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~~I: 4-17-58~~

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Individual Differences in EEG ~~Behavioral~~ Response to Convulsive Therapy

In a series of investigations of the role of neurophysiologic factors in the changes in behavior induced by convulsive therapy, it was concluded that an alteration in brain function was a necessary, though not a sufficient prerequisite, for behavioral change and "improvement" ( ). Changes in brain function were measured by a variety of indices, of which alteration in the waking EEG was the most satisfactory ( ). Convulsive therapy consistently induces a shift in the EEG spectrum to slower frequencies, with the development of runs and bursts of high voltage delta activity. ~~With equal numbers and frequ~~ However, there is wide variability in the ~~slowest~~ frequency and per-cent time of the slow wave activity ~~voltage and degree of burst activity~~ developed at various stages of the treatment process ~~by~~ in different subjects. The degree and rate of development of delta activity have been related to the age of the subject ( ), frequency of treatment ( ), and mode of induction (electrical, chemical, photo-chemical). Yet, when these factors are held constant, variability in the degree of delta activity is still manifest ( ).

Previous experience has demonstrated that both the behavioral response and ratings of improvement to convulsive therapy may be related to various perceptual ~~physiologic~~ processes as the number and type of Rorschach responses ( ),

score on the California F scale ( ), and errors on figure-ground tasks (,); and to such sociologic factors as age, education level, and place of birth ( ), ~~and economic status ( )~~. Since the technical aspects of the treatment ~~fail~~ failed to explain the degree of EEG variability, ~~this assessment was undertaken of the relation of the individual~~ the difference in variability of subjects, ~~as measured by~~ their perceptual-psychologic performances, ~~processes, in this observation.~~ and ~~Also, individual variability as measured by~~ pre-treatment EEG characteristics ~~was also assessed~~ were studied. It is the purpose of this study to relate pre-treatment perceptual ~~psychologic~~ and EEG characteristics to the variability in physiologic response to convulsive therapy, as measured by the degree of induced EEG delta activity.

SUBJECTS AND METHOD:

~~Eighty-five~~ Consecutive patients referred for convulsive therapy in a voluntary psychiatric hospital were studied. The patients ranged in age from 22 to 66 with a median of 49 years; and were diagnosed as suffering from psychotic depressive, schizophrenic and cyclothymic reactions.

While the range of conventionally applied diagnostic categories was broad, the population exhibited certain common characteristics. They were primarily from a single ethnic

OBSERVATIONS:

1. Variability of Induced ~~Delta~~ Activity

In the patients receiving convulsive treatment and investigated by the methods outlined, the variability in the ~~degree of induced delta~~ activity is considerable. We have summarized the observations in 146 patients in Table I.

TABLE I

While the per-cent of records in the high degree category increases with successive treatment given at three times a week, half the population has not achieved ~~the~~ degree ~~of delta~~ activity in the third week, and 40% ~~in the~~ in the fourth week. By the fourth week, however, ~~delta activity~~ is apparent in all subjects.

TABLE I

Slow wave
Degree of Induced ~~Delta~~ Activity With Convulsive Therapy

(Per cent of Group, N=146)

Slow Wave ~~Delta~~ Activity	Rx #	Treatment Period First Week	Second Week	Third Week	Fourth Week
		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%
None		16%	3%	2%	0%

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2. Relation of Pre-Treatment Rorschach ~~Factors~~ Responses to EEG Variability

In the analyses of ~~perceptual~~ the ~~responses to~~ ~~Aspects~~ Rorschach ~~visual stimuli~~ data, the number of responses and qualitative aspects ~~as~~ of movement and color were related to the degree of induced ~~delta~~ electrographic activity. ~~In the number of responses~~ there were significantly fewer ~~responses~~ total Rorschach responses in patients with high degrees of ~~delta~~ slow wave activity than ~~on~~ in those manifesting moderate and low degrees of such activity.

insert 7A

TABLE II

An analyses of the total number of movement responses (M+Fm+m) also demonstrated that patients with high degrees of ~~EEG~~ delta activity reported significantly ~~fewer~~ less movement ~~responses~~ in the Rorschach cards.

~~This observation is more clearly demonstrated in the next table.~~ When patients were classified as to the type of movement response ~~those reporting any human movement, any movement or no movement to the Rorschach figures~~, significant differences in EEG reactivity were observed. In patients who failed to report movement, higher degrees of ~~delta~~ Slow wave activity were observed, than in those with any movement, ~~and~~ or those with human movement.

Table 3

In patients with high degrees of EEG slow wave activity, there were significantly fewer total responses, and fewer movement responses (M + Fm + m). ~~Of these~~ Of ~~these~~

~~Such~~ Table 12.

~~Subjects perceptive tunnels normal~~

TABLE III

A similar relationship is noted for color responses. Patients who expressed form-color ~~responses~~ in the Rorschach developed lower degrees of delta activity with treatment than those who expressed color, and color-form, and only or failed to give color responses. Combining both ~~the~~ movement and ~~the~~ color, ~~responses~~, greater degrees of EEG slowing ~~delta activity was~~ were observed in patients who gave neither human movement nor form-color responses, than in those patients who expressed either or both these responses.

Analyses for number of whole responses (W), per-cent of good form responses (F+%), and per-cent of popular (P) responses, failed to demonstrate significant relationships with the degree of induced ~~delta~~ slow wave activity.

