2 Psychophysiology and Personality: Extraversion, Neuroticism and Psychoticism

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Abstract In this chapter we consider the three major dimensions of personality as they emerge from a multitude of descriptive studies of personality, and look at major theories of the underlying psychophysiological causes for the observed differences in behaviour. Also given is a brief review of the evidence regarding the theories in question. Extraversion–introversion appears to be related to differences in cortical arousal, mediated by the reticular formation, in the sense that introverts are characterized by greater resting levels of arousal. Neuroticism–stability appears to be related to differences in limbic system functioning, mediated by the autonomic system, in the sense that unstable people are characterized by excessive function of these variables. Psychoticism appears to be linked with certain hormonal and biochemical secretions, such as serotonin and dopamine metabolites and with sex hormones. There seems to be little doubt that personality traits have a firm basis in the individual's biological structure and functioning.

This chapter deals with the underlying neurophysiological and hormonal bases of the major dimensions of human personality. The first few paragraphs will introduce the descriptive aspects of the personality theory in question, and the reasons for suspecting a strong biological involvement in the determination of individual differences along the various dimensions in question. The rest of the chapter deals with the research that has been carried out to verify or disprove the biological theories associated with the personality model discussed.

I. The Trait Model: Extraversion and Neuroticism

Essentially all successful models of personality are **trait models**; in other words, they describe differences in human behaviour in terms of a number of

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traits. These traits are usually found correlated together into higher order type concepts, such as extraversion, neuroticism and psychoticism. Trait concepts have been criticized by Gordon Allport (1937) on theoretical grounds, but in all his empirical work Allport and his students have nevertheless found it necessary to use trait concepts, very much like everyone else. Mischel (1976) has criticized the usefulness of trait concepts, and has advocated the importance of situational constraints on behaviour; this would seem an inappropriate dichotomy. All traits are manifested in situations and the situations are often specified directly in the very language of the trait nomenclature. Thus "sociability" relates to social situations, "persistence" relates to situations involving endurance, "impulsiveness" relates to situations involving spontaneous and non-thinking activity, etc. Eysenck and Eysenck (1980) have critically discussed the issues involved, and have come to the conclusion that the various criticisms of trait theory are not for the major part tenable.

On the whole, American authors prefer *lower level* trait concepts, like sociability, persistence and impulsiveness; British authors have on the whole preferred *higher order* concepts, i.e. type concepts based on the observed inter-correlations between traits. Figure 1 shows such a systematic higher order arrangement of two type-concepts, namely extraversion and neuroti-

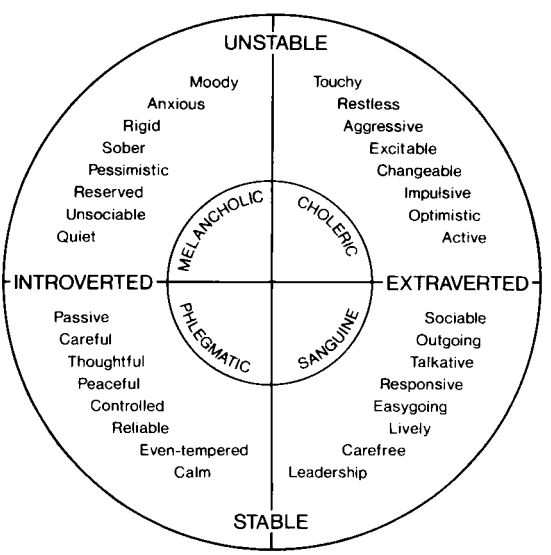

Fig. 1 *Diagrammatic representation of two major axes of personality: extraversion versus introversion, and emotional instability versus stability (neuroticism).*

cism; shown on the periphery are the traits which are found to be correlated. In the centre are found the four Greek temperaments which historically preceded the more modern view of dimensions, but which clearly demarcate the four quadrants into which the two independent dimensions subdivide the person's space.

