George A. Nemeth Ph.D.

Arousal, orienting response and psychopathology

AROUSAL AND ORIENTING RESPONSE
IN PSYCHOPATHOLOGICAL GROUPS

by

George A. Nemeth

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Department of Psychology
McGill University
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Ph.D. Psychology

George A. Nemeth

Arousal and Orienting Response
in Psychopathological Groups

Rate and variability of respiration, skin conductance level, and GSR were recorded in chronic and acute non-paranoid schizophrenics, anxious-depressive neurotics and normal control subjects, before, during and after simple visual and auditory stimulus sequences of increasing, decreasing, and constant intensity. These data were correlated with ratings of socially adaptive behavior in the psychiatric groups. Significant differences were found between control and experimental groups in respiration rate and variability; rate of habituation of the basal skin conductance level; amplitude, frequency, and duration of the GSR startle response; differential GSR responsivity and habituation to visual versus auditory stimuli. Ratings of overt behavior correlated significantly with psychophysiological variables.

Psychophysiological data were seen to describe three parameters: a) arousal; b) attention, and c) adaptation. Neurotics and schizophrenics showed similar behavior on the first two parameters. Adaptation difficulty appears characteristic only of schizophrenics. Relevance of previous findings and suggestions for further research were discussed.

Ph.D. Psychologie

George A. Nemeth

Excitation et reponse d'orientation chez des groupes psychopathologiques

Nous avons enregistré le taux et la variabilité respiratoires, le seuil de conductibilité de la peau et la réponse psychogalvanique (GSR) chez quatre groupes de sujets, avant, pendant et après la présentation d'un stimulus visuel et auditif simple donné en séquences d'intensité croissante, décroissante et maintenue constante. Notre échantillon était composé de sujets schizophrènes non-paranoides, chroniques et en crise aiguë, de sujets névrotiques anxieux-dépressifs et d'un groupe contrôle composé de sujets normaux. Nous avons établi la corrélation entre ces données et les scores de comportement social adaptif chez les groupes psychiatriques.

Nous avons trouvé des différences significatives entre les groupes experimentaux et le groupe contrôle pour le taux et la variabilité respiratoires; pour le taux d'habituation du seuil basal de conductibilité de la peau, pour l'amplitude, la fréquence et la durée de la GSR initiale; enfin, nous avons trouvé une sensibilité differentielle de la GSR et de l'habituation aux stimuli visuel et auditif. Les scores de comportement avaient une corrélation significative avec les variables psychophysiologiques.

Les données psychophysiologiques décrivaient trois paramètres: a) l'excitation; b) l'attention; et c) l'adaptation. Les sujets névrotiques et les schizophrènes ont montré des conduites similaires en ce qui concerne les deux premiers paramètres. Seuls les schizophrènes ont montré une difficulté d'adaptation.

La discussion a porté sur l'opportunité des résultats obtenus anterieurement, et sur des suggestions en vue de recherches ulterieures.

TABLE OF CONTENTS

Introduction

There have been many investigations in the field of psychopathology concerned with the demonstration of differences between psychiatric patients assigned to a particular diagnostic category and a control group, composed of individuals judged to be "normal". It has been suggested that such differences between disturbed and normal individuals reflect some deviation, defect, or loss in function in the "psychiatric" group. The deficit has been identified or investigated at three interrelated levels.

The first level is that of "psychiatric symptomatology". Here, complex behaviors are observed and catalogued, giving rise to diagnostic signs and groupings usually in accordance with a "medical model" of emotional illness. The inference has been that a disease process underlies the behavioral deviations.

The second level is one of specific behaviors (perceptual, cognitive, motivational) under specific stimulus conditions. Investigations cut across diagnostic boundaries and often serve to support a "psychological model" of emotional dysfunction, e.g., "faulty" learning.

The third level concerns psychophysiological function: The "neuronal substratum" (Thompson and Spencer, 1966) or "visceral level" (Lacey, Kagan, Lacey,& Moss, 1963) as it is sometimes called. Investigations focus on phenomena said to be directly related to an existing state of affairs in the central and autonomic nervous systems. The assumption here is that observable behaviors regardless of stimulus conditions are a function or correlate of an underlying physiological state of the organism. This orientation has been associated with both the medical and psychological models.

There are a number of formulations of the psychophysiological approach, e.g., Duffy, (1962); Hebb, (1955); Lindsley, (1951); Malmo, (1962); Sokolow, (1963). These have been utilized to postulate a causal relationship between deviant "visceral" function and deviant overt behaviors in behaviorally disturbed groups. (Fish, 1961; Lang & Buss, 1965; Venables, 1964, 1966). The present study is concerned with the question of diagnostic specificity at the psychophysiological level in individuals who are considered behaviorally disturbed or deviant.

Reviews of psychophysiological research on normal and psychiatric groups refer to two major categories of central and peripheral psychophysiological function. (Broen, 1968; Claridge, 1967; Duffy, 1962; Lader & Wing, 1966; Malmo, 1965; Venables, 1966).

The first category concerns the individual's basal or tonic levels of functioning. These are estimates based on averaged responses, or continuous levels of function in a central or peripheral system and are recorded over long time periods. It reflects slow changes (trends) in a psychophysiological system.

The second category covers two types of responsivity to discrete stimuli. The first, called phasic responsivity is a sudden observable change in a psychophysiological system following an identifiable stimulus and usually has the following parameters: Latency, how long after the onset of the stimulus the response appears; Duration, how long it takes a system to return to a baseline; Magnitude, how large a deviation away from a baseline the response represents.

