A NOTE ON THE USE OF THE PSYCHOGALVANIC REFLEX.

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THERE can be little doubt that the psychogalvanic reflex is the most delicate method yet devised for the detection and measurement of affective tone, and inasmuch as the latter appears to be the most important determinant of all mental states, it is clearly desirable to refine, by every means in our power, any technique adapted to its quantitative study.

One of the chief difficulties connected with the use of this method is that of making comparable with one another the reactions observed in different subjects and on different occasions. It might be supposed that the absolute magnitude of the reflex produced by such physical stimuli as pricks, burns, sudden noises and so forth, would afford an indication of the comparative 'emotivity[1]' of the subject concerned, and that this might be used as a 'vocational test' for occupations demanding self-control. But it was soon realised that factors other than emotivity greatly affect the absolute magnitude of the reflex which is, therefore, of small value as a test of that quality.

It is with this question of the comparability of reactions that the following observations are mainly concerned.

The phenomenon appears to be a very complex one and we are at present far from a thorough understanding of its mechanism. There seem to be, for instance, at least two clearly distinguishable forms of the reflex; first, a change in the effective resistance offered by the skin to the passage of an electric current and, second, a generated electromotive force which is independent of any current applied *ab extra*.

Of these two varieties the former is certainly a skin effect, though whether it is due to a change within the skin itself or to a change of polarisation at its surface is not yet clear. It is with this form that I shall concern myself below.

Many methods have been used for studying the reflex. Following Waller, I myself have always used a Wheatstone's bridge and D'Arsonval galvanometer in conjunction with two zinc-plate electrodes, covered with

[1] 'Emotivity' being here used to denote liability to react to an exciting stimulus.

wash-leather and soaked in a concentrated solution of common salt; these were applied to the palm and back of the subject's left hand which thus formed the external resistance of the bridge.

The following factors appear to be involved in determining the absolute magnitude of the galvanometer deflexion produced by a given stimulus:

(i) The intensity of the emotion actually evoked.

(ii) The proportion of it which finds expression through those efferent channels which innervate the skin-mechanisms responsible for the reflex.

(iii) The responsiveness of the skin to such innervation[1].

(iv) The initial resistance of the skin.

(v) The sensitivity of the galvanometer.

(vi) The magnitude of the fixed resistances of the bridge.

(vii) The E.M.F. applied to the bridge.

Of these, (i) is the quantity which we wish to measure, (v), (vi) and (vii) are easily kept constant or, if not, suitable corrections can be made on their account. Of the remainder, (iv) can readily be measured, and I deal below with the appropriate correction for it, but (ii) and (iii) are variables for which, at present, no allowance can be made.

I propose to deal here with the question of what correction should be applied to compensate for variations in the initial resistance of the skin.

This point is of importance for two reasons. First: even if we cannot eliminate all the causes of variation, other than (i) above, between different subjects, it is desirable to remove as many as we can, both with a view to closer study of those which remain and in order to reduce the amount of fortuitous variations to be neutralised by the use of such statistical methods as may be necessary. Second: if we are studying the behaviour of the same subject on different occasions we shall wish to make the results obtained as comparable as possible with respect to (i) and we may for the present assume that (ii), at least, and perhaps (iii) are not likely to vary greatly in the same subject from time to time.

One of the obvious results of a difference in resistance between two subjects will be that a heavier current will be passed through the subject of lower resistance than through the one of higher resistance (assuming the E.M.F. on the bridge to be kept constant).

It is easy to show experimentally that, in general, the greater the current passed through the subject, the greater is the absolute magnitude of his reactions. The question then arises whether this increased reaction

[1] I think it probable that this factor may, for all practical purposes, be subsumed under (ii) or (iv) or both.

is due simply to what I may call 'normal' electrical causes or whether, as has been suggested by Prideaux, the heavier current produces some definite effect on the subject of such a nature as to increase his 'irritability' quite apart from the increased deflexion which would be expected on purely electrical grounds. In other words, can the living subject be treated, so far as differences of initial skin resistance are concerned, as if he were an inanimate resistance whose changes we were observing?