These two dimensions have been found in very large numbers of descriptive studies, often using factor analysis of intercorrelation matrices as the statistical tool. A third major dimension, also frequently found in large scale factor analytic studies of personality, is psychoticism (Eysenck and Eysenck, 1976). This refers to a dimension the high scoring end of which is characterized by personalities that are cold, egocentric, hostile, suspicious, impersonal and aggressive. The opposite pole is sometimes called, following Freud, "superego". Royce (1973) has summarized the very large literature leading to the postulation of these three major dimensions of personality. It is not suggested that these are the *only* major dimensions of personality, merely that at the present state of knowledge these are the ones which have been most frequently found in large scale studies of intercorrelations between traits on various human populations. These dimensions have emerged not only from analyses of questionnaires administered to English speaking Western groups but also from quite different cultures, including Japanese, Nigerian, Indian, Hungarian, Greek, Yugoslav and many other nationalities and cultures (Eysenck and Eysenck, 1980). Note also that similar dimensions have been found in animal populations, particularly monkeys (Chamove *et al.*, 1972). It should be further noted that these personality dimensions are intimately linked with various types of behaviour of social importance. Thus antisocial behaviour and criminality are often found correlated with high P, high N and high E scores; this has been found true not only in Western countries but also in Communist and Third World countries (Eysenck, 1977a). Neurosis is usually associated with high N and low E personality types; psychosis and psychopathy with high P scores; drug addiction with high P and high N; and so forth. Sexual behaviour, smoking behaviour, drinking behaviour and many other types of behaviour have been found associated in a predictable manner with these three major dimensions of personality (Wilson, 1981). There are various links mediating this relationship. These will be understood better once we have looked at the physiological bases of these personality dimensions.

II. Heredity

Before turning to our discussion of the psychophysiology of personality, however, let us consider one important determinant of personality, namely

heredity. It used to be assumed until fairly recently that genetic factors played little part in the determination of differences in personality, but recent work has decisively contradicted this belief. Studies of identical twins brought up in separation, differences between monozygotic and dizygotic twins, studies of familial correlations and of adopted children have all demonstrated that the major dimensions of personality have a strong genetic basis, accounting for twice as much of the phenotypic variability as do environmental factors (Fulker, 1981). This is not the place to enter into the complex new methods of investigation and analysis that have been brought to bear on this topic in recent years; the fact of heritability is important because it suggests immediately that underlying individual differences in personality there must be biological factors of a psychophysiological or hormonal kind. Heredity cannot directly affect behaviour, it can only affect anatomical structures and physiological functions within the central nervous system, the autonomic nervous system, the hormonal system, or subsections of these systems. We turn, therefore, to theories and experiments in psychophysiology with the firm hope that these will throw some light on the nature and genesis of individual differences along the major personality dimensions.

III. Brain Mechanisms in Activation and Arousal

Let us first look at extraversion and neuroticism, because these dimensions have been prominent for a much longer time than psychoticism and theories regarding them are much more clearcut than those regarding psychoticism. Figure 2 shows in diagrammatic form a theory advanced by the present writer (Eysenck, 1967) to account for the major facts known about these dimensions. According to the theory, differences along the neuroticism-stability axis are produced by individual differences in the neurophysiology of the *limbic system* or *visceral brain*, the system which coordinates and governs the activities of the autonomic system in both its sympathetic and parasympathetic branches. Largely independent of this system, extraversion-introversion differences are determined by the *reticular formation-cortex* arousal loop, in the sense that extraverts tend to have lower resting arousal level than introverts. It is postulated that most of the time these two systems are indeed independent, but note that under conditions of strong limbic system activation there will be an overspill into the reticular formation, producing strong cortical arousal, so that under strong emotional stimulation it is impossible for the organism to remain in a state of low cortical arousal. For most of the time, of course, human beings are not in a state of high emotional arousal, and consequently for most of the time (including most laboratory investigations) the two systems are independent.

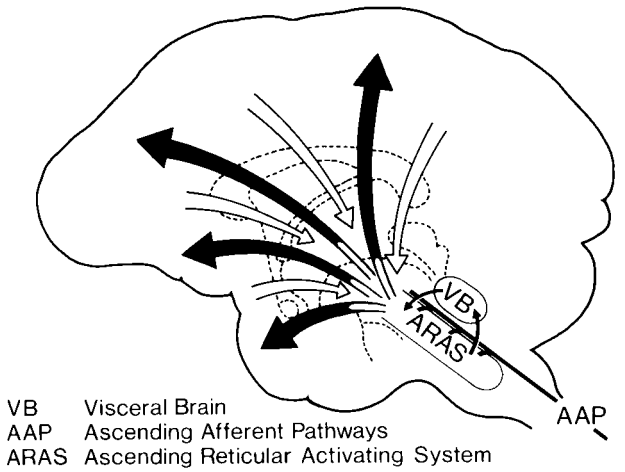

Fig. 2 *Diagram illustrating the hypothetical physiological basis of extraversion (reticular formation – cortical arousal) and neuroticism (limbic system or visceral brain).*

At first sight, the hypothesis that limbic system activation is responsible for individual differences in neuroticism may seem unlikely because of the well known facts that correlations between different measures of autonomic arousal are relatively poor, that there is considerable specificity of emotional reaction, and that correlations between autonomic measures and perceived emotionality are usually fairly low. This latter fact has given rise to the concept of desynchrony (Rachman and Hodgson, 1974; Hodgson and Rachman, 1974), in other words, the well substantiated fact that the three major aspects of emotional arousal (physiological, behavioural and introspective) tend to behave along rather independent lines.