TABLE II

Relation of Number of Rorschach Responses to Induced
Slow Wave
EEG ~~Delta~~ Activity

EEG Slow Wave	Mean	S.D.	Diff.	t	p
			Number of Responses (R)		
High Degree ~~Delta~~	14.2	7.2			
			6.6	2.8	<.01
Moderate, Low Degree ~~Delta~~	20.8	15.0			
			Number of Movement Response (M+Fm+m)		
High Degree ~~Delta~~	2.9	3.4			
			2.1	2.3	<.05
Moderate, Low Degree ~~Delta~~	5.0	5.1			

TABLE III

Relation of Movement and Color Rorschach Responses
Slow wave
To Induced EEG ~~Delta~~ Activity

	N	High Degree ~~Delta~~		Moderate, Low Degree ~~Delta~~		Signif.
Human Movement (M)	38	20	(53%)	18	(47%)	$X^2 = 6.19$
Other Movement (FM+m)	28	20	(71%)	8	(29%)	$p < .05$
No Movement -	19	16	(84%)	3	(16%)	
Form Color (FC)	33	17	(52%)	16	(48%)	$X^2 = 3.88$
Other Color (C, CF or None O-C)	52	39	(75%)	13	(25%)	$p < .05$
Both M+FC	23	11	(48%)	12	(52%)	$X^2 = 7.60$
Either M or FC	25	15	(60%)	10	(40%)	$p < .05$
Neither M nor FC	37	30	(81%)	7	(19%)	

[redacted]

3. Relation of Pre-Treatment Errors on Hidden-Figures Test to Physiologic Variability

In a previous study ( ) errors on the hidden-figures test were related to changes in the degree of EEG ~~delta~~ slow wave activity and to positive responses on the amobarbital test for cerebral dysfunction ( ). Combining the physiologic responses into a ~~combined~~ single index, a range of changes from zero to ~~surplus~~ six plus ~~is~~ was scored (Table IVa). The larger the pre-treatment error score, the greater the degree of physiologic change with treatment. The triserial correlation is +0.34, significant at the .05 level.

TABLE IV

In a similar analysis of the pre-treatment errors to EEG variability, induced alone, the difference just fails of significance (Table IVb).

4. Relation of Pre-Treatment EEG Pattern to EEG Variability.

Considering the variability in modulation, voltage, and frequency spectrum in the pre-treatment EEG amongst the subjects, an analysis of the relation between some of these characteristics and the EEG responsivity was made. An initial study ( ) of those patients whose pre-treatment EEG

TABLE IV

Relation of Pre-Treatment Errors in Hidden-Figures Test to Physiologic Variability

(a) Combined EEG - Amobarbital Index:

Physiologic Changes		Mean # Errors	
5+, 6+	(8)	13.3	
3+, 4+	(19)	11.2	Correlation = +0.34
0, 1+, 2+	(16)	7.9	$p < .05$

(b) EEG ~~Delta~~ Slow Wave Activity:

			S.D.	Diff.	t	p
High ~~Delta~~ Degree	(31)	11.4	7.2	3.2	1.5	N.S.
No High ~~Delta~~ Degree	(13)	8.2	4.8			

manifested slow wave activity had demonstrated that high degrees of delta activity appeared earlier and were sustained longer than in patients without such activity, confirming ~~the~~ are earlier reports of Kennard and Willner ( ).

As one approach to the problem, the pre-treatment per-cent time alpha activity was correlated with the degree of induced ~~delta~~ activity, measured as per-cent time ~~delta~~ such activity.* In 44 subjects, a correlation of +0.35, significant at the .05 level, was observed during the fourth treatment week (10-12 treatment).

see Pg. 9

DISCUSSION:

In these studies, the degree of induced EEG delta activity during convulsive therapy has been related to pre-treatment perceptual and EEG patterns. While these observations are limited in scope and conclusions regarding interdependence are premature, the consistency of these observations with clinical data and theoretic constructs warrants further exploration. In earlier reports the behavioral patterns of euphoria, hypomania and denial were shown to be consistently interpreted by the psychiatric observer or family as "improvement," while somatization, panic, paranoia and excitement were rated as "unimproved," ( ). Improvement in convulsive therapy has been related to such pre-treatment variables as high

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* Previously demonstrated as a correlation of +0.84 with degree of delta activity ( ).

scores on denial personality indices ( ) and ~~high scores on authoritarian~~ ~~scales, as~~ the California F scale ( ); absence of human movement, color, form-color responses, low number of responses, or high number of whole and good form responses on Rorschach tests ( ); and low educational attainment and foreign birth ( ). Thus, in an environment where verbal therapy is most highly esteemed, patients least like the therapist in social ( ), and educational ( ) ~~and economic ( )~~ attributes are referred for somatic (or non-verbal) therapy. Under the conditions of induced altered brain function, those subjects with least discriminative ability ~~in perceptual and linguistic discrimination,~~ respond with non-verbal behavioral modes of euphoria, hypomania, denial, displacement and minimization, and are rated as ~~"improved,"~~ "much improved" while subjects with greater perceptual and linguistic discrimination respond with the more verbal patterns of paranoia, panic, somatization and anxiety, and are rated "unimproved."

In the observations reported here, the pre-treatment perceptual mode is also related to the degree of physiologic response. The greater the perceptual discrimination and verbal descriptive ability on the Rorschach, the lower the degree of induced ~~delta~~ slow wave activity; the fewer the Rorschach responses, the less

discriminating and the less the ability to separate figure from ground, the greater the physiologic responsivity to induced convulsions. It is difficult to formulate a causal relationship ~~for the aspects of~~ between clinical behavior, (both pre and post-treatment) perceptual patterns and physiologic response. But it is operationally meaningful to interpret these various tasks behaviors ~~as aspects~~ as related in this of the subject ~~to~~ interaction with the environment, with each measure of behavior representing an abstract or sample of subject-examiner relationship. In this framework the problem of the relationship between personality and physiologic measures is transformed from one of "whether" to one of "how" and "under what conditions." In these ~~series of~~ subjects, heightened perceptual discrimination appears related to low degrees of alpha activity in routine, ~~awake~~ waking records ~~recording~~ and decreased ~~delta activity~~ amount induced slowing in responsivity to convulsive therapy. In clinical behavior such subjects are prone to ~~inner~~ introspection, anxiety and ideational disturbances; and show poor improvement ratings to convulsive therapy.

These observations are consistent with previous studies relating personality and EEG aspects by Kennard, Ulett and Shagass. Kennard and Schwartzman ( ) related resting EEG spectra of low alpha index to schizophrenic personality,

psychotics,
while high alpha index to non-~~psychiatric~~, psychopaths and young individuals.