This would be easy to determine if we could apply standard stimuli to subjects of different resistances and measure the deflexions produced. This procedure, however, appears to me impracticable, partly because a stimulus of small emotional import to one subject may arouse intense emotion in another and partly on account of possible and unknown effects due to the factors (ii) and (iii).

These difficulties can, however, be largely surmounted by the use of appropriate statistical methods.

In connexion with some experiments on memory and affective tone described in an earlier paper[1], I had occasion to apply a word-association test of 100 words to 50 different subjects, and to compute the mean resistance of each for the period of the test. I therefore first calculated the coefficient of correlation between the mean galvanometer deflexion and the mean resistance for these 50 subjects. Its value was $-\cdot 497$; that is to say, there is a strong tendency, as we would expect, for deflexions to increase as resistance decreases.

On general grounds it seemed probable that initial resistance and the deflexion produced by a given stimulus would be connected by a relation of the form

$$R^x D = K$$

when R is the initial resistance, D the deflexion and K a constant. I therefore calculated the values of the coefficient of variation for the expression, $R^x D$, for this series of 50 subjects, giving x the values 0, 1 and 2 successively.

The resulting values are:

x	C of V,
0	·656,
1	·572,
2	·704.

These values lie on the curve $V = \cdot 098x^2 - \cdot 182x + \cdot 656$, which has a minimum at the point $x = \cdot 925$; $V = \cdot 5717$.

[1] This *Journal* (Gen. Sect.), 1921, XI, 236.

That is to say the effect on the absolute magnitude of deflexions, of differing resistances of the subjects, can be more perfectly removed by multiplying the deflexions by $R^{\cdot 925}$*—which is substantially equal to R—than by any other power of R.*

(It may be noted that the improvement effected by using the expression $R^{\cdot 925}D$ instead of RD is inappreciable, for the coefficient of variation only changes from ·572 to ·5717.)

As a check on this, I substituted a resistance box for the subject and obtained by direct calibration the deflexions corresponding to a constant percentage decrease in resistances of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 thousand ohms. Similar treatment of these gave an optimum value for x of approximately ·9. We may therefore conclude that so far as variations of initial skin resistance are concerned, the subject does behave in substantially the same way as an inanimate resistance, and that the differences observed as the effect of passing a larger or smaller current through the subject are wholly due to normal electrical causes and not to any further effect of the current upon the subject himself.

It is not always necessary to apply this correction; but in cases where it is desirable to do so, the inconvenience of actually multiplying each deflexion by the resistance of the subject can be obviated by any one of the three methods described below.

(i) If we take a subject of resistance 1000 ohms, say, as 'standard' and use for such a subject a galvanometer shunt of x ohms selected so as to give deflexions of suitable size for ordinary stimuli (producing a decrease of resistance of about 2·5–3·0 per cent.), it is easy to obtain by calculation or, preferably, by direct calibration, the values of the shunts which will give the same deflexion for the same percentage decrease of resistance in the case of subjects of resistances 2000, 3000, 4000, etc., ohms. These values can be plotted graphically as ordinates against resistances as abscissae and the shunt appropriate to a subject of any resistance can be read off from the resulting graph.

(ii) Another method is to use no shunt on the galvanometer but to control the magnitude of the deflexions by varying the E.M.F. applied to the bridge by means of a potentiometer. Here again, the best procedure will be to calibrate the apparatus directly by substituting a resistance box for the subject, balancing resistances of 1, 2, 3, 4, 5, etc. thousand ohms on the bridge, reducing each of these when balanced by the same percentage—2·5 say—and adjusting the potentiometer so as to give the same deflexion in each case. Potentiometer adjustments can then be plotted against resistances as before.

(iii) A third method, which has the advantage that it requires considerably less apparatus than either of the foregoing, is to abolish the use of the bridge altogether and to employ a modification of Binswanger's arrangement described in Jung's *Studies in Word Association*, p. 446. The subject, battery and electrodes are here placed in series and no bridge is used[1].