While the facts are not in dispute, Thayer (1970) has suggested that the difficulties may be apparent rather than real. Using several different autonomic system variables, and recording individual reactions in these as well as giving state questionnaires of emotional arousal, he was able to show that, although the correlations between the physiological indices and between these indices and the questionnaires were all low, nevertheless, when the psychophysiological reaction scores were summed appropriately, they showed quite a high and acceptable correlation with the subject's emotional state, as recorded on the questionnaire. In other words, what seems to happen is that the individual is capable of *integrating* the input from several autonomic systems and interpreting this total input as emotional activation or arousal. Thus, experimental studies using only one autonomic input would not be expected to support the hypothesis strongly; what is needed are several different systems whose activation is measured simultaneously and combined

in a meaningful fashion. When this is done results become much more positive.

A similar point may be made with respect to the arousal system; here too measurement of arousal by a single index, whether EEG, GSR, evoked potentials, or CNV is unlikely to give results as positive as the combination of measures. The great majority of studies, unfortunately, has been restricted to a single measure, so that we cannot point to much experimental evidence for this deduction. However, the logic of the theory, and such data as we possess strongly suggests that multiple measurement is better than single measurement with respect to cortical arousal as well as autonomic activation.

A very thorough review of the whole literature has been given by Stelmack (1981), and no attempt will be made here to replicate this review. Before turning to a brief discussion of some of the major areas, however, one point needs to be stressed, because it is of vital importance in testing deductions from the hypotheses outlined above. This point relates to what Pavlov called "transmarginal inhibition", a concept that is similar to the so-called Yerkes-Dodson Law, or the inverse-U shaped relationship between drive and performance. To explain briefly, Pavlov first of all postulated the "law of strength", according to which reaction (say the growth of a conditioned response) increased *pari passu* with the *strength* of the unconditioned stimulus (see Chapter 9 by Strelau). By and large, of course, this is true, but he found that beyond a certain point the relationship became inverted, so that *further increase in the strength of the stimulus produced a weakening in the reaction*. He labelled this process "transmarginal inhibition" or "protective inhibition", his hypothesis being that the nerve cells of the subject were protecting themselves against too strong stimulation by evoking some form of inhibition. The neurophysiology underlying this concept is of course very unrealistic, but the phenomenon itself has been observed many times, in many different connections. A single example may suffice to illustrate its relevance to the measurement of extraversion–introversion.

On the hypothesis that introverts have a higher arousal level than extraverts, and that arousal facilitates Pavlovian conditioning, it has been predicted that introverts would condition better than extraverts (Eysenck, 1957). Using eyeblink conditioning to test this hypothesis, Eysenck and Levey (1972) tested groups of extraverts and introverts with a relatively weak puff strength (3 psi) and found the predicted relationship (Fig. 3). On Pavlovian principles, we should find an inversion of this relationship if we increase the strength of the puff to something like 6 psi, and when this was done Eysenck and Levey (1972) did indeed report that extraverts showed better conditioning that introverts (Fig. 4). In other words, there is a point in the continuum relating to strength of the unconditioned stimulus, where transmarginal inhibition reverses the relationship observed at lower levels. This, of course, is

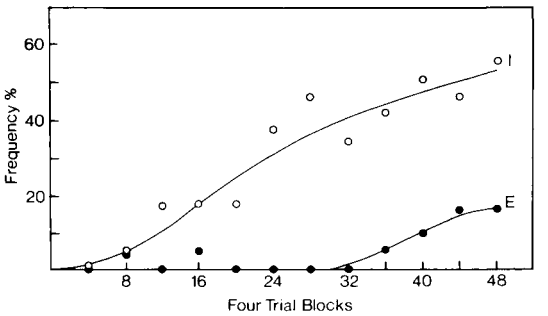

Fig. 3 *Rate of eyelid conditioning for introverts and extraverts under conditions of weak UCS, partial reinforcement and short CS–UCS interval.*

just an illustration; many other examples are found in the literature (Eysenck, 1967).

