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Sedation Threshold, Autonomic Lability and the Excitation-Inhibition Theory of Personality

I. The Cold Pressor Test

By G. S. CLARIDGE, R. J. WAWMAN and M. H. DAVIES

Introduction

In a previous paper (Claridge and Herrington, 1960) it was demonstrated that by using a modified version of the sedation threshold technique, originally described by Shagass (1954), it was possible to differentiate neurotics diagnosed as hysterics and those diagnosed as anxiety states (dysthymics). In keeping with Eysenck's theory of neurosis (1955) and drug action (1957), it was found that dysthymics had significantly higher thresholds for sodium amylobarbitone than hysterics. In addition, supporting the earlier findings of Claridge (1960) and again Eysenck's theory of personality, dysthymics were found to have significantly longer visual after-effects to a rotating spiral than did hysterics.

Throughout the investigations leading up to the present series it has been felt that in neurotics the level of autonomic drive is an important determinant of the excitation-inhibition balance, variations in which account, according to Eysenck, for dysthymic and hysterical reactions. In the most recent of the papers (Claridge and Herrington, 1962) a good deal of evidence, both psychological and neurophysiological, was reviewed and further experiments described. As a result, the hypothesis was suggested that the level of central nervous excitability is maintained from two sources. The first source is the level of sensory afferent input, variations in which are thought to account for the excitation-inhibition balance, which Eysenck suggests is the underlying concomitant of introversion-extraversion. The second source of excitability, and one which is particularly important in neurotics, is the degree of autonomic reactivity (lability). The extreme positions of dysthymics and hysterics on tests said to measure Eysenck's *single* dimension of excitation-inhibition were thought to be due to the fact that these patients are, in effect, extreme with respect to both sources of total nervous excitability.

Some evidence supporting this hypothesis was presented in the paper quoted. Sedation threshold was found to correlate significantly with a measure of autonomic response, although the latter failed to correlate with Archimedes spiral after-effect, which, it was felt, might be more a measure of sensory excitation level. Because of the promising nature of these preliminary results, it was decided to carry out a more intensive investigation of the problem, using a variety of tests of autonomic function.

It is true, of course, that other workers have, without success, attempted to demonstrate a relationship between sedation threshold and autonomic response. Ackner and Pampiglione (1958), for example, report negative findings in this respect, while Shagass himself (1958) found no correlation between the sedation threshold and the blood pressure response to mecholyl (Funkenstein test). However, in recent years some doubt has been cast (Seager, 1960; Thorpe and Barker, 1957) on the reliability of Shagass' sedation threshold technique, which, with a variety of modifications, has been used by most workers, including Ackner and Pampiglione (*op. cit.*). By using what has proved over several years to be a more reliable index of the sedation threshold, it was hoped that less equivocal evidence would emerge of a relationship between autonomic response and barbiturate tolerance.

In the series of studies described here the

relationship was examined between the blood pressure response to three physical stressors and the basic measures used by Claridge and Herrington (1960), viz. sedation threshold, Archimedes spiral after-effect, and the two scales of the Maudsley Personality Inventory. For the first experiment, which is reported in this paper, the method chosen for inducing autonomic response was the cold pressor test. This is a simple and well-known physiological test, where the blood pressure response to cold water is measured. In the following two papers some work with autonomic drugs is described. In the first case, the well-known Funkenstein test was used, while in the second, the response to a drug not previously used in personality research was studied. This was phentolamine, a sympatholytic agent.

Description of Subjects

The investigation of the cold pressor test was carried out on 32 neurotic and 13 normal subjects, all male. The patients consisted of a group of mixed neurotics* tested as soon as possible after admission to hospital and before treatment. All available patients were taken who showed no evidence of psychosis, organic brain disease, or inadequacy. The normal subjects were volunteers from the hospital staff employed on a variety of duties, including that of nursing orderly, laboratory technician, kitchen orderly and clerk. The mean age of the neurotic group was 24·3, S.D. 4·40 years, and of the normal group 23·4, S.D. 5·03 years.

