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Plenum Press • New York and London

CHAPTER 5

*Concepts of Activation and
Arousal in the Theory of
Emotionality (Neuroticism)*

A Multivariate Conceptualization

JOCHEN FAHRENBERG

INTRODUCTION

Autonomic arousal and cortical arousal are essential concepts in Eysenck's theory of personality because individual differences in these functions are related to the well-known dimensions of emotionality (neuroticism) and extraversion-introversion. Psychophysiological personality research has been strongly influenced by these postulates, although autonomic and cortical arousal are theoretical constructs that still lack consistent operationalizations. Research has not yet produced standard patterns or dimensions of physiological processes specifying the CNS, ANS, and behavioral parameters that define the concepts and those that do not. No standardized assessment has been put forth to reliably measure individual differences and to allow for cross-laboratory comparison and, thus, for possible integration of experimental results. An evaluation of the contradictory research evidence remains extremely difficult.

Research on habitual physiological correlates of emotionality has

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been particularly frustrating. As soon as the correlation analysis is restricted to the questionnaire level there can, however, be no serious doubt that the empirical data strongly suggest the notion of a second order trait dimension of emotionality (neuroticism). Many investigators have observed positive correlations between an individual's N (neuroticism)-score and the reported frequency as well as subjectively rated intensity of complaints on various autonomic, sensory, and somatic functions, fatigue, stress, and so on. Such findings on a general trait of nervousness or psychosomatic irritability are at variance with findings from psychophysiological research: Correlations between an individual's N-score and objectively assessed measures of physiological reactivity are low and in most cases insignificant. This state of affairs could lead to retaining the null hypothesis or could elicit argumentation leading to conceptual clarification and more advanced research programs.

In this chapter, Eysenck's notion of autonomic arousal (activation) is discussed from several points of view. Neither a complete review of the experimental literature nor a comprehensive historical account of the development of this theory is intended. The discussion is mainly based on a series of psychophysiological experiments and questionnaire studies from the Forschungsgruppe Psychophysiologie, University of Freiburg, conducted during the last 20 years. Subsequently, a number of research perspectives are formulated as well as general heuristics that could be of strategic use to further developing and theoretically refining the important issues and, hopefully, help to solve the puzzling contradiction in research on emotionality.

EMOTIONALITY (NEUROTICISM) AS ASSESSED BY QUESTIONNAIRE

Clinical descriptions of nervousness that date back to Whytt (1765) depict a syndrome of mood fluctuation and irritability associated with sleeplessness and many physical complaints of autonomic, somatic, and sensory dysfunctions. Such items have been used in questionnaires to assess individual differences in emotionality and anxiety. This nervousness syndrome is also obvious in Eysenck's Maudsley Medical Questionnaire (MMQ) and subsequent inventories—MPI, EPI, and EPQ (Eysenck & Eysenck, 1969, 1976). Emotionality is a second-order personality dimension comprising such first-order components as mood fluctuations, sleeplessness, nervousness, irritability, sensitivity, inferiority feelings, and absentmindedness. However, somatic complaints were gradually omitted during test development and the EPQ-N-scale now

retains only a few items of this kind: sleeplessness, tiredness, and fidgetiness.

A considerably higher proportion of somatic complaints is included in the item pool of the *Freiburger Persönlichkeitsinventar* (FPI), a personality inventory that is widely used in Germany (Fahrenberg & Selg, 1970). The FPI-1 Nervousness scale represents a broad spectrum of somatic and psychosomatic complaints. An even more extended item pool was used in factor analyses to develop the 10 scales, 6 to 10 items each, of the *Freiburger Beschwerdenliste* (FBL) (Questionnaire for Somatic Complaints, Fahrenberg, 1975): General State of Health, Emotional Reactivity, Cardiovascular, Gastrointestinal, Nose and Throat, Tension, Sensory, Pain, Motoric, Skin, and Somatic Complaint Total Score.

The FPI consists of 10 first-order scales and, additionally, 2 second-order scales—FPI-E and FPI-N. The latter were derived during this test construction to match Eysenck's concepts. At that stage, FPI-N did not contain any somatic complaint items in order to investigate the relationship between Emotionality and FPI-1 Nervousness. Although the content of the items did not overlap, a substantial correlation exists between FPI-N and FPI-1, namely $r = .64$ ($N = 3318$ normal subjects, male and female, with an age range from 15 to 84 years). With respect to particular dimensions of somatic complaints, subsequent investigations revealed consistent relationships between Emotionality (FPI-N) and all of the 10 FBL scales with a correlation between FPI-N and FBL-11 (total score) on the order of $r = .55$ (Fahrenberg, 1975; Hampel & Fahrenberg, 1982; Myrtek, 1984).

