree of EEG delta activity; and to conclude with a summary of the present neurophysiologic adaptive view of convulsive therapy.

Method:

One hundred and forty-eight consecutive ~~patien~~ electroshock referrals have been studied. Electroencephalograms were taken before treatment, on a day after a treatment at weekly intervals during, and following the course of therapy, until the record had achieved its pre-treatment characteristics. Various treatment procedures have been used, including alternating current threshold and suprathreshold electroshock; parathreshold unidirectional current electroshock; and subconvulsive techniques with pentothal premedication.

The alternating current suprathreshold ( ) and unidirectional parathreshold (Reiter) techniques are well described in the threshold alternating current methods, patients, without prior sedation, received a low current, 90 volts for 0.1 second, which was usually sufficient for a petit mal absence. At 20 second intervals, voltage was increased by 10 volts up to 140 volts, 0.1 second. Voltage was then reduced to 100 volts x 0.2 second, and increased by 10 volt steps until a grand mal convulsion was induced. The voltage and time just necessary to induce a grand mal was the threshold value. In subconvulsive techniques, patients were given pentothal intravenously until asleep, and then either low voltage unidirectional current for 60 seconds; or alternating current of 80 to 120 volts x 0.1 second were administered for one to three applications.

All treatments were given three times a week initially, for 12-20 treatments. Patients who failed to develop a significant behavioral or clinical response, or EEG changes of significant degree, were subsequently treated 5-10 times per week.

All EEG records were quantitatively measured for the degree of delta activity. This index was determined by measuring the per cent time delta

in 180 seconds of each of three lead combinations, and both the average and the highest index in any one lead were used; the slowest frequency and highest amplitude delta; and the duration of the longest burst . Records in the initial series were placed into sequence. The upper third - those with the greatest changes in slow wave activity - were called "High Degree Delta Activity." The middle and lower thirds were "Moderate Degree Delta Activity" and "Low Degree Delta Activity." The specific limits of each range are described in the earlier report.

The following three slides demonstrate a High-Middle and Low degree record obtained during the fourth week of treatment.

(Figs. 1, 2, 3)

Evaluations of changes in behavior were made by the supervising psychiatrist and resident therapist at the height of the treatment effect. The ratings of "improvement" were made by these physicians two to three weeks after treatment was terminated, and were based on the four fold classification of "recovered," "much improved," "Improved" and "unimproved or worse."

In our initial reports (,) we noted that patients who developed

high degree delta activity early, and in whom such delta activity was sustained, were evaluated as "much improved" or "recovered" with a significantly greater incidence than those patients who failed to demonstrate such delta activity. These observations are portrayed in slide 4.

(Slide 4; Graph EST #1)

These patients had been treated with a unidirectional convulsive therapy. In a subsequent series of 54 patients, a predictive study was undertaken in which the degree of delta activity induced during the second and third weeks of treatment was determined. Of the subjects in whom high degrees of delta activity were induced during both weeks, 67% were eventually rated as much improved; while of those who did not have a high degree record in either week, only 30% were so evaluated. Of these patients, half were treated with a unidirectional current; and half with a suprathreshold alternating current technique.

Slide 5 - (Table I, Exp. Studies)

Results:

1. Role of Convulsions in Therapy.

In the most recent series of patients, randomly selected subjects

received subconvulsive therapies instead of grand mal; and both alternating current and unidirectional current techniques were used.

Of the subjects who received convulsive therapy, ____ had high degree delta records in both second, third and fourth weeks of treatment; ____ during two of the three weeks, and ____ during only one of the test periods. Only ____ subjects failed to show a single high record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none demonstrated middle or high degree delta activity records during any week of treatment. Low degrees of delta activity were noted in three subjects during both the second and third weeks of treatment, and in 8 subjects during the fourth week.

Concurrent analyses of the behavioral ratings showed ____ of the convulsive group rated as showing marked behavioral change; while of the subconvulsive group, 25 showed no behavioral changes. Of these, nineteen were referred for a second course of therapy. In 14 of these, grand mal electroshock induced high degree delta activity and all showed a significant behavioral change. Of the five who failed to demonstrate high degree delta activity on convulsive electroshock, all showed middle degree records;

and two of the five showed a behavioral change.

2. Factor of Type of Therapy:

In view of the variety of electroshock techniques employed, and the relationship between EEG delta activity and the behavioral response, an analysis of the effect of type of electroshock in EEG delta activity was undertaken. The results are graphically presented in Figures 6 and 7. The first related the percentage of records in each treatment group during the second, third and fourth weeks of treatment who demonstrated high degrees of EEG delta activity. In each period, threshold alternating current techniques gave a lower percentage of high degree delta records. The unidirectional technique was also less effective than the supra-threshold alternating current technique, in all these periods. Although more effective than threshold alternating current methods, early in the course of therapy. Note, that subconvulsive techniques yield no high degree delta activity records.

In the next figure, the converse is demonstrated. The relationship between type of treatment, treatment period and percentage of treatment group showing no delta activity or only low degrees of such activity.

Here, the subconvulsive group is 100% for each treatment period. Supra-threshold alternating current techniques show the least number of such records in each period.

3. Frequency of Treatment:

Another factor on the rate of development of delta activity is the frequency treatment. While all patients were initially treated three times a week, a number who failed to develop high degrees of delta activity on convulsive therapies were treated more intensively. Treatments were given daily or twice daily. In all such instances high degrees of delta activity were induced.

4. Factors of Age and Diagnosis:

In the initial series of patients, it was noted that younger patients, under 45 years of age, developed greater degrees of delta activity during the first and second weeks of treatment; while older subjects developed such activity to a significant degree during the third week. By the fourth week of treatment, age was no longer a differentiating aspect between the groups. With increasing series of patients, utilizing various treatment techniques, the differences between successive groups is largely a matter of treatment technique rather than age.

Similarly, conventional discharge diagnoses bear no relation either to the rate or degree of delta activity induced. The delta activity induced in young schizophrenics, older depressed, older schizophrenic paranoid, and younger reactive depressed subjects are similar in incidence of high, middle and low degrees at different stages of therapy. The diagnosis is not, of itself, a significant neurophysiologic factor in electroshock.

combining the data from all convulsive therapies supports this observation. During the second week,43% of records are high degree delta in patients 40; but only 30% in patients from 40-60, and 18% 61 and over. In the third and fourth weeks, the differences are no longer present and approximately 2/3 of the subjects have high degree delta records when treated 3 times per week.

TABLE ___

Variation in % High Degree Delta EEG Records with Age

		Treatment Period		
Age	(N)	4-6	7-9	10-12
To 40 years	(28)	43%	61%	69%
41-50	(28)	29%	40%	56%
51-60	(28)	32%	56%	55%
61+	(18)	18%	50%	80%

5. Pre-Treatment Record Characteristics:

Previous reports, summarized by Chusid and Pacella, ( ) rated a significant relationship between pre-treatment records characteristics and the degree of induced "abnormality." Records with predominant alpha rhythm or "abnormal" (Chusid and Pacella) or "borderline abnormal"

(Bagchi et al) records were more liable to develop alterations in the EEG than those with predominantly low voltage fast activity patterns.

Rank order correlations of the pre-treatment per cent time alpha in selected leads (anterior temporal - vertex) with the degree of delta activity during the third and fourth weeks of treatment in 43 patients demonstrated correlations of +.24 and +.35 respectively The relationship in the fourth week is significant at the .05 level of confidence; while that in the third week fails of significance, although the trend is apparently indicated.

Discussion:

Two aspects of these studies warrant discussion; the significance of the convulsion in the electroshock process; and the role of electroencephalography in the rational management and study of convulsive therapies.

(1) Significance of Convulsions:

In the initial studies of convulsive therapy numerous authors, including Kalmansky Kalinowsky et al. (1942), and Pacella et al. (1942) emphasized both the clinical and electroencephalographic differences between the grand-mal and petit-mal responses. While grand mal seizures induced clinical improvement in 60 to 80% of cases, petit mal induced changes in less than

25% of subjects. Similarly, the electroencephalographic response to grand mal is one of delta activity, and to petit mal, is no delta activity.

In subsequent years, various subconvulsive, brief stimulus, unidirectional stimulating, monopolar stimulating, focal convulsive techniques have been described, and each, in turn, discarded in routine therapy. Bergman et al.,( ) for example, in describing the electroencephalographic effects of focal seizure techniques noted that 70% of ~~the~~ patients had normal records after 15 such "seizures;" while 70 - 75% had "abnormal" records after grand mal seizures. Ulett et al. ( ), in a careful control convulsive-subconvulsive study, reported the significant differences in the clinical changes between the convulsive therapies (60-80%) and subconvulsive (33%), and noted the discrepancy in EEG response in the two groups, and emphasized the significance of the seizure for the therapeutic effect.

These studies emphasize the significance of the grand mal convulsion, both for the clinical therapeutic effect and the electroencephalographic response. Recent reports by various observers, and based on a variety of data, support this conclusion.

If the convulsion is the essential element in the EEG and

behavioral response in electrotherapy, does it matter in what way the convulsion is induced?. In the studies reported here, small differences in both the degree of EEG delta activity and the rate of the development were observed. Clinical evaluation demonstrated concomitant greater degrees of clinical efficacy for the suprathreshold alternating current method to the two other convulsive techniques.

Other studies have also shown differences in clinical results for various convulsive techniques. Ulett et al. ( ) noted similar differences in clinical results in a study of patients receiving alternating current; and photic-metrazole convulsive and subconvulsive techniques. He reported improvement rate of 57%, 76% and 33% respectively; and concluded, that the convulsive photoshock technique had the greatest clinical efficacy. Epstein and Wender (1955) compared alternating and unidirectional current techniques, and reported no difference in clinical results but that unidirectional techniques required one to two treatments more than alternating current methods. More recently, Edwalds, describing a new convulsant drug, PM 1090, ascribed to it a clinical efficacy slightly greater than electroconvulsive techniques.

While some variability in clinical results is reported, it is clear that with repeated convulsions, no matter how induced, improvement rates of 60 - 80% are induced. The differences are small, and for the most part, may be obviated by increasing the frequency of treatment. We may conclude that convulsive therapy is non-specific with regard to its mode of induction. In previous reports (EEG Theory) we have noted that convulsive therapy is non-specific with regard to their application in mental illness, nor is their clinical or behavioral effects. The present studies amplify, therefore, the previous conclusion that convulsive therapies are non-specific.

2. Role of Electroencephalography in Convulsive Therapy:

We have applied methods of quantitative, serial EEG analyses in the studies reported here. While clinical estimates of behavioral change may give similar data, such evaluations are more closely dependent on the attitudes of the observer ( ) than the EEG. Further application of EEG analyses to other problems in convulsive therapies may provide a rational basis for comparison of different treatment techniques.

We have previously noted that EEG analyses may be applied in the clinical management of patients receiving convulsive therapy. In our experience, the early and sustained induction of high degrees of delta activity provides the physiologic basis for behavioral change in convulsive therapy. An electroencephalogram in patients who fail to show a significant behavioral response on treatment regimens of three times per week may serve as a rational basis for clinical management. In those subjects in whom high delta activity has not been induced, increasing treatment frequency, withholding premedication, or shifting to a therapeutically more effective convulsant method, may result in the neurophysiologic changes. If the degree of delta activity is high; and it may be maintained for a number of weeks, other factors, as personality ( ) or environmental ( ) may be assumed to preclude s satisfactory behavioral response, even when the neurophysiologic substrate is assured; and further convulsive therapy may well be discontinued. A similar application has been suggested by Roth ( ) for thiopental activated EEG records.

The successful application of quantitative EEG techniques to convulsive therapies, has led to their application to other physiodynamic therapies. Recent reports from these laboratories note a similar application for the rational management and understanding of psychopharmacologic agents ( ).

Summary and Conclusions:

EEG Correlates of the Electroshock Process

During the past few years, renewed attention has been given to the relation between changes in the electroencephalogram and behavioral changes induced by electroshock. In 1953, in the laboratories at Hillside Hospital, an analysis of neurophysiologic aspects of electroshock was undertaken. The studies were based on a hypothesis expressed by Weinstein and his co-workers ( ) in which they related improvement in electroshock to the development of persistent states of altered cerebral function.

In this initial EEG study ( ), we noted a significant relationship between the degree and duration of the induced delta activity and clinical evaluations of behavioral change and "improvement." It is the purpose of this report to review these findings; to describe recent studies in which various neurophysiologic aspects of the treatment process were assessed; and to suggest the application of electroencephalography in studies and rational management of physiodynamic therapies.

Method:

One hundred and forty-eight consecutive electroshock referrals have been studied. Electroencephalograms were taken before treatment, and on a day after a treatment at weekly intervals during and following the course

of therapy until the record had achieved its pre-treatment characteristics. Patients in whom the pre-treatment EEG demonstrated slow wave or spike activity, or significant asymmetry were excluded from the series.