IV. The Evidence

Turning now to the actual evidence for or against the theory linking extraversion and arousal, we must first of all discuss EEG differences between the groups. This is because the concept of arousal has been intimately linked with the frequency and amplitude of alpha waves on the EEG, high arousal being linked with fast, low amplitude waves and lack of arousal with slow, high

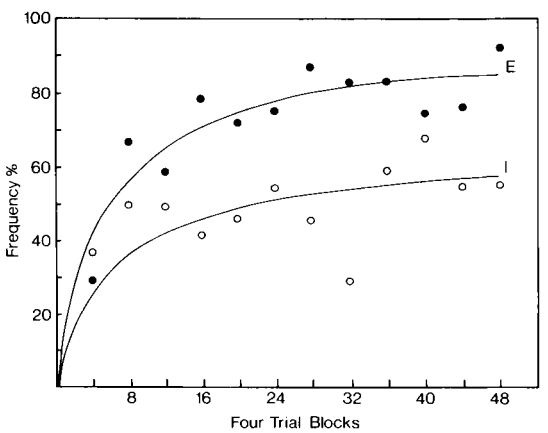

Fig. 4 *Rate of eyelid conditioning for extraverts and introverts under conditions of strong UCS, 100% reinforcement and long CS–UCS interval.*

amplitude waves. We would therefore expect that under resting conditions introverts would show the former type of waves and extraverts the latter. Gale (1973) has given a review of the fairly large literature on this topic which should be consulted in order to appreciate the complexity of the problem. As he points out, "There have been more than a dozen studies of this relationship and they have yielded three classes of outcome. Extraverts have been shown to be less aroused than introverts, more aroused than introverts, or equally aroused. . . . Can one make any sense out of such discrepant findings?" (p. 217). Gale suggests a generalization which takes into account the different *conditions* under which the EEG has been taken in the investigations summarized by him. "My general proposition is that when extraverts are either too bored with the procedure or too interested with the task, they will be more aroused than introverts. That is to say, a moderate level of arousal is required to optimize on the personality differences in this context. Where the extravert is too bored (habituation tasks, or simply lying with eyes closed) boredom leads to self-arousal, possibly involving imagining, which its turn activates the EEG. Where tasks are interesting (performing arithmetic problems, watching the Archimedes Spiral, talking to the experimenter) the extravert becomes aroused. With moderately arousing tasks (opening and shutting eyes upon instruction, or a simple eyes closed recording procedure in a laboratory which does not preclude sound of the experimenter's activities) the extraverted subject is more able to obey the instruction to relax and keep his mind clear." (p. 245). Gale gives a table showing that in three studies where the conditions are highly arousing, extraverts show greater arousal; in six studies where the conditions are likely to produce very low arousal, again extraverts show greater arousal. There are seven studies in which conditions are moderately arousing, and in all of these introverts show greater arousal. This outcome fits in very well with the notion of *transmarginal inhibition*, high arousal in the testing situation producing "protective inhibition" in the introvert but not the extravert.

The notion that experimental conditions which lack any arousing qualities should produce high arousal in extraverts may need an explanation. We may see the sort of thing that happens in an experiment on sensory deprivation reported by Tranel (1961). On the basis of our hypothesis, we would expect that introverts would be able to tolerate sensory deprivation better than extraverts. Studying 20 extraverts and 20 introverts, Tranel found that: "As a group, extraverts tolerated the isolation conditions significantly better than introverts in terms of time spent in the room." He also, however, discovered the reason for this unexpected result. Subjects had been instructed to lie quietly on their couch, to estimate the time every half hour and not to go to sleep. "In general the extraverts reacted by ignoring the instructions . . . while the introverts reacted by attempting to adhere rigidly to instruction." The

mean number of movements observed per minute was 0·38 for the extraverts and 0·23 for the introverts; the difference would have been much greater if some extraverts had not reacted by going to sleep. "All of the extraverts who spoke during isolation, with one exception, mentioned difficulty in keeping awake. None of the introverts mentioned such a difficulty." Tranel describes the behaviour of the extravert thus: "Extraverts largely ignored the instruction to lie quietly. They moved about quite freely and this movement was part of their coping behaviour. In other words, extraverts reverted to a form of self-stimulation in the form of tapping, moving, or exploration of the surroundings. They seemed to be much more concerned with devising ways to endure the situation than with following the instructions." Thus, conditions resembling sensory deprivation (such as those under which some EEG records were taken) are so intolerable to extraverts as to produce protective behaviour on their part which in turn is arousing, and produces EEG patterns characteristic of arousal. Looked at it in this way all the seemingly contradictory results fall into place.