The revised FPI-R (brought out in 1984) now reunites emotionality items and somatic complaint items to give an integrated FPI-R-N second-order dimension (Fahrenberg, Hampel, & Selg, 1984). Based on a sample of 2035 adults 16 years and older that are representative of the population of the Federal Republic of Germany, it may be concluded that Emotionality (FPI-R-N) is substantially related to the first-order factors, Life Satisfaction ($r = -.64$), Strain (.61), Irritability (.58), and Somatic Complaints (.55). Consequently, it can be reliably predicted that individuals who report mood fluctuations, irritability, worry, and feelings of inferiority will also report more frequently and more intensely various autonomic, motor, and sensory complaints. Derived by statistical methods, a generalized and rather stable trait of psychosomatic dysregulation is evident, thus giving an empirical basis to Whytt's (1765) original notion of nervousness. Although it is an extremely global concept, it proves to be a highly reproducible trait dimension. Evidence derived from questionnaires continues to be a strong motive to seek for objective psychophysiological correlates that could explain nervousness as a constitutional pattern or trait.

ACTIVATION (AUTONOMIC AROUSAL) IN EYSENCK'S THEORY

The personality dimension *emotionality (neuroticism)* derived from Q data is related to individual differences in emotional and autonomic responsiveness. The limbic system of the brain is thought to be the neuroanatomical basis of this trait because it appears to be largely involved in the regulation of emotions. It has been postulated that

some people are innately predisposed to respond more strongly, more lastingly and more quickly with their autonomic nervous system to strong, painful or sudden stimuli impinging upon the sense organs. (Eysenck & Rachman, 1965, p. 31)

Thus individual differences in emotionality are interpreted in terms of differential thresholds of hypothalamic activity and differences in responsiveness of the sympathetic nervous system. Eysenck used the term *activation* to distinguish this autonomic arousal from cortical arousal produced by reticular activity. Various ascending and descending pathways link the reticular activating system with the hypothalamus, thus connecting both arousal systems. Eysenck assumes that reticular activity does not necessarily affect limbic system activity, but postulates that limbic system activity will increase reticular and cortical arousal. Both arousal processes are partially independent, but they may interact. The distinction between these systems tends to break down when a high level of activation/arousal is induced or when highly emotional individuals are involved (Eysenck, 1967; Eysenck & Eysenck, 1985).

A wide range of physiological measures are thought to be indicative of autonomic arousal: skin conductance, muscular tension, heart rate, blood pressure, EEG, and respiration rate. Eysenck states, however, that there usually are no significant differences between high-N and low-N subjects in measures of autonomic arousal obtained in relaxed conditions. Such differences should emerge in stressful conditions or in chronic emotional states in neurotic patients.

EVALUATION OF PSYCHOPHYSIOLOGICAL RESEARCH ON EMOTIONALITY

EYSENCK'S CONCLUSIONS AND SUGGESTIONS

As mentioned before, Eysenck assumes a partial independence between autonomic arousal and cortical arousal. However, the physiological measures that are considered to be appropriate indicators of autonomic arousal are also discussed as measures of cortical arousal. The habituation paradigm and EEG parameters appear to be more specific-

ly related to the dimension of extraversion-introversion (Eysenck, 1967; Eysenck & Eysenck, 1985). The discriminant validity of these hypothetical indicators is, however, equivocal and consequently so is the operationalization of two arousal processes. The following passages are cited from the Eysencks' recent book to illustrate the conceptual difficulties as well as the frustrating evaluation of empirical findings.

However, we are still left with various uncertainties, since psychophysiological measures do not reflect directly the activity of either the reticular formation or the visceral brain. For instance, EEG desynchronization occurs as a consequence of either arousal or activation. This means that it is difficult to provide a satisfactory empirical test of the notion that arousal and activation are related but separate. (Eysenck & Eysenck, 1985, p. 218)

Attempts have been made to discover physiological differences between introverts and extraverts in a variety of experimental paradigms and using a number of psychophysiological measures (e.g., the EEG, electrodermal responses, pupillary responses). It is perhaps reasonable to conclude that introverts usually show greater physiological responsiveness than extraverts to stimulation, with the most consistent findings being obtained with electrodermal measures. (Eysenck & Eysenck, 1985, p. 231)

The data are undoubtedly disappointing, and it is hard to disagree with Stelmack's (1981) pessimistic conclusion that correlations between neuroticism and psychophysiological responsiveness have not been reported with sufficient consistency to permit inferences of the physiological determinants (p. 61). The problem may lie in the persistent use of insufficiently stressful conditions. (Eysenck & Eysenck, 1985, p. 234)

A higher degree of physiological responsiveness in EEG-measures as well as autonomic responsiveness is, accordingly, related to the introverted personality type. Conceptual clarification seems to be needed. Therefore, in the following discussion several issues are raised to assist theoretical and methodological developments.

INDEPENDENT EMPIRICAL TESTS

A comprehensive review of research literature pertaining to the psychophysiology of emotionality (neuroticism) cannot be given here (see Eysenck, 1967; Eysenck & Eysenck, 1985; Fahrenberg, 1967, 1977; Stelmack, 1981). The discussion will be restricted to a series of psychophysiological experiments conducted in our laboratory at the University of Freiburg. These investigations were large-scale, multiparameter, and multisituation studies that included systematic replications. The term *activation process* is used in the following discussion as a general term for arousal, excitation, stress and strain, and the like.

