THE EFFECT OF ELECTRO-CONVULSIVE THERAPY ON THE PSYCHO-GALVANIC RESPONSE

By

M. BASSETT, Dip.Soc.Sc.

and

W. ROSS ASHBY, M.A., M.D., D.P.M.

Department of Research, Barnwood House, Gloucester

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INTRODUCTION

THOUGH electro-convulsive therapy (E.C.T.) is one of our most useful treatments, its mode of action is still largely unknown, and this ignorance is preventing us from making it more successful and more widely applicable. Among its possible modes of action is the possibility of its having some "activating" action on the basal, and more particularly on the hypothalamic, structures. Such activation might be expected to show in the psycho-galvanic response (P.G.R.), and we have therefore investigated something of the relationship between them. Many of the facts that would justify this investigation need not be given here as they have been reviewed in previous publications (Ashby and Bassett, 1950; Ashby, 1952(b)).

Knowledge of the effect of E.C.T. on the P.G.R. may at least help in establishing a primary orientation in the question of how E.C.T. acts therapeutically; for at present the possibilities range from an action by some shock-like effect on the pituitary and other endocrines, through events in the psycho-analytic mechanisms, to a randomly distributed effect on the cerebral cortex, forcing disorganization and subsequent re-integration (Roth, 1952; Ashby, 1952(a)). Study of its effect on the P.G.R. may help to give such an orientation, and we decided therefore to follow the P.G.R. over the weeks of treatment, particularly with the aim of seeing whether the treatment would lead to any sustained increase in the patient's responsiveness.

Since we wished to follow the P.G.R. over some weeks, and therefore wished to get as smooth a curve as possible, we decided not to evoke the response by the use of emotionally toned words, since their effects might by expected to fluctuate widely, but to use more or less direct physical stimuli whose properties could be controlled within narrow limits. We therefore used such stimuli as a flash of light to the eye. We wished, however, to explore something of the subject's "higher" reactions to his environment, so we decided also to test his response to the merely threatened application of the physical stimulus, bringing the lamp into position but not making it flash. Various stimuli were used, as will be described below.

It was clear that the chief difficulty in the interpretation of the results would lie in assessing the effect of habituation—the universal tendency of the reacting organism to react less and less as a series of non-injurious and repetitive stimuli are given. Repetition there had to be, for the later results must be comparable with the earlier.

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Consideration suggested that it would be necessary to compare how the P.G.R. changed during E.C.T. with how it changed in other groups that were comparable but which did not have the treatment. Two other groups were therefore tested, as will be described below.

A number of minor factors had to be considered, but they can be described as they become relevant. We can now proceed to a description of the method used.

Apparatus and Tests

Our apparatus and method of testing followed the same basic form that we had used previously (Ashby and Bassett, 1950). The details need not be given here as they were given in the previous publication. Briefly, the subject's resistance was measured by a Wheatstone bridge and microammeter, the hands being immersed in saline. Before and after each stimulus the subject's resistance was measured, and the maximal deviation caused by the stimulus was noted.

The stimuli consisted of four fairly strong peripheral stimulations:

1. A pinch to the lobe of the left ear by a clip of standardized strength;
2. A smell of 2 per cent. (v/v) ammonia;
3. A brief flash of light from a "Photoflood" lamp held at fifteen inches from the eyes;
4. A touch on the right conjunctiva by a wisp of cotton wool.

At each session, each of these was given both by direct application and by threat; in the latter case the apparatus for the peripheral stimulation (clip, lamp, etc.) was brought near the patient so that he knew that stimulation was about to occur, but the actual stimulation was not given. (The two sets of stimuli will be distinguished below by the adjectives "Real" and "Threatened".) So that the subject should not know whether any given presentation was to be real or threatened, the eight stimuli were given, at each session, in random order, the actual order being obtained by the use of a table of random numbers (Fisher and Yates, 1938).

Subjects were tested over five weeks, usually for a week before commencing E.C.T. and then during the first four weeks of treatment. They were deliberately tested with a variety of intervals between convulsion and test, and were tested at various times of day, so that the effects of these factors could be assessed. So far as the clinical and administrative requirements allowed, a similar routine was followed for all. (Evidence will be given below suggesting that the minor variations were without significant effect on the conclusions drawn.)