The other type of responsivity is usually referred to as tonic reactivity and it differs from a phasic response in its duration and shape. With either a sudden or gradual change in a psychophysiological system, the altered psychophysiological response continues over varying lengths of time, usually accompanies sequences of stimulus events (e.g., sustained stimulation) and does not return quickly to its original baseline as is the case for the phasic response. There are three further measures which apply both to tonic level changes and to phasic responses.

I. The nature of the response to the first stimulus introduced: This is variously called startle reflex (Landis & Hunt, 1939) orienting reflex (Sokolow, 1963) or orientating reaction. (Berlyne, 1960).

II. Habituation: The progressive decrement in response strength and eventual cessation of responding with repeated exposure to the same stimulus.

III. Adaptation: The modification of response to changes in stimulus components (intensity, complexity or direction) during a stimulus sequence.

It has been generally assumed that under ordinary circumstances the categories and parameters of responses in the peripheral systems represent characteristic reproducible events in the central nervous system. Evidence for this assumption derives from two sources:

a. Neurophysiological studies of central nervous system representation of a specific peripheral system.

b. Studies dealing with the relationship between "peripheral" responsivity and simultaneous changes in the electroencephalogram (EEG) the latter measure serving as "direct" representation of a central state of affairs.

A review of specific systems will be presented later in which both types of evidence will be considered.

General Characteristics of Psychophysiological Response Categories and their Parameters

A. Basal Activity Levels

Ideally, basal activity levels of all psychophysiological systems would be derived from organisms in a state of prolonged rest, such as occurs in normal sleep. In biologically intact organisms all psychophysiological systems show their lowest levels of output while the organism is asleep. However, even during sleep, tonic changes which are not related to any apparent stimulation are seen on the EEG (Johnson, 1969) and on electrodermal measures. (Tait, 1967). Upon awakening, output levels in all systems tend to rise sharply (Weybrew & Alves, 1959; Lynn, 1966) although the system in which the greatest change occurs and the relative magnitude of the change show marked inter and intraindividual variability. Once the organism is awake basal activity levels in most systems can only be inferred from statistical approximations, because continuing stimulation from the environment superimpose marked variations on the tonic activity levels of those systems.

B. Response to Discrete Stimuli

1. Response to the first stimulus

When a new stimulus of above-threshold intensity is presented, the organism tends to respond with generalized activity in many bodily systems. If the stimulus is sudden and intense, a very fast reflex action, the "startle reflex" occurs. (Landis & Hunt, 1939). Response to more moderate and complex stimuli has been termed the orienting reflex (OR) by Sokolow, (1963) and orientating reaction by Berlyne, (1960). Sokolow, (1963) includes changes in tonic central and peripheral activity following a novel stimulus as part of an orienting reflex. According to Lader & Wing (1966) there is no qualitative difference between startle and orienting reflexes. In the case of a strong stimulus a startle reflex includes an orientating reaction; a weak stimulus evokes an orientating reaction only.

In normal subjects the magnitude of the orienting response is positively related to the intensity, modality, complexity and associative value of the stimulus. Berlyne, Crow, Salapatek,& Lewis, (1963) and Germana, (1968) have also shown that the orienting response is more enhanced by stimuli requiring the execution of an overt response, i.e., by "signal" stimuli than by "non-signal" stimuli.

2. Habituation

When non-noxious stimulus conditions remain invariant, levels of tonic activity tend to decline over time. Similarly, phasic reactivity in psychophysiological systems diminishes and finally disappears if the organism is exposed to the same stimulus over and over again (extinction). Phasic response (but not necessarily tonic reactivity) can be reinstated if a new stimulus is introduced, if an old stimulus is reintroduced after a rest period, or if a dimension of a stimulus (intensity, complexity, demand characteristics) is changed. (Hernandez-Peon, 1960; Lynn, 1966; Thompson & Spencer, 1966).

In the case of simple sensory stimuli speed of habituation depends on:

a. the sense modality in which the stimulus is presented: habituation is faster to visual than to auditory stimuli, (Bernhaut, Gellhorn,& Rasmussen, 1953; Kubis, 1948) - even when stimuli are subjectively equated for intensity. (White, 1964).

b. stimulus interval: shorter intervals lead to faster habituation. (Geer, 1966; Schaub, 1965).

c. duration of stimulus: shorter stimuli result in faster habituation. (Koepke & Pribram, 1966).

Habituation may not occur if the stimuli are noxious or perceived as threatening to the subject, and psychophysiological response may even increase. (Mandler, Mandler, Kremen,& Sholiton, 1961; Sokolow, 1963; Stern, Gaupp,& Leonard, 1970). This has been termed the defensive reflex (DR) by Sokolow, (1963) and Lynn, (1966). It is thought to be neurologically different from the orienting reflex. In general, habituation is also delayed in vigilance situations when subjects are instructed to pay special attention to all or specific types of stimuli. (Mackworth, 1968).

3. Adaptation to stimulus demands. ("Matching" psychophysiological responsivity).

In Western research literature the concept of adaptation is often used synonymously with habituation and eventual extinction of a response. Sokolow (1963) describes an adaptive response (AR) as one which does not habituate but is related to stimulus characteristics. In the present study "adaptation" is used in this sense to describe the "matching" of the response of a psychophysiological system to characteristics of either a single stimulus, or to an ongoing stimulus situation. In this context habituation may be considered a special case of adaptation.

Gross differences in central activation such as sleep versus awake states (Weybrew & Alves, 1959) and drowsy versus alert states, (McDonald, Johnson,& Hard, 1964; Roessler, Burch,& Childers, 1966) are accompanied by increased basal autonomic activity as well as increased reactivity to discrete stimuli. In alert subjects tonic activity increases with increasing intensity and complexity of the stimulus. If the performance of an overt response is also required of the subject, tonic activity tends to "follow" the characteristics of the tasks to be performed. (Duffy & Lacey, 1946; MacNeilage, 1966; Malmo & Davis, 1956; Pinneo, 1961; Schnore, 1959). Adaptation of peripheral tonic activity to a persistent complex stimulus situation often takes the form of gradients characteristic to the system in which they appear (Malmo, 1965). The autonomic systems appear to be protected from overload however; in face of prolonged stimulation both tonic and phasic activity tend to decrease before biological limits are reached. (Malmo & Belanger, 1967; Wilder, 1957).