Myrtek (1984), in his extensive investigations of constitutional psychophysiology conducted with about 700 individuals (healthy subjects

and cardiac patients), studied among other trait dimensions the hypothetical constructs *autonomic lability*, *sympathicotonia-vagotonia*, and *physical fitness*. He used an unusually broad spectrum of physiological measures and a variety of stressor conditions that differed in intensity and quality. Correlational analysis, factor analysis, and cluster analysis revealed that the notion of a relatively consistent dimension or pattern of autonomic lability is not tenable on empirical grounds. Second, in summing up the findings from these extensive and carefully conducted studies, Myrtek (1984) was forced to retain the "null hypothesis of psychophysiological covariation" with respect to emotionality (FPI-N) and measures of autonomic nervous system functions.

The negative results and conclusions of Myrtek's research are in agreement with two other investigations from our laboratory that used a different approach to test Eysenck's hypothesis. In the first study, an individual's Emotionality score was thought to be an important predictor of activation state and activation reaction in a stress situation and should prove so under conditions of a typical activation experiment. Male students ($N = 125$), none from psychology courses, were examined under five conditions (rest, mental arithmetic, interview, anticipation, and blood taking). Criterion variables were self-rating of tenseness, as well as heart rate, finger pulse volume amplitude, electrodermal activity, respiratory irregularity, eye blink activity, forehead and extensor digitorum electromyogram, and relative power of EEG alpha. Statistical analysis by correlation and multiple regression procedures revealed that Emotionality (FPI-N) and Total Score of Somatic Complaints (FBL-11) fail to reliably predict individual differences in state and reaction parameters of activation processes (Fahrenberg, Walschburger, Foerster, Myrtek, & Müller, 1979, 1983).

The second investigation employed data that were obtained from 58 students of physical education under five conditions (rest, mental arithmetic, reaction time, preparing a free speech, cold pressor test). The recordings were repeated at intervals of about 3 weeks, 3 months, and 1 year. Financial rewards were given to increase the challenge imposed by performance tests and the painful cold pressor test. Further recordings were conducted outside the laboratory in prestart conditions and during performance of a 1000-m run in the stadium. These data allowed the test of the predictive validity of questionnaire scores of emotionality and frequency of somatic complaints in a manner nearly identical to the multivariate study just described. Again, the null hypothesis was retained (Fahrenberg, Foerster, Schneider, Müller, & Myrtek, 1984). Concerning the generalizability of results, appropriate reservations certainly should be made. These investigations, however, did take special precautions with respect to subject sample size, broad sampling of physiologi-

cal measures, intensity of stimulation, reliability estimates, different scoring methods, and use of the jackknife technique as well as a simulated random number model as a reference. Because the extended research reports can be found in the three resulting books, it may suffice here to present the essential conclusion from this research program: Further use of emotionality (neuroticism) supposing a consistent psychophysiological basis would be misleading as this theoretical construct has not been sufficiently substantiated by empirical data.

METHODOLOGICAL ASPECTS

In their evaluation of research on physiological correlates of emotionality, Eysenck and Eysenck (1985) cite only a few experiments, and they do not refer explicitly to methodological developments in psychophysiological assessment. A number of multivariate investigations that deal with the empirical test of the theory have not been mentioned. The general conclusions are still based on univariate experiments, although a multivariate reconceptualization of the activation-arousal theory appears to be inevitable.

In some laboratories, considerable progress has been made in assessing individual differences in activation (arousal) processes. The basic facts of response fractionation and response patterning in physiological data demand methodological consequences. Univariate experiments to test psychophysiological hypotheses have become obsolete in most instances.

Reviews of psychophysiological research usually deal at some length with the covariation issue and inquire into possible explanations of inconsistent, generally low, or negligible correlations between psychological and physiological parameters of activation processes. Many sources of error have been revealed that could threaten the internal validity of psychophysiological experiments (for overviews, see Fahrenberg, 1983, 1986a,b; Gale & Edwards, 1983; Rösler, 1984).

Problems of measurement, sampling, and experimental design cannot be discussed here. Internal validity should, of course, be increased by avoiding or reducing obvious sources of error. However, it appears to be extremely improbable that the frustrating state of affairs with respect to physiological correlates of emotionality could be explained merely by errors of measurement. Such an interpretation ignores recent investigations that carefully analyzed such methodological issues by conducting parameter studies, employing many experimental and statistical controls, and developing more precise assessment strategies.

Evaluating Eysenck's theory has led to another fundamental issue: Precisely under what conditions is an appropriate test to be conducted?

(Eysenck & Eysenck, 1985; Gale, 1983; Myrtek, 1984; Stelmack, 1981). According to Eysenck (1981a), his basic assumptions are valid only if certain "parameters of testing" are adequately selected. He considers two major aspects: (a) arousal-producing characteristics of the experiment itself, that is, strength of stimuli, intensity of stressor conditions, stimulus background, overall setting, and demand characteristics; and (b) interactive effects due to the supposed higher sensitivity of emotional labile subjects who perform under threatening conditions. Operational definitions of appropriate stimulus parameters and experimental settings, however, were not suggested by Eysenck, although such specifications are essential for empirical testing and cross-laboratory comparisons.