Another EEG measure which has been used is the so-called CNV (contingent negative variation). An experiment by O'Connor (1980) illustrates very well the relationship between arousal and personality, and also the inversion due to the law of transmarginal inhibition. Subjects, i.e. groups of extraverts and introverts as determined by questionnaire responses, were tested under two conditions, one arousing, the other one not. The arousing condition consisted of smoking a cigarette (nicotine is well known to have stimulant pharmacological properties), while the non-arousing situation consisted of sham smoking, i.e. the subject manipulating an unlit cigarette. The CNV was used as a measure of arousal, and the prediction is shown in Fig. 5. Extraverts

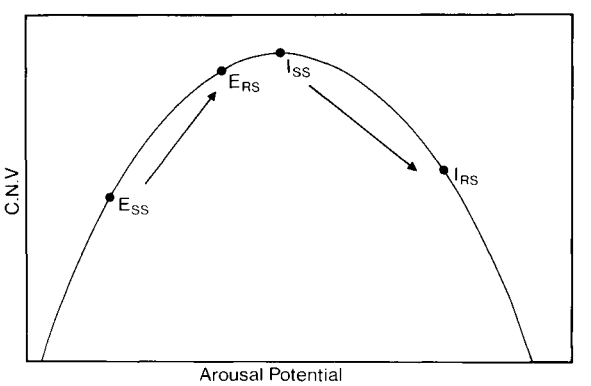

Fig. 5 *Diagram illustrating the theory linking arousal potential in introverts and extraverts with CNV measurement of arousal. (SS – sham smoking; RS – real smoking).*

are predicted to show lower CNV arousal than introverts under sham smoking conditions, i.e. $I_{SS}>E_{SS}$. After smoking a cigarette, however, extraverts would show an increase in CNV arousal, whereas introverts, due to the action of transmarginal inhibition, would show a decrement, as indicated by the arrows in Fig. 5. This is precisely what happened in the experiment, at a high level of significance; introverts showed greater arousal than extraverts under low arousal conditions, but after smoking a cigarette extraverts showed higher arousal than introverts.

Cortical evoked potentials are another EEG measure which has been studied in relation to extraversion–introversion. Stelmack (1981), in his review, points out that increased levels of cortical activity for introverts, inferred from the somatosensory evoked potential, have been reported by various authors, but there are also some negative findings.

There are many reasons for the apparent contradictions, thus for instance Stelmack *et al.* (1977) found the expected differences between extraverts and introverts with low frequency auditory stimulation, but not with high frequency auditory stimulation. Much greater attention will have to be paid to stimulus parameters before we can say that we fully understand the relationship between personality and the evoked potential.

Quite a different line of research has been concerned with the orienting response, which is usually accepted as an important precursor of the conditioning process. Here again, while the majority of studies are favourable, some are unfavourable to the hypothesis, as in the case of the EEG. As Stelmack points out, "it appears that conditions which favour differentiating between extraversion groups with the electrodermal measures of the OR can be described as moderately arousing, a consideration which may serve as a rough guide in the selection of stimulus conditions." In other words, here too, as in the case of the EEG, we find that it is absolutely imperative to have regard to stimulus conditions and other parameters of the experimental procedure if positive results are to be obtained. The similarity between these electrodermal studies, and the EEG ones summarized by Gale, is exactly what would be predicted on the basis of the general theory.

Other measures of electrodermal recording which have shown differences between introverts and extraverts along theoretically predictable lines have often been found to depend on the recording technique or circuitry employed and the type of transformations applied to the measures obtained. Significant differences between introverts and extraverts have been observed with both tonic and phasic measures, with differences in phasic response measures more frequently noted. As Stelmack points out, "differences in electrodermal activity between introverts and extraverts have been demonstrated with both simple auditory stimuli of moderate intensity and visual stimulation, and usually under non-stress conditions, where more than passive participation is

required. Electrodermal activity is typically greater for introverts than extraverts. Differences in phasic response, in particular with introverts showing more persistent electrodermal responses to repetitive stimulation, has been the effect most frequently observed . . . there is also some evidence that introverts demonstrate high skin conductance levels and greater frequency of nonspecific responses than extraverts. These observations imply differences in basic arousal processes and suggest that the effect is not exclusively stimulus bound."