If a stimulus situation includes a sequence in which stressful and non-stressful events alternate such as occurs in the well-known tribal initiation film (Lazarus, Speisman, Mordkoff,& Davison, 1962) or if a sequence of varying stress conditions is interspersed with rest periods, (Reynolds, 1962) then tonic activity and phasic reactivity follow the pattern of the stimulus sequence.

The phasic orienting reflex in normal subjects also matches characteristics of a discrete stimulus. The magnitude of the response to the first stimulus varies with the complexity of the stimulus (Zahn, 1964) and with its intensity. (Bernstein, 1970; B.D. Smith, 1967). In general, the phasic orienting response is proportional to the intensity and associative value of the stimulus for normal subjects when stimulation is non-noxious.

Theoretical models:

a. Baseline activity and tonic reactivity

The most frequently used theoretical construct to account for the maintenance of and changes in central and peripheral activity levels is "activation" as outlined by Duffy (1962); Lindsley (1951); Malmo (1962); and Malmo & Belanger (1967). A common feature of these theorists' formulations is a postulated central state of "arousal" or "activation" on which the nature, frequency, intensity and organizational quality of overt behavior depend. Activation is regarded as more basic than motivation, emotion, attention (vigilance); it is essentially undirected alertness ranging from sleep to extreme excitement. Elaborations of the theory are associated mainly with Moruzzi & Magoun's (1949) description of a non-specific alerting system in the brain stem (Ascending Reticular Activating System: ARAS) activating cortical areas of the brain. Later on, complex feedback arrangements between the ARAS and the cortex were described by Dell, Bonvallet,& Hugelin (1961) and Segundo, Arana,& French (1955). Further description of central activation phenomena, particularly the role of the hypothalamus, is found in Feldman & Waller (1962). High or fast central and peripheral activity is generally interpreted as reflecting high activation level.

The relationship between overt behavior and activation level has been represented in Malmo's (1962) "inverted U" model. Quality and efficiency of overt behavior tend to be optimal under conditions of moderate activation. Behavioral deficit (either the amount or the quality of the behavior emitted - or both) occurs at very low and very high levels of activation. A more linear model for autonomic systems was advanced by Wilder (1957). His Law of Initial Values states that base level activity and phasic reactivity in the same autonomic system are inversely related. When activity approaches the physiological limits of a system, a response either may not occur or may change in direction. It can be predicted from activation theory that excessively high or low activation levels and failure of activation levels to adapt to the characteristics of a stimulus situation will result in a diminished or absent psychophysiological response, and varying degrees of behavioral disorganization. These deficits may occur either simultaneously or out of phase with each other.

Activation theory has received support from findings on two classes of psychoactive drugs - tranquillizers and stimulants. Tranquillizing drugs (which have a specific blocking effect on the ARAS) and sedatives (which have a depressant effect on cortical activity) tend to reduce behavioral overactivity <u>and</u> also to shift central psychophysiological activity in the direction of lowered activation. In contrast, stimulant drugs (having a facilitatory effect on the ARAS and the cerebral cortex) increase overt behavioral output as well as central psychophysiological activity. Ban (1969) discusses the neurophysiological effects of these drugs in great detail. Drug effects on particular central and peripheral measures in normal subjects will be discussed later as will the relevance of tranquillizers which are employed in changing the behavior of the "psychiatrically ill" to theories of psychopathology.

Despite general support from drug studies however, activation theory has had certain difficulties in trying to account adequately for changes both in central (EEG) and autonomic - muscular activity levels. Criticism stems from four controversial issues reviewed in detail by Lacey (1967).

I. Different peripheral systems often show uncorrelated responses during the same stimulus situation. In addition, one subject may respond predominantly in one peripheral system while another will show a response in another system to the same stimulus. Lacey & Lacey (1958) termed this as autonomic response stereotypy.

II. The correlation between "central" and "peripheral" indices of activation is generally found to be weak. Furthermore, even within the central nervous system activation of the ARAS and the cerebral cortex are not necessarily synchronized.

III. The relationship of psychophysiological activity to task performance does not always follow predictions based on activation theory.

IV. In the cardiovascular system changes in the tonic levels of heart rate as well as variation in the direction of change vary with the nature of the stimulus rather than with other indices of activation.

Although activation theory remains a controversial issue, a number of two-factor activation models have been advanced in order to deal with the question of maintenance of tonic activity levels between reasonable limits. These models generally postulate a long-term arousal system, and a modulating (feedback) system which prevents overload of input in the long-term arousal system and ensures responsivity adapted to stimulus demands. Details of such models are given by Butler & Rice (1962); Claridge (1967); and Routtenberg (1968).

b. Reactivity and habituation

Activation theory also has had difficulty with OR and habituation phenomena. The theory can predict OR magnitude and speed of habituation in relation to gross differences in baseline activity within the responding system but it does not deal adequately with variations in response magnitude and direction when basal activity levels are held relatively constant. Nor does activation theory deal with the characteristics of the OR and habituation process itself.