The Subjects

The thirty-nine subjects were drawn from three groups:

1. Normal persons, volunteers from the staff (referred to below as "Normal");
2. Patients who did not receive E.C.T. (referred to below as "Untreated");
3. Patients who received E.C.T. (referred to below as "Treated").

Subjects of the first two groups were, of course, required as controls for those in the third. In all three groups, the majority were women.

(1) *The "Normal" Group*

Of the seven volunteers from the staff of the hospital, two were men and five women. The range of their ages was from 19 to 50. None, as far as is known, had had any psychiatric disability and all were in good physical health. They were studied chiefly in order to show the amount of habituation normally developed during the five-weeks' course of testing.

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(2) *The "Untreated" Group*

The sixteen subjects in this group were all in-patients, three being men and thirteen women. The range of their ages was from 17 to 60. They were all sufficiently co-operative to undergo the five weeks of rather monotonous testing and they were all clinically such that they would have had E.C.T. had not some extraneous factor prevented it. They were therefore closely similar to the group of patients that did have E.C.T. Clinically they included various conditions, chiefly depressions. Six of them received E.C.T. after the testing had been completed.

This group was required generally to act as control to the "Treated" group.

(3) *The "Treated" Group*

The sixteen subjects that formed this group, ten women and six men, were all in-patients. The range of their ages was from 17 to 62. The criterion for inclusion in the group was that they should be sufficiently co-operative and that E.C.T. should be commenced a week after the commencement of testing. Clinically, the group closely resembled the "Untreated".

It was this group's reaction to E.C.T. that formed the subject of the work.

Scale of Measurement

Experience over some weeks of preliminary testing showed that the responses to the four different stimuli (pinch, smell, flash and touch) were highly correlated. As this meant that the distinctions between them were hardly worth preserving, we decided that the basic "response" should be some function of the average of the four separate responses, the distinction between "Real" and "Threatened" being retained. The four responses (in divisions of the galvanometer deflection) were therefore averaged at once to give the basic "response". The question then arose, when response was to be compared with response, which scale would relate the responses most suitably.

The best method of converting the response into numerical form has been the subject of discussion for a number of years. It was recognized long ago that the size of the P.G.R. was dependent upon, among other factors, the initial resistance of the skin, and that a direct comparison of the deflections given on two different occasions was therefore not appropriate. To allow for this, the size of the response was often expressed as a percentage of the subject's mean reaction to all stimuli. Later, Hunt and Hunt (1935) compared five different ways of scoring the response; they found that the intercorrelation between the five methods approached unity, but nevertheless concluded that the absolute number of ohms change was preferable. Darrow (1937) suggested that a better method would be the use of a measure based on the logarithm of the conductance. Since then, the question has been studied thoroughly by Haggard. He tested a variety of functional forms on abundant and suitable material, and used modern statistical techniques to find the best. His views developed in two stages. He first (Haggard and Garner, 1946) showed that if the resting ohmic resistance is x ohms and the extreme resistance during the response is y ohms, then the function

$$\frac{\log_{10}(x-y)}{x} \quad \ldots\ldots \text{(A)}$$

was independent of the initial skin resistance over a wide range, even when the maximal responses were provoked by strong electrical shocks. He also showed that the residual variance of this expression was satisfactorily constant at the

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different levels of skin resistance, and also at the different levels of mean response.

He must, however, have been dissatisfied with this form for he later (1949) made further studies with new forms. Among the forms studied were the logarithm of the change in conductance

$$\log\left(\frac{1}{y}-\frac{1}{x}\right) \quad \ldots.(B)$$

and the change in the logarithm of the resistance

$$\log y - \log x,$$

which is the same, of course, as

$$\log\frac{y}{x} \quad \ldots.(C)$$

He came to the conclusion that form B was best.