CONCEPTUAL ASPECTS

The distinction between *activation (autonomic arousal)* and *arousal (cortical arousal)* still appears to be an essential postulate of Eysenck's theory, although the physiological parameters used, admittedly, lack discriminant validity. In an attempt to solve basic problems of Eysenck's theory, Gray (1981) has proposed a reformulation on both the physiological and the questionnaire levels. He reviewed evidence from animal experiments and postulated that there are (a) a fundamental behavioral inhibition system (BIS), comprising the septohippocampal system, with its monoaminergic afferents from the brain stem and its neocortical projections to the frontal lobe; and (b) a behavioral activation system (BAS) corresponding to Old's reward system. Furthermore, he considers the primary fight/flight system and unspecific arousal functions of reticular structures. Obviously, this approach is based on neurophysiological considerations and thus conforms to Krech's (1950) opinion that psychologists should develop hypothetical constructs that are basically compatible with neurological concepts.

Gray (1983) again addressed the issue concerning where, in the multidimensional personality space, we are likely to find factors reflecting the causal influence of separable subsystems in the brain. He extends his considerations to the octants of Eysenck's three-dimensional PEN system, includes neurotic and psychotic disorders, circadian influences in arousal thresholds, and many other phenomena. These associations and theoretical speculations may be of heuristic value but are at the same time frustrating because nearly everything seems to fit: It is a rotational procedure, so to speak, without simple structure criteria.

Several authors besides Gray have elaborated on such hypothetical neurobiological multicomponent models (e.g., Andresen, 1987; Ehrhardt, 1975; Fowles, 1980; Pribram & McGuiness, 1975). There is little

doubt that neurosciences gradually will advance in this respect. However, these suggestions and postulates appear to be of little consequence for research in differential psychophysiology unless the proponents of such "models" and flow charts suggest practical strategies as to how to differentially assess the activity of such neural subsystems, loops, and other brain structures in the intact human individual participating in an experiment. Such specifications and precise topography of arousal processes are extremely desirable but are, unfortunately, not available at present. We can imagine that some aspects of regional CNS activity may be indicated by positron emission tomography or magnetic resonance spectrography in the future, but for the time being peripherally recorded physiological functions and the EEG have to be used in order to differentiate patterns of regulation and to develop valid indicators of theoretically postulated subsystems of CNS activity.

The issue addressed by Amelang and Bartussek (1985) is theoretically important. The questionnaire scales that measure the dimensions *E* and *N* were developed to fit into an orthogonal system, although activation and arousal are considered to be dependent on each other. Amelang and Bartussek (1985) assume that this orthogonality serves to distort the functional relationships. Tellegen (1978) raised another theoretical point that deserves attention. Emotionality scales usually consist of items that predominantly describe negative feelings and negative experiences—moodiness, depression, worry, inferiority, lability, and other aspects of neuroticism. Positively toned states are hardly included in this concept. On the other hand, it is a reasonable assumption that the limbic system and parts thereof will be correspondingly active in positive emotional states. The questionnaire scales are designed for clinical groups representing nervousness and obviously do not depict a bipolarity of the hypothetically underlying neurophysiological processes. Andresen (1987) has reviewed the evidence for monopolar or bipolar concepts in research on emotion and emotionality. He concluded that in psychophysiological research a dimension of positively toned activation should be separated from a dimension of negatively toned activation.

Another issue that needs conceptual clarification is the choice of experimental designs that deal with the assumed interaction of *E* and *N*. The interaction of these traits introduces further difficulty in interpreting the findings of a given experiment. This issue has not been incorporated into designs that are common to this research but has been eliminated or partialled out by selecting "high-" or "low-" *N* subjects. Such designs that use extreme groups instead of samples representing the trait continuum are open to methodological criticism. Instead of simple ANOVA designs, multiple regression procedures, or some kind of "dose-depen-

dent" analysis seems to be much more adequate to depict the postulated nonlinear dependency of E and N that is, in turn, modulated by stimulus intensity.

For conceptual clarification, it may be of heuristic value to consider Eysenck's comments on investigations that report negative results. I refer to his reviews on the three respective books from our laboratory for the journal *Personality and Individual Differences* (Eysenck 1981b, 1982, 1985). In these reviews, Eysenck concludes that a contradiction exists between this research and research from other laboratories covered by Stelmack's (1981) review. Stelmack, however, notably excepts emotionality from his positive conclusion concerning the psychophysiology of extraversion-introversion.

Eysenck (1982) considers types of stressors and types of physiological measures as possible reasons for negative results. It would be impossible to maintain that conditions and dependent variables other than those selected in our experiments would have produced the same negative results. The methods used in our study include a number of rather conventional, together with some less familiar, measures, but there exist many more that have not yet been tried. A typology of such stressor conditions as suggested by Eysenck is desirable and would be useful to restrict the fields of validity of the theory. It is conceivable that during this process of conceptual clarification and operationalization criteria for appropriate testing the hypotheses can be established eventually.

A PHILOSOPHY OF SCIENCE APPROACH

An attempt at conceptual clarification was made by Brocke (1985). His argument is based on the premise derived from the philosophy of science that the standard representation made for psychological theories must fulfil some minimum requirement as is common with the physical sciences. Such a basis of representing a theory is needed (a) for the precise evaluation of the present status of the theory; and (b) for the monitoring of the empirical progressivity of theory development.