Four treatment procedures employing different types of stimuli have been used; 1) alternating current at threshold strength; 2) alternating current at suprathreshold strength; 3) unidirectional current (parathreshold); 4) subconvulsive techniques with pentothal premedication. The alternating current suprethreshold ( ) and unidirectional parathreshold ( ) techniques are well described. In the threshold alternating current method patients, without prior sedation, received low currents, (90 volts for 0.1 second), usually sufficient for a petit mal response. At 20 second intervals, voltage, and, if necessary, durations were increased until a grand mal convulsion was induced. The voltage and time necessary to just induce a grand mal was the threshold value.

In subconvulsive techniques, patients were given pentothal intravenously until asleep, and then either low voltage unidirectional current for 60 seconds ( ); or alternating current of 80 to 120 volts x 0.1 second were administered for one to three applications, for a total of 24 to 36 petit mal treatments.

All treatments were given three times a week initially, for 12-20 treatments. Patients who failed to develop a significant behavioral or clinical response, or EEG changes of significant degree, were subsequently treated 5-10 times per week.

All EEG records were quantitatively measured for the degree of delta activity. The records were evaluated as to whether they demonstrated "high," "moderate" or "low" degrees of delta activity, according to criteria previously published ( ).

The following three slides demonstrate a high, middle and low degree delta records during the fourth week of treatment.

(Figs. 1, 2, 3)

Evaluations of changes in behavior were made by the supervising psychiatrist and resident therapist at the height of the treatment effect. The ratings of "improvement" were made by these physicians two to three weeks after treatment was terminated, and were based on the four fold classification of "recovered," "much improved," and "unimproved or worse."

In our initial reports (,) we noted that patients who developed

high degree delta activity early, and in whom such delta activity was sustained, were evaluated as "much improved" or "recovered" with a significantly greater incidence than those patients who failed to demonstrate such delta activity. These observations are portrayed in slide 4.

(Slide 4: Graph Est #1)

Slide 5 - (Table 1, Esp. Studies)

Results:

1. Convulsive vs Subconvulsive Techniques:

In the most recent series of patients, randomly selected patients referred for electrotherapy received subconvulsive therapies instead of grand mal; and both alternating current and unidirectional current techniques were used.

Of the 47 subjects who received convulsive therapy, 9 had high degree delta records in both second, third and fourth weeks of treatment; 12 during two of the three weeks, and 13 during only one of the test periods. Thirteen of the 47 subjects failed to show a single high degree delta record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none

demonstrated middle or high degree delta activity records during any week of treatment. Low degrees of delta activity were noted in three subjects during both the second and third weeks of treatment, and in 8 subjects during the fourth week.

Concurrent analyses of the behavioral ratings showed 42 of the 47 subjects in the convulsive group rated as showing marked behavioral change; while of the subconvulsive group, 25 of the 27 showed minimal or no behavioral changes. Of the latter group, 19 were referred for a second course of therapy. In 14 of these, grand mal electroshock induced high degree delta activity and all showed a significant behavioral change. Of the five who failed to demonstrate high degree delta activity on convulsive electroshock, all showed middle degree records; and two of the five showed a behavioral change.

Thus, convulsive therapy induced significantly greater behavioral changes associated with EEG delta activity, while subconvulsive therapy induced minimal behavioral change, and minimal EEG delta activity. Furthermore, patients showing neither an EEG or behavioral response to subconvulsive therapy, showed both the EEG and behavioral changes when placed on convulsive therapy.

2. Role of Type of Convulsive Therapy:

In view of the variety of electroshock techniques employed, and the relationship between EEG delta activity and the behavioral response, an analysis of the effect of type of electroshock on EEG delta activity was undertaken. The results are graphically presented in Figures 5 and 6. The first figure relates the treatment type to the percentage of records in each treatment group during the second, third and fourth weeks of treatment demonstrating high degrees of EEG delta activity. In each period, treatment with alternating current at suprathreshold strength gave the highest percentage of high degree delta records. Treatment with unidirectional current and with alternating current at threshold strength was less effective than the suprathreshold alternating current technique, in each period; the unidirectional current treatment being more effective than the threshold alternating current method only early in the course of therapy. Subconvulsive techniques yield no high degree delta activity records.

The next figure demonstrates the same relationship by measuring the per cent of each treatment group showing no delta activity or only low degrees of such activity. Here, the subconvulsive group is 100% for each treatment

period. Suprathreshold alternating current techniques show the least number of such records in each period, with threshold and parathreshold techniques in between.

3. Frequency of Treatment:

Another factor on the rate of development of delta activity is the frequency of treatment. While all patients were initially treated three times a week, a number who failed to develop high degrees of delta activity on convulsive therapies were treated more intensively. In nine such patients, treatments were given daily or twice daily, and in each instance middle or high degrees of delta activity were induced. Similar EEG correlates were previously demonstrated by Pacella et al. ( ), and Callaway ( ).

4. Factor of Age:

In the initial series of patients, it was noted that younger patients, under 45 years of age, developed greater degrees of delta activity during the first and second weeks of treatment; while older subjects developed such activity to a significant degree during the third week. By the fourth week of treatment, age was no longer a differentiating aspect between the groups.

Combining the data from all convulsive therapies supports this observation. During the second week, 43% of records are high degree delta in patients under the age of 40; but only 30% in patients from 40-60, and 18% in patients 61 and over. In the third and fourth weeks, the differences are no longer present and approximately 2/3 of the subjects have high degree delta records when treated 3 times per week.

TABLE

Variation in % High Degree Delta EEG Records with Age *

		Treatment Period		
Age	(N)	4-6	7-9	10-12
To 40 years	(28)	43%	61%	69%
41-50	(28)	29%	40%	56%
51-60	(28)	32%	56%	55%
61+	(18)	18%	50%	80%

* The difference in incidence of high degree records is significant at .01% between the second and fourth weeks and .05% between the second and third weeks of treatment in patients over 50 years of age; but is not significantly different for these periods in groups under 50 years.

5. Pre-Treatment Record Characteristics:

Previous reports, summarized by Chusid and Pacella,( ) noted a significant relationship between pre-treatment record characteristics and the degree of induced "abnormality." Records with predominant alpha rhythm or "abnormal" (Chusid and Pacella) or "borderline abnormal" (Bagchi et al.) records were more liable to develop alterations in the EEG than those with predominantly low voltage fast activity patterns.

In these series of patients, subjects whose pre-treatment record demonstrated slow wave activity of a diffuse, or dysrhythmic variety, or spike or spike wave activity were not included in the statistical analyses. Eight such subjects were treated with convulsive techniques and seven of them developed high degrees of delta activity earlier, and for more sustained periods than in patients without such pre-treatment abnormality.

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The relationship in the fourth week is significant at the .05 level of confidence; while that in the third week fails of significance, although the trend is indicated.

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Two aspects of these studies warrant discussion; the significance of the convulsion in the electroshock process; and the role of serial electroencephalograph in the rational management and study of convulsive therapies.

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In the initial studies of convulsive therapy numerous authors, including Kalinowsky et al. (1942), and Pacella et al. (1942) emphasized both the clinical and electroencephalographic differences between the grand mal and petit mal responses. While grand mal seizures induced clinical improvement in 60 to 80% of cases, petit mal induced changes in less than 25% of subjects. Similarly, the electroencephalographic response to grand mal is one of delta activity, and to petit mal, is no delta activity.

In subsequent years, various subconvulsive, brief stimulus, unidirectional stimulating, monopolar stimulating, focal convulsive techniques have been

described, and each, in turn, discarded in routine therapy. Bergman et al. ( ) for example, in describing the electroencephalographic effects of focal seizure techniques noted that 70% of patients had normal records after 15 such "seizures;" while 70 - 75% had "abnormal" records after grand mal seizures. Ulett et al. ( ), in a careful control convulsive-subconvulsive study, reported a significant difference in clinical response of patients receiving convulsive therapies (60-80%) and those receiving subconvulsive (33%), or controls (38%). He noted the discrepancy in the EEG response in the two groups, and emphasized the significance of the seizure for the therapeutic effect. Recent additional reports by various observers, based on a variety of data, emphasize the significance of the convulsion. (Weinstein and Kahn, Roth, Fleming). Thus, the evidence indicates that convulsions per se, are or reflects the significant physiologic events which are the bases for therapeutic efficacy of "convulsive therapies."

If the convulsion is the essential element/in both the EEG and in the behavioral reponse, does the mode of induction of the seizure play any role in this response?. In the studies reported here, small but statistically significant differences in both the degree of EEG delta activity

and the rate of its development were observed between different methods of induction of grand mal seizure. This data thus provides an experimental basis for the clinical judgment that suprathreshold alternating current techniques are most effective in routine convulsive therapy.

Other studies have also shown differences in clinical results for various convulsive techniques. Ulett et al. ( ) noted similar differences in clinical results in their studies of patients receiving alternating current convulsive and photic-metrazol convulsive and subconvulsive techniques. He reported improvement rate of 57%, 76% and 33% respectively; and concluded that the convulsive photoshock technique had the greatest clinical efficacy. More recently, Edwalds, describing a new convulsant drug, PM 1090, ascribed to it a clinical efficacy slightly greater than electroconvulsive techniques.

In our studies we have noted that the convulsions induced by various techniques have varying characteristics of latency, duration, preponderance of clonic or tonic phase, apnea, etc. From these studies, it has become apparent that not all grand mal seizures are equivalent; and that a

seizure is not an "all or none" phenomenon. Difference seizure patterns occur and these may reflect the differences in physiologic effect of the different treatment method. Further studies of this problem are in progress.

While this variability in clinical results is reported, it is clear that with repeated convulsions, no matter how induced, improvement rates of 60 - 80% are observed. The differences between various types of treatment are small, and, for the most part, may be obviated by increasing the frequency or number of treatments. We may conclude that convulsive therapy is non-specific with regard to the way the convulsion is induced. The significant element is the brain change subsequent to the convulsion, and not the agent used in bringing about this brain change. In previous reports (EEG, Theory) we have noted that convulsive therapy is also non-specific with regard to its application in mental illness, and in its clinical and behavioral effects. The present studies amplify, therefore, the previous conclusion of the non-specificity of convulsive therapies.

2. Role of Electroencephalography in Convulsive Therapy:

We have applied methods of quantitative, serial EEG analyses in the studies reported here. While clinical estimates of behavioral change may give similar data, such evaluations are more dependent on the attitudes of the observer ( ) than the EEG. Further application of EEG analyses to other problems in convulsive therapies may provide a rational basis for comparison of different treatment techniques.

We have previously noted that EEG analyses may be applied in the clinical management of patients receiving convulsive therapy ( ). In the experiences reported here, the early and sustained induction of high degrees of delta activity provides the physiologic basis for behavioral change in convulsive therapy. An electroencephalogram in patients who fail to show a significant behavioral response on treatment regimens of three times per week may serve as a rational basis for clinical management. In those subjects in whom high delta activity has not been induced, increasing treatment frequency, withholding premedication, or shifting to a therapeutically more effective convulsant method, may result in the neurophysiologic changes. If the degree of delta activity is high; and it may be maintained for a number of weeks, other factors, as personality

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The successful application of quantitative EEG techniques to convulsive therapies, has led to their application to other physiodynamic therapies. Recent reports from these laboratories note a similar application for the rational management and understanding of psychopharmacologic agents ( ).

Conclusions:

1. In serial quantitative analysis of degree of induced EEG delta activity in subjects receiving various convulsive therapies, a positive relationship between the degree of induced delta activity and both the degree of behavioral change and ratings of improvement is reported.

2. An induced grand mal convulsion is essential for both the EEG and behavioral change.

3. The rate and degree of induced delta activity is dependent upon:

   a. Mode of seizure induction

   b. Frequency of treatment

   c. Age of subject

   d. Pre-treatment EEG record characteristics

4. It is recommended that serial quantitative electroencephalography provides a rational basis both for the study and clinical management of various psychodynamic therapies.

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EEG Correlates of the Electroshock Process

During the past few years, renewed attention has been given to the relation between changes in the electroencephalogram and behavioral changes induced by electroshock. In 1953, in the laboratories at Hillside Hospital, an analysis of neurophysiologic aspects of electroshock was undertaken. The studies were based on a hypothesis expressed by Weinstein and his co-workers ( ) in which they related improvement in electroshock to the development of persistent states of altered cerebral function.

In the initial EEG study ( ), we noted a significant relationship between the degree and duration of the induced delta activity and clinical evaluations of ~~behavioral change and~~ "improvement." It is the purpose of this report to review these findings; to describe recent studies in which various neurophysiologic aspects of the treatment process were assessed; and to suggest the application of electroencephalography in studies and rational management of physiodynamic therapies.

Method:

One hundred and forty-eight consecutive electroshock referrals have been studied. Electroencephalograms were taken before treatment, and on a day after a treatment at weekly intervals during and following the course

of therapy until the record had achieved its pre-treatment characteristics. Patients in whom the pre-treatment EEG demonstrated slow wave or spike activity, or significant asymmetry were excluded from the series.