Haggard, however, omitted zero responses from his calculations, and studied the best conversion of the remainder. In our work a zero response must be considered meaningful, and therefore as probably best not ignored. The inclusion of zero responses, however, makes his form B unusable, for when the response is zero form B becomes $-\infty$, a quantity that cannot be used in the subsequent arithmetic. His function C, however, was also shown by him to remain constant when, with constant stimulation, the skin resistance was made to vary over a range of 1,000 to 8,000 ohms. As, in addition, it transforms a zero response to zero, we used it to convert the skin resistance and observed deviation to a scale suitable for statistical treatment. For its computation a nomogram was constructed, allowing the value of the function to be read off when the subject's basic resistance and the number of divisions of deflection were known.

A minor question to be decided was whether to take account of the deflection's direction. Thus, if the responses were $+5$ and -5 divisions, should we take their simple average, and regard the "average response" as zero, which seemed artificial in this context, or should we take the average of their absolute values, and consider it to be 5? After consideration we decided on the latter. (In fact the decision mattered little as almost all responses were in the same direction.)

For convenience in computation we multiplied the function C by 1,000, and this multiple is the number used in the Figures below. So a value z in a Figure means that

$$\frac{y}{x} = \text{antilog}_{10}\left(\frac{\pm z}{1{,}000}\right);$$

thus "25 logarithmic units" means that (if the resistance fell)

$$\begin{aligned}\frac{y}{x} &= \text{antilog}_{10}\,(-0{\cdot}025)\\ &= \text{antilog}_{10}\,\bar{1}{\cdot}975\\ &= 0{\cdot}944,\end{aligned}$$

i.e. that the skin resistance fell by 5·6 per cent.

This measure, although more complex than a direct record of the change in ohms, has the advantage that both its size and its residual variance are almost entirely independent of the resting level of the skin resistance.

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With these methods were tested our series of patients, the actual testing being done throughout by one person (M.B.). The factors that were deliberately varied in order to explore the causal relationships were:

1. The sensory mode of the stimulation.
2. Whether the stimulation was real or threatened.
3. Whether the subject was psychiatrically normal or not.
4. The time of day of the test.
5. The time that had elapsed since the last convulsion.
6. The time that had elapsed since the testing or the E.C.T. had commenced.

Results

In this investigation we were hampered by the difficulty, common when working with patients, that the conditions could not be controlled and selected as they can with animals. The details of the testing could be controlled, but not the many factors relating to the patient's illness and recovery. We have been forced therefore to depart to some extent from the proper balance of test and control, deviating from the arrangement in which the factors would vary with strict orthogonality. When the orthogonality is incomplete, the statistical testing and the interpretation of the results become complex and less reliable.

Our results deviated, in their entirety, only slightly from the orthogonal, so we were often able, in the statistical analysis, to take a subset of our full results and thereby to get a group over which the factors varied with exact orthogonality. Where such a subset existed we have used it. Where none existed we have either used the next best approximation or have tested the factor over more than one set, so as to minimize any risk of error. In our description of the results below, we have confined our statements to those which we are satisfied are free from any serious risk of error.

The results will be given for each of the groups (normal, untreated, and treated) in turn, and then we will consider the point of the investigation, the comparison of group with group.

The "Normal" Group

Figure 1 shows how, on the average, the normal subjects reacted to the

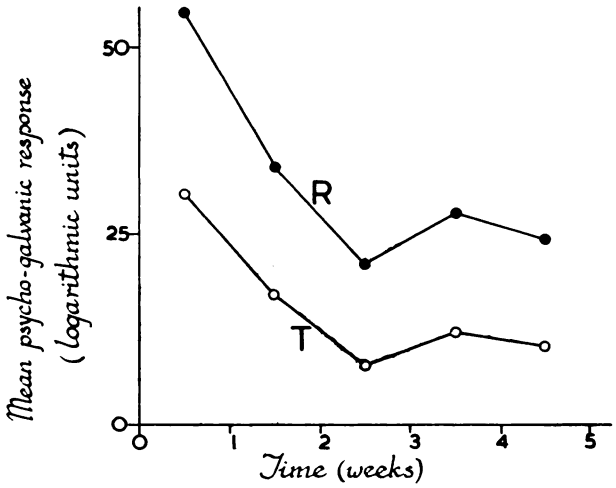


FIG. 1.—Average psycho-galvanic responses (in logarithmic units) to real (R) and to threatened (T) stimuli over five weeks of testing. Normal subjects.