A comprehensive, often quoted model for the OR and its habituation has been put forth by Sokolow (1963). The "neuronal model" construct assumes that the CNS compares all perceived stimuli with an internal "model". If there is no previous model of the stimulus, or the existing model does not "match" the stimulus, an orienting response takes place. The response is thought to have the characteristics of a reflex. As the stimulus is repeated, a "neuronal model" of the stimulus is being built up in the CNS. Habituation represents the process of building up the neuronal model. The OR is extinguished when "matching" of the stimulus with the internal model takes place. The model handles the OR and habituation of both central and peripheral tonic psychophysiological reactivity as well as phasic reactivity to discrete responses. It accounts for the fact that habituation is faster to simple sensory stimuli of low and moderate intensity than to complex stimuli. (Germana & Chernault, 1968; Lynn, 1966; Thompson & Spencer, 1966). The model can also explain why recovery of response occurs when a stimulus dimension is changed.

Certain assumptions of Sokolow's model have been challenged. Bernstein (1968) has shown that after an OR is extinguished to a stimulus of a specific intensity, a more intense stimulus is more likely to reinstate the OR than a less intense one. Recovery of the OR therefore may depend on the <u>direction</u> of stimulus change as well as on change itself. Bernstein (1969) has also questioned the reflexive nature of the OR. He proposed an additional CNS control mechanism (a second 'stage' of an OR) which would 'tell' the system whether or not to emit an OR. This suggests that attention, perception and orienting are related to one another in a fashion more complex than postulated by Sokolow. The absence of the OR cannot be used as prima facie evidence that the subject was not paying attention to or was not perceiving the stimulus.

Unlike their effects on baseline tonic activity levels, tranquillizer and stimulant drugs influence responsivity to discrete stimuli in ways which do not readily fit into a theoretical framework. Experimental findings are also contradictory and unclear. In general, however, the magnitude and frequency of the phasic OR are not affected by tranquillizing medication. (Bernstein, 1970). Tonic and phasic habituation trends are facilitated, however, and conditioning is made more difficult. Stimulant drugs, by contrast, delay habituation and facilitate conditioning. (Ban, 1969).

Central and peripheral psychophysiological measures.

Theoretical formulations of activation and orienting behavior have been derived from studies of CNS electrical potential changes, autonomic systems (cardiovascular and electrodermal), respiration and muscle potential changes. A brief survey follows of the measures associated with such studies, their characteristic findings, and the problems related to each measure.

The electroencephalogram (EEG).

The EEG is considered a measure of central nervous system arousal. (Lykken & Maley, 1968; Malmo, 1962; Moruzzi & Magoun, 1949; Woodworth & Schlosberg, 1954). A detailed account of EEG behavior in normal and abnormal states can be found in Hill & Parr (1963).

The major EEG wave patterns representing electrical potential changes in the CNS can be arranged in a continuum ranging from low frequency, high amplitude, irregular waves, to high frequency, low amplitude, regular wave patterns. This continuum in a normal organism corresponds to the behavioral continuum of sleep - relaxed wakefulness - to organized activity. Tonic levels of EEG activity have been related to such complex phenomena as the ongoing 'self-regulatory activity' of the brain, (Darrow, 1946) differing degrees of alertness (Larsson, 1956), psychological changes over relatively lengthy periods of time, (Kennard & Schwartzman, 1956) and adaptation to various tasks requiring attention, concentration and effort. (MacNeilage, 1966; Pinneo, 1961; Stennett, 1957a).

In the normal organism the EEG shows an OR and a habituation pattern to ongoing stimuli. (Sharpless & Jasper, 1956).

Tranquillizing agents such as chlorpromazine and sedatives such as secobarbital increase amplitude and decrease frequency of the EEG wave patterns. Excitant drugs such as atropine have an opposite effect. Phasic EEG responsivity may be similarly affected. (Mirsky, 1970). Central and peripheral-behavioral effects of psychoactive drugs are not always correlated however. (Ban, 1969; Mirsky, 1970). Reported linear correlations of the EEG with peripheral psychophysiological activity are generally of a low order. (Mundy-Castle & McKiever, 1953; Weybrew & Alves, 1959). Non-linear relationships (MacNeilage, 1966; Stennett, 1957b) are subject to different interpretations. (Lacey, 1967; Malmo & Belanger, 1967).

Many difficulties are associated with the quantification of EEG records. (Hill & Parr, 1963). This poses an added problem in trying to correlate peripheral variables to EEG output.

Cardiovascular measures.

a. Heart rate

Heart rate is usually recorded either by means of the electrocardiogram (EKG)(electronic method) or by using a mechanical device to count the arterial pulse rate. (The EKG gives information of cardiovascular functioning beyond simple pulse rate). Measurement is expressed in terms of number of heart beats over a certain time interval.

In addition, the direction of change in heart beats over successive time periods is also considered. A description of the central nervous system control of cardiovascular activity is found in Bard (1960) and Delgado (1960).

The heart rate measure has been used extensively to gauge autonomic effects of motivational and attitudinal differences and changes in attention. (Elliott, 1969). It has also been studied in relation to degree of anxiety, (Deane, 1969) variations in incentive conditions, (Schnore, 1959) and preparation to respond. (Campos & Johnson, 1967). A general feature of this measure is that it shows its most characteristic responses including habituation to complex or intense stimuli. Simple stimuli of low intensity may fail to evoke responses. Tonic habituation also may not be observed. (Galbrecht, Dykman, Reese,& Suzuki, 1965).

Heart rate changes show characteristic increments (gradients) in response to stimulus conditions demanding sustained attention and effort.