Ulett et al. ( ) indicated anxiety proneness was ~~highly~~ correlated with

poor alpha activity, and slow and fast activity in the resting record, and poor

response to photic stimulation in the alpha range. In Shagass' studies of

the sedation threshold ( ), low responsivity to barbiturate as measured by

amplitude of beta activity was positively correlated with anxiety and tension

( ), and with poor clinical response to convulsive therapy ( ). Thus,

behavioral responsivity and interaction, reflected in personality ~~theory~~ and concepts in

psychiatric nosology may be related to neurophysiologic reactivity as reflected

by EEG patterns, within the limits of the sensitivity of our measurements or

methods of experimentally altering (activating) both behavior and EEG.

Inherent in neurophysiologic responsivity are all the aspects of the

internal milieu, as reflected in individual differences in biochemistry, and

in the pre-treatment EEG record characteristics; the individual environment

continuum as reflected in perception, motor patterns, moods and verbalization;

but also the sociologic aspects of the individual's experience. In the series

of patients studied here, an analysis of educational level with degree of EEG

responsivity demonstrated a ~~significant~~ significant (- $p < .02$) relationship. Subjects

with nine or more years of formal education had a lower percentage of high slow wave Electrographic degree records than subjects with less than eight years of education.

CONCLUSION:

The variability in the degree of induced ~~delta~~ slow wave activity manifest during convulsive therapy has been related to technical factors of the treatment. Yet, when these are held constant, variability is still manifest. In these EEG slowing studies, ~~delta activity~~ has been related to pretreatment perceptual and EEG patterns. Patients with fewer number of responses, fewer movement responses, and absence of human movement, color and form-color responses on the Rorschach; greater errors on figure-ground discrimination tasks; and higher per-cent time alpha activity had higher degrees of induced ~~delta~~ slow wave activity.

Physiologic reactivity, measured in EEG patterns; interpersonal ~~behavior~~, behavior, manifest personality measures and descriptions of clinical or verbal behavior ~~on~~ are different aspects of the interaction of subjects and environment. In the framework, EEG and personality variables are related within the limits of the sensitivity of the measures used.

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II: 12/7/59

Individual Differences in EEG Response to Convulsive Therapy

In a series of investigations of the role of neurophysiologic factors in the changes in behavior induced by convulsive therapy, it was concluded that an alteration in brain function was a necessary, though not a sufficient prerequisite, for behavioral change and "improvement" ( ). Changes in brain function were measured by a variety of indices, of which alteration in the waking EEG was the most satisfactory ( ). Convulsive therapy consistently induced a shift in the EEG spectrum to slower frequencies, with the development of runs and bursts of high voltage delta activity. However, there is variability in the frequency and per-cent time of the slow wave activity developed at various stages of the treatment process in different subjects. The degree and rate of development of delta activity have been related to the age of the subject ( ), frequency of treatment ( ), and mode of induction (electrical, chemical, photo-chemical). Yet, when these factors are held constant, variability in the degree of delta activity is still manifest ( ).

Previous experience has demonstrated that both the behavioral response and ratings of improvement to convulsive therapy may be related to various perceptual processes as the number and type of Rorschach responses ( ), score on the California F Scale ( ), and errors on figure-ground tasks (,); and to such sociologic factors as age, education level, and place of birth ( ). Since the technical aspects of the treatment fail to explain the degree of EEG variability, the variability of the subjects in their perceptual-psychologic performances, and pre-treatment EEG characteristics were studied.

SUBJECTS AND METHOD:

Consecutive patients referred for convulsive therapy in a voluntary psychiatric hospital were studied. The patients ranged in age from 22 to 66 with a median of 49 years; and were diagnosed as suffering from psychotic depressive, schizophrenic and cyclothymic reactions. While the range of conventiahally applied diagnostic categories was broad, the population exhibited certain common characteristics. They were primarily from a single ethhic (Jewish), socio-economic (lower middle and upper lower class), immigrant and first generation, group. Their psychiatric behavior patterns were chiefly in ideation and mood. They were voluntarily hospitalized, predominantly for the first time, with a short period (few months to few years) of psychiatric illness.

Within a week prior to treatment subjects were tested with Rorschach and figure-ground discrimination tasks. The Rorschach protocol was scored for presence or absence of human movement responses (M), total movement responses (M+FM+m), type and number of color responses (C, CF and FC) and total number of responses (R). In the figure-ground discrimination task, a modification of Gottschaldt's hidden figures ( ), the subject

is presented with a page containing two forms - a simple geometric figure, and below it a complex figure in which the simple figure is embedded. The task is to outline the embedded figure in the complex figure.

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FIGURE I

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Electroencephalograms were obtained prior to treatment, and at weekly intervals on a day following a treatment. Patients whose pre-treatment records contained measurable delta activity were excluded from the study. The amount of induced slow wave activity was measured by determining the per-cent time of frequencies of 7 cps or slower in three selected leads, the slowest frequency and highest amplitude of slow wave activity, and longest duration of burst activity in the record. Based on these indices, records were classified as "low," "moderate" or high" degree slow wave activity, according to criteria previously described ( ). In the observations reported here, the development of high desgrees of slow wave activity in the second and third weeks of treatment (4-6, 7-9 treatment intervals) was used in the tabulation. Patients who developed high

degrees of slow wave activity during either or both these periods were ~~x~~ classed in the high degree group. Those whose records did not demonstrate this degree of activity in either week were classed in the moderate-low class.

Electroconvulsive treatment was administered three times a week, using suprathreshold unidirectional or alternating current methods. The number of treatments varied from ten to thirty, with most patients ending treatment after twelve to fifteen treatments.

OBSERVATIONS:

1. Variability of Induced Slow Wave Activity

In the patients receiving convulsive treatment and investigated by the methods outlined, the variability in the amount of manifest slow wave activity is considerable. We have summarized the observations in 146 patients in Table I.

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TABLE I

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While the per-cent of records in the high degree category increases with successive treatment given at three times a week, half the population has not achieved a high degree activity record in the third week, and 40% in the fourth week. By the fourth week, however, EEG slowing is apparent in all subjects.