Brocke (1985) proposes a semantic structuring of subsequent stages of Eysenck's arousal-activation theory and proceeds to a set of theoretical postulates that includes theories of situational arousal and habitual arousal. The essential parameters of testing are systematically stated as "peripheral conditions" that should precede each set of postulates. The fields of validity thus have limitations depending on whether, in an experimental design, a variable or a constant level of arousal is produced with or without any confounding influence of activation-related processes (see Brocke & Battmann, 1986).

Brocke (1985) does not advance to a similar specification for the

semantic content of the theory's terms. This, of course, would be a troublesome task because it would require operationalization of theoretical constructs of activation and arousal and specifications of appropriate levels of stimulus (stress) intensity. Such specifications are necessary for ethical and practical reasons because psychophysiological experiments cannot begin to gradually increase stimulus intensities from the lowest possible level to a very high intensity. Such specifications of "high" or "low" stimulus levels are crucial for theory testing. They cannot, however, be found in the original research publications on emotionality.

Semantic analysis of Eysenck's theory certainly would lead to three fundamental issues: (a) the aforementioned lack of sufficient operationalization and empirical discrimination of activation and arousal; (b) the definition of appropriate levels of stimulus (stress) intensity, ranging from the specific stimulus to the general experimental setting, demand characteristics, and individual coping style; and (c) the recognition of a possible circularity in defining the preceding "peripheral conditions" on empirical grounds by measures that are the dependent variables in hypothesis testing.

Brocke's (1985) discussion helps to remind us that an empirical theory should only be subjected to appropriate tests and that a theory should demonstrate progressivity. To avoid immunization, however, psychological theories, at each stage, must be formulated in such a way that essential deductions could be rejected (falsified) on empirical grounds.

MULTIVARIATE ACTIVATION THEORY

Because activation processes are higher nervous system functions of varying intensity and synergistic patterning, their study requires a complementary and multivariate psychological-physiological approach. However, as an extended discussion of multivariate activation research has already been given elsewhere, a condensed presentation of some basic aspects may suffice here (Fahrenberg, 1983, in press).

Many investigations have demonstrated the well-known psychophysiological reaction to stimulation, that is, the ergotropic, synergistic pattern of increased alertness and tension, decreased synchronization of the EEG, increased cardiac output and respiratory functions, increased muscular tension, increased output of adrenaline, cortisol, and so forth. This frequently observed average response profile formerly has been conceived as an indication of a unitary dimension of activation or deactivation shown in a systemic, unidirectional, homogeneous increase/

decrease of many parameters, which depict a synergistic action of the organism as a whole.

An evaluation of such data from a differential perspective, however, has failed to establish an empirical basis for an unidimensional activation theory. This traditional notion is only tenable as a rather restricted concept, that is, only for certain experimental conditions and only to response profiles *averaged across subjects*. An individual's score on a specific activation variable may characterize the functioning of the particular response system, but there is no sufficient empirical support to reliably assume a *corresponding proportional* state score or state change on another autonomic, somatic, or psychological system in that same individual. The striking response fractionation found in psychophysiological data has encouraged many additional hypotheses to explain it and, thus, has stimulated methodological advancements. The patterning of physiological responses consequently has attracted more attention, and in such investigations, important theoretical contributions were achieved. For example, the patterning with respect to stimulus-specific, individual-specific, and motivation-specific responses has been reliably established (Fahrenberg, 1986; Foerster, 1985; Foerster, Schneider, & Walschburger, 1983). In differential psychophysiology, multiparameter-multisituational data sets are needed that are suited for genuine multivariate analysis. Only such data sets can meet the requirements of comprehensive research in general synergisms and in physiological individuality.

Criticism of the general factor model in activation theory has encouraged speculation on two-factor and multiple-factor models. This development resembles the history of factor analytic research on intelligence. It is, however, questionable whether the latent trait model and the concept of unitary factor dimensions, familiar to psychological trait theories, can be readily applied to physiological data. Compared to convergent problem solving and performance data, in physiological functions, synergistic and antagonistic regulatory processes, that is, non-linear relationships, interactions, and functional fluctuation seem to be more prominent, thus calling for dynamic modeling approaches, time series, and thorough differentiation of patterns.

Although there is little support for global concepts or two-factor models suggested by several authors, the notion of activation as a *multi-component* process with *various degrees* of coupling between such response systems continues to be a viable concept. Based on the literature, a number of hypothetical components can be derived in each of the domains of subjective state, behavioral activity, central nervous systems, autonomic systems, and neuroendocrine systems. At present, rather heterogeneous perspectives prevail directed at *functional systems*

like sympathetic-adrenergic activity or sleep-waking cycle, *dimensional concepts* like mood factors derived from R- and P- technique analyses, and demarcations with respect to specific *organ systems* like neocortex, heart, or skin.

As compared to speculations on arousal systems in reticular and limbic structures, such a multicomponent approach is much more inclined to operationalizations. Physiological measures for such components exist and eventually more valid marker variables that could be employed in the psychophysiological laboratory will be available. The refinement of such construct-operation units (see Fiske 1978) in future research programs would serve to overcome the acknowledged inconsistencies of psychophysiological investigations.