Interpretation of heart rate changes is not without difficulty however. When attention must be focused on the environment, cardiac deceleration rather than acceleration occurs. (Elliott, 1969; Obrist, 1963). Similar problems occur in cardiac phasic responsivity in that direction of heart rate OR depends on the intensity of the stimulus. (Graham & Clifton, 1966). A further difficulty is the bi-phasic nature of the cardiac response, i.e., acceleration followed by deceleration or vice versa. Unless both phases are considered, results are difficult to evaluate. (Malmo & Belanger, 1967).

b. Blood pressure

Blood pressure, its psychophysiological significance and its measurement are described in detail in basic texts. (Woodworth & Schlosberg, 1954). The measure is most sensitive to stressful stimulation (Malmo & Shagass, 1952; Malmo, Shagass,& Smith, 1951) and to frustrating social situations when an aggressive response cannot be carried out. (Hokanson & Shetler, 1961). When stressful stimulation is withdrawn in normal subjects, the measure quickly returns to pre-stimulation levels. (Malmo & Shagass, 1952). In addition, the volume changes of certain body parts (usually the finger or the chin) can be monitored, based on the autonomic responses of vascular vasoconstriction and vasodilation. Data on these measures are related to other cardiovascular variables. (Davis, Buchwald,& Frankman, 1955). In general, pressure and volume changes in the cardiovascular system show a characteristic bi-phasic OR (vasoconstriction followed by vasodilation) and adaptive responses to simple thermal stimuli. (Zimny & Miller, 1966). Accuracy of measurement may be a problem in continuous monitoring of these variables, while problems of interpretation could be similar to that of the heart rate.

The electromyogram (EMG)

Muscle tension (striate muscle potential), although not an autonomic measure, is often included in psychophysiological studies along with autonomic indices because its behavior is often similar to autonomic and central variables. The measure has a continuous tonus (basal level); introduction of a new stimulus results in increase in tonus, constituting an OR (Galbrecht et al. 1965, Sokolow 1963) with subsequent habituation.

Two kinds of EMG activity are studied in psychophysiological work; "relevant" activity of a muscle which is involved in a motor task, and "irrelevant" activity, i.e., changes of potentials in a muscle not involved in motor behavior. (Benson & Gedye, 1962 cited by Lader & Wing, 1966).

The EMG appears specific to muscles relevant to a stimulus situation (Malmo, Shagass,& Davis 1951). It shows characteristic rising gradients (adaptation) under complex or stressful stimulation (MacNeilage, 1966; Pinneo, 1961).

The EMG is a continuous recording of composite muscle action potentials which are considered proportional to the isometric contraction of the muscle (Jacobson, 1951; Lippold, 1952). The resulting record appears similar to high frequency EEG tracings and presents quantification problems somewhat similar to those of the EEG.

Electrodermal phenomena

Measures derived from two electrical properties of the skin have been most frequently used in psychophysiological research. The first associated with the work of Fere (Fere 1888, cited by Woodworth & Schlosberg 1954) is the resistance of the skin to an impressed constant electric current; the second is the electrical potential between two areas of the skin (Tarchanoff 1890 - cited by Woodworth & Schlosberg 1954). Both phenomena can be measured by means of electrodes placed on the skin where the concentration of the sweat glands is greatest.

It is now generally accepted that electrodermal phenomena reflect sweat gland activity, which under reasonably normal circumstances is related to some form of CNS activity rather than to peripheral changes (Martin & Venables, 1966; Montagu & Coles, 1966). The tonic and phasic aspects of electrodermal activity are easily recognizable on recording. Slow, tonic changes appear as gradual shifts over time. After a stimulus event, sudden, well-defined departures from the baseline are seen. These departures are variously called psychogalvanic reflex (PGR), galvanic skin response (GSR), or simply electrodermal response (Woodworth & Schlosberg, 1954). In this study the designation GSR will be used.

Tonic electrodermal activity is generally regarded as an index of activation or arousal (Berlyne, 1960; Bernstein, 1967; Duffy, 1962). The direction of tonic activity toward lower skin resistance or lessened potential is interpreted as a rise in activation. It shows an OR to a great variety of stimuli ranging from simple tones of medium and high intensity (Epstein & Fenz, 1970; Montagu, 1963; Mundy-Castle & McKiever, 1953) and flashes of light (Bernstein, 1967) to the presentation of arithmetical problems (Duffy & Lacey, 1946; MacNeilage, 1966). Tonic electrodermal activity levels during stimulation are proportional to the complexity of task (Duffy & Lacey, 1946). Its pattern of habituation is different from other central and peripheral tonic activity levels; during ongoing stimulation basal electrodermal levels show decreasing rather than increasing gradients (Duffy & Lacey, 1946; Eason, Beardshall,& Jaffe, 1965; Malmo, 1965). There are however some exceptions; under specific circumstances tonic electrodermal levels can also show rising gradients (Pinneo, 1961).

The phasic component of electrodermal activity, the GSR is perhaps the most researched autonomic response. It is easily conditionable and has been extensively used as a CR (Welch, 1953). It presents a clear-cut OR and a characteristic habituation curve to simple stimuli - particularly to auditory signals (Davis, Buchwald,& Frankman, 1955; Montagu, 1963; Mundy-Castle & McKiever, 1953). The GSR OR is more enhanced to stimuli which require the execution of an overt response than to those which do not (Germana, 1968). "Externally motivated" subjects produce more frequent GSR's to visual patterns than do subjects without such motivation; the introduction of incongruous stimulus material increases the amplitude of the GSR (Berlyne et al. 1963).

The GSR is a unidirectional response. It always consists of a drop in skin resistance.

Problems of measurement and quantification of both tonic and phasic elements of electrodermal activity have been discussed in detail by Hume (1965), Lader (1970), Martin & Venables (1966), Montagu & Coles (1966) and Woodworth & Schlosberg (1954). The most important point which seems to emerge is that skin conductance values (the reciprocal of skin resistance) ought to be used in research work, not only because of the advantageous statistical properties of conductance values, but also for biologically meaningful results (Lader 1970).