TABLE I

Degree of Induced Slow Wave Activity

with Convulsive Therapy

(Percent of Group, N=146)

Slow Wave Activity	Treatment Period			
	First Week	Second Week	Third Week	Fourth Week
RX #	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%
None	16%	3%	2%	0%

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2. Relation of Pre-Treatment Rorschach Responses to EEG Variability

In the analyses of the Rorschach data, the number of responses and the qualitative aspects of movement and color were related to the degree of induced electrographic activity.

In patients with high degrees of EEG slow wave activity, there were significantly fewer total responses and fewer movement responses (M+Fm+m).

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TABLE 2

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When patients were classified as to the type of movement response, significant differences in EEG reactivity were observed. Higher degrees of slow wave activity were observed in patients who failed to report movement than in those with any movement, or those with human movement.

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TABLE 3

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A similar relationship is noted for color responses. Patients who expressed form-color in the Roschach developed lower degrees of delta activity with treatment than those who expressed color and color-form only

TABLE II

Relation of Number of Rorschach Responses to Induced EEG Slow Wave Activity

EEG Slow Wave	Mean	S.D.	Diff.	t	p
		Number of Responses (R)			
High Degree	14.2	7.2	6.6	2.8	<.01
Moderate, Low Degree	20.8	15.0			
		Number of Movement Responses (M*FM*m)			
High Degree	2.9	3.4	2.1	2.3	<.05
Moderate, Low Degree	5.0	5.1			

Relation of Movement and Color Rorschach Responses to Induced EEG Slow Wave Activity

	N	High Degree	Moderate, Low Degree	Significance
Human Movement (M)	38	20 (53%)	18 (47%)	$X^2 = 6.19$
Other Movement (FM+m)	28	20 (71%)	8 (29%)	$p < .05$
No Movement -	19	16 (84%)	3 (16%)	
Form Color (FC)	33	17 (52%)	16 (48%)	$X^2 = 3.88$
Other Color (C., CF, C-C) or None	52	39 (75%)	13 (25%)	$p < .05$
Both M+FC	23	11 (48%)	12 (52%)	$X^2 = 7.60$
Either M or FC	25	15 (60%)	10 (40%)	$p < .05$
Neither M nor FC	37	30 (81%)	7 (19)	

or failed to give color responses. Combining both movement and color, greater degrees of EEG slowing were observed in patients who gave neither human movement nor form-color responses, than in those patients who expressed either or both these responses.

Analyses for number of whole responses (W, per-cent of good form responses (F+%), and per-cent of popular (P) responses, failed to demonstrate significantly relationships with the degree of induced slow wave activity.

3. Relation of Pre-Treatment Errors on Hidden-Figures Test to Physiologic Variability

In a previous study ( ) errors on the hidden-figures test were related to changes in the degree of EEG slow wave activity and to positive responses on the amobarbital test for cerebral dysfunction( ).

Combining the physiologic responses into a single index, a range of changes from zero to six plus was scored (Table IVa). The larger the pre-treatment error score, the greater the degree of physiologic change with treatment. The triserial correlation is +0.34, significant at the .05 level.

TABLE IV

Relation of Pre-Treatment Errors in Hidden-Figures Test to Physiologic Variability

(a) Combined EEG - Amobarbital Index:

Physiologic Changes		Mean # Errors	
5+, 6+	(8)	13.3	
3+, 4+	(19)	11.2	= ⁺0.34
0, 1+, 2+	(16)	7.9	p < .05

(b) EEG Slow Wave Activity:

			S.D.	Diff.	t	p
High Degree	(31)	11.4	7.2	3.2	1.5	N.S.
No High Degree	(13)	8.2	4.8			

DISCUSSION:

In these studies, the degree of induced EEG delta activity during convulsive therapy has been related to pre-treatment perceptual and EEG patterns. In earlier reports the behavioral patterns of euphoria, hypomania and denial were shown to be consistently interpreted by the psychiatric observer of family as "improvement", while somatization, panic, paranoia and excitement were rated as "unimproved" ( ). Improvement in convulsive therapy has been related to such pre-treatment variables as high scores on denial personality indices (m) and the California F Scale ( ); absence of human movement, color, form-color responses, low number of responses, or high number of whole and good form responses on Rorschach tests ( ); and low educational attainment and foreign birth ( ). Thus, in an environment where verbal therapy is most highly esteemed, patients least like the therapist in social and educational ( ) attributes are referred for somatic (or non-verbal) therapy. Under the conditions of induced

altered brain function, those subjects with least discrimina-
ve
tiun ability respond with non-verbal behavioral modes of euphoria, hypomania, denial, displacement and minimization, and are rated as "much improved", while subjects with greater perceptual and linguistic discrimination respond with the more verbal patterns of paranoid, panic, somatization and anxiety, and are rated "unimproved."

In the observations reported here, the pre-treatment perceptual mode is also related to the degree of physiologic response. The greater the perceptual discrimination and verbal discriptive ability on the Rorschach, the lower the degree of induced slow wave activity; the fewer the Rorschach responses, the less discriminating and the less the ability to separate figure from ground, the greater the physiologic responsivity to induced convulsions. It is difficult to formulate a casual relationship between clinical behavior (both pre and post-treatment) perceptual

patterns and physiologic response. But it is operationally meaningful to interpret these various tasks as related behaviors of the subject in his interaction with the environment, with each measure of behavior representing an abstract or sample of subject-examiner relationship. In this framework the problem of the relationship between personality and physiologic measures is transformed from one of "whether" to one of "how" and "under what conditions." In these subjects, heightened perceptual discrimination appears related to low degrees of alpha activity in routine, waking records and decreased amounts of induced slowing in response to convulsive therapy. In clinical behavior such subjects are prone to introspection, anxiety and ideational disturbances; and show poop improvement ratings to convulsive therapy.