For example, in cardiovascular psychophysiology, there is recently a trend away from the oversimplified use of heart rate, heart rate variability, and blood pressure measures. Psychophysiolgists now are more readily following the lead of physiologists in applying more refined methods for differentiating functional systems of alpha- and beta-adrenergic as well as vagal influences on the heart and the arterial system by employing, for example, specific ECG parameters, spectral analysis of heart rate variability, amplitude of sinus arrhythmia to depict respiratory gating of vagal innervation, noninvasive measures of stroke volume, preejection period, left ventricular ejection time, contractility, pulse wave velocity, and other haemodynamic parameters. There is a good chance to learn, especially in cardiovascular psychophysiology, whether by refined measurement and parameter combination the objectives of systemic analysis can be achieved.

Multivariate activation theory should be further developed to give an adequate account of general synergistic patterns and differential aspects, response fractionation and response patterning, assessment strategies, and predictive validity. The scope of such a multivariate approach will provoke criticism concerning its feasibility and practical application. However, conventional single-channel physiological measurement approaches are obsolete in most psychophysiological research orientations.

SOME PERSPECTIVES/ALTERNATIVES IN PSYCHOPHYSIOLOGICAL RESEARCH ON EMOTIONALITY

TOP-DOWN AND BOTTOM-UP STRATEGIES

Research on physiological correlates of emotionality appears to have reached a standstill. The null hypothesis has been empirically retained though not provable for logical reasons. To overcome the relative

stagnation in this field of research, new heuristics and modified research programs are needed. At any rate, conceptual clarifications as suggested in the preceding paragraphs will result in a recategorization of issues. Science advances by replacing rather global conceptions by a set of more specific propositions, that is, more refined postulates and terms that can be more readily subjected to empirical test.

The Eysenckian theory, from its beginnings, has provided such differentiation by its hierarchical structure, although this perspective of at least four organizational levels (specific response level, habitual response level, primary trait level, and secondary type level) has found less attention during the past years. The structure of personality with respect to this hierarchical organization was investigated predominantly using the questionnaires. It should be noted, however, that even a single item usually represents a complex, subjectively weighted average or aggregate across behavior elements, situations, and replications over the individual's lifetime. Hierarchical analyses that parallel the construction of the N-scales for physiological measures and for behavioral elements of the second-order trait dimension cannot be found in the literature.

In systems theory, two approaches that complement each other are labeled *top down* and *bottom up*. Bottom-up analyses demand conceptual and methodological refinement as well as precise assessment of lower levels (subsystems) that gradually advance to higher levels of organization. Top-down analyses would lead to stepwise decomposition of global systemic properties.

In psychophysiological research, it is obvious that we are dealing with quite different levels of organization and various degrees of abstraction or complexity that require studies of the relationships between somatic data, calling for a hierarchical model (Fahrenberg, 1967, 1977). There have been many attempts to correlate rather crude single physiological measures with personality variables of some kind, often in a very arbitrary manner. An alternative would be to establish physiological patterns first, and then, subsequently, look for correlates or matches with known psychological patterns, dimensions, or types. Probably the latter approach is more promising because it appears to correspond better to the assumption of different levels in the psychobiological organism.

Myrtek (1984) has subjected this proposition to empirical testing. His factor analytic work indicated that the generally low covariation between emotionality (FPI-N) and autonomic lability data cannot be increased by structuring the physiological data to obtain factor scores. This disappointing result may not, however, be the final statement on the issue of adequate matching of functional levels within the hierarchy of subsystems.

Two general heuristics can be conceived: (a) *decomposition* of the global second-order dimension N to systematically consider primary dimensions, items, and even more elementary self-ratings of momentary state; and (b) integration of elementary physiological measures and microprocesses by empirical analysis that relates to known physiological patterns and regulatory mechanisms, and by means of psychometric methods (i.e., developing composite scores by scale construction and aggregation techniques). Another essential aspect would be to further develop behavioral indicators, that is, behavior ratings and objective behavior measures of emotionality. This multimodal conceptualization of neuroticism was more obvious at the beginning of this trait's history in psychological research.

DECOMPOSING NEUROTICISM

Eysenck and Eysenck (1969) are rather sceptical concerning personality dimensions at the primary level. They suppose that E and N on the secondary level hold far more promise as invariant and theoretically promising factors than do the primary factors they discussed. These primary factors are not, from their point of view, invariant across sex, age, and education, and represent "half arbitrary, half accidental conglomerations of items" (Eysenck & Eysenck, 1969, p. 331). The task of structuring personality at the primary level thus remains unsolved.

Major components of emotionality (neuroticism) assessed by questionnaires have been mentioned already. With respect to the MPI and EPI, findings from different analyses depict some inconsistencies that may possibly be explained by differences in sampling and statistical procedures (Eysenck & Eysenck, 1969; Howarth, 1976; Loo, 1979). Factor analysis of items from existing N-scales is probably not an appropriate strategy for decomposing N into salient primaries because the item pool in the process of scale construction becomes gradually restricted by selecting a small number of relatively homogeneous items. Such components of N could be considered when physiological and behavioral correlates are investigated.