The neurophysiology of the GSR is relatively well-known (Bloch & Bonvallet, 1959; Dell, Bonvallet,& Hugelin, 1961; Martin & Venables, 1966; Wang, 1957, 1958). As in the case of other peripheral measures there is a hierarchical representation of structures mediating the GSR involving the ARAS, the hypothalamus and the cortex.

The only reported sex difference in autonomic reactivity occurs in GSR habituation. Women habituate faster than men to simple visual stimuli (Kimmel & Kimmel, 1965) and to simple auditory stimuli (Korn & Moyer, 1968).

Respiration

Compared to other psychophysiological systems, relatively little systematic work has been done on respiration as a psychophysiological measure. Most research, often complex, has been conducted on the physical-mechanical, biochemical and neurophysiological aspects of respiration. Findings of this large body of work appear in standard texts of physiology and medicine.

Central control of respiration appears in the familiar hierarchical arrangement. The cortex (W.K. Smith 1939, 1945), hypothalamus (Redgate & Gellhorn, 1958), and the ARAS (Hugelin & Cohen, 1961) are all involved. Otis & Gruyatt (1968) use the analogy of a pump to describe the respiratory system. It works as a variable-stroke pump operated by two motors which alternately switch on and off. The operation is controlled by two systems; a sensing (scanning ?) component controlling the limits of the respiratory cycle, and the motor system controlling the muscular aspect of the act of breathing. The latter is related to the "workload" on the muscles.

The conventional apparatus used in psychophysiological work is the pneumograph (Woodworth & Schlosberg, 1954). This is a pleated rubber hose placed across the chest and secured in the back. The movement of the chest wall during respiration changes the shape of the hose which in turn changes the air pressure inside the hose. In modern versions of the pneumograph one end of the hose is attached through a flexible tube to a transducer. This device converts pressure changes into electronic impulses which are amplified and recorded on a polygraph.

The startle reflex (Landis & Hunt, 1939) and the orienting reflex (Sokolow, 1963) have a respiratory component which is described as deceleration, followed by acceleration of the breathing rate. ("Catching one's breath" when surprised or shocked.)

There is some evidence that respiration rate (RR) shows a directional as well as an intensity response to stimuli of an ideational nature. The RR rises during the performance of mental arithmetic (Skaggs 1930) and while writing down auditorily presented numbers (MacNeilage 1966). It also shows a rising gradient while listening to strongly rhythmic music (Ellis & Brighouse, 1952). Simple auditory stimuli, according to Davis et al. (1955) evoke a response of slower, deeper breathing. The same authors also report that habituation of the breathing response occurred to the strongest auditory stimulus, but repeated presentation of low intensity stimuli maintained the slower, deeper breathing pattern. On the other hand, Galbrecht et al. (1965) did not find systematic responsivity or habituation phenomena in respiratory rate to low intensity auditory stimuli.

Drug effects on peripheral psychophysiological activity

The effects of psychoactive drugs on peripheral systems depend on so many variables (including dosage, chemical structure and individual differences in systemic response) that studies controlling for most relevant variables are rare. In general, sedatives and tranquillizing drugs have their most clear-cut effect on the electrodermal system. Sedatives, such as cyclobarbitone depress tonic skin conductance level and increase habituation of the GSR without affecting the OR itself. The effects increase with increased dosage (Lader & Wing, 1966). The same authors report no significant drug effects on resting levels of muscle tension, and a slight increase in heart rate. The effects of a major tranquillizer, chlorpromazine are similar to those of sedatives on electrodermal activity - including impairment on conditionability (Kristoffersen & Cormack, 1960; Mitchell & Zax, 1959). Scholander (1961, cited by Lader & Wing, 1966) finds that chlorpromazine increases and the stimulant amphetamine retards habituation of autonomic responses. Elkes (1961) also notes the differential effect of these two substances on psychophysiological activity. Anti-depressant drugs show no consistent effects on psychophysiological activity (Ban 1969). Apart from their effects on EEG and electrodermal activation, psychoactive drugs appear to have a more dramatic influence on complex overt behaviors than on peripheral psychophysiological activity.

A survey of psychophysiological studies suggests that the greater portion involve the monitoring of EEG and peripheral (autonomic and motor) concomitants of task performance. The psychophysiological data gathered from such studies do not fit into an all-encompassing theoretical model. Neither basal activity, nor tonic reactivity in each system separately can be used as an "index of arousal" in an interchangeable fashion. Behavior of these systems varies according to the "meaning" of stimulus material, demand characteristics of the stimuli, and instructions given to the subject. (Effects of set.).

Turning to phasic responsivity, for certain systems (e.g., cardiovascular) it is difficult to define the limits of a phasic response; nor is it always clear to what the OR is responding to (Bernstein 1969).

The smaller portion of studies deals with psychophysiological behavior in response to simple, non-ideational stimuli in essentially passive subjects.

This avenue of research while having fewer pitfalls yields information of a somewhat restricted nature because of its focus on responses to low stimulus loads. In such studies intensity appears to be the major independent variable. Problems exist here too. At low intensity levels the problem of threshold differences between systems emerges; at higher intensities, some subjects may emit "defensive" type responses with the result that the response defines whether or not the stimulus is stressful. Also, in spite of their relevance, the influence of stimulus modality, and sex has not been adequately explored in studies of this type. Finally, it will be recalled from previous discussion that peripheral systems do not correlate well in the same subject or across subjects. Each subject has a characteristic pattern of psychophysiological responding ("autonomic response stereotypy" - Lacey & Lacey, 1958).

Despite these difficulties it remains possible and useful to investigate psychophysiological response to simple, non-ideational stimulation provided that the pitfalls are avoided or taken into account in the experimental design and interpretation of results.