Experimental Procedure

Sedation threshold. This was determined in each subject according to the method described by Claridge and Herrington (1960), where details of the technique can be found. Briefly, the subject is asked to double digits played over a tape-recorder. While doing this he receives an intravenous injection of sodium amylobarbitone at the rate of 0·1 G/min. The injection is continued until the subject is consistently failing to respond. His sedation threshold is then expressed in terms of milligrammes of drug injected per kilogramme of body weight.

Archimedes spiral. Here the subject is asked to fixate a rotating spiral, which, when stopped, induces a visual after-effect taking the form of apparent rotation in the opposite direction. In the present investigation a four-throw spiral was used, a one minute fixation period being given with rotation in the direction required to give a contracting visual after-effect. Two trials of one minute each were given, the visual after-effect being recorded in seconds. The mean of the two trials was taken as a measure of the subject's performance on this test.

Cold pressor test. All blood pressure readings were taken by auscultation with the subject in a standing position. The systolic and diastolic blood pressures were taken once a minute for three minutes in order to obtain a basal reading. The subject was then asked to plunge the whole of the opposite hand into a vessel containing water kept, as far as possible, at a constant temperature of 4 degrees centigrade. The systolic and diastolic blood pressures were then taken once every half-minute for a further three minutes.

For both the systolic and diastolic pressures the following measures were computed on each subject:

(*a*) A measure of the pre-stress blood pressure level expressed in terms of the mean of the two readings prior to the cold pressor test. This will be referred to as pre-stress BP/Systolic or Diastolic as the case may be.

(*b*) A measure of change in blood pressure due to cold water, expressed in terms of the maximum change in pressure from the basal level as defined above. This will be referred to as the BP Rise/Systolic or Diastolic.

* The emphasis in this series of papers is less on the differences between extreme neurotic groups than on the inter-relationships between the different variables under investigation. For this reason, although the extreme examples of dysthymia and hysteria were not deliberately avoided, the selection of neurotic cases was not confined to those presenting with clear-cut symptoms of anxiety and hysteria. As a result, considerable overlap was expected, and was found, between the performance levels of neurotics and normals, a state of affairs which it was felt would facilitate, rather than handicap, our interpretation of the results.

(*c*) A measure of change in blood pressure due to cold water, expressed in terms of the area under the plotted blood pressure readings. The blood pressure readings for each subject were plotted on squared paper and the area of both rise and fall from the basal level was computed in arbitrary units. Areas of fall were considered as negative and subtracted from areas of rise to give the final measure of change. This index was felt to give a good overall estimate of autonomic reactivity, taking account as it does of the degree, the direction and the duration of the blood pressure response to the stressor. The measure will be referred to as BP Area/Systolic or Diastolic.

Results

Taking the total group of 45 subjects a number of product-moment correlations were carried out between, on the one hand, sedation threshold and spiral after-effect, and, on the other, the various measures of response on the cold pressor test. These correlations are shown in Table I,

Table I

Correlation between blood pressure, sedation threshold, and spiral after-effect

		Sedation Threshold	Spiral After-effect
Pre-stress BP	Systolic	+0·04	+0·30*
	Diastolic	+0·13	+0·37*
BP Rise	Systolic	+0·13	+0·01
	Diastolic	+0·18	−0·05
BP Area	Systolic	+0·16	+0·04
	Diastolic	+0·26	−0·10

*=p < 0·05 N=45

the blood pressure measures used including those of level and the two indices of response to cold water. Both the systolic and diastolic pressures were considered.

It can be seen from the table that the pre-stress level of blood pressure, both systolic and diastolic, correlated significantly with the spiral after-effect, although near-zero correlations were found between sedation threshold and both blood pressure measures.

Turning to the measures of blood pressure response, it can be seen that neither spiral after-effect nor sedation threshold correlate significantly with either measure of BP change, although the sedation threshold shows consistently higher correlations than the spiral after-effect.

Attention was then turned to the possibility that the measures of change may be dependent on the pre-stress resting levels. It is well-documented (e.g. Lacey, 1956) that the degree of autonomic disturbance following a stimulus is related to the level of autonomic activity obtaining before the application of the stimulus. Usually the correlation is a negative one, that is to say proportionately less change will be shown if the pre-stimulus level is high than if it is low.