Psychophysiological relationships on the item level have not been systematically investigated so far. The availability of corresponding physiological measures remains the major obstacle in this single-item approach to psychophysiological correlations. This strategy was employed some years ago in a preliminary attempt to validate questionnaire items relating to somatic complaints similar to those in the FBL questionnaire (Fahrenberg, 1967). The results were far from promising. The fact that for the great majority of the questionnaire items no distinct physiological measures were available, at that time discouraged

any attempt at validating single somatic complaint items in questionnaires.

More research findings are available at an even more elementary level. In many psychophysiological investigations, self-ratings are employed to obtain data on actual state of mood, tenseness, irritation, perceived heart rate, perceived muscular tension, and so forth (e.g., Fahrenberg *et al.*, 1983; Stemmler, 1984). These ratings represent momentary dispositional predicates as compared to habitual dispositional predicates found in answering questionnaire items. However, correlation coefficients (R technique) between state and change ratings of "tense," "alert," "irritated," and various physiological measures generally failed to obtain significance levels, thus suggesting response fractionation (Fahrenberg & Foerster, 1982).

MORE ADEQUATE PHYSIOLOGICAL VARIABLES

Systemic/Hierarchical Aspects of Physiological Processes. Corresponding to the decomposition of N, a bottom-up strategy could be employed for physiological data. It seems trivial, but physiological variables differ widely with respect to functional level, physiological system, and complexity. Psychophysiolgists have, in the past, been concerned with only a small segment of this variable domain. Even under this restriction, it remains equivocal what kind of data could be more rewarding in correlational studies: parameters abstracted from the EEG (complicated by topography and intricate spatial folding of the many cortical sources of dipoles) or from the autonomic-neuroendocrine systems (complicated by effector organ properties and mediating variables). Gradually, a more systemic approach that overcomes univariate and often arbitrary variable selection will be necessary.

Another aspect in acquisition of valid physiological data refers to the intensity and generalizability of experimentally induced activation processes. There can be little doubt that psychophysiolgists will follow new research options that are provided by development of portable monitoring systems for physiological functions (for a review and an empirical laboratory-field comparison, see Fahrenberg, Foerster, Schneider, Müller, & Myrtek, 1984, 1986).

Aggregation of Physiological Data. The assessment of relevant physiological parameters, systemic properties, and reaction patterns in the laboratory and in field conditions eventually could serve to attain theoretically meaningful integration of the data. An analogous, although basically psychometric approach to higher order properties, is the aggregation strategy that has been much discussed (Paunonen, 1984), although rarely applied, in personality research. For example, Wittmann

and Schmidt (1983) employed an aggregate of data from self-reports and tests that were obtained for 16 days over an interval of 8 weeks to predict the individual score on Extraversion. Results were promising, although the small student sample ($N = 20$) requires special reservations.

Composite scores and factor scores that constitute aggregations across different physiological variables are well known in psychophysiological methodology, although the initially postulated superiority of such scores in linking physiological to psychological variables is not yet shown (for further discussion, see Fahrenberg, 1983; Myrtek, 1984). Besides Myrtek's (1984) factor analytic work two large-scale investigations employed psychometric procedures to develop more complex physiological scores (Fahrenberg *et al.*, 1979, 1984; Fahrenberg & Foerster, 1982). Factor analyses and item analyses were applied on physiological data for the construction of scales, for example, a cardiovascular scale and an electrodermal scale. While constructing physiological scales, primary data were aggregated across physiological variables, across experimental conditions, across replications of the entire experiment, and finally, across certain conditions in the laboratory and in the field. It must be said, however, that the results were not encouraging because the composites did not result in more substantial correlation coefficients or superior predictability with respect to FPI-N than did single measures. The evaluation of such analyses constitutes a complex problem so that independent investigations appear to be desirable.

Schweizer (1986) made a new attempt in aggregating physiological data that are obtained under various conditions of observation. This even broader approach calls for a planned replication that is possible with respect to the aforementioned two large-scale data sets. From the findings of this systematic investigation, it may be concluded that psychometric aggregation is not a promising approach in psychophysiological personality research.

CONSEQUENCES FOR THE CONSTITUTIONAL APPROACH

Reviewing a series of empirical investigations that retain the null hypothesis places in doubt the biological-constitutional theory of emotionality (neuroticism). The sceptical conclusion was stated precisely by Averill and Opton (1968, p. 285): "It appears unlikely that normal variations in personality are greatly dependent upon gross constitutional differences in physiological functioning." This point of view has also been found, analogously, in biological psychiatry where research has not yet succeeded in identifying the specific neurophysiological-neurotransmitter basis of endogeneous depression and schizophrenia.

Such scepticism now is very common in psychomorphological re-

search that relates somatic types, derived from anthropometric measures, to temperament traits (e.g., Myrtek, 1984). A small proportion of common variance that may exist could be explained by two hypothetical effects. A large, muscular individual may differ in his or her experience of common challenges and consequently may adapt differently than a leptomorphic individual. The process of shaping one's self-concept may be influenced by social stereotypes that do, indeed, relate somatic types and temperament (Buse & Pawlik, 1984). Thus the constitutional theory of body types would be replaced by a cognitive interpretation of psychomorphological relationships that would emphasize the role of learning and self-attribution processes during an individual's development rather than genetic, neurobiological aspects.