The foregoing presentation of the relevant parameters, theoretical models and major findings associated with psychophysiological research has been oriented to the functioning of normal individuals. The aim has been to provide a frame of reference for a similarly organized review which follows concerning psychophysiological behaviors in psychologically disturbed individuals.

Tonic activity levels in psychopathological states

a) EEG

EEG studies in psychopathological states have yielded inconsistent results. Reviews such as those of Duffy (1962), Ellingson (1954) and Hill & Parr (1963) list contradictory findings in studies using the same types of patients. Ellingson (1954) goes so far as to suggest that EEG differences between normals and psychiatric groups may stem from the fact that psychiatric subjects do not readily relax in a test situation. Thus the differences do not necessarily reflect an "intrinsic" difference in brain functioning.

Certain trends among the findings persist however. EEG records of psychiatric patients are often described as "unstable" or "variable" as compared to control subjects (Brockway, Gleser, Winokur,& Ulett, 1954). Highly anxious patients (Shagass 1955) and certain schizophrenics (Hill 1957) are frequently reported to show an EEG wave-pattern of high-frequency and low amplitude. In contrast, patients suffering from "endogenous" depressive states may show a low-frequency - high amplitude pattern (Shagass 1955). In reviewing a number of EEG studies, Venables (1966) concludes that the high-frequency - low amplitude EEG is characteristic of chronic, behaviorally withdrawn non-paranoid schizophrenics.

b) Peripheral systems

In surveying investigations of peripheral psychophysiological function those studies conducted prior to the 1950's are omitted. They are difficult to evaluate because of methodological problems. Detailed reviews and criticism of early work can be found in Altschule (1953) and Duffy (1962). In addition only those studies which use a control group are considered here.

1. Base level peripheral activity has been frequently reported to be high

in chronic schizophrenics across many psychophysiological systems as compared to normal control subjects. High resting level heart rates have been noted in chronic schizophrenics by Gunderson (1953); Jurko, Jost,& Hill (1952); Reynolds (1962); B.D. Smith (1967), and Williams (1953). Jurko et al., Reynolds, and Williams also report high respiration rates in this group. Reynolds (1962) reports high resting level blood pressure and muscle tension as well in chronic schizophrenics when compared to normal control subjects. Studies of tonic electrodermal activity have provided equivocal results. Most studies do not find significant differences between schizophrenics and normal control subjects (Fenz & Velner, 1970; Goldstein & Acker, 1967; Malmo & Shagass, 1949; Pishkin & Hershiser, 1963; B.D. Smith, 1967; Thayer & Silber, 1971). Some studies (Howe 1958) report lower, others (Bernstein, 1967; Venables & Wing, 1962; Zahn, Rosenthal,& Lawlor, 1968) find higher resting levels in chronic schizophrenics than in control subjects.

In chronic non-paranoid schizophrenics the behavioral dimension of activity-withdrawal is associated with resting levels of central and peripheral psychophysiological activity. Behaviorally withdrawn patients tend to show many psychophysiological signs of high baseline activity (B.D. Smith, 1967; Spain, 1966; Venables & Wing, 1962). Subjects variously described as "psychoneurotic", "anxiety neurotic" or as showing "morbid anxiety" also demonstrate increased baseline tonic activity. Pre-stimulus levels of high tonic electrodermal activity among such subjects were found by Howe (1958) and Lader & Wing (1966). Tonic heart rate and muscle tension levels among psychoneurotic subjects were also found to be elevated by Malmo & Shagass (1949) and Malmo & Smith (1955). A review of studies by Wenger (1966) concludes that high baseline activity of psychophysiological systems characterizes both neurotic and schizophrenic patients as compared to normal control subjects, i.e., both groups lie along the same continuum of sympathetic overactivity.

11. <u>The OR and its habituation in schizophrenic and psychoneurotic subjects</u>

In a significant percentage of schizophrenic subjects a decrement or absence of the OR has been reported across all peripheral systems. Tonic changes in response to a novel stimulus were reported to be smaller than those of normal control subjects on the measures of heart rate and muscle tension by Williams (1953) and Reynolds (1962). Electrodermal findings are again equivocal; Bernstein (1967) and Zahn, Rosenthal,& Lawlor (1968) report increased tonic electrodermal OR among chronic schizophrenics relative to control subjects. Others (Lykken & Maley, 1968; Thayer & Silber, 1971) report no significant differences.

The absence of the phasic OR in certain schizophrenics has been noted by Russian researchers (Lynn 1963). Western studies tend to corroborate the absence of the OR to diverse stimuli in chronic schizophrenics. Fenz & Steffy (1968) found that the GSR to such significant stimuli as presentation of food was absent in a number of chronic hospitalized schizophrenics. Bernstein (1970) reported diminished or absent GSR-OR to low intensity, simple auditory stimuli in a similar group of patients. In this study OR frequency increased with increased intensity of the stimulus. Bernstein (1964) also found that phasic electrodermal orienting to simple visual stimuli was reduced in chronic schizophrenics.

Generally, in studies such as those cited above which find impaired phasic OR among chronic schizophrenics, habituation to discrete stimuli is found to be faster than in control subjects. Habituation of conditioned autonomic responses also tends to be faster in chronic schizophrenics than in controls (Ax, Bamford, Beckett, Fretz,& Gottlieb, 1970). Zahn et al. (1968) drew attention to what they call an "on and off" quality in the habituation pattern of chronic schizophrenics. These authors found that such patients show a somewhat random pattern of GSR responding to discrete stimuli resulting in an irregular habituation curve. By contrast, tonic electrodermal habituation in such patients is found to be slower than in normal control subjects during a vigilance task (Claridge 1967) and during presentation of simple visual stimuli (Bernstein 1967). Finally, Thayer & Silber (1971) found no significant differences between control subjects and chronic schizophrenics in phasic and tonic electrodermal habituation to simple stimuli. In this study habituation was related to the amount of spontaneous GSR activity (lability of the tonic electrodermal level) in both groups, regardless of diagnosis.