Four treatment procedures employing different types of stimuli have been used; 1) alternating current at threshold strength; 2) alternating current at suprathreshold strength; 3) unidirectional current (parathreshold); 4) subconvulsive techniques with pentothal premedication. The alternating current suprathreshold ( ) and unidirectional parathreshold ( ) techniques are well described. In the threshold alternating current method patients, without prior sedation, received low currents, (90 volts for 0.1 second), usually sufficient for a petit mal response. At 20 second intervals, voltage, and, if necessary, durations were increased until a grand mal convulsion was induced. ~~The voltage and time necessary to just induce a grand mal was the threshold value.~~

In subconvulsive techniques, patients were given pentothal intravenously until asleep, and then either low voltage unidirectional current for 60 seconds ( ); or alternating current of 80 to 120 volts x 0.1 second were administered for one to three applications, for a total of 24 to 36 petit mal treatments.

All treatments were given three times a week initially, for 12-20 treatments. Patients who failed to develop a significant behavioral or clinical response, or EEG changes of significant degree, were subsequently treated 5-10 times per week.

All EEG records were quantitatively measured for the degree of delta activity according to criteria previously published, and were rated as "high," "moderate" or "low" degree of delta activity. ~~The records were evaluated as to whether they demonstrated according to criteria previously published ( ).~~

The following three slides demonstrate a high, middle and low degree delta record during the fourth week of treatment.

(Figs. 1, 2, 3)

Evaluations of changes in behavior were made by the supervising psychiatrist and resident therapist at the height of the treatment effect. The ratings of "improvement" were made by these physicians two to three weeks after treatment was terminated, and were based on the four fold classification of "recovered," "much improved," "improved" and "unimproved or worse."

In our initial reports (,) we noted that patients who developed

high degree delta activity early, and in whom such delta activity was sustained, were evaluated as "much improved" or "recovered" with a significantly greater incidence than those patients who failed to demonstrate such delta activity. These observations are portrayed in slide 4.

(Slide 4: Graph Est #1)

~~Slide 5 - Table 1, Exp. Studies~~

Results:

The relation between neurophysiologic and behavioral response will be assessed according to five aspects:

1) ~~Convulsive and Subconvulsive Techniques~~ Factor of the Convulsion
2) Type of Convulsive Therapy
3) Frequency of Treatment
4) Factor of Age
5) Pre-treatment Record Characteristics

Of the 47 subjects who received convulsive therapy, 9 had high degree delta records in both second, third and fourth weeks of treatment; 12 during two of the three weeks, and 13 during only one of the test periods. Thirteen of the 47 subjects failed to show a single high degree delta record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none

high degree delta activity early, and in whom such delta activity was sustained, were evaluated as "much improved" or "recovered" with a significantly greater incidence than those patients who failed to demonstrate such delta activity. These observations are portrayed in slide 4.

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Results:

1. Convulsive vs Subconvulsive Techniques:

In the most recent series ~~of patients,~~ randomly selected patients referred for electrotherapy received subconvulsive therapies instead of grand mal; and both alternating current and unidirectional current techniques were used.

Of the 47 subjects who received convulsive therapy, 9 had high degree delta records in both second, third and fourth weeks of treatment; 12 during two of the three weeks, and 13 during only one of the test periods. Thirteen of the 47 subjects failed to show a single high degree delta record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none

demonstrated middle or high degree delta activity records during any week of treatment. Low degrees of delta activity were noted in three subjects during both the second and third weeks of treatment, and in only 8 subjects during the fourth week.

Concurrent [redacted] behavioral ratings showed 42 of the 47 subjects in the convulsive group rated as [redacted] "marked behavioral change"; while of the subconvulsive group, 25 of the 27 manifested minimal or no behavioral changes. Of the latter group, 19 were referred for a second course of therapy. In 14 of these, grand mal electroshock induced high degree delta activity and all showed a significant behavioral change. Of the five who failed to demonstrate high degree delta activity on convulsive electroshock, all showed middle degree records; and two of the five showed a behavioral change.

Thus, convulsive therapy induced significantly greater behavioral changes associated with EEG delta activity, while subconvulsive therapy induced minimal behavioral change, and minimal EEG delta activity. Furthermore, patients showing neither an EEG or behavioral response to subconvulsive therapy, showed both [redacted] EEG and behavioral changes when placed on convulsive therapy.

2. Role of Type of Convulsive Therapy:

In view of the variety of electroshock techniques employed, and the relationship between EEG delta activity and the behavioral response, an analysis of the effect of type of electroshock on EEG delta activity was undertaken. The results are graphically presented in Figures 5 and 6. The first figure relates the treatment type to the percentage of records in each treatment group during the second, third and fourth weeks of treatment demonstrating high degrees of EEG delta activity. In each period, treatment with alternating current at suprathreshold strength gave the highest percentage of high degree delta records. ~~Treatment with~~ parathreshold unidirectional current and ~~with~~ alternating current at threshold strength was less effective than the suprathreshold alternating current technique, in each period; the ~~unidirectional current~~ parathreshold treatment being more effective than the threshold alternating current method only early in the course of therapy. Subconvulsive techniques yield no high degree delta activity records.

The next figure demonstrates the same relationship by measuring the per cent of each treatment group showing no delta activity or only low degrees of such activity. Here, the subconvulsive group is 100% for each treatment

period. Suprathreshold alternating current techniques show the least number of such records in each period, with threshold and parathreshold techniques in between.

3. Frequency of Treatment:

Another factor in the rate of development of delta activity is the frequency of treatment. While all patients were initially treated three times a week, a number who failed to develop high degrees of delta activity on convulsive therapies were treated more intensively. In nine such patients, treatments were given daily or twice daily, and in each instance middle or high degrees of delta activity were induced. Similar EEG correlates were previously demonstrated by Pacella et al. ( ), and Callaway ( ).

4. Factor of Age:

In the initial series of patients, it was noted that younger patients, under 45 years of age, developed greater degrees of delta activity during the first and second weeks of treatment; while older subjects developed such activity to a significant degree during the third week. By the fourth week of treatment, age was no longer a differentiating aspect between the groups.

Combining the data from all convulsive therapies supports this observation. During the second week, 43% of records are high degree delta in patients under the age of 40; ~~but only~~ 30% in patients from 40-60, but only ~~and~~ 18% in patients 61 and over. In the third and fourth weeks, the differences are no longer present and approximately 2/3 of the subjects have high degree delta records when treated 3 times per week.

TABLE

Variation in % High Degree Delta EEG Records with Age *

		Treatment Period		
Age	(N)	4-6	7-9	10-12
To 40 years	(28)	43%	61%	69%
41-50	(28)	29%	40%	56%
51-60	(28)	32%	56%	55%
61+	(18)	18%	50%	80%

* The difference in incidence of high degree records is significant at .01% between the second and fourth weeks and .05% between the second and third weeks of treatment in patients over 50 years of age; but is not significantly different for these periods in groups under 50 years.

5. Pre-Treatment Record Characteristics:

In earlier studies, a relationship between pre-treatment record characteristics, notably degree of abnormality or predominant alpha, and the degree of induced "abnormality" was noted (,).

In these series of patients, subjects whose pre-treatment record demonstrated slow wave activity of a diffuse, or dysrhythmic variety, or spike or spike wave activity were not included in the statistical analyses. Eight such subjects were treated with convulsive techniques, however, and seven of them developed high degrees of delta activity earlier, and for more sustained periods than in patients without such pre-treatment abnormality.

A specific analysis of the relation between pre-treatment alpha and delta activity was undertaken. Rank order correlations of the pre-treatment per cent time alpha ~~in selected leads (anterior temporal - vertex)~~ with the degree of delta activity during the ~~third and~~ four weeks of treatment in 43 patients demonstrated a correlation of ~~+.21 and~~ +.35, ~~respectively.~~ which is significant at .05 level of confidence.

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   a. Mode of seizure induction

   b. Frequency of treatment

   c. Age of subject

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4. It is recommended that serial quantitative electroencephalography provides a rational basis both for the study and clinical management of various psychodynamic therapies.

EASTERN PSYCHIATRIC RESEARCH ASSOCIATION, INC.

TWELFTH SCIENTIFIC MEETING

THURSDAY, FEBRUARY 6, 1958, 8:00 P. M. SHARP

NEW YORK UNIVERSITY MEDICAL SCHOOL

ALUMNI HALL — HALL "A"

30TH STREET AND FIRST AVE., (ENTRANCE ON 30TH STREET)

(Parking on Grounds)

PROGRAM

1. Electroencephalographic Correlates in EST.

   Max Fink, M. D.
   Martin Green, M. D.

2. A Drawing Completion Test
   (An Incisive Interpretation of the Unconscious)

   Ferruccio di Cori, M. D.
   Discussant: Dr. David Wechsler

3. Apparatus and Method for the Study of Conditional Reflexes in Man.

   Leo Alexander, M. D.

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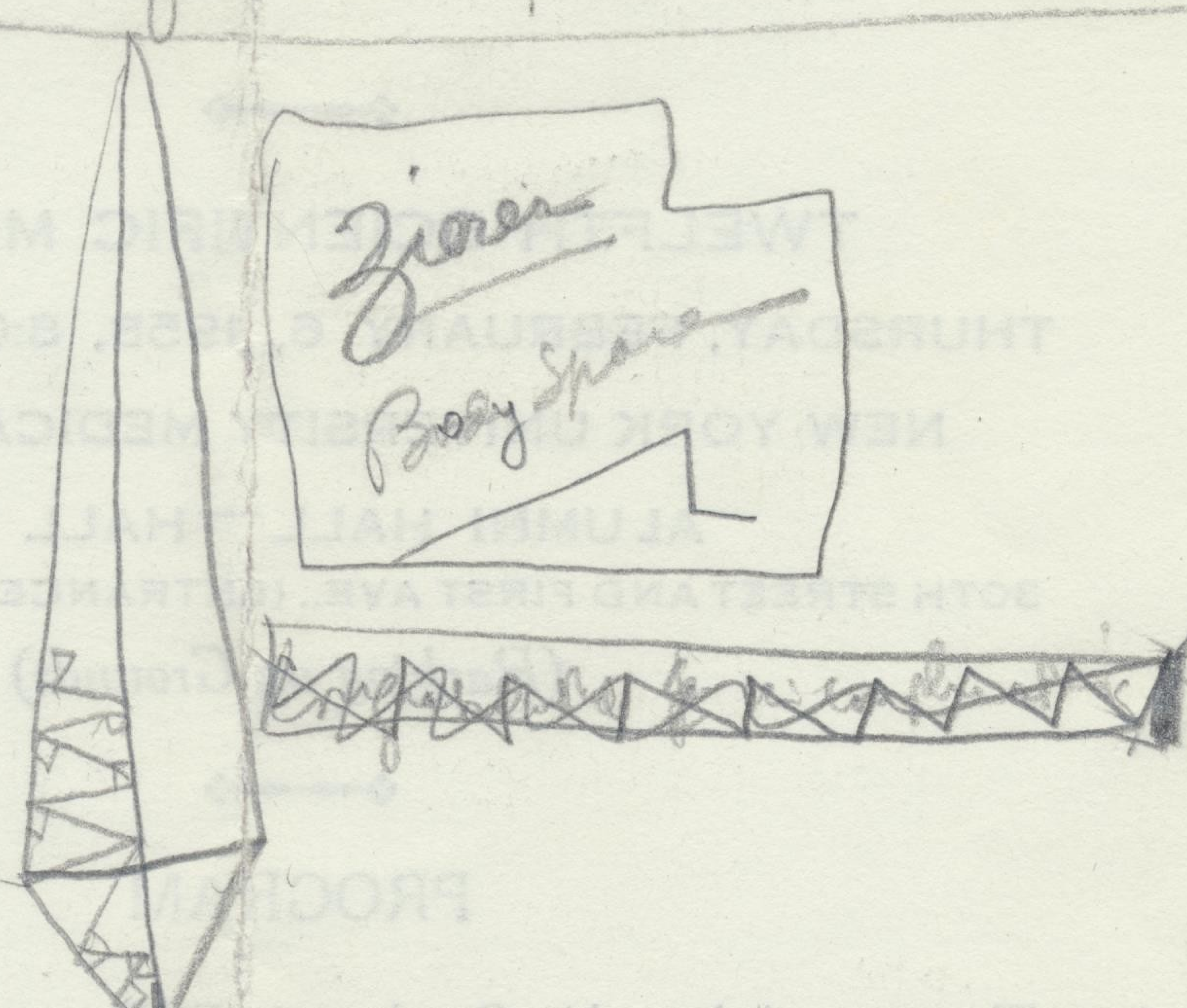