When the subject is at rest and not stimulated, there will, of course, be an initial steady deflexion of the galvanometer. Assuming that the resistance of the latter and of the remainder of the circuit is small compared with that of the subject, and that the galvanometer deflexions are proportional to the current over the range in question, the deflexion will increase by a percentage equal to that by which the subject's resistance decreases.

Thus, for a subject of resistance 5000 ohms, the initial deflexion will be twice as great as for one of 10,000 ohms, and so will the added deflexion corresponding to any given stimulus.

If we interpose a potentiometer between the battery and the circuit, we can always pass the same current through the subject, thereby producing a constant initial deflexion and constant subsequent deflexions for the same percentage decrements in the subject's resistance, whatever the absolute magnitude of the latter may be. This is what is required.

The only disadvantage of this method is that the galvanometer always starts with a large deflexion of which only a small percentage increase is observed as the result of stimuli. In its simpler form it has, however, been successfully used by Binswanger, Veraguth and others, and its simplicity and cheapness are very much in its favour.

As I have observed above, it is not always necessary to apply a correction for the resistance of the subject by any of these means or by direct multiplication. The way in which results are handled and the form in which they are expressed should depend upon the objects of the experiments. Thus, if we are using the reflex merely as a 'complex indicator' in a word-association test—as a preliminary to psycho-analytic treatment, for example—no corrections of any sort need be applied, for all that concerns us is the *relative* degree of emotion evoked by the various stimulus words. If, on the other hand, we are seeking to ascertain which words of a list, or which members of a series of other stimuli provoke most emotion, on the average, in a given class of subjects, it will be best to express the reaction to each stimulus as a percentage of the mean

[1] An alternative arrangement combining the advantages of this with those of the bridge mentioned has been described by Prideaux (*Brain*, 1920, XLIII. 50–73).

reaction of the subject concerned for all the stimuli. Thus, if ten stimuli are applied to a given subject with the following results:

Stimulus	A	B	C	D	E	F	G	H	I	K
Reaction	7	3	9	14	2	11	8	6	12	5

of which reactions the arithmetic mean is 7·7, we should express the results for every such subject as follows:

Stimulus	A	B	C	D	E	F	G	H	I	K
Reaction (% of mean)	91	39	117	182	26	143	104	78	156	65

This eliminates not only variations due to resistance but also the danger of the results being unduly influenced by excessively large or small reactions, of whatever origin, on the part of a single subject.

Whether the arithmetic or the probable mean should be used will depend on circumstances; in nearly all cases the latter is preferable. But if we wish to compare the behaviour of different classes of subjects with respect to the psychogalvanic-reflex in general, it will be necessary to apply the correction for resistance. For the classes may differ by virtue of the factors (ii) and (iii) mentioned on p. 283 above, and this may be important. For instance, if we are comparing normal with mentally deficient persons, it may be, as is suggested by some as yet unpublished experiments by Prideaux, that the latter persons give very small reactions to all classes of stimuli because only a small proportion of the emotion aroused finds expression through the mechanisms responsible for the reflex, or because they have skins of resistance much higher than the normal, or because they really feel less—*i.e.* less emotion is actually aroused.

If the uncorrected results were simply averaged for a number of such defective persons and compared with the similarly treated results for normal persons, we could form no definite conclusions on the subject. Whereas, if due allowance is made for variations in skin resistance, any difference between the size of the reactions given by the two classes of subject can either be ascribed to this cause or, when it is eliminated, shown to be due to one or more of the others.

Finally, inasmuch as the phenomenon consists essentially in a lowering of the resistance of the skin, and as the percentage decrease of resistance appears to be, very approximately, directly proportional to the intensity of the emotion aroused, it is desirable that all results which are published with a view to comparison with those obtained by other experimenters should be expressed in terms of percentage decrement of resistance or, at least, that sufficient data should be given to enable the results to be reduced to these terms. Absolute deflexions are valueless for comparative purposes, as they depend so largely on the particular arrangement of apparatus used.

It may be of interest to note that in the case of the 50 subjects mentioned above to whom I applied a word-association test, the mean resistance for all subjects was 4400 ohms and the mean deflexion 7·32 mm. This corresponds, with my apparatus, to a decrement of resistance of about 2·3 per cent.

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