Among psychoneurotic subjects autonomic overreactivity (both tonic and phasic) to novel stimuli has been reported, particularly if the stimuli were considered stressful or noxious. Heart rate (Wishner 1953) and muscle tension, specifically the activity of the frontalis muscle (Malmo & Smith, 1955; Sainsbury & Gibson, 1954) reflect this heightened response. Some studies, however, do not find significant differences between neurotic and control subjects on GSR responsivity (S.B.G. Eysenck, 1956; Jurko et al. 1952) and on other peripheral measures except vascular responses (Kelly, Brown,& Shaffer, 1970).

In the studies which find initial overresponsivity to a variety of stimuli in neurotic subjects, a delay in habituation is also noted. Habituation is markedly delayed in most peripheral systems during and following stressful stimulation in anxiety neurotics when compared to control subjects (Malmo & Shagass, 1949; Malmo & Smith, 1955). GSR habituation to simple auditory stimuli is also delayed in patients suffering from "morbid anxiety" (Lader & Wing 1966) and in a high-anxiety non-patient population (Katkin & McCubbin 1969). In another study (Lader 1967) GSR habituation was found to be delayed only in patients suffering from both anxiety and depressive complaints. Patients with simple phobias did not differ from control subjects in this study.

III. Adaptation of peripheral psychophysiological systems in schizophrenic and neurotic subjects

In schizophrenic subjects a deficit in adaptation of both tonic and phasic responsivity to stimulus characteristics has repeatedly been found. In a number of studies (Gunderson, 1953; Reynolds, 1962; Williams, 1953) autonomic differentiation of stress versus non-stress periods tended to be poorer among chronic schizophrenics than among normal control subjects. Goldstein & Acker (1967) report essentially similar findings in their schizophrenic subjects during the viewing of a "tension-arousing" film. Zahn (1964) found that autonomic responsivity declined as the stimuli presented became more complex. "Matching" of the GSR to low intensities of auditory stimuli is not accomplished well by chronic schizophrenics (Bernstein, 1970; Smith, 1967). In general, Fenz & Velner (1970) note that psychophysiological events do not bear the same relationship to overt behaviors as they do in normal subjects. In neurotic Ss the studies reviewed above do not indicate systematic departures of psychophysiological adaptation behavior from patterns established in control Ss - except for overreactivity to manifestly stressful stimuli.

Activation and orienting in psychopathological states: theoretical formulations

Attentional disturbance has been considered a characteristic feature in schizophrenia leading to impaired formation of complex perceptual and cognitive sets and giving rise to the clinically well-known distortions of reality typically associated with this disorder (McGhie & Chapman, 1961; Shakow, 1963; Venables, 1963). Research evidence of the type reviewed above has led to the argument that activation levels are so high in schizophrenics that no efficient central and peripheral adaptation to stimulus changes can take place - thereby reducing the ability to attend selectively and efficiently.

Modified drive theories which identify high anxiety as a high-drive - high arousal condition also postulate high drive as a disrupting factor in schizophrenia both in input (sensory-perceptual) and in output (overt response) processes. Mednick (1958) suggested that high drive conditions allow competing responses to emerge simultaneously resulting in thought disorder and ambivalence of feeling and action. Broen & Storms (1966) hypothesized that drive levels that may not be disruptive for normal individuals may cause at least partial collapse of response hierarchies among schizophrenics - with resultant disorganized behaviors. Some theorists postulate malfunction of the ARAS to account for observed high activation levels (Fish, 1961; Jurko, Jost,& Hill, 1952; McGhie & Chapman, 1961). Others emphasize some form of defensive overactivity or overinhibition in the CNS explaining decrement of the OR, and impaired tonic and phasic adaptation in schizophrenics. Leach (1960) suggests an integrative defect on the basis of decreased nystagmic eye movements in response to body rotation among schizophrenic Ss. Meehl (1962) speculates about selective overactivity of inhibitory neurons. Russian research on schizophrenia as summarized by Lynn (1963) emphasizes Pavlov's concept of "protective inhibition" of the cerebral cortex in the face of intolerable stimulus loads. Bernstein (1970) reaches similar conclusions in commenting on OR deficiency among chronic schizophrenics. A form of defensive overactivity of the cerebral cortex is also postulated by Silverman (1967). He suggests that such overactivity may be responsible for "filtering out" ideational aspects of a stimulus ("ideational gating") which in turn, results in "sensory enhancement", i.e., overreactivity to simple sensory aspects of a stimulus situation.

Impairment of stimulus input process in chronic schizophrenics was also noted by Venables (1964) and Brawley & Pos (1967). The latter authors, reviewing evidence of schizophrenic behavioral deficit, come to the conclusion that schizophrenics suffer from an underload of relevant input even though they behave as if they were overstimulated. Protective overactivity seems to defeat its purpose by shutting out relevant as well as irrelevant information. Broen (1968) suggests that feedback arrangements between the ARAS and the cortex are impaired in chronic schizophrenics so that long-term activity levels of psychophysiological systems are "stuck". The high levels of tonic activity may be the result of an "anticipatory physiological set" which protects the system from stimulation perceived as noxious. This set then attenuates the intensity and meaning of a stimulus before a response can be organized with a poor match resulting between stimulus and response.

Finally, a neo-Pavlovian position is represented by Epstein (Epstein, 1967; Epstein & Coleman, 1970; B.D. Smith, 1967). He proposes that poor autonomic adaptivity in chronic schizophrenics stems from impaired discrimination learning of intensity differences