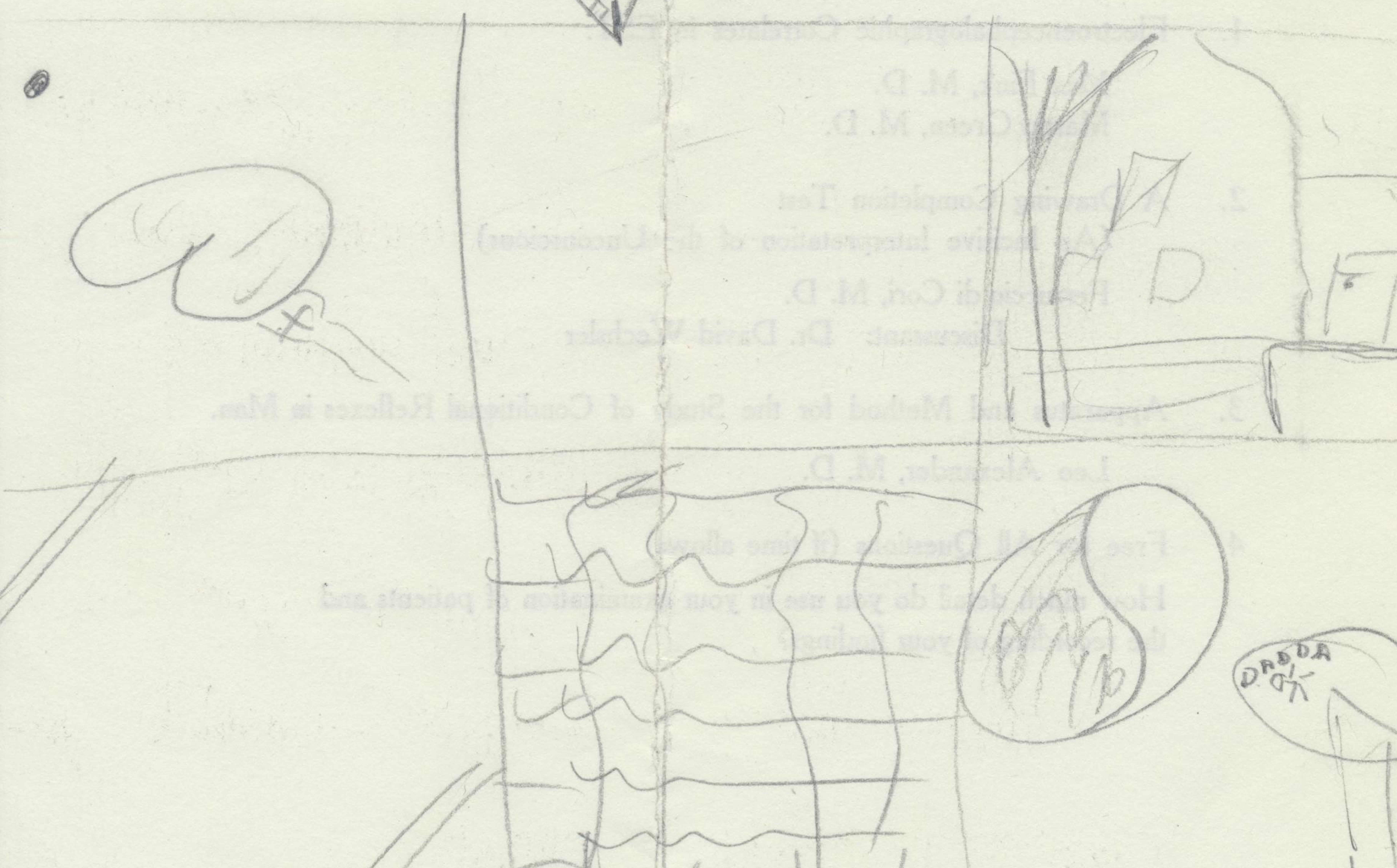

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Electroencephalographic Correlates of the Electroshock Process

Max Fink M.D.

and

Martin A. Green M.D.

From the Department of Experimental Psychiatry, Hillside Hospital, Glen Oaks, N.Y.

Aided, in part, by grant M-927, National Institutes of Mental Health, National Institutes of Health, U.S. Public Health Service.

Read at the meeting of the Eastern Psychiatric Research Association, New York, February 6, 1958.

EEG Correlates of the Electroshock Process

During the past few years, renewed attention has been given to the relation between changes in the electroencephalogram and behavioral changes induced by electroshock (1-4). Based on a hypothesis expressed by Weinstein and his co-workers (5) in which they related improvement in electroshock to the development of persistent states of altered cerebral function, an analysis of the neurophysiologic aspects of electroshock was undertaken in the laboratories at the Hillside Hospital in 1953.

In our initial EEG study (6), a significant relationship between the degree and duration of the induced delta activity and clinical evaluations of behavioral change and "improvement" was reported. This study was based on convulsions induced by a unidirectional current instrument (Reiter). Subsequent experiences with alternating current techniques demonstrated differences in the rate and degree of development of delta activity. Age of subject and frequency of treatment were also factors in the EEG response to convulsions. It is the purpose of this report to assess the role of treatment method, age of subject, frequency of treatment and pre-treatment EEG record characteristics in the EEG and clinical response to convulsive therapy.

Method:

One hundred and forty-eight consecutive electroshock referrals have been studied. Electroencephalograms were taken before treatment, and on a day after a treatment at weekly intervals during and following the course of therapy until the record had achieved its pre-treatment characteristics. Patients in whom the pre-treatment electroencephalogram demonstrated slow wave or spike activity, or significant assymetry, were excluded from the series.

Four treatments procedures employing different types of stimuli have been used: 1) alternating current at threshold strength; 2) alternating current at suprathreshold strength; 3) unidirectional current (parathreshold); 4) subconvulsive techniques with pentothal premedication. The alternating current suprathreshold (7) and unidirectional parathreshold (8) techniques are well described. In the threshold alternating current method patients, without prior sedation, received low currents, (90 volts for 0.1 second), usually sufficient for a petit mal response. At 20 second intervals, voltage, and, if necessary, durations were increased until a grand mal convulsion was induced. The voltage and time necessary to just induce a grand mal was the threshold value.

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All EEG records were quantitatively measured for the degree of delta activity. The records were evaluated as to whether they demonstrated "high," "moderate" or "low" degrees of delta activity, according to criteria previously published (6).

Evaluations of changes in behavior were made by the supervising psychiatrist and resident therapist at the height of the treatment effect,

and were scored as "marked," "moderate," "minimal" or "none." The ratings of "improvement" were made by these physicians two to three weeks after treatment was terminated, and were based on the four fold classification of "recovered," "much improved," and "unimproved or worse."

Results:

1. Convulsive vs Subconvulsive Techniques:

In the most recent series of patients, randomly selected patients referred for electrotherapy received subconvulsive therapies instead of grand mal; and both alternating current and unidirectional current techniques were used.

Of the 47 subjects who received convulsive therapy, 9 had high degree delta records in both second, third and fourth weeks of treatment; 12 during two of the three weeks, and 13 during one of the test periods. Thirteen of the 47 subjects failed to show a single high degree delta record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none demonstrated middle or high degree delta activity records during any week of treatment. Low degrees of delta activity were noted in three subjects during both the second and third weeks of treatment, and in 8 subjects during the fourth week.

In concurrent behavioral ratings, 42 of the 47 subjects in the convulsive group showed marked behavioral change; while of the subconvulsive group, 24 of the 27 showed minimal or no behavioral changes. (Table I). Of the latter group, 19 were referred for a second course of therapy. In 14 of these, grand mal electroshock induced high degree delta

activity and all showed a significant behavioral change. Of the five who failed to demonstrate high degree delta activity on convulsive electroshock, all showed middle degree records; and two of the five showed a behavioral change.

TABLE I

Ratings of Behavioral Change, Convulsive-Subconvulsive Therapies
Fourth-Fifth Weeks of Treatment

	Degree of Change			
	Marked	Moderate	Minimal	None
Convulsive Therapy (47)	27	15	5	0
Subconvulsive Therapy (27)	0	3	8	16

In evaluations two weeks after treatment of the degree of "improvement," 51% of the convulsive therapy group were rated as "much improved" or "recovered," and 32% as "improved." On discharge, 51% were evaluated at sustaining the same degrees of improvement, while 42% were "improved," and only 7% were "unimproved." Of the subconvulsive group, however, 11% were rated in the first two categories; 19% in the "improved," but 70% were "unimproved." As these were referred for a second course of therapy, hospital discharge evaluations do not reflect the effects of subconvulsive therapy.

TABLE II

Ratings of Improvement, Convulsive-Subconvulsive Therapies
(Two Weeks After Last Treatment)

	Recovered	Much Improved	Improved	Unimproved Worse
Convulsive Therapy (47)	9	15	15	8
Subconvulsive Therapy (27)	2	1	5	19

Thus, convulsive therapy induced significantly greater behavioral change and evaluations of improvement than subconvulsive therapy which induced minimal degrees of behavioral change. The clinical observations parallel the electroencephalogram. Also, patients who showed neither an EEG or a behavioral response to subconvulsive therapy, showed both EEG and behavioral changes when placed on convulsive therapy.

2. Role of Type of Convulsive Therapy:

In view of the variety of electroshock techniques employed, and the relationship between EEG delta activity and the behavioral response, an analysis of the effect of type of electroshock on EEG delta activity was undertaken. The results are graphically presented in Figures 1 and 2. The first figure relates the treatment type to the percentage of records in each treatment group during the second, third and fourth weeks of treatment demonstrating high degrees of EEG delta activity. In each period, treatment with alternating current at suprathreshold strength gave the highest percentage of high degree delta records. Treatment with unidirectional current and with alternating current at threshold strength was less effective than the suprathreshold alternating current technique, in each period; the unidirectional current treatment being more effective than the threshold alternating current method only early in the course of therapy.* Subconvulsive techniques yielded no high degree delta activity records.

The second figure demonstrates the same relationship by measuring the per cent of each treatment group showing no delta activity or only low

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* During 4-6 and 7-9 treatment periods, the difference between suprathreshold and threshold treatment methods is significant at .05 by chi square. Differences between parathreshold methods, and for each method in 10-12 period is not significant.

degrees of such activity. Here, the subconvulsive group is 100% for each treatment period. Suprathreshold alternating current techniques show the least number of such records in each period, with threshold and parathreshold techniques in between.

3. Frequency of Treatment:

Another factor on the rate of development of delta activity is the frequency of treatment. While all patients were initially treated three times a week, a number who failed to develop high degrees of delta activity on convulsive therapies were treated more intensively. In nine such patients, treatments were given daily or twice daily, and in each instance middle or high degrees of delta activity were induced. Similar EEG correlates were previously demonstrated by Pacella et al. (9), and Calloway (10).

4. Factor of Age:

In the initial series of patients, it was noted that younger patients, under 45 years of age, developed greater degrees of delta activity during the first and second weeks of treatment; while older subjects developed such activity to a significant degree during the third week. By the fourth week of treatment, age was no longer a differentiating aspect between the groups. Combining the data from all convulsive therapies supports this observation. During the second week, 43% of records are high degree delta in patients under the age of 40; but only 30% in patients from 40-60, and 18% in patients 61 and over. In the third and fourth weeks, the differences are no longer present and approximately 2/3rds of the subjects have high degree delta records when treated 3 times per week.

TABLE III

Variation in % High Degree Delta EEG Records With Age *

		Treatment Period		
Age	(N)	4-6	7-9	10-12
To 40 years	(28)	43%	61%	69%
41-50	(28)	29%	40%	56%
51-60	(28)	32%	56%	55%
61+	(18)	18%	50%	80%

5. Pre-Treatment Record Characteristics:

Previous reports, summarized by Chusid and Pacella, (3) noted a significant relationship between pre-treatment record characteristics and the degree of induced "abnormality." Predominant alpha rhythm, "abnormal" (3) or "borderline abnormal" (11) records were more liable to develop alterations in the EEG than those with predominantly low voltage fast activity patterns.

In these series of patients, subjects whose pre-treatment record demonstrated diffuse slow wave activity, spike or spike wave activity were not included in the statistical analyses. Eight such subjects were treated with convulsive techniques and seven of them developed high degrees of delta activity earlier, and for more sustained periods, than patients without such pre-treatment abnormality.

A specific analysis of the relation between pre-treatment alpha and the degree of induced delta activity was undertaken, Rank order

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* The difference in incidence of high degree records is significant at .01% between the second and fourth weeks and .05% between the second and third weeks of treatment in patients over 50 years of age; but is not significantly different for these periods in groups under 50 years.

correlations of the pre-treatment per cent time alpha in selected leads (anterior temporal-vertex) with the degree of delta activity during the third and fourth weeks of treatment in 43 patients demonstrated correlations of +.24 and +.35 respectively. The relationship in the fourth week is significant at the .05 level of confidence; while that in the third week fails of significance, although the trend is indicated.

Discussion:

Two aspects of these studies warrant discussion; the significance of the convulsion in the electroshock process; and the role of serial electroencephalograms in the rational management and study of convulsive therapies.

(1) Significance of Convulsions:

In the initial studies of convulsive therapy numerous authors, including Kalinowsky et al. (12), and Pacella et al. (9) emphasized both the clinical and electroencephalographic differences between grand mal and petit mal responses. While grand mal seizures induced clinical improvement in 60 to 80% of cases, petit mal induced changes in less than 25% of subjects. Similarly, electroencephalograms in grand mal therapy demonstate delta activity, while in petit mal therapy, no delta activity is seen.