These observations are consistent with previous studies relating personality and EEG aspects by Kennard, Ulett and

Shagass. Kennard and Schwartzman ( ) related resting EEG spectra of low alpha index to schizophrenic personality, while high alpha index to non-psychotics, psychopaths and young individuals. Ulett et al. ( ) indicated anxiety proneness was correlated with poor alpha activity, and slow and fast activity in the resting record, and poor response to photic stimulation in the alpha range. In Shagass' studies of the sedation threshold ( ), low responsivity to barbiturate as measured by amplitude of beta activity was positively correlated with anxiety and tension ( ), and with poor clinical response to convulsive therapy ( ). Thus, behavioral responsivity and interaction, reflected in personality concepts and in psychiatric nosology may be related to neurophysiologic reactivity as reflected by EEG patterns, within the limits of the sensitivity of our measurements or methods of experimentally altering (activating) both behavior and EEG.

Inherent in neurophysiologic responsivity are all the aspects of the internal milieu, as reflected in individual differences in biochemistry, and in the pre-treatment EEG record characteristics; the individual environment continuum as reflected in perception, motor patterns, mood and verbalization; but also the sociologic aspects of the individual's experience. In the series of patients studied here, an analysis of educational level with degree of EEG responsivity demonstrated a significant (- $p < .02$) relationship. Subjects with nine or more years of formal education had a lower percentage of high degree slow wave electrographic records than subjects with less than eight years of education.

CONCLUSION:

The variability in the degree of induced slow wave activity manifest during convulsive therapy has been related to technical factors of the treatment. Yet, when these ae held constant, variability is still manifest. In these studies, EEG slowing has been related to pretreatment perceptual and EEG patterns. Patients with fewer number of responses, fewer movement responses, and absence of human movement, color and form-color responses on the Rorschach; greater errors on figure-ground discrimination tasks; and higher percent time alpha activity had higher degrees of induced slow wave activity.

Physiologic reactivity, measured in EEG patterns; interpersonal behavior, manifest personality measures and descriptions of clinical or verbal behavior are different aspects of the interaction of subjects and environment. In this framework, EEG and personality variables are related within the limits of the sensitivity of the measures used.

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INDIVIDUAL DIFFERENCES IN ELECTROGRAPHIC RESPONSE IN CONVULSIVE THERAPY

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This study was completed in the laboratories of the Department of Experimental Psychiatry, Hillside Hospital, New York.

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Individual Differences in Electrographic Response in Convulsive Therapy

Investigations of neurophysiological factors in convulsive therapy suggest that an alteration in brain function is a necessary, though not a sufficient prerequisite, for behavioral change and "improvement" (3). Changes in brain function were measured by a variety of indices, of which alteration in the scalp-recorded EEG was the most satisfactory (4). Convulsive therapy consistently induces changes in the EEG spectrum to slower frequencies with the appearance of runs and bursts of high voltage delta activity. However, the average frequency and amount of slow wave activity varies during treatment in different subjects. The rate of development and the amount of delta activity have been related to the age of the subject, frequency of treatment, and mode of induction (electrical, chemical, photochemical) (6). These aspects of treatment, however, are insufficient to explain the variations in the degree of delta activity induced during treatment.

Previous studies demonstrated relationships between ratings of improvement and various perceptual processes, including the number and type of Rorschach responses (7, 19), score on the California F Scale (24), and errors on figure-ground tasks (25) and such sociological factors as age, educational level, and place of birth (22, 23).

In a continuation of these studies, individual differences in perceptual-psychological performances and the pre-treatment EEG characteristics of subjects were studied for their relationship to the degree of induced EEG slow wave activity.

SUBJECTS AND METHOD:

The methods followed earlier studies (3-7 18-25) which describe the population characteristics. Consecutive patients referred for convulsive therapy in a voluntary psychiatric hospital were studied.

During the week prior to treatment subjects were tested with Rorschach and figure-ground discrimination tasks. The Rorschach protocol was scored for presence or absence of Human Movement responses (M), total Movement responses (M+FM+m), type and number of Color responses, (C, CF and FC) and total number of responses (R). The figure-ground discrimination task was a modification of Gottschaldt's hidden figures.

Electroencephalograms were obtained prior to treatment and at weekly intervals on a day following treatment. Patients whose pre-treatment records contained measurable delta activity were excluded from the study. Records were classified as "low," "moderate" or "high" in the amount of slow wave activity, according to visual measurement of the percent time of frequencies of 7 cps or slower, the slowest frequency and highest amplitude of slow wave activity, and longest duration of burst activity in the record (4). Patients who developed high degrees of slow wave activity during either or both the second and third weeks of treatment (4-6, 7-9 treatment intervals) were classed in the high degree group. Those whose records did not demonstrate this degree of activity in either week were classed in the moderate-low class.

The amobarbital test for altered brain function was performed weekly on a morning immediately preceding a treatment. Persistent errors in orientation, confabulation, and induced denial of illness were scored as "positive" amobarbital test (21).

Electroconvulsive treatment was administered three times a week using suprathreshold unidirectional or alternating current methods (6). The number of treatments varied from ten to thirty, with most patients ending treatment after twelve to fifteen treatments.

OBSERVATIONS:

1. Variability of Induced Slow Wave Activity

The amount of EEG slow wave activity was variable (Table I). While the percent of records in the high degree category increased with successive treatments, half the population has not achieved a high degree activity record in the third week, and 40% in the fourth week. By the fourth week, however, EEG slowing to some degree was apparent in all subjects.

Table I

TABLE I

Degree of Induced Slow Wave Activity

with Convulsive Therapy

(Percent of Group, N=146)

	Treatment Period			
Slow Wave Activity	First Week	Second Week	Third Week	Fourth Week
RX #	1-3	4-6	7-9	10-12
High Degree	4%	28%	46%	60%
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Low Degree	68%	48%	25%	18%
None	16%	3%	2%	0%

2. Pre-Treatment Rorschach Responses and EEG Variability

In the Rorschach data, the number of responses and the qualitative aspects of movement and color were both related to the degree of induced electrographic activity. Patients with high degrees of EEG slow wave activity had expressed significantly fewer total responses and fewer Movement responses (Table II).

Table II

Differences were also seen in relation to the type of movement response. Patients who failed to report Human Movement exhibited higher degrees of slow wave activity than those subjects describing Human or any Movement responses (Table 3).