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repeated testing; habituation is marked. The response fell over the first few weeks and then settled at a basic level. The change with time is significant statistically, for P is less than 0·001 when the averages are compared over the five weeks. The curves for Real and Threatened stimuli are similar, with the value for Real usually about twice as large as that for Threatened. (The difference between the mean heights, allowing for Time, is significant with $P<0·001$; there is no significant difference between the regressions: $P>0·05$.)

The average responses given at various times of the day by this group were:

	10 a.m.	12 noon	3 p.m.
Real	30·3	35·4	28·7
Threatened	15·0	17·5	14·6

The small differences, for given type of stimulus, are not significant statistically ($P>0·05$). Evidently time of day is not an important factor in this group.

The "Untreated" Group

Figure 2 shows how this group responded to the continued testing. Again the initial fall is marked; it is also significant as a regression, for P lies between

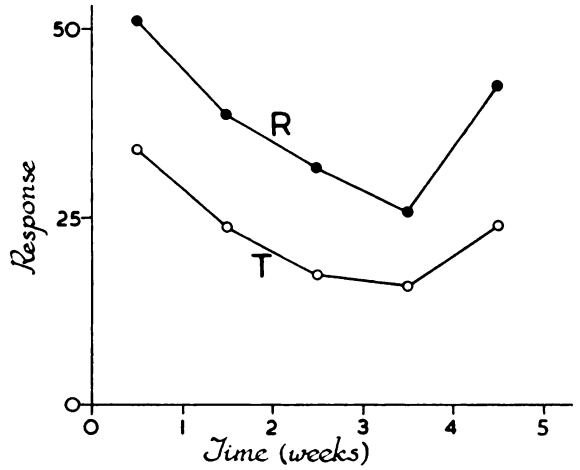


FIG. 2.—Average responses to real (R) and to threatened (T) stimuli over five weeks of testing. Untreated subjects.

0·01 and 0·001. The regressions for R and T do not differ significantly. The increase of response in the fifth week has an origin that is discussed later.

The difference in mean response between R and T is again significant ($P<0·001$).

The average responses given by this group at various times of the day were:

	10 a.m.	12 noon	3 p.m.
Real	52·9	42·3	30·6
Threatened	36·7	26·7	16·0

In this group the mean responses differ significantly with the same type of stimulus (P is between 0·01 and 0·001), contrasting with what was found in the Normal group.

The "Treated" Group

This group, it will be recalled, were tested while undergoing their course of treatment, which commenced after the first week's testing. As in the other two

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groups, the response to Real stimuli was always about twice as large as that to Threatened (Fig. 3). The difference between them was significant with $P<0{\cdot}001$.

The average responses given by this group at various times of the day were:

	10 a.m.	12 noon	3 p.m.
Real	33·3	41·8	36·2
Threatened	21·2	24·4	23·9

None of the changes is significant, a matter of some importance, as it might have been thought that our practice of giving E.C.T. in the morning would introduce a serious bias.

For the same reason we also studied how E.C.T. affected the P.G.R. within a few hours of the convulsion, for this knowledge was necessary in order to plan the general form of the investigation. Observations were therefore made of the patient's responses at three sessions held on the same day as the convulsion at $\frac{1}{2}$, $2\frac{1}{2}$, and $5\frac{1}{2}$ hours after it. Six patients were studied in this way; their average responses were:

	$\frac{1}{2}$ hour	$2\frac{1}{2}$ hour	$5\frac{1}{2}$ hour
Real	30·8	30·5	31·0
Threatened	20·2	19·9	22·3

Analysis of the variance showed that no significant difference exists between the responses at the times within the range covered. It is of interest to notice that E.C.T. has little effect on the P.G.R., even when the test is made only half an hour after the convulsion. (The skin resistance is usually much less, but the functional form C makes the appropriate allowance for this.)