In subsequent years, various subconvulsive, brief stimulus, unidirectional stimulating, monopolar stimulating, and focal convulsive techniques have been described, and in each, in turn, discarded in routine therapy. Bergman et al. (13) for example, in describing the electroencephalographic effects of focal seizure techniques noted that 70% of patients had normal records after 15 such "seizures;" while 70-75% had "abnormal" records after grand

mal seizures. Ulett et al. (14), in a careful control convulsive-subconvulsive study, reported a significant difference in the clinical response of patients receiving convulsive therapies (60-80%) and those receiving subconvulsive (33%), or controls (38%). He noted the discrepancy in the EEG response in the two groups, and emphasized the significance of the seizure for the therapeutic effect. Recent additional reports by various observers, based on a variety of data further emphasize the significance of the convulsion in the therapeutic response (1, 15, 16) (Weinstein and Kahn, Roth, Fleming). The evidence thus indicates that convulsions per se are, or reflect, the significant physiologic events which are the basis for therapeutic efficacy of convulsive therapies.

If the convulsion is the essential element both in the EEG and in the behavioral response, does the mode of induction of the seizure play any role in this response?. In the studies reported here, small differences in both the degree of EEG delta activity and the rate of its development were observed between different methods of induction of grand mal seizure.*

Ulett et al. (14) reported an improvement rate of 57% for the alternating current convulsive technique, and 76% for the photo-metrazol technique. While the differences are small, the authors ascribe greater clinical efficacy to the convulsive photo-metrazol technique. In a discussion of this report, Kalinowsky noted that metrazol convulsions have impressed various workers as being more efficacious than electrically induced convulsions. More recently, Edwalds, (17) describing a new convulsant drug, PM 1090, ascribed to it clinical results slightly better than electroconvulsive techniques.

We have further noted that the convulsions induced by various techniques have varying characteristics of latency, duration, preponderance

of clonic or tonic phase, apnea, etc. All grand mal seizures are seemingly not equivalent; and a seizure is not an "all or none" phenomenon. Different seizure patterns occur and these may reflect the differences in physiologic effect of the different treatment method. Further studies of this problem are in progress.

While this variability in clinical results is reported, it is clear that with repeated convulsions, no matter how induced, improvement rates of 60 - 80% are observed. The differences between various types of treatment are small, and, for the most part, may be obviated by increasing the frequency or number of treatments. We may conclude that convulsive therapy is non-specific with regard to the way the convulsion is induced. The significant element is the brain change subsequent to the convulsion, and not the agent used in bringing about this brain change. In previous reports (6, 18, 19) we have noted that convulsive therapy is also non-specific with regard to its application in mental illness, and in its clinical and behavioral effects. The present studies amplify, therefore, the previous conclusion of the non-specificity of convulsive therapies.

2. Role of Electroencephalography in Convulsive Therapy:

We have applied methods of quantitative, serial EEG analyses in the studies reported here. While clinical estimates of behavioral change have yielded similar data, such evaluations are more dependent on the attitudes of the observer (20), and less amenable to quantification than the EEG. Further application of EEG analyses to other problems in convulsive therapies provide a rational basis for the comparison of different treatment techniques.

We have previously noted that EEG analysis may be applied in the clinical management of patients receiving convulsive therapy (6). In patients

who fail to show a significant behavioral response on treatment regimens of three times per week, an electroencephalogram may serve as a guide for further therapy. In those subjects in whom high degree delta activity has not been induced, increasing treatment frequency, withholding premedication, or shifting to a more effective convulsant method, may result in the neurophysiologic changes. If the degree of delta activity is high and sustained for a number of weeks, other factors, as personality (21) or environment (18) may be assumed to preclude a satisfactory behavioral response, even when the neurophysiologic substrate is assured; and further convulsive therapy may well be discontinued. A similar application has been suggested by Roth (2) for thiopental activated EEG records.

The successful application of quantitative EEG techniques to convulsive therapies, has led to their application to other physiodynamic therapies. Recent reports from these laboratories note a similar application for the rational management and understanding of psychopharmacologic agents (19).

Conclusions:

Applying serial quantitative analyses of the degree of induced EEG delta activity in subjects receiving various convulsive therapies to the problem of the mode of action of convulsive therapy, following conclusions were derived.

1. An induced grand mal convulsion is essential for both the EEG and behavioral change.

2. The rate and degree of induced delta activity is dependent upon:

   a. Mode of seizure induction

   b. Frequency of treatment

   c. Age of subject

   d. Pre-treatment EEG record characteristics

3. It is recommended that serial quantitative electroencephalography provides a rational basis both for the study and clinical management of convulsive therapies.

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Electroencephalographic Correlates of the Electroshock Process

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EEG Correlates of the Electroshock Process

During the past few years, renewed attention has been given to the relation between changes in the electroencephalogram and behavioral changes induced by electroshock (1-4). Based on a hypothesis expressed by Weinstein and his co-workers (5), in which they related improvement in electroshock to the development of persistent states of altered cerebral function, an analysis of the neurophysiologic aspects of electroshock was undertaken in the laboratories at the Hillside Hospital in 1953.

In the initial EEG study, [redacted] a significant relationship between the degree and duration of the induced delta activity and clinical evaluations of behavioral change and "improvement" was reported (6). This study was based on convulsions induced by a unidirectional current instrument (Reiter). Subsequent experiences with alternating current techniques demonstrated differences in the rate and degree of development of delta activity. Age of subject and frequency of treatment were also factors in the EEG response to convulsions. It is the purpose of this report to assess the role of treatment method, age of subject, frequency of treatment and pre-treatment EEG record characteristics in the EEG and clinical response to convulsive therapy.

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Method:

One hundred and ~~forty-eight~~ seventy three consecutive electroshock referrals have been studied. Electroencephalograms were taken before treatment, and on a day after a treatment at weekly intervals during and following the course of therapy until the record had achieved its pre-treatment characteristics. Patients in whom the pre-treatment electroencephalogram demonstrated slow wave or spike activity, or significant ~~asymmetry~~ ASYMMETRY, were excluded from the series.

In the ~~initial~~ studies, ~~only~~ convulsive techniques alone were employed, and demonstrated ~~a~~ ~~production~~ a relationship between EEG delta activity and behavioral change.

In the INITIAL studies, two convulsive techniques ~~alone~~ were employed: alternating current at suprathreshold strength and unidirectional current (subthreshold). In 1956, a convulsive-subconvulsive control study was instituted. Randomly selected patients referred for electrotherapy received subconvulsive therapy instead of grand mal. In ~~the~~ subconvulsive technic

the group, two ~~techniques~~ grand mal techniques were employed: threshold alternating current and subthreshold unidirectional current. After the conclusion of the convulsive-subconvulsive study, convulsive electrotherapy ~~to~~ of controls received convulsive therapy with threshold alternating current alone.

2a

Four treatments procedures employing different types of stimuli have been used: a) alternating current at threshold strength; b) alternating current at suprathreshold strength; c) unidirectional current (parathreshold); d) subconvulsive techniques with pentothal premedication.

The alternating current suprathreshold (7) and unidirectional parathreshold (8) techniques have been well described. In the threshold alternating current method patients, without prior sedation, received small amounts of current (90 volts for 0.2 second), usually sufficient for a petit mal response. At 20 second intervals voltage, and if necessary, duration was increased until a grand mal convulsion was induced. The minimal voltage and duration necessary to induce a grand mal was the threshold value.

In subconvulsive techniques, patients were given pentothal intravenously until asleep, and then either low voltage unidirectional current for 60 seconds (8); or alternating current of 80 to 120 volts for 0.2 second were administered for one to three applications, for a total of 24 to 36 petit mal Responses.

insert 2b →

All treatments were given three times a week initially, for 12-20 treatments. Patients who failed to develop a significant behavioral or clinical response, or middle or high degrees of delta activity in the EEG, were subsequently treated five to ten times per week.

All EEG records were quantitatively measured for the degree of delta activity. The records were evaluated as to whether they demonstrated "high," "moderate" or "low" degrees of delta activity, according to criteria previously published (6).

Evaluations of changes in behavior were made by the supervising psychiatrist and resident therapist at the height of the treatment effect,

(2B)

In the Cooperative-submaximal control study, 27 patients received a course of submaximal therapy. ~~Hosts of grand mal.~~ The remaining 146 referrals received grand-mal therapy — 57 by threshold alternating current, 26 suprathreshold alternating current and 63 by facilitated unidirectional current methods.

and were scored as "marked," "moderate," "minimal" or "none." The ratings of "improvement" were made by these physicians two to three weeks after treatment was terminated, and were based on the four fold classification of "recovered," "much improved," and "unimproved or worse." (6)

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Results:

1. Convulsive vs Subconvulsive Techniques:

~~In the most recent series of patients, Randomly selected patients referred for electrotherapy received subconvulsive therapy instead of grand mal; and both alternating current and unidirectional current techniques were used.~~

Of the 47 subjects* who received convulsive therapy, 9 had high degree delta records in both second, third and fourth weeks of treatment; 12 during two of the three weeks, and 13 during one of the test periods. Thirteen of the 47 subjects failed to show a single high degree delta record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none demonstrated middle or high degree delta activity records during any week of treatment. Low degrees of delta activity were noted in three subjects during both the second and third weeks of treatment, and in 8 subjects during the fourth week.

In concurrent behavioral ratings, ~~47~~ 25 of the ~~47~~ initial 28 subjects in the convulsive group showed marked behavioral change; while of the subconvulsive group, 24 of the 27 showed minimal or no behavioral changes. (Table I). Of the latter group, 19 were referred for a second course of therapy. In 14 of these, grand mal electroshock induced high degree delta

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* These included 28 subjects who received grand mal therapy on a random selection basis, plus the 19 subconvulsive subjects referred for a "second course" of Convulsive therapy.

activity and all showed a significant behavioral change. Of the five who failed to demonstrate high degree delta activity on convulsive electroshock, all showed middle degree records; and ~~two~~ three of the five showed a behavioral change. Three of the 47 convulsive therapy subjects, 42 showed a significant behavioral change.

TABLE I

Ratings of Behavioral Change; Convulsive-Subconvulsive Therapies
(Fourth-Fifth Weeks of Treatment)

	Degree of Change			
	Marked	Moderate	Minimal	None
Convulsive Therapy (47)	27	15	5	0
Subconvulsive Therapy (27)	0	3	8	16

In evaluations two weeks after treatment of the degree of "improvement," 51% of the convulsive therapy group were rated as "much improved" or "recovered," and 32% as "improved." (Table II). On discharge, 51% were evaluated as sustaining the same degrees of improvement, while 42% were "improved," and only 7% were "unimproved." Of the subconvulsive group, however, 11% were rated in the first two categories, 19% in the "improved," but 70% were "unimproved." (two weeks after treatment) As these were referred for a second course of therapy, hospital discharge evaluations do not reflect the effects of subconvulsive therapy.

TABLE II

Ratings of Improvement; Convulsive-Subconvulsive Therapies
(Two Weeks After Last Treatment)

	Recovered	Much Improved	Improved	Unimproved Worse
Convulsive Therapy (47)	9	15	15	8
Subconvulsive Therapy (27)	2	1	5	19

Convulsive therapy induced significantly greater behavioral change and more favorable evaluations of improvement than did subconvulsive therapy, ~~which induced minimal degrees of behavioral change~~. The clinical observations thus parallel the electroencephalographic data. Also, patients who showed neither an EEG or a behavioral response to subconvulsive therapy, showed both EEG and behavioral changes when placed on convulsive therapy.

2. Role of Type of Convulsive Therapy:

In view of the variety of electroshock techniques employed, and the relationship between EEG delta activity and the behavioral response, an analysis of the effect of type of electroshock on EEG delta activity was undertaken. The results are graphically presented in Figures 1 and 2. The first figure relates the treatment type to the percentage of records in each treatment group during the second, third and fourth weeks of treatment demonstrating high degrees of EEG delta activity. In each period, treatment with alternating current at suprathreshold strength gave the highest percentage of high degree delta records. Treatment with unidirectional current and with alternating current at threshold strength was less effective than the suprathreshold alternating current technique in each period; the unidirectional current treatment being more effective than the threshold alternating current method only early in the course of therapy.* Subconvulsive techniques yielded no high degree delta activity records.

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(5a)

* During the 4-6 and 7-9 treatment period. The differences between suprathreshold and threshold treatment methods are significant at .05 by chi square for 4-6 and 7-9 treatment pairs, but not in 10-12 pairs. Parathreshold treatment methods ~~during any period, and all treatments in ~~10-12~~ treatment period~~ are not significantly different from the other two methods during any treatment period.

degrees of such activity. Here, the subconvulsive group is 100% for each treatment period. Suprathreshold alternating current techniques show the least number of such records in each period, with threshold and parathreshold techniques in between.

3. Frequency of Treatment:

Another factor in the rate of development of delta activity is the frequency of treatment. While all patients were initially treated three times a week, a number who failed to develop high degrees of delta activity on convulsive therapies were treated more intensively. In nine such patients, treatments were given daily or twice daily, and in each instance middle or high degrees of delta activity were induced. Similar EEG correlates were previously demonstrated by Pacella et al. (9), and Callaway (10).

4. Factor of Age:

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The successful application of quantitative EEG techniques to convulsive therapies, has led to their application to other physiodynamic therapies. Recent reports from these laboratories note a similar application for the rational management and understanding of psychopharmacologic agents (19).

Summary and Conclusions: } - Copy New Pg.