Table III

Color responses showed a similar relationship. Patients who expressed Form-Color in the Rorschach developed lower degrees of delta activity with treatment than those who expressed Color and Color-Form only or failed to give color responses. Combining both Movement and Color, greater degrees of EEG slowing were observed in patients who expressed neither Human Movement nor Form-Color responses than in those patients who expressed either or both these responses.

Analyses for number of whole responses (W), percent of good Form responses (F+%), and percent of Popular (P) responses, failed to demonstrate relationships with the degree of induced slow wave activity.

TABLE II

Relation of Number of Rorschach Responses to Induced EEG Slow Wave Activity

EEG Slow Wave	Mean	S.D.	Diff.	t	p
	Number of Responses (R)				
High Degree	14.2	7.2			
			6.6	2.8	<.01
Moderate, Low Degree	20.8	15.0			
	Number of Movement Responses (M+FM+m)				
High Degree	2.9	3.4			
			2.1	2.3	<.05
Moderate Low Degree	5.0	5.1			

TABLE III

Relation of Movement and Color Rorschach Responses

to Induced EEG Slow Wave Activity

	N	High Degree	Moderate, Low Degree	Significance
Human Movement (M)	38	20 (53%)	18 (47%	$X^2 = 6.19$
Other Movement (FM+M)	28	20 (71%)	8 (29%)	$p < .05$
No Movement	19	16 (84%)	3 (16%)	
Form Color (FC)	33	17 (52%)	16 (48%)	$X^2 = 3.88$
Other Color (C, CF, 0-C) or None	52	39 (75%)	13 (25%)	$p < .05$
Both M+FC	23	11 (48%)	12 (52%)	$X^2 = 7.60$
Either M or FC	25	15 (60%)	10 (40%)	$p < .05$
Neither M nor FC	37	30 (81%)	7 (19%)	

3. Pre-Treatment Errors on Hidden-Figures Test and Physiological Variability

In a previous study (25) errors on the hidden-figures test were related to changes in the degree of EEG slow wave activity and to positive responses on the amobarbital test for cerebral dysfunction. Combining the physiological responses into a single index, a range of changes from zero to six plus was scored (Table IVa). The larger the pre-treatment error score, the greater the degree of physiological change with treatment. The triserial correlation is +0.34, significant at the .05 level.

Table IV

In a similar analysis of the pre-treatment errors in induced EEG variability alone, the difference failed of significance (Table IVb).

4. Pre-Treatment EEG Pattern to EEG Variability

The variability in modulation, voltage, and frequency pattern in the pre-treatment EEG was studied in relation to response to induced convulsions. An initial study (4) of those patients whose pre-treatment EEG manifested slow wave activity had demonstrated that high degrees of delta activity appeared earlier and were sustained longer than in patients without such activity, confirming an earlier report (29).

As one approach to the problem, the pre-treatment percent time alpha activity was correlated with the degree of induced slow wave activity, measured as percent time of such activity. In forty-four subjects, a correlation of +0.35 was observed during the fourth treatment week (10-12 treatments).

TABLE IV

Relation of Pre-Treatment Errors in

Hidden-Figures Test to Physiological Variability

(a) Combined EEG - Amobarbital Index:

Physiologic Changes		Mean # Errors	
5+, 6+	(8)	13.3	
3+, 4+	(19)	11.2	= +0.34
0, 1+, 2+	(16)	7.9	$p < .05$

(b) EEG Slow Wave Activity:

			S.D.	Diff.	t	p
High Degree	(31)	11.4	7.2	3.2	1.5	N.S.
No High Degree	(13)	8.2	4.8			

DISCUSSION:

These studies demonstrate relationships between the degree of induced EEG delta activity during convulsive therapy and pre-treatment perceptual and EEG patterns. Lesser amounts of slow wave activity were found in subjects with perceptual discrimination and verbal descriptive ability on the Rorschach test. Fewer Rorschach responses, less discriminative ability and lesser ability to separate figure from ground were associated with greater physiological changes.

Such changes in a physiological measure in response to stress has been observed with other physiological measures and has been suggested as a way of classifying psychiatric subjects. Studies by Shagass (31-35), Goldman (10-13), Itil (14,15), Ulett (16, 40) and Kennard (26-28) using EEG indices; Funkenstein (8-10) with blood pressure; and Shagass and Schwartz (36-39) and Callaway (2, 17) with evoked potentials are a few examples. In these studies, the responsitivity of the EEG to amobarbital or pentothal, the blood pressure to epinephrine and methacholine, or the evoked response to sensory stimuli have been related to clinical diagnosis and to response to somatic treatment. These studies suggest that behavioral responsitivity and interaction, reflected in personality measures and in psychiatric nosology may be related to the reactivity of the brain within the limits of the sensitivity of our measurements.

In the present study of the electroshock process, heightened perceptual discrimination is related to lesser amounts of alpha activity in routine waking records and decreased amounts of induced

slowing. The possibility that the learned perceptual patterns of a subject may reflect physiological differences is a major aspect of recent neonatal studies (30) biochemical specificity studies (41) and the individual differences in learning in animals (1). Perhaps it is operationally meaningful to interpret psychological tasks and physiological tasks as related behaviors of the subject in his interaction with the environment, with each measure of behavior representing one facet of the subject-examiner relationship. In this view the problem of the relationship between personality and physiological measures is transformed from one of "whether" to one of "how" and "under what conditions."

These observations are also consistent with earlier studies of convulsive therapy in which behavioral patterns were related to pre-treatment personality aspects. Euphoria, hypomania and denial were shown to be interpreted by both psychiatric observers and the family as "improvement," while somatization, panic, paranoia and excitement were evaluated as "unimproved" (5). These behaviors have been related to high scores on denial personality indices (18) and to the California F Scale (24); absence of Human Movement, Color, Form-Color responses, low number of responses, and high number of whole and good Form responses on Rorschach tests (19); and low educational attainment and foreign birth (22, 23). These observations were interpreted in sociological terms, suggesting that in an environment where verbal therapy was highly esteemed, patients least like the therapist in social and educational attributes were referred for

somatic (or non-verbal) therapy. With induced changes in brain function, the subjects with the least discriminative ability responded with such non-verbal behavioral modes as euphoria, hypomania, denial, displacement and minimization, and were rated as "much improved"; while those subjects with greater perceptual and linguistic discrimination responded with such more verbal patterns of paranoia, panic, somatization and anxiety, and were rated as "unimproved."