This lack of effect over a few hours is confirmed when, in the Treated group, the average size of the response on the days in which a convulsion was given is compared with the average size on the days without convulsion. For real stimuli the effect is statistically insignificant, while for threatened stimuli the difference gave $P=0{\cdot}05$. On the whole, the effect is slight if it exists at all.

This being so, the factor "time of day at which the test was conducted" can be eliminated as ineffective within our system of testing.

We now come to the point of the experiment. Figure 3 shows the actual responses made by those in the Treated group, the commencement of the treat-

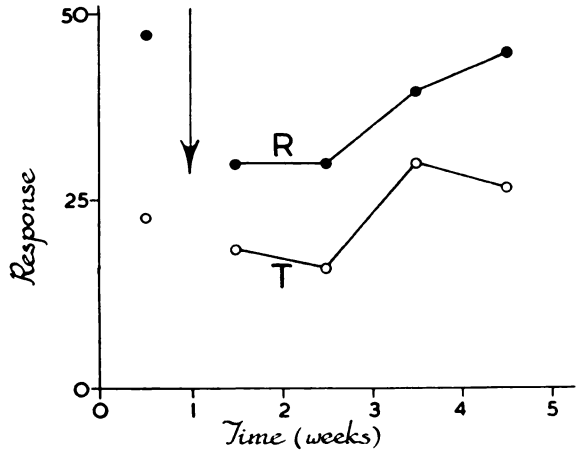


FIG. 3.—Average responses to real (R) and to threatened (T) stimuli over five weeks during which a course of E.C.T. was begun (at the arrow).

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ment being at the arrow. Before discussing its significance, however, we must consider the main complicating factor.

HABITUATION

We now come to the question of how much habituation is occurring in the Treated group while the course of E.C.T. is being given and while the E.C.T. is having its (unknown) effect on the P.G.R. Such habituation is, of course, tending to mask the effect we are trying to discover.

First the facts. Figure 3 shows how the Treated group changed, week by week, in their responses to real (R) and to threatened (T) stimuli. The two isolated points on the left show the responses before the treatment was started, and those to its right show the combined effects of the treatment and of the habituation.

An approximate assessment of the effect of the E.C.T. on the response can be made by comparing the curves in Figure 3 with those in Figures 1 and 2 (the curves for the Normal and Untreated groups). Habituation is most clearly seen in the Normal group; and inspection would suggest that the Treated group was showing some increase, in the later weeks, over the level produced by habituation. Some test of statistical significance is, however, required. Consideration suggests that the fitting of some elaborate curve, some high order polynomial, would be of dubious advantage, and a low order polynomial (straight line or parabola) is obviously inappropriate. The most suitable method seems to be to compare simply the averages of the three groups at each of the five weeks, giving five independent tests. Though somewhat insensitive, this method has the advantage of indicating significance only if the significance is unquestionable.

The results for the five weeks are as follows:

Week 1: The average *R* responses in the three groups show no significant differences; neither do the average *T* responses. (This homogeneity confirms our impression that the three groups of subjects were, so far as their P.G.R.s are concerned, sufficiently uniform before the E.C.T. was applied.)

Week 2: (As Week 1.)

Week 3: As Week 1 in the *R* responses. In their *T* responses, *P* was between 0·05 and 0·01, the responses in the Normal group being lower than those in the other two. (The difference is probably of little importance.)

Week 4: As Week 1 in the *R* responses. In the *T* responses, *P* was between 0·01 and 0·001, the responses in the Treated group being higher than those in the other two groups. This confirms, as statistically significant, the visual impression that the curve runs high in the Treated group (Fig. 3).

Week 5: In the *R* responses, *P* is less than 0·001; in the *T* responses, *P* is between 0·05 and 0·01. In each, the response is significantly larger in the Treated group.

The tests are thus decisive in showing that some real effect is tending to cause a rise in the later weeks, the value rising above that to which the response would sink by simple habituation. We now have to consider whether the effect is due to the E.C.T. or to some correlated factor.