Serial quantitative analyses of the degree of induced EEG delta activity were made in 173 consecutive Electrotherapy referrals. Patients were treated ~~in~~ ~~on~~ by three convulsive methods: suprathreshold alternating current, threshold alternating current and parathreshold unidirectional current. ~~In addition, a convulsive subconvulsive Control Groups was studied.~~ Random Electrotherapy ~~on~~ patients received a convulsive subconvulsive treatment ~~under fan~~ instead of grand-mal, in a Convulsive - Subconvulsive control study.

1. An induced grand mal convulsion is essential both for the electroencephalographic and the behavioral changes ascribed to "shock" ~~Convulsive~~ therapy.

2. The rate and degree of induced EEG delta activity ~~is~~ ~~varies~~ is dependent upon:

(a) Mode of current induction: suprathreshold alternating current techniques induce EEG changes earlier and to a higher degree than threshold techniques. The results of Unidirectional current methods fall between these two techniques.

(b) Frequency of treatment: increasing frequency increases degree of EEG delta activity.

(c) Age of subject: younger patients under 45 develop greater degrees of delta activity earlier than older patients, but by the fourth week of treatment, differences are ~~not great~~ insignificant.

(d) Pre-treatment trend characteristics: Patients with ~~abnormal records or high~~ dysrhythmic records or high per-cent time Alpha activity develop greater degrees of delta activity earlier than patients with low per-cent time alpha activity.

(3) ~~Serial~~ It is ~~often~~ suggested that ~~the~~ serial quantitative electroencephalography provides a rational basis for the study and clinical management of convulsive therapies.

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Electroencephalographic Correlates of the Electroshock Process

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Aided, in part, by grant M-927, National Institutes of Mental Health, National Institutes of Health, U.S. Public Health Service.

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Electroencephalographic Correlates of the Electroshock Process

During the past few years, renewed attention has been given to the relation between changes in measures of cerebral function, and the behavioral changes induced by electroshock (1, 2). Alteration in various aspects of the electroencephalogram has been emphasized by various observers (3, 4, 5) as a sensitive index of changes in cerebral function. In an initial study in this laboratory, a significant relationship between the degree and duration of induced delta activity and clinical evaluation of "improvement" was observed (6). Subsequent studies have focused on various parameters of the EEG changes including frequency of treatment, type of current, age of subject and pre-treatment record characteristics. It is the purpose of this report to assess the relation of these aspects of treatment to changes in the EEG and in clinical response; and to describe the role of serial electroencephalograms in the rational management and study of convulsive therapies.

METHOD:

One hundred and seventy-three consecutive electroshock referrals have been studied. Electroencephalograms were taken before treatment, and on a day after treatment at weekly intervals during and following the course of therapy until the record had achieved its pre-treatment characteristics. Patients in whom the pre-treatment electroencephalogram demonstrated slow wave or spike activity were excluded from the series.

All the EEG records were quantitatively measured for the amount of delta activity. On the basis of the per-cent time, slowest frequency, and highest voltage of total delta activity, and longest duration of bursts of slow waves, in selected lead combinations, the records were classified into "high," "moderate" and "low" degrees of delta activity, according to criteria previously published (6).

Three types of current ~~convulsive techniques~~ were employed in convulsive treatment: suprathreshold alternating current, threshold alternating current and ~~parathreshold~~ unidirectional current (designated by us as "parathreshold"). ~~methods.~~ The alternating current suprathreshold (7) and unidirectional parathreshold (8) treatments followed established techniques. In the threshold alternating current method, patients without prior sedation received a small amount of current (90 volts for 0.2 second), ~~usually sufficient for a petit mal response~~ as the initial stimulus. At 20 second intervals voltage, and if necessary, duration was increased until a grand mal convulsion was induced. The minimal voltage and duration necessary to induce a grand mal was the threshold value.

In addition, a convulsive-subconvulsive control study was instituted during a period of these observations. Randomly selected patients referred

for electrotherapy received subconvulsive therapy instead of grand mal. In this technique, patients were given pentothal intravenously until asleep, and then either low voltage unidirectional current for 60 seconds (8) or alternating current of 80 to 120 volts for 0.2 second were administered for one to three applications, for a total of 24 to 36 petit mal responses.

Of the 173 electrotherapy referrals, 146 received grand mal therapy - 57 by threshold alternating current, 26 by suprathreshold alternating current and 63 by parathreshold unidirectional current methods. Twenty-seven subjects received a course of subconvulsive therapy.

All treatments were given three times a week, for 12-20 treatments. Patients who failed to develop a significant behavioral or clinical response, or middle or high degrees of delta activity in the EEG, were subsequently treated five to ten times per week.

Evaluations of clinical response were made by the supervising psychiatrist and resident therapists on two occasions. At the height of the treatment effect, the degree of behavioral change was scored as "marked," "moderate," "minimal" or "none." These ratings were estimates of the change in behavior in interviews and on the ward from the pre-treatment patterns. Ratings of "improvement" were also made by these physicians two to three weeks after treatment was terminated. These ratings were value judgments and were based on the four-fold classification of "recovered," "much improved," "improved" and "unimproved or worse" (2, 6).

RESULTS:

1. Variability in Delta Activity with Convulsive Therapy:

The wide variability in the degree of induced delta activity reported in the initial 24 patients (6) is confirmed in these series of convulsive therapy referrals (Table I). While the number of high degree records increases with treatment, ~~27% in the third week, and 18% in the fourth week,~~ a significant number of records in the third + fourth weeks of treatment are still rated as "low" or "moderate" degrees of delta activity.

TABLE I

Degree of EEG Delta Activity with Convulsive Therapy

(Per-cent of Group)

	Treatment Period			
	First Week 1-3	Second Week 4-6	Third Week 7-9	Fourth Week 10-12
High Degree	4%	28	46	60
Moderate Degree	12%	21	27	22
Low Degree	68%	48	25	18
No Delta Activity	16%	3	2	0

2. Role of Convulsion in EEG Response:

The significance of the convulsion per se in the EEG and behavioral response was assessed in the convulsive-subconvulsive study. Of the 47 subjects* who received convulsive therapy* in this study, 9 had

* These included 28 subjects who received grand mal therapy on a random selection basis, plus 19 subconvulsive subjects referred for a "second course" of therapy, ~~which consisted of convulsive therapy.~~

high degree delta records in both second, third and fourth weeks of treatment, 12 during two of the three weeks, and 13 during one of the test periods. Thirteen of the 47 subjects failed to show a high degree delta record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none demonstrated middle or high degree delta activity records during any week of treatment. Low degrees of delta activity were noted in three subjects during both the second and third weeks of treatment, and in 8 subjects during the fourth week.

In concurrent behavioral ratings, 25 of initial 28 subjects in the convulsive group showed marked behavioral change; while of the subconvulsive group, 24 of the 27 showed minimal or no behavioral changes (Table II). Of the latter group, 19 were referred for a second course of therapy. In 14 of these, grand mal electroshock induced high degree delta activity and all showed a significant behavioral change. Of the five who failed to demonstrate high degree delta activity on convulsive electroshock, all showed middle degree records; and three of the five showed a behavioral change. Thus, of the 47 convulsive therapy subjects, 42 showed a significant behavioral change.

TABLE II

Ratings of Behavioral Change: Convulsive - Subconvulsive Therapies

(Fourth-Fifth Weeks of Treatment)

	Marked	Moderate	Minimal	None
Convulsive Therapy (47)	27	15	5	0
Subconvulsive Therapy (27)	0	3	8	16

In evaluations of the degree of "improvement" two weeks after treatment, 51% of the convulsive therapy group were rated as "much improved" or "recovered," and 32% as "improved" (Table III). On discharge, 51% were evaluated as sustaining the same degrees of improvement, while 42% were "improved," and only 7% were "unimproved." Of the subconvulsive group, however, 11% were rated in the first two categories, 19% in the "improved," but 70% were "unimproved," two weeks after treatment. As these were referred for a second course of therapy, hospital discharge evaluations do not reflect the effects of subconvulsive therapy.

TABLE III

Ratings of Improvement: Convulsive-Subconvulsive Therapies

(Two Weeks After Last Treatment)

	Recovered	Much Improved	Improved	Unimproved, Worse
Convulsive Therapy (47)	9	15	15	8
Subconvulsive Therapy (27)	2	1	5	19

Thus, the EEG changes during sub-convulsive therapy were minimal whereas those with convulsive therapy were pronounced.

Convulsive therapy induced significantly greater behavioral change and more favorable evaluations of improvement than did subconvulsive therapy. The clinical observations ~~thus~~ paralleled the electroencephalographic data. Also, patients who showed neither an EEG or a behavioral response to subconvulsive therapy, showed both EEG and behavioral changes when placed on convulsive therapy.

3. Role of Type of Convulsive Therapy:

In view of the variety of electroshock techniques employed, and the relationship between EEG delta activity and the behavioral response, an analysis of the effect of type of electroshock on EEG delta activity was undertaken. The results are graphically presented in Figures 1 and 2. The first figure relates the treatment type to the percentage of records demonstrating high degrees of EEG delta activity in each treatment group during the second, third and fourth weeks of treatment. In each period, treatment with alternating current at suprathreshold strength gave the highest percentage of high degree delta records. Treatment with unidirectional current and with alternating current at threshold strength was less effective than the suprathreshold alternating current technique in each period; the unidirectional current treatment being more effective than the threshold alternating current method only early in the course of therapy.* Subconvulsive techniques yielded no high degree delta activity records.

The second figure demonstrates the same relationship by measuring the per cent of each treatment group showing no delta activity or only low degrees

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* The differences between suprathreshold and threshold treatment methods are significant at .05 by chi square in the 4-6 and 7-9 treatment periods, but not in this 10-12 period. Parathreshold treatment methods are not significantly different from the other two methods during any treatment period.

of such activity. Here, the subconvulsive group is 100% for each treatment period. Suprathreshold alternating current techniques show the least number of such records in each period, with threshold and parathreshold techniques in between.

4. Frequency of Treatment:

Another factor in the rate of development of delta activity is the frequency of treatment. While all patients were initially treated three times a week, a number who failed to develop high degrees of delta activity were treated more intensively. In nine such patients, treatments were given daily or twice daily, and in each instance middle or high degrees of delta activity were induced. Similar EEG correlates were previously demonstrated by Pacella et al. (9), and Callaway (10).

5. Factor of Age:

In the initial series of patients, it was noted that younger patients, under 45 years of age, developed greater degrees of delta activity earlier during a course of treatment than did ~~during the first and second weeks of treatment; while~~ older subjects. ~~developed such activity to a significant degree during the third week.~~ By the fourth week of treatment, age was no longer a differential factor, ~~differentiated between the groups.~~ Combining the data from all convulsive therapies supports this observation. During the second week, 43% of records are measured high degree delta in patients under the age of 40; but only 30% in patients from 40-60, and 18% in patients 61 and over. In the third and fourth weeks, the differences were no longer present and approximately 2/3rds of the subjects have high degree delta records when treated 3 times per week.

TABLE IV

Variation in Per Cent High Degree Delta EEG Records with Age *

			Treatment Period		
			Second Week	Third Week	Fourth Week
Age	(N)	EST NO.	4-6	7-9	10-12
To 40 years	(28)		43%	61%	69%
41-50 years	(28)		29%	40%	56%
51-60 years	(28)		32%	56%	55%
Over 61 years	(18)		18%	50%	80%

6. Pre-Treatment Record Characteristics:

Previous reports, summarized by Chusid and Pacella (3), noted a significant relationship between pre-treatment record characteristics and the degree of induced "abnormality." Predominant alpha rhythm, "abnormal" (3) or "borderline abnormal" (11) records were more liable to develop alterations in the EEG than those with predominantly low voltage fast activity patterns.

In these series of patients, subjects whose pre-treatment record demonstrated diffuse slow wave activity or spike or spike wave activity were not included in the statistical analyses. Eight such subjects were

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* The difference in incidence of high degree records is significant at .01 level of confidence between the second and fourth weeks and .05 between the second and third weeks of treatment in patients over 50 years of age; but is not significantly different for these periods in groups under 50 years.

treated with convulsive techniques, however, and seven of them developed high degrees of delta activity earlier, and for more sustained periods, than patients without such pre-treatment abnormality.

A specific analysis of the relation between pre-treatment alpha and the degree of induced delta activity was undertaken. Rank order correlations of the pre-treatment per cent time alpha in selected leads (anterior temporal-vertex) with the degree of delta activity during the third and fourth weeks of treatment in 43 patients demonstrated correlations of +.24 and +.35 respectively. The relationship in the fourth week is significant at the .05 level of confidence; while that in the third week fails of significance, although the trend is indicated.

DISCUSSION:

Two aspects of these studies warrant discussion: the significance of the convulsion in the electroshock process, and the role of serial electroencephalograms in the rational management and study of convulsive therapies.

In the early studies of convulsive therapy numerous authors, including Kalinowsky et al. (12) and Pacella et al. (9), emphasized both the clinical and electroencephalographic differences between grand mal and petit mal responses. While grand mal seizures induced clinical improvement in 60 to 80% of cases, petit mal induced changes in less than 25% of subjects. Similarly, electroencephalograms in grand mal therapy demonstrate prominent delta activity, while in petit mal therapy, no or minimal delta activity is seen.