CONCLUSION

Variability in the degree of induced slow wave activity during convulsive therapy has been related to technical factors of the treatment. When these are held constant, however, variability is still manifest. In the present studies, EEG slowing has been related to pretreatment perceptual and EEG patterns. Patients with fewer total responses, fewer Movement responses, and absence of Human Movement, Color and Form-Color responses on the Rorschach, greater errors on figure-ground discrimination tasks, and higher percent time alpha activity had higher degrees of induced slow wave activity.

Physiological reactivity measured in EEG patterns, interpersonal behavior, personality measures and descriptions of clinical or verbal behavior are different aspects of the interaction of subjects with the environment. In this frame-work , EEG and personality variables are related within the limits of the sensitivity of the measures used.

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February 21, 1957

Individual Differences in EEG Responsivity

Max Fink, M.D.

1) Problem tonight is to present observations made in the laboratory of Experimental Psychiatry at the Hillside Hospital and then try to discuss their significance. We have no explanation but wish to present this material for the clarification it may bring.

The problem is to account for the variability in EEG response to electroshock.

The Observations:

1) Repeated EST induces EEG changes. These are of many kinds including disorganization of frequency; decrease in beta frequency, % time and amplitude; increase in delta % time and amplitude; delta bursts; spike discharges; increased sensitivity to hyperventilation, amobarbital, -

2) There is a direct relation in group data of (a) # of treatments with degree of induced EEG changes (b) frequency of treatment (c) type of treatment (gm or pm).

Note that our analyses are devoted to one aspect of the EEG response - i.e., delta.

The quantitative measurements were described here in 1955 by Dr. Kahn and myself and included were % time delta, highest % time delta, duration of bursts; slowest frequency and highest amplitude of delta.

3) But analysis of our records, so classified as high, middle and low demonstrated a definite relation between the EEG response and the "improvement" in the behavioral response.

Presented at the Metropolitan EEG Society, February 21, 1957.

In the first 24 patients, the following table was obtained:

	% High Abnormality			
	1-3	4-6	7-9	10-12
Much improved (11)	25	80	91	88
Moderately improved (6)	0	16	50	40
Unimproved (7)	0	0	0	20

We were first struck by this correlation, and, devoted the subsequent year to demonstrating the significance of this relationship. You may know of our conclusion - that, improvement in electroshock therapy requires the induction of a state of altered brain function, of which the EEG-delta index is a cardinal sign.

More recently, we took a second look at the part of our table which notes that 3 of 24 patients had high records within 1-3 treatments, and that after 10-12 treatments 5 patients still had not achieved a single high record! Why this difference?

Let me demonstrate some of our records to show the difference in EEG responsivity to electroshock.

It is important to note here that all treatments were given in the first series by Reiter instrument; and in the latest by Medcraft - three times a week. That extraneous factors as threshold or suprathreshold stimulus was eliminated, all recent treatments have been given at threshold stimulation, achieved by Dr. Green by repeated PM in increasing dosage until a seizure resulted.

1) High EEG response. - Lesnick

2) Moderate EEG response. - Baum

3) Low EEG response. - Silverwater

To what can we ascribe the difference in response? A number of factors immediately come to mind, and I will discuss each one briefly:

(a) Age:

Age is a factor in this varying responsivity, but not the significant one. It is true that some younger patients achieve high EEG abnormality early; as do some patients over 60; but an analysis of the data of our first two electroshock studies, for which I am indebted to Dr. Green, indicates age to play a small role.

Analyzing the records of 49 patients, Dr. Green divided the results into those above and below 45; above and below 50 - as significant cut-off points. There was a tendency for the older group to have lower EEG ratings in the 4-6 period; but by the 7-9 period, the difference was gone.

(b) Sex:

Clearly not a factor.

(c) Clinical diagnosis:

This factor is difficult to assess. As you know, clinical diagnoses have no independent reliability. They are approximate descriptions of clinical states and depend largely on the examiner's bias, experience, setting of the examination, purpose, etc; also on the patient's age; and only incidentally on any operationally defined observable pattern in the patient. For these reasons, this analysis is deferred.

However, gross inspection shows that patients with low reactivity have more often been called schizophrenic and paranoid, than involutional depressives and manic depressive- and that patients with high reactivity have more often been called involutional depressives and manic depressives than schizophrenia-paranora.

(d) Technical factors of treatment as frequency of treatment and type of treatment:

Both are significant factors, and since we are describing the results of individuals treated in groups in whom these factors were constant, we are not going to explain this further than to say that it is possible, in some instances, to convert a low EEG response to three times per week electroshock to a high EEG response by going from Reiter to Medcraft; or by going from three times per week to five times per week or twice a day. But these factors only amplify further the variation in response. Exp. DeFede

We have assumed that the development of cerebral changes, of which delta abnormality is a prototype, is the logical outcome of repeated electroshock. We have looked for an explanation, therefore, of the failure of delta to appear after adequate courses of shock.

It may be that not all patients respond to brain trauma by delta, but may respond by other changes (as increased beta voltages and frequency; or increased disorganization; or increased responsivity to hyperventilation). Regardless of the construction, a difference in responsivity exists, and is manifested in our series.

We have conceptualized the problem as one of "cerebral reactivity." The factors we have already outlined are important in such reactivity, as we have described, but we believe that more is involved. Out studies are now in the progress along the following lines:

1) The Factor of Personality: In the course of our study of factors which bare on the type of behavioral response to electroshock (i.e., denial, euphoria, paranoia, withdrawal -), we undertook a study of personality. To define personality is extremely difficult. But Dr. Kahn in our laboratory has done so by the use of a variety of indices. The Rorschach; an interview with relatives designed to elicit premorbid behavior, especially denial; figure-ground perception; tachistoscopic recognition of words, etc.