This argument may also hold for emotionality. There is no consistent relationship between self-rated emotionality and *specific* properties of CNS and/or ANS functioning. Mood fluctuations and somatic complaints are due to subjective evaluation of the *milieu interne*, that is, exaggerated concern about perceived somatic functions, ubiquitous autonomic activity, concern about strain and overload, insufficiency, and so forth. These postulates remind one of the traditional concept of hypochondria (see Fahrenberg, 1967; Pennebaker, 1982).

The remarkable homogeneity of test items depicting various aspects of nervousness may be explained by assuming a process by which an individual's information about his or her internal monitoring of bodily functions and interoceptions are interpreted and shaped to conform to a scheme: cognitive consistency instead of a unitary psychobiological trait. The concepts of hypochondria and nervousness both are viable and rival concepts.

Instead of elaborating here on such a cognitive reformulation of the concept of emotionality, it only will be pointed out that the role of cognitive processes appears to be compatible with at least some of the empirical findings, especially with the null hypothesis of psychophysiological covariation discussed by Myrtek (1984). Neurophysiological correlates of individual differences in emotionality need not necessarily be denied by this theory, but these could be represented as an unspecific activity in the associative neocortex and all areas where symbolic-semantic analyses like problem solving, moral and aesthetic evaluations, and its like take place. It probably will depend on the researcher's general attitude toward the neuroscience or the cognitive science whether he or she tends to postulate that relatively consistent and stable personality traits like emotionality, assessed by questionnaires, are based on distinct properties of separable subsystems of neuronal substrate or on diffuse cortical, but essentially semantic, representations.

In psychophysiological activation experiments, we still have no means to assess global properties of the limbic system like "thresholds," "activity," "excitability," or individual differences in such functions. These are very global, neurophysiologically vague concepts; theoretical constructs that entirely lack indicators of established empirical discriminant-convergent validity. We have to acknowledge, furthermore, that psychophysiological research, with the possible exception of electromyographic analyses of facial expression (see Fridlund & Izard, 1983), has not yet attained reliable identification of basic emotional patterns derived from autonomic, endocrine, or EEG measures. Although it appears to be a common conviction that such patterns are represented in and may be elicited from distinct parts of the limbic system, attempts at reliable empirical discrimination have failed so far (for a critical review see Stemmler, 1984). Advances in psychophysiological differentiation of emotional patterns would indicate that properties of limbic system functioning could be assessed with sufficient validity so that psychophysiological theories of individual differences in emotionality may, one day, be subjected to appropriate tests.

CONCLUSIONS

Psychophysiological research on physiological correlates of the established *emotionality* (*neuroticism*) trait dimension has come to a standstill. Findings of questionnaire studies generally support the postulated psychophysiological relationship, but research that employs objectively measured physiological parameters in large-scale, methodologically well-controlled and replicated investigations has not substantiated these hypotheses. This paradox imposes a challenge to clarify theoretical and methodological issues, some aspects of which may be traced to the traditional concepts of nervousness and hypochondria.

In conclusion, further theoretical clarification appears to be mandatory especially with respect to the vague concept of physiological responsivity, to the empirical distinction of autonomic and cortical arousal, and to the specification of appropriate testing conditions. The methodology to assess individual differences in activation processes can be further improved, although it seems to be extremely improbable that negative results with respect to Eysenck's hypotheses can be explained by unreliability of present psychophysiological measurement. Advanced research programs, however, should be based on a multivariate activation theory as outlined before. There have been essential contributions made to differential psychophysiology by establishing response specificities, by developing multicomponent models of activation pro-

cesses, and by refining assessment strategies to account for patterning and hierarchical organization as well as including more adequate parameters of physiological systemic functioning. The acknowledgment of various levels of organization in higher nervous system functions may have heuristic value if consequently bottom-up and top-down strategies with respect to emotionality and elementary physiological parameters will be evaluated. The biological basis of distinct personality traits remains a relevant question that has many implications for psychosomatic and psychiatric disorders, psychotherapy, stress-strain research, and many other fields.

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CHAPTER 6

Individual Characteristics of Brain Limbic Structures Interactions as the Basis of Pavlovian/Eysenckian Typology

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Using the parameters of intensity, mobility, and balance of excitation and inhibition processes as a basis for formulating his classification of higher nervous activity types, Pavlov pointed to the importance of individual features in the interaction of brain macrostructures. For instance, he related an "intellectual type" of person to the functional predomination of the frontal neocortical areas and an "artistic type" to the predomination of other neocortical areas and "emotive" subcortical formations. Elaborating the concepts of Pavlov, Teplov and Nebylitsyn have defined general properties of the nervous system: activity and emotionality. Nebylitsyn (1968) assumed that "activity" depends on the individual features of the functional system, the frontal neocortical regions-activating reticular formation, whereas "emotionality" depends on the interaction of the frontal neocortex with the brain limbic system. According to Eysenck (1972), interaction of the ascending activating system with the frontal neocortical regions lies at the root of the nervous system strength parameter as well as the degree of extraversion-intro-

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