In subsequent years, various subconvulsive, brief stimulus, unidirectional stimulating, monopolar stimulating, and focal convulsive techniques have been described, and in each, in turn, discarded in routine therapy. Bergman et al. (13), for example, in describing the electroencephalographic effects of focal seizure techniques noted that 70% of patients had normal records after 15 such "seizures", while 70-75% had "abnormal" records after grand mal seizures. Ulett et al. (14), in a careful convulsive-subconvulsive control study, reported a significant difference in the clinical response of patients receiving convulsive therapies (60-80%) from those receiving subconvulsive therapy (33%), or from controls (38%). He noted the difference in the EEG response in the two groups, and emphasized the significance of the seizure for the therapeutic effect. Recent additional reports by various observers, based on a variety of data, further emphasize the significance of the convulsion

in the therapeutic response (4, 15, 16). The evidence thus indicates that convulsions per se are, or reflect, the significant physiologic events which are the basis for therapeutic efficacy of convulsive therapies.

If the convulsion is the essential element both in the EEG and in the behavioral response, does the mode of induction of the seizure play any role in this response?. In the studies reported here, small differences in both the degree of EEG delta activity and the rate of its development were observed between different methods of induction of grand mal seizure.

Ulett et al. (14) reported an improvement rate of 57% for the alternating current convulsive technique, and 76% for the photo-metrazol technique. While the differences are small, the authors ascribe greater clinical efficacy to the convulsive photo-metrazol technique. In a discussion of this report, Kalinowsky noted that metrazol convulsions have impressed various workers as being more efficacious than electrically induced convulsions. More recently, Edwalds, (17) describing a new convulsant drug, PM 1090, ascribed to it clinical results slightly better than electroconvulsive techniques.

We have further noted that the convulsions induced by various techniques have varying characteristics of latency, duration, preponderance of clonic or tonic phase, apnea, etc. All grand mal seizures are seemingly not equivalent; and a seizure is not an "all or none" phenomenon. Different seizure patterns occur and these may reflect differences in the physiologic effect of different treatment methods. Further studies of this problem are in progress (18).

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While this variability in clinical results is reported, it is clear that with repeated convulsions, no matter how induced, improvement rates of 60 to 80 per cent are observed. The differences between various types of treatment are small, and, for the most part, may be readily obviated by the simple expedient of increasing the frequency or number of treatments. We may conclude that convulsive therapy is non-specific with regard to the way the convulsion is induced. The significant element is the brain change subsequent to the convulsion, and not the agent used in bringing about this brain change. In previous reports (6, 19, 20) we have noted that convulsive therapy is also non-specific with regard to its application in mental illness, and in its clinical and behavioral effects. The present studies, amplify , therefore, the previous conclusion of the non-specificity of convulsive therapies.

We have applied methods of quantitative, serial EEG analyses in the studies reported here. While clinical estimates of behavioral change have yielded similar data, such evaluations are more dependent on the attitudes of the observer (21), and less amenable to quantification than the EEG. Application of EEG analyses to problems in convulsive therapies provides a rational basis for the comparison of different treatment techniques.

We have previously noted that EEG analyses may be applied in the clinical management of patients receiving convulsive therapy (6). In patients who fail to show a significant behavioral response on treatment regimens of three times per week, an electroencephalogram may serve as a

guide for further therapy. In those subjects in whom high degree delta activity has not been induced, increasing treatment frequency, withholding premedication, or shifting to a more effective convulsant method, may result in the neurophysiologic changes. If the degree of delta activity is high and sustained for a number of weeks, other factors as personality (22) or environmental (19) may be assumed to preclude a satisfactory behavioral response, even when the neurophysiologic substrate is assured; and further convulsive therapy may well be discontinued. A similar application has been suggested by Roth (5) for thiopental activated EEG records.

The successful application of quantitative EEG techniques to convulsive therapies, has led to their application to other physio-dynamic therapies. Recent reports from these laboratories note a similar application for the rational management and understanding of psychopharmacologic agents (20).

SUMMARY AND CONCLUSIONS:

Serial quantitative analysis of the degree of induced EEG delta activity were made in 173 consecutive electrotherapy referrals. Patients were treated by three convulsive methods: suprathreshold alternating current, threshold alternating current and parathreshold unidirectional current. Random electrotherapy patients received a course of subconvulsive treatment instead of grand mal, in a convulsive-subconvulsive control study.

1. An induced grand mal convulsion is essential both for the electroencephalographic and the behavioral changes ascribed to "shock" therapy.

2. The rate and degree of induced EEG delta activity is dependent upon:

(a) Mode of seizure induction: suprathreshold alternating current techniques induce EEG changes earlier and to a higher degree than threshold techniques. The results of unidirectional current methods fall between these two techniques.

(b) Frequency of treatment: increasing frequency increases degree of EEG delta activity.

(c) Age of subject: Patients under 45 develop greater degrees of delta activity earlier than older patients, but by the fourth week of treatment, differences are insignificant.

(d) Pre-treatment record characteristics: Patients with dysrhythmic records or high per-cent time alpha activity develop greater degrees of delta activity earlier than patients with low per-cent time alpha activity.

3. It is suggested that serial quantitative electroencephalography provides a rational basis for the study and the clinical management of convulsive therapies.

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Electroencephalographic Correlates of the Electroshock Process

MAX FINK, M.D., and MARTIN A. GREEN, M.D.

In the course of an evaluation of the role of altered brain function in the electroshock process, the relation between electroencephalographic change and behavioral response has been re-assessed.

Subjects and Method:

Eighty consecutive electroshock patients have been studied. All patients received electroencephalograms before treatment, on a day after a treatment at weekly intervals during, and following the course of therapy until the records had achieved their pre-treatment characteristics. Treatment procedures varied, including unidirectional and alternating current electroshock, and subconvulsive technics with Pentothal premedication. Treatment was usually instituted at three times per week for 12 to 20 treatments. Patients who failed to develop a clinical response, or EEG changes of significant degree, were subsequently treated at 5 to 10 times per week.

The EEG records were classified for degree of delta activity into "high," "middle" and "low" degree delta records using the following indices: the percent-time delta; highest percent-time delta in any lead; slowest wave in the record; highest amplitude of delta; and duration of burst activity. (Arch. Neurol. & Psychiat., 78: 516-525, 1957.)

Evaluations of change in behavior were made by the supervising psychiatrist at the height of the electroshock effect; and ratings of improvement were made two to three weeks following the termination of therapy.

Read at the meeting of Eastern Psychiatric Research Association, Inc., held Feb. 6, 1958.

Results:

1) The appearance of a high degree EEG delta activity during the second and third weeks of treatment was significantly correlated with change in behavior and ratings of improvement.

3) High EEG delta activity was induced in patients receiving convulsive electroshock only, and was not observed in subconvulsive therapy.

3) Alternating current instruments induced high degree EEG delta activity earlier than unidirectional instruments, but by the 4th week of treatment, the differences were eliminated.

4) There was a direct relation between the degree of EEG delta activity and the frequency of treatment; and an inverse relationship to age.

Conclusion:

1) There is a relationship between the degree of EEG delta activity in the EEG and clinical change in behavior.

2) The time of the appearance of EEG delta activity and its persistence is related to:

a) induction of grand mal seizures;
b) type of current employed;
c) frequency of treatment; and
d) age of the patient.

3) Early and sustained high degree electroencephalographic delta activity is a necessary, though not sufficient, pre-requisite for improvement in the electroshock process.

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Of the 173 electrotherapy referrals, 146 received grand mal therapy - 57 by threshold alternating current, 26 by suprathreshold alternating current and 63 by parathreshold unidirectional current methods. Twenty-seven subjects received a course of subconvulsive therapy.

All treatments were given three times a week, for 12-20 treatments. Patients who failed to develop a significant behavioral or clinical response, or middle or high degrees of delta activity in the EEG, were subsequently treated five to ten times per week.

Evaluations of clinical response were made by the supervising psychiatrist and resident therapists on two occasions. At the height of the treatment effect, the degree of behavioral change was scored as "marked," "moderate," "minimal" or "none." These ratings were estimates of the change in behavior in interviews and on the ward from the pre-treatment patterns. Ratings of "improvement" were also made by these physicians two to three weeks after treatment was terminated. These ratings were value judgments and were based on the four-fold classification of "recovered," "much improved," "improved" and "unimproved or worse" (2, 6).

RESULTS:

1. Variability in Delta Activity with Convulsive Therapy:

The wide variability in the degree of induced delta activity reported in the initial 24 patients (6) is confirmed in these series of convulsive therapy referrals (Table I). While the number of high degree records increases with treatment, 27% in the third week, and 18% in the fourth week, are still rated as "low" degrees of delta activity.

TABLE I

Degree of EEG Delta Activity with Convulsive Therapy

(Per-cent of Group)

	Treatment Period			
	1-3	4-6	7-9	10-12
High Degree	4	28	46	60
Moderate Degree	12	21	27	22
Low Degree	68	48	25	18
No Delta Activity	16	3	2	0

2. Role of Convulsion in EEG Response:

The significance of the convulsion per se in the EEG and behavioral response was assessed in the convulsive-subconvulsive study. Of the 47 subjects* who received convulsive therapy in this study, 9 had

* These included 28 subjects who received grand mal therapy on a random selection basis, plus 19 subconvulsive subjects referred for a "second course" of therapy.

high degree delta records in both second, third and fourth weeks of treatment, 12 during two of the three weeks, and 13 during one of the test periods. Thirteen of the 47 subjects failed to show a high degree delta record on convulsive therapy.

Of the 27 subjects who received subconvulsive therapy, however, none demonstrated middle or high degree delta activity records during any week of treatment. Low degrees of delta activity were noted in three subjects during both the second and third weeks of treatment, and in 8 subjects during the fourth week.

In concurrent behavioral ratings, 25 of initial 28 subjects in the convulsive group showed marked behavioral change; while of the subconvulsive group, 24 of the 27 showed minimal or no behavioral changes (Table II). Of the latter group, 19 were referred for a second course of therapy. In 14 of these, grand mal electroshock induced high degree delta activity and all showed a significant behavioral change. Of the five who failed to demonstrate high degree delta activity on convulsive electroshock, all showed middle degree records; and three of the five showed a behavioral change. Thus, of the 47 convulsive therapy subjects, 42 showed a significant behavioral change.

TABLE II

Ratings of Behavioral Change: Convulsive - Subconvulsive Therapies

(Fourth-Fifth Weeks of Treatment)

	Marked	Moderate	Minimal	None
Convulsive Therapy (47)	27	15	5	0
Subconvulsive Therapy (27)	0	3	8	16

In evaluations of the degree of "improvement" two weeks after treatment, 51% of the convulsive therapy group were rated as "much improved" or "recovered," and 32% as "improved" (Table III). On discharge, 51% were evaluated as sustaining the same degrees of improvement, while 42% were "improved," and only 7% were "unimproved." Of the subconvulsive group, however, 11% were rated in the first two categories, 19% in the "improved," but 70% were "unimproved," two weeks after treatment. As these were referred for a second course of therapy, hospital discharge evaluations do not reflect the effects of subconvulsive therapy.

TABLE III

Ratings of Improvement: Convulsive-Subconvulsive Therapies

(Two Weeks After Last Treatment)

	Recovered	Much Improved	Improved	Unimproved, Worse
Convulsive Therapy (47)	9	15	15	8
Subconvulsive Therapy (27)	2	1	5	19

Convulsive therapy induced significantly greater behavioral change and more favorable evaluations of improvement than did subconvulsive therapy. The clinical observations thus parallel the electroencephalographic data. Also, patients who showed neither an EEG or a behavioral response to subconvulsive therapy, showed both EEG and behavioral changes when placed on convulsive therapy.

3. Role of Type of Convulsive Therapy:

In view of the variety of electroshock techniques employed, and the relationship between EEG delta activity and the behavioral response, an analysis of the effect of type of electroshock on EEG delta activity was undertaken. The results are graphically presented in Figures 1 and 2. The first figure relates the treatment type to the percentage of records demonstrating high degrees of EEG delta activity in each treatment group during the second, third and fourth weeks of treatment. In each period, treatment with alternating current at suprathreshold strength gave the highest percentage of high degree delta records. Treatment with unidirectional current and with alternating current at threshold strength was less effective than the suprathreshold alternating current technique in each period; the unidirectional current treatment being more effective than the threshold alternating current method only early in the course of therapy.* Subconvulsive techniques yielded no high degree delta activity records.

The second figure demonstrates the same relationship by measuring the per cent of each treatment group showing no delta activity or only low degrees

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* The differences between suprathreshold and threshold treatment methods are significant at .05 by chi square in the 4-6 and 7-9 treatment periods, but not in 10-12 period. Parathreshold treatment methods are not significantly different from the other two methods during any treatment period.

of such activity. Here, the subconvulsive group is 100% for each treatment period. Suprathreshold alternating current techniques show the least number of such records in each period, with threshold and parathreshold techniques in between.