Correlations were, therefore, calculated between pre-stress BP level and the four measures of BP change, viz. BP Rise/Systolic, BP Rise/Diastolic, BP Area/Systolic and BP Area/Diastolic. These are shown in Table II,

Table II

Correlations between pre-stress BP level and post-stress BP change

		BP Rise		BP Area	
		Systolic	Diastolic	Systolic	Diastolic
Pre-stress BP	Systolic	−0·36*	—	−0·28	—
	Diastolic	—	−0·34*	—	−0·35*

*=p < 0·05 N=45

where it can be seen that all correlations were, as expected, negative in sign. Only that between pre-stress level and BP Area/Systolic just failed to reach significance at the 0·05 level of confidence.

There was strong evidence, therefore, that on this test at least, the amount of change was partly a function of the pre-stress level of blood pressure. In view of this the relationship was re-examined between sedation threshold and the various measures of blood pressure change, partialling out the effect of pre-stress level. The appropriate partial correlation co-efficients are

shown in Table III. It can be seen that, by holding constant the effect of resting level, all correlations between blood pressure change and sedation threshold are increased, although only that with BP Area/Diastolic reaches an acceptable level of significance.

TABLE III

Partial correlations between BP change and sedation threshold

		Sedation Threshold
BP Rise	Systolic	+0·16
	Diastolic	+0·24
BP Area	Systolic	+0·18
	Diastolic	+0·33*

*=$p < 0.05$ N=45

DISCUSSION

The results reported here are suggestive, at least, of a relationship between barbiturate tolerance and the responsiveness of the autonomic nervous system. With a cold water stressor the diastolic blood pressure seems to be the measure most highly related, perhaps because the immediate and primary effect of cold water is to induce vasoconstriction and, therefore, increased peripheral resistance. This is expected to have its initial effect on the diastolic pressure. An overall index of the latter's response, seems superior to a single measure of maximum rise, probably because it maximizes individual differences in response. This is so because it takes account, not only of the extent of the BP change, but also of the speed of change and recovery of the blood pressure.

Confirming the previous findings, the Archimedes spiral after-effect showed no relationship with the measures of *change* in autonomic response, although a significant relationship with *level* of both systolic and diastolic pressures appeared. This would be consistent with the proposal of Claridge and Herrington (1962) that the two tests—spiral after-effect and sedation threshold—may measure basically different psychophysiological functions, the raised level of autonomic activity in those with long spiral after-effects simply being another reflection of the higher level of arousal in these subjects. Responsiveness to stress could be a separate process, characteristically neurotic. In this connection mention should be made of van der Merwe's (1948) demonstration of two factors in autonomic response, viz. "lability", differentiating neurotics from normals and "resting autonomic tone", differentiating neurotic introverts and extraverts. Further discussion of the theoretical implications of the results will, however, be delayed until the following papers, where more confirmatory evidence of the authors' point of view will be presented.

SUMMARY

The experiment reported was the first of three investigations of the relationship between sedation threshold and autonomic lability. The blood pressure response to cold water was examined in 32 neurotic and 13 normal subjects, on whom measures of sedation threshold and Archimedes spiral after-effect were also obtained. By partialling out the relationship between pre-stress level and post-stress change, consistently positive correlations were found between sedation threshold and blood pressure rise, although only in the case of one measure of the diastolic response was this significant. The spiral after-effect correlated significantly and positively with the pre-stress blood pressure level, which, in turn, showed a near-zero correlation with sedation threshold. These results were considered sufficiently encouraging for further investigations to be carried out, using more adequate measures of autonomic function. They were also held to support the view that it is necessary to hypothesize two sources of arousal to account for some of the postulates of Eysenck's theory of personality.

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G. S. Claridge, B.A., Ph.D., *Department of Experimental and Clinical Psychology, Barrow Hospital, Barrow Gurney, near Bristol*

R. J. Wawman, M.B., Ch.B., D.P.M., *The Queen Alexandra Military Hospital, Millbank, London, S.W.1*

M. H. Davies, M.B., B.Chir., D.T.M. and H., D.P.M., *Royal Victoria Hospital, Netley, near Southampton*