Another series of studies has been concerned with the pupillary response. The iris muscle that circumscribes the pupillary aperture is reciprocally innervated by the autonomic nervous system and the effects of this system are particularly dominant in the pupillary light reflex. With the onset of a light stimulus, activity of primarily parasympathetic origin can be inferred from an initial rapid constriction phase that is then moderated by increasing sympathetic opposition, while the rapid redilation at the offset of the stimulus signals parasympathetic relaxation followed by slower redilation that is due to peripheral sympathetic activity. Introverts have been found to have larger tonic pupil size prior to stimulation (Frith, 1977; Stelmack and Mandelzys, 1975), which would support the association of introversion with higher levels of cortical arousal. The less intensive pupillary constriction during the pupillary light reflex for extraverts (Holmes, 1967; Frith, 1977) may also be interpreted along the same lines, but rather less unequivocally.

While on the whole the evidence in favour of the hypothesis linking arousal with introversion is reasonably convincing, studies of the hypothesis linking neuroticism with the limbic system have been rather more ambiguous. There are many reasons for this. One of these is the difficulty of inducing high autonomic activation under laboratory conditions, which would usually be regarded as unethical. Thus, we have to rely on quite mild degrees of stimulation which may not be sufficient for practical purposes. Second, we have the difficulties associated with the law of initial value, which tells us that increases in autonomic activity are dependent on the initial state of the organism; this is seldom similar for high and low N scorers under laboratory conditions of testing. Third, we have ceiling conditions which make it impossible for high N scorers to obtain higher levels after successful autonomic stimulation than low N scorers. Possibly the most successful way of discovering differences in autonomic functioning between high and low N scorers is to look at the terminal phase of the experiment, i.e. the length of time needed after stimulation to reach base level again. Here longer periods seem to be required by high N scorers than by low N scorers (Eysenck, 1967).

As an example of the kind of results found, we may refer to a study by Kelly and Martin (1969), who reported significant differences between neurotic patients and control groups differing in degree of neuroticism for tonic levels

of heart rate, blood pressure and blood flow during an unstressful control period, a result consistent with expectations of high sympathetic activity for high neuroticism subjects who have experienced chronic or reactive anxiety states. No differences in these measures were evident during a stressful mental arithmetic task, a failure presumably due to ceiling effects associated with the obvious agreement of the results with the law of initial value. A review of similar studies employing anxiety–neurotic patients (Lader, 1969) also suggested that patient groups are generally autonomically less reactive than controls and draws attention to the possible limiting of responsiveness due to initially raised pre-stimulus levels in patient groups.

Along similar lines, using normal subjects, Katkin (1975) has observed that under high stress conditions (that of shock) no differences between groups emerged when these are defined in terms of manifest anxiety scores, but that under moderate levels of stress (mild ego-involving threat) subjects with high trait anxiety showed greater increase in number of electrodermal responses than subjects with low trait anxiety scores. Mention of these two different stressors (shock and ego threat) suggests another possibility, discussed by Saltz (1970), namely that pain-induced stress may have quite different and indeed opposite results. Thus, the studies that have been done in this field require to be evaluated with respect to the type of stress imposed; neuroticism according to Saltz, is related to failure-induced stress, but not to pain-induced stress.

V. Brain Mechanisms and Behaviour

Having looked in some brief outline at the experimental support for the general hypotheses of physiological bases for neuroticism and introversion–extraversion, we must next look at the links between these bases and the types of behaviour which originally gave rise to the descriptive concept of extraversion and neuroticism. In the case of neuroticism the relation is a fairly direct one; the items on a questionnaire defining neuroticism are items directly describing strong emotional reactions which persist longer than usual, are easier to evoke than usual, and are stronger than normal. In addition, however, we must bear in mind than in the Hullian system anxiety has the status of a drive, and that Spence, in particular, has been arguing, with the support of a large body of experimental data, that anxiety-neuroticism drive is very important in producing individual differences in learning. Thus, the learning of stimulus–response sequences already having some habit strength would be facilitated by high anxiety, while the learning of stimulus–response sequences having low response probabilities would be made more difficult by high anxiety. A detailed discussion of these hypotheses and the

evidence relating to them is given by Eysenck (1973), who on the whole comes to the conclusion that much of the evidence supports Spence's view.