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The "Recovery" Factor

We were interested in the question whether measurement of the P.G.R. would be of value for prognostic purposes and we therefore separated our results into two groups according to whether the patients did, or did not subsequently recover, and we did this of course, in both the Treated and the Untreated groups. We found that the size of the P.G.R., particularly in the fourth and fifth weeks of testing, was markedly dependent on this factor of whether or not recovery followed eventually. The results were therefore reanalysed completely. The full details need not be given here, as a new and more thorough investigation of the phenomenon is now in progress. We can, however, summarize the facts so far as they are necessary.

To display the relation more clearly, the responses to real and to threatened stimuli can be combined to a single "response" S by forming the linear function (or weighted average)

$$S = \frac{1}{3}(R+2T),$$

where R and T are the responses to real and to threatened stimuli. The loss of the distinction is of no importance here since the various parts of the investigation (e.g. Figs. 1, 2 and 3) have shown that the two responses have no individual peculiarity in their relations to the other factors.

The subjects in the Treated and Untreated groups were divided into Recovered and Not-recovered, the criteria being:

1. In the Treated group, the Recovered were those, and only those, who were discharged as "recovered" or "improved" within six weeks of the end of the convulsive treatment;
2. In the Untreated group, the Recovered were those, and only those, who were discharged as "recovered" or "improved" within 12 weeks of admission.

Examination of the groups showed that they were sufficiently well balanced for age, sex, and clinical condition to be comparable.

Figure 4 shows, by the contrast between the continuous (————) and the broken (– – – – – – –) lines, how the Recovered group differed from the Not-recovered in their responses (respectively) as time progressed. The

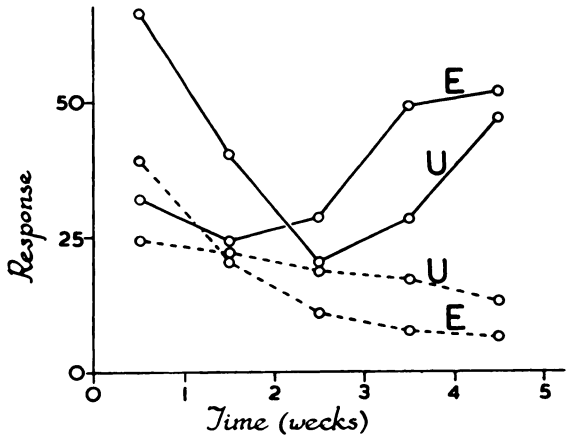


FIG. 4.—Average responses in the groups Recovered (————) and Not-recovered (– – – – – – –) over five weeks of testing. Curves for the Treated (E) and Untreated (U) groups are shown separately.

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results are shown separately for the Treated (E) and the Untreated (U) groups; it will be seen that they are in substantial agreement.

This visual impression was confirmed by an analysis of variance over the forty averages given by the forty combinations of the factors:

1. Between weeks (4 degrees of freedom).
2. Whether Recovered or Not-recovered (1 d.f.).
3. Whether Treated or Untreated (1 d.f.).
4. Whether Real or Threatened stimuli were used (1 d.f.).

(The latter distinction was restored as a check on whether any significant difference existed.)

Since the analysis of variance is decisive in this question, it is given in full.

TABLE

*Analysis of variance according to the factors as numbered in the text. First order interactions represented thus: 2/4. Under "Significance", * means "significant at the 5 per cent. level", and ** means "significant at the 1 per cent. level."*

Variance	D.F.	Sum Sq.	Mean Sq.	*F*	*P*	Significance
Between weeks ..	4	2,272.	568.	3·79	0·02	*
Recovery	1	4,494.	4,494.	29·9	0·001	** (a)
Treatment	1	73.	73.	—	—	0 (b)
Real or not	1	2,722.	2,722.	15·1	0·002	**
1/2	4	1,484.	371.	2·47	0·1	0
1/3	4	287.	72.	—	—	0
1/4	4	226.	56.	—	—	0
2/3	1	5.	5.	—	—	0
2/4	1	29.	29.	—	—	0
3/4	1	4.	4.	—	—	0
Higher order interactions ..	17	2,558.	150.	—	—	—
Total	39	14,154.	—	—	—	—

The factors are numbered for convenience as in the list just given. The significance of (a), in the right-hand column, and the insignificance of (b) are decisive in showing that it is the factor 2 ("Recovery"), and not factor 3 ("Treatment"), that correlates with the size of the response. The remainder of the table shows that no interaction was significant, so there is no reason to suspect that the relationships are complicated.