To our surprise, significant correlations between the degree of delta abnormality and two Rorschach factors (M & C) as well as the denial interview score were achieved. I have listed the table of M & C scores in our initial 63 patients, and the EEG responsivity.

The EEG's were done in the 4-6 and 7-9 treatment period. The negative score reflects a low or middle EEG response; the plus, a high response.

CHART IS THEN REFERRED TO

The significance of this chart is in the "apparent" diverse phenomena that it purports to relate. If borne out by future observations, it states, that patients who have no movement responses and either no color or color-form responses have 44% chance of high EEG delta response in the 2nd and 3rd week of treatment; while patients with Form-color responses have only a 16% chance for such a result.

Could it be that one's perception of the world is directly related to one's cerebral responsivity? Or, do the conditions which permit delta to appear, that is, those that require an ability to withdraw and assume a passive attitude as described by Ostow for alpha index, also midify the patient's response to the Rorschach?

We have become increasingly interested in this problem of passive attitude, or, as we choose to describe it - in the problem of "vigilance" - "alertness." In our laboratory, Drs. Pollack and Kahn are engaged in developing psychophysical measures of such "vigilance;" while we have become increasingly aware of the influence of the observer's activity on the ongoing EEG.

2) A second factor which interests us with regard to the problem of individual responsivity is the concept of physiologic reactivity. Electroshock

EEG Responsivity to ECT or R

	--	-H H-	HH	
OM OC	2 (17)	3 (25)	7 (58)	12
OM CF/C	4 (33)	4 (33)	4 (33)	12
M CF/C	3 (30)	3 (30)	4 (40)	10
M OC	1 (25)	1 (25)	2 (50)	4
OM FC	5 (71)	2 (29)	0 -	7
M FC	9 (50)	5 (28)	4 (22)	18
				63

5% level of conf.

	--	HH
OM-OC, OM CF	6	11
FC - M OM	14	4

is a way of inducing certain diffuse chemical changes in the nervous system. So is metrazol - barbiturate - hypoglycemia - hyperventilation. Each of these activation technics show significant variation in responsivity. For example, it is commonly known that hyperventilation induced delta readily in some patients - especially children - but in others, no such response is noted. Dr. Green of our laboratory has hypothesized, and is now studying, the possibility that a degree of physiologic responsivity - which is measurable - is an inherent characteristic of organisms. To this end, he is carrying out pretreatment activation records in all our subjects; as well as measuring their threshold for electrically induced convulsions.

I am confident that there are other "factors" on which the variation in EEG responsivity to electroshock - and perhaps to all activation - may depend. We are excited by the ones described, namely personality, vigilance, and physiologic responsivity.

We have emphasized tonight, not the common characteristic of the EEG response to activation, but the individual variability and the factors on which this depends. We have tried to exemplify our problem by our data of the variation in delta response to electroshock. Further study of each activation technic to relate the role of personality, vigilance and physiologic reactivity to the variation in EEG responsivity.

(Jewish), socio-economic (lower middle and upper lower class), immigrant and first generation, group. The psychiatric ~~reactive~~ behavior patterns ~~are primarily~~ were chiefly ideational ~~and~~ and mood, ~~responses.~~ They ~~are~~ were voluntary ~~patients,~~ hospitalized, predominantly in the first ~~hospitalization~~ time, with a short period (few months to few years) of psychiatric illness. Electroconvulsive treatment was administered three times a week using ~~xxxx~~ suprathreshold unidirectional or alternating current methods. The number of treatments varied from 10 to 30, with most patients ending treatment after 12-15 treatments.

Within a week prior to treatment subjects were tested with Rorschach and figure-ground discrimination tasks. The Rorschach protocol was scored for presence or absence of human movement responses (M), total movement responses (M + FM+ m), type and number of color responses (C, CF and FC) and total number of responses (R). In the figure-ground discrimination task, ~~which was Battersby's~~ modification of Gottschaldt's hidden figures, the subject is presented with a page containing two forms - a simple geometric figure, and below it a complex figure in which the simple figure is embedded. The task is to outline the embedded figure in the complex figure.

Figure I

Electroencephalograms were obtained prior to treatment, and at weekly intervals on a day following a treatment. Patients whose pre-treatment records contained

measurable delta activity were excluded from the study. The amount of induced slow wave activity was measured ~~visually~~ by determining the per-cent time of frequencies of 7 cps, ~~and less~~ or slower in three selected leads; the slowest frequency and highest amplitude of slow wave activity, and longest duration of burst activity in the record. Based on these indices, records were classified as "low," "moderate" or "high" degree ~~delta~~ slow wave activity, according to criteria previously described ( ). In the observations reported here, the development of high degrees ~~delta~~ (of slow wave) activity in the second and third weeks of treatment (~~1, 6, 7~~ 4-6, 7-9 treatment intervals) was used in the tabulation. Patients who developed high degrees of ~~delta~~ slow wave activity during either or both these periods were classed in the high degree group. Those whose records did not demonstrate the degrees of activity in either week were classed in the moderate-low class.

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TABLE IV

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In a similar analysis of the pre-treatment errirs in induced EEG variability alone, the difference just fails of significance (Table IBb).

4. Relation of Pre-Treatment EEG Pattern to EEG Variability.

Considering the variability in modulation, voltage, and frequency spectrum in the pre-treatment EEG amongst the subjects, an analysis of the relation between some of these characteristics and the EEG responsivity was made. An initial study ( ) of those patients whose pre-treatment EEG manifested slow wave activity had demonstrated that high degrees of delta activity appeared earlier and were sustained longer than in patients without such activity, confirming an earlier report of Kennard and Willner ( ).

As one approach to the problem, the pre-treatment per-cent time alpha activity was correlated with the degree of induced slow wave activity, measured as per-cent time of such activity.* In forty-four subjects, a correlation of +0.35, level significant at the .05, was observed during the fourth treatment week (10-12 treatment).

* Previously demonstrated as a correlation of +0.84 with degree of delta activity ( ).