Turning to the relationship between arousal and the social consequences of extraversion–introversion, we have two major links. The first of these has already been mentioned, in connection with the Eysenck and Levey experiment on conditioning. If under most ordinary conditions introverts form conditioned responses more strongly, more easily, and more lastingly than extraverts, then all those behaviour patterns controlled by conditioning contingencies would be expected to show differences in favour of introverts. This would account for the connection between introversion and neurosis (introverts condition the emotional behaviours characteristic of neurosis more readily than do extraverts – Eysenck, 1977a). If we assume, as the author does, that socialized behaviour is acquired through a Pavlovian conditioning process responsible for the creation of a "conscience" (Eysenck, 1977b), then the difficulties that extraverts have in forming strong conditioned responses would be responsible for their more antisocial and even criminal type of behaviour. These suggestions will of course sound much more dogmatic than they are meant to, because of the lack of space to develop the theories in question; readers will have to look at the actual research evidence in order to find the support given there to these hypotheses.

A rather different connection is made in terms of the relationship between level of arousal and hedonic tone (Fig. 6). There is much evidence to show that very low sensory input (sensory deprivation), associated with very low arousal, and very high intensity sensory input (pain), leading to very high levels of arousal, are both unpleasant and produce negative hedonic tone. Preferred levels of sensory stimulation, and of arousal, are intermediate, as

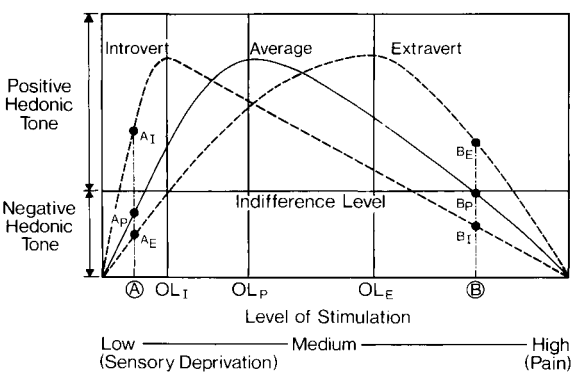

Fig. 6 *Relationship between level of stimulation and hedonic tone, for the general population, introverts and extraverts.*

shown by the central curve in the diagram. When identical conditions of sensory stimulation impinge on organisms differing in their resting level of arousal, then the resulting curve would be displaced to the left (in the case of introverts) or to the right (in the case of extraverts). This would equally displace the optimal level of stimulation (O.L.) from the general population mean in the centre to the left or right respectively. Sensory stimulation at extremes, such as points A and B, would be at the indifference level of hedonic tone for the average person, but would be positive or negative respectively for extraverts and introverts (Eysenck, 1967.)

We would thus postulate that extraverts would seek strong sensory stimulation, whereas introverts would seek to avoid it. This may account, for instance, for the sociability of extraverts; other human beings produce strong arousal in most people and extraverts seek this arousal, while introverts wish to avoid it. There is much evidence along all these lines (Eysenck, 1980) as well as regarding the obvious experimental deductions to be made from Fig. 6, namely that introverts would be more tolerant of sensory deprivation, extraverts of physical pain.

VI. Biological Bases of Psychoticism

There is no more space to delve into the complexities of the situation, which inevitably cannot be discussed in a brief chapter such as this. We must turn finally to a discussion of what is known about the biological bases of our last personality variable, namely psychoticism. A continuum of this kind was postulated originally because much work had shown that psychoses are not *qualitatively* differentiated from normal states, but tend to blend imperceptibly into odd and unusual personalities, and finally into normal human behaviour. Psychiatric research, much of it German, has indicated the existence of a psychotic "Erbkreis", i.e. genetic connections between the different types of functional psychosis, such as schizophrenia and manic depressive illness, and also between these and psychopathy, alcoholism, criminality, drug addiction, and various types of odd and unusual behaviour. These connections were found by looking at the relatives of schizophrenic or manic depressive probands, where it was found that these relatives showed these aberrations in much larger number than would be expected by chance. (Note that the relatives of psychotic probands did not show neurotic behaviour to any greater extent; this is strong support for the hypothesis that psychosis and neurosis are quite separate types of disorder – Eysenck, 1972).

We have several clues as to the direction in which to look for biological correlates of psychoticism. One of these is obviously the fact that psychotics, particularly schizophrenics, are characterized by certain biological features

which would be expected to be found in high P scorers. Thus schizophrenics are differentiated from non-schizophrenics by serotonin level, and it has been found that psychoticism is significantly correlated with serotonin metabolites in normal groups (Schalling, personal communication). Similar findings have been made with respect to dopamine metabolites and to MAO (ibid.).