It seems therefore to be clear that *E.C.T. has little or no direct effect on the size of the P.G.R.*

DISCUSSION

So far as we can trace, there seem to have been no previous measurements of the effect of E.C.T. on the P.G.R. with which our results can be compared. Solomon *et al.* (1939) found that the P.G.R. was increased in those patients who recovered after metrazol or insulin—a finding compatible with ours. Funkenstein *et al.* (1950), though not working with the P.G.R., had similar results when testing the reactions of patients, especially those who had recovered after E.C.T., to adrenaline. They found that whenever the clinical state of the patient changed with E.C.T. autonomic changes were detectable. They also came to the conclusion that patients' responses to E.C.T. correlated better with their responses to test injections of adrenaline and mecholyl than with their diagnostic category.

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With regard to our own results, so little is known of the mechanism underlying the P.G.R. that only rather broad deductions can be made in regard to the question of how E.C.T. acts therapeutically. It is clear that our results must be regarded as unfavourable to those theories of E.C.T. that regard its action as being chiefly on some emotional factor or on the physical basis of such a factor. Were E.C.T. to work by making active some thalamic or hypothalamic centre, or even by working through the pituitary and adrenals, some increase in the average responsiveness would probably be seen. Figure 4 and the Table, however, show clearly that any rise that might be suggested by Figure 3 is to be attributed simply to the fact that the Treated group contains an undue number of patients who recover and not to the treatment *per se*. E.C.T. in itself is having little effect.

If E.C.T. is having little effect on the functions related to the emotions and the P.G.R., our work would, indirectly, tend to support those who hold that the action of E.C.T. is mostly direct on the cerebral cortex, where it produces a temporary disorganization, so that the normal processes of integration, given a new start, have another chance of developing a more normal pattern of behaviour (Roth, 1952; Ashby, 1952(a)). The question is, however, too large to be discussed adequately here; we merely remark that our results give it some indirect support.

The most striking finding of the investigation is that the size of the P.G.R. tends to go up in those who are about to recover; but as the matter is now under investigation, its discussion can be postponed.

Summary

Continuing our investigations into the mode of action of electro-convulsive therapy, we have studied its effect on the psycho-galvanic response.

Four different stimuli were used. Each was given both directly and in symbolic form. The responses were tested at various times after the convulsion and were also followed week by week after the commencement of treatment. Normal subjects were used as controls, and so were patients of similar clinical type who did not have the treatment. The number of responses observed was over six thousand.

We find that:

(1) In general, the effect of electro-convulsive therapy on the psycho-galvanic response is small.

(2) The effect of habituation, as session follows session, is marked.

(3) Most patients who are about to recover show an increased response, whether the recovery follows E.C.T. or is spontaneous.

We consider that our results favour the theory that E.C.T. acts directly on the cerebral cortex.

References

ASHBY, W. ROSS, *Design for a Brain*, 1952(a). London.
Idem, *J. Ment. Sci.*, 1952(b), **99**, 202.
Idem and BASSETT, M., *ibid.*, 1950, **96**, 458.
DARROW, C. W., *Arch. Neurol. Psychiat.*, 1937, **37**, 641.
FISHER, R. A., and YATES, F., *Statistical Tables*, 1938. Edinburgh.
FUNKENSTEIN, D. H., GREENBLATT, M., and SOLOMON, H. C., *Am. J. Psychiat.*, 1950, **106**, 901.
HAGGARD, E. A., and GARNER, W. R., *J. Exp. Psychol.*, 1946, **36**, 59.
HAGGARD, E. A., *J. Exp. Psychol.*, 1949, **39**, 378.
HUNT, W. A., and HUNT, E. B., *J. Exp. Psychol.*, 1935, **18**, 383.
ROTH, M., *J. Ment. Sci.*, 1952, **98**, 44.
SOLOMON, A. P., DARROW, C. W., and BLAUROCK, M., *Psychosom. Med.*, 1939, **1**, 118.

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