4. Frequency of Treatment:

Another factor in the rate of development of delta activity is the frequency of treatment. While all patients were initially treated three times a week, a number who failed to develop high degrees of delta activity were treated more intensively. In nine such patients, treatments were given daily or twice daily, and in each instance middle or high degrees of delta activity were induced. Similar EEG correlates were previously demonstrated by Pacella et al. (9), and Callaway (10).

5. Factor of Age:

In the initial series of patients, it was noted that younger patients, under 45 years of age, developed greater degrees of delta activity during the first and second weeks of treatment; while older subjects developed such activity to a significant degree during the third week. By the fourth week of treatment, age no longer differentiated between the groups. Combining the data from all convulsive therapies supports this observation. During the second week, 43% of records are measured high degree delta in patients under the age of 40; but only 30% in patients from 40-60, and 18% in patients 61 and over. In the third and fourth weeks, the differences are no longer present and approximately 2/3rds of the subjects have high degree delta records when treated 3 times per week.

TABLE IV

Variation in Per Cent High Degree Delta EEG Records with Age *

		Treatment Period		
		Second Week	Third Week	Fourth Week
Age	(N)	4-6	7-9	10-12
To 40 years	(28)	43%	61%	69%
41-50 years	(28)	29%	40%	56%
51-60 years	(28)	32%	56%	55%
Over 61 years	(18)	18%	50%	80%

6. Pre-Treatment Record Characteristics:

Previous reports, summarized by Chusid and Pacella (3), noted a significant relationship between pre-treatment record characteristics and the degree of induced "abnormality." Predominant alpha rhythm, "abnormal" (3) or "borderline abnormal" (11) records were more liable to develop alterations in the EEG than those with predominantly low voltage fast activity patterns.

In these series of patients, subjects whose pre-treatment record demonstrated diffuse slow wave activity, spike or spike wave activity were not included in the statistical analyses. Eight such subjects were

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* The difference in incidence of high degree records is significant at .01 level of confidence between the second and fourth weeks and .05 between the second and third weeks of treatment in patients over 50 years of age; but is not significantly different for these periods in groups under 50 years.

treated with convulsive techniques, however, and seven of them developed high degrees of delta activity earlier, and for more sustained periods, than patients without such pre-treatment abnormality.

A specific analysis of the relation between pre-treatment alpha and the degree of induced delta activity was undertaken. Rank order correlations of the pre-treatment per cent time alpha in selected leads (anterior temporal-vertex) with the degree of delta activity during the third and fourth weeks of treatment in 43 patients demonstrated correlations of +.24 and +.35 respectively. The relationship in the fourth week is significant at the .05 level of confidence; while that in the third week fails of significance, although the trend is indicated.

DISCUSSION:

Two aspects of these studies warrant discussion: the significance of the convulsion in the electroshock process; and the role of serial electroencephalograms in the rational management and study of convulsive therapies.

In the early studies of convulsive therapy numerous authors, including Kalinowsky et al. (12) and Pacella et al. (9), emphasized both the clinical and electroencephalographic differences between grand mal and petit mal responses. While grand mal seizures induced clinical improvement in 60 to 80% of cases, petit mal induced changes in less than 25% of subjects. Similarly, electroencephalograms in grand mal therapy demonstrate delta activity, while in petit mal therapy, no delta activity is seen.

In subsequent years, various subconvulsive, brief stimulus, unidirectional stimulating, monopolar stimulating, and focal convulsive techniques have been described, and in each, in turn, discarded in routine therapy. Bergman et al. (13), for example, in describing the electroencephalographic effects of focal seizure techniques noted that 70% of patients had normal records at 15 such "seizures;" while 70-75% had "abnormal" records after grand mal seizures. Ulet et al. (14), in a careful convulsive-subconvulsive control study,reported a significant difference in the clinical response of patients receiving convulsive therapies (60-80%) and those receiving subconvulsive (33%), or controls (38%). He noted the discrepancy in the EEG response in the two groups, and emphasized the significance of the seizure for the therapeutic effect. Recent additional reports by various observers, based on a variety of data further emphasize the significance of the convulsion

in the therapeutic response (4, 15, 16). The evidence thus indicates that convulsions per se are, or reflect, the significant physiologic events which are the basis for therapeutic efficacy of convulsive therapies.

If the convulsion is the essential element both in the EEG and in the behavioral response, does the mode of induction of the seizure play any role in this response?. In the studies reported here, small differences in both the degree of EEG delta activity and the rate of its development were observed between different methods of induction of grand mal seizure.

Ulett et al. (14) reported an improvement rate of 57% for the alternating current convulsive technique, and 76% for the photo-metrazol technique. While the differences are small, the authors ascribe greater clinical efficacy to the convulsive photo-metrazol technique. In a discussion of this report, Kalinowsky noted that metrazol convulsions have impressed various workers as being more efficacious than electrically induced convulsions. More recently, Edwalds, (17) describing a new convulsant drug, PM 1090, ascribed to it clinical results slightly better than electroconvulsive techniques.

We have further noted that the convulsions induced by various techniques have varying characteristics of latency, duration, preponderance of clonic or tonic phase, apnea, etc. All grand mal seizures are seemingly not equivalent; and a seizure is not an "all or none" phenomenon. Different seizure patterns occur and these may reflect differences in the physiologic effect of different treatment methods. Further studies of this problem are in progress (18).

While this variability in clinical results is reported, it is clear that with repeated convulsions, no matter how induced, improvement rates of 60 to 80 per cent are observed. The differences between various types of treatment are small, and, for the most part, may be readily obviated by the simple expedient of increasing the frequency or number of treatments. We may conclude that convulsive therapy is non-specific with regard to the way the convulsion is induced. The significant element is the brain change subsequent to the convulsion, and not the agent used in bringing about this brain change. In previous reports (6, 19, 20) we have noted that convulsive therapy is also non-specific with regard to its application in mental illness, and in its clinical and behavioral effects. The present studies, amplify , therefore, the previous conclusion of the non-specificity of convulsive therapies.

We have applied methods of quantitative, serial EEG analyses in the studies reported here. While clinical estimates of behavioral change have yielded similar data, such evaluations are more dependent on the attitudes of the observer (21), and less amenable to quantification than the EEG. Application of EEG analyses to problems in convulsive therapies provides a rational basis for the comparison of different treatment techniques.

We have previously noted that EEG analyses may be applied in the clinical management of patients receiving convulsive therapy (6). In patients who fail to show a significant behavioral response on treatment regimens of three times per week, an electroencephalogram may serve as a

guide for further therapy. In those subjects in whom high degree delta activity has not been induced, increasing treatment frequency, withholding premedication, or shifting to a more effective convulsant method, may result in the neurophysiologic changes. If the degree of delta activity is high and sustained for a number of weeks, other factors as personality (22) or environmental (19) may be assumed to preclude a satisfactory behavioral response, even when the neurophysiologic substrate is assured; and further convulsive therapy may well be discontinued. A similar application has been suggested by Roth (5) for thiopental activated EEG records.

The successful application of quantitative EEG techniques to convulsive therapies, has led to their application to other physiodynamic therapies. Recent reports from these laboratories note a similar application for the rational management and understanding of psychopharmacologic agents (20).

SUMMARY AND CONCLUSIONS:

Serial quantitative analysis of the degree of induced EEG delta activity were made in 173 consecutive electrotherapy referrals. Patients were treated by three convulsive methods: suprathreshold alternating current, threshold alternating current and parathreshold unidirectional current. Random electrotherapy patients received a course of subconvulsive treatment instead of grand mal, in a convulsive-subconvulsive control study.

1. An induced grand mal convulsion is essential both for the electroencephalographic and the behavioral changes ascribed to "shock" therapy.

2. The rate and degree of induced EEG delta activity is dependent upon:

(a) Mode of seizure induction: suprathreshold alternating current techniques induce EEG changes earlier and to a higher degree than threshold techniques. The results of unidirectional current methods fall between these two techniques.

(b) Frequency of treatment: increasing frequency increases degree of EEG delta activity.

(c) Age of subject: Patients under 45 develop greater degrees of delta activity earlier than older patients, but by the fourth week of treatment, differences are insignificant.

(d) Pre-treatment record characteristics: Patients with dysrhythmic records or high per-cent time alpha activity develop greater degrees of delta activity earlier than patients with low per-cent time alpha activity.

3. It is suggested that serial quantitative electroencephalography provides a rational basis for the study and the clinical management of convulsive therapies.

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Discussion - N.Y. Neurological Society 3-11-58

DR. FINK: The common basis for the mode of action of various forms of somatic therapies is that they induce an alteration in brain function; they do not induce improvement. Altered brain function provides the stage in which the changes in behavior occur. Personality differences amongst the subjects referred for treatment provides the differences in behavioral response which we evaluate as to "improvement."

In these studies, changes in the EEG are only one index. Memory scales, perceptual tests, both visual and tactile, and language tests are indices of altered brain function, and for each, there is a correlation between changes in the tests and the behavioral response. In each, however, personality aspects are the second factor in the improvement response.

In reply to Dr. Sullivan, the EEG pattern of various drugs was recently summarized in the Journal of the Hillside Hospital, October, 1957.

Dr. Belsky's question highlights the problem of the relation between the pretreatment EEG to both the EEG and the behavioral response. We have recently found a significant correlation between the pretreatment per-cent time alpha activity and the degree of delta activity induced in the fourth week of treatment.

Electroencephalographic Correlates of the Electroshock Process *

Max Fink, M.D. and Martin A. Green, M.D.

In the course of the evaluation of the role of altered brain function in the electroshock process, the relation between electroencephalographic change and behavioral response has been re-assessed. Previous studies (A.M.A. Arch. Neurol. & Psychiat. 78: 516, 1957) demonstrated a relation between the degree of induced delta activity and the behavioral response. The present study reports on the role of treatment method, frequency of treatment, age and pre-treatment record characteristics in the EEG and clinical response to convulsive therapy.

One hundred and seventy-three consecutive electroshock referrals have been studied. All patients received electroencephalograms before treatment; on a day after a treatment at weekly intervals during, and following the course of therapy until the records had achieved their pre-treatment characteristics. Treatment procedures varied, including alternating current suprathreshold, alternating current threshold, parathreshold unidirectional current and subconvulsive techniques with pentothal premedication. Treatment was usually instituted at three times per week for 12-20 treatments. Patients who failed to develop a clinical response, or EEG changes of significant degree, were subsequently treated at 5-10 times per week.

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* From the Department of Experimental Psychiatry, Hillside Hospital, Glen Oaks, L.I., N.Y.

Read at the meeting of the Eastern Psychiatric Research Association, New York, February 6, 1958.

3-3-58

The EEG records were classified for degree of induced delta activity into "high" "middle" and "low" degree delta records using the following indices: the per cent-time delta; highest per cent-time delta in any lead; slowest wave in the record; highest amplitude of delta; and duration of burst activity.

Evaluations of change in behavior were made by the supervising psychiatrist at the height of the electroshock effect during the fourth and fifth weeks of treatment, and ratings of improvement were made two to three weeks following the termination of therapy.

Results:

High degrees of EEG delta activity were observed in 73% of patients receiving convulsive therapy, but was not observed in any subjects receiving subconvulsive treatment. In concurrent behavioral ratings, marked behavioral change was shown by 89% of subjects on convulsive therapy, but only 9% of those on subconvulsive therapy during the fourth and fifth weeks of treatment. In ratings of "improvement" two weeks after treatment, 51% of the convulsive therapy group were rated as "much improved" or "recovered," while only 11% of the subconvulsive therapy group were so rated.

In evaluations of the role of type of convulsive therapy, suprathreshold alternating current techniques induced degrees of delta activity higher and earlier in course of treatment than parathreshold unidirectional and threshold alternating current techniques. While differences between the two alternating current techniques are significant

in the second and third week, the differences are not significant by the fourth week.

Increasing the frequency of convulsive treatment, for any technique, increased the degree of EEG delta activity.

Patients under 45 years of age develop high degrees of delta activity earlier than patients over 45. While differences are present for the second and third weeks of treatment they are no longer present in the fourth week.

With regard to pre-treatment EEG record characteristics, subjects whose records demonstrated slow wave activity or spike, and spike-wave activity, developed high degrees of delta activity earlier, and for more sustained periods than patients without such delta activity. Rank order correlations of the pre-treatment and per cent-time alpha with the degree of delta activity during the fourth week of treatment was +.35, significant at .05 level of confidence.

Conclusions:

1. An induced grand mal convulsion is essential both for the electroencephalographic and the behavioral changes ascribed to "shock" therapy.

2. The rate and degree of induced EEG delta activity is dependent upon:

(a) Mode of seizure induction: suprathreshold alternating current techniques induce EEG changes earlier and to a higher degree than threshold techniques. The results of unidirectional current methods fall between these two techniques.

(b) Frequency of treatment: increasing frequency increases degree of EEG delta activity.

(c) Age of subject: Patients under 45 develop greater degrees of delta activity earlier than older patients, but by the fourth week of treatment, differences are insignificant.

(d) Pre-treatment record characteristics: patients with "abnormal" records or high per-cent time alpha activity develop greater degrees of delta activity earlier than patients with low per-cent time alpha activity.

(3) It is suggested that serial quantitative electroencephalography provides a rational basis both for the study and the clinical management of convulsive therapies.