Schizophrenia has also been found to be associated with the human leucocyte antigen (HLA) system (McGuffin, 1979). Some recent unpublished work has shown that, in schizophrenic groups, those with HLA had much higher psychoticism scores than those not having HLA. These lines of evidence strongly support a biological basis of psychoticism.

Another line of research originated from the fact that males tend to have much higher P scores than females. This is in good agreement with the behavioural connotations of high P, it is in good agreement with the fact that criminals tend to be mostly male, and also that psychosis is related to maleness. We would consequently expect sex hormone differences between high and low P scorers, and while the evidence is not conclusive it is certainly suggestive of such a relationship (Eysenck and Eysenck, 1976). Unfortunately, psychoticism scales have only been in existence for a few years, so that not enough is known about the biological foundations of psychoticism to say much more than this; clearly the field is in a very interesting state and much research will no doubt be done in the near future to clarify these issues.

Many other chapters in this book deal with issues relevant to this chapter, particularly the chapters by Gray, Zuckerman, Buchsbaum *et al.*, Strelau, O'Gorman, Blackburn, and Lader. What is beginning to emerge is a model of personality (Eysenck, 1980) which covers a good deal of ground, which is internally consistent and which links experimental psychology, social psychology and physiological psychology through the intermediate concept of personality. By also bringing into the picture genetics, biochemistry, and other biological sciences, this set of theories attempts to put forward a proper biosocial model of man which neglects neither the social nor the biological side of human nature, and tries to integrate both with whatever is known about the psychology of human beings.

VII. Summary

In this chapter, we have looked at some of the evidence linking physiological and hormonal functioning with the major personality dimensions. On the whole, the conclusion seems to be that there is good support for the major hypotheses linking these two areas, but it must also be added that there are many difficulties in the way of finding experimental support for deductions from the theories in question. The existence of curvilinear relations of a

prominent kind (Pavlov's law of transmarginal inhibition, the Yerkes-Dodson law, the law of inverse-U relation) is one such example. Others are the law of initial value, the law of ceiling effects, the rules concerning desynchrony of physiological, behavioural and verbal indices of emotion, and many others. Attempts at verification of hypotheses linking personality and psychophysiology must be very careful in taking parameter values into account which can often be derived from knowledge of these laws; when this is not done, the outcome of experiments cannot be predicted, and the results are not clearly related to theory. Research seems to be moving into a better understanding of these general rules of procedure, and it is to be hoped that future work will clarify many of the anomalies which still cloud some of the issues in this field. This qualification does not affect our main conclusion, namely that *no clear understanding of individual differences can be gained without close attention to the role of psychophysiological variables.*

Further Reading

Eysenck, H. J. (ed.), (1981). "A Model for Personality". Springer Verlag, New York.
A full account of the present position with respect to the various aspects of the writer's personality theory is given in this edited book. This includes a summary chapter on the psychophysiology of personality, and another one on genetics and personality research. An earlier presentation of the model is given in:
Eysenck, H. J. (1967). "A Biological Basis of Personality". C. C. Thomas, Springfield.
Nebylitsyn, V. D. and Gray, J. A. (1972). "Biological Bases of Individual Differences". Academic Press, New York and London.
Another directly relevant book, which is concerned also with the Pavlov–Teplov–Nebylitsyn system of personality description and its relation to Western systems.
Hobson, J. A. and Brazier, M. A. (eds.), (1980). "The Reticular Formation Revisited". Raven Press, New York.
This book provides an up-to-date detailed discussion of the reticular formation.
Fulker, D. W. (1981). The genetic and environmental architecture of psychoticism, extraversion and neuroticism. *In* "A Model for Personality" (H. J. Eysenck, ed.). Springer Verlag, New York.
Fulker discusses in a critical manner the genetics of personality. He also provides an excellent introduction to modern methods of biometrical genetical analysis. For a textbook treatment of these methods, see:
Mather, K. and Jinks, J. L. (1971). "Biometrical Genetics". Chapman and Hall, London.
The following two books present reprints of important papers in this general area:
Eysenck, H. J. (1976). "The Measurement of Personality". Medical and Technical Publications, Lancaster.
Prentky, R. A. (1979). "The Biological Aspects of Normal Personality". Medical and Technical Publications, Lancaster.
A general review of extraversion–intraversion is given by Morris in:
Morris, L. W. (1979). "Extraversion and Introversion". Hemisphere, New York.

Eysenck, H. J. and Eysenck, S. B. G. (1969). "Personality Structure and Measurement". Routledge and Kegan Paul, London.
This book provides a thorough discussion of the descriptive basis of the personality system used in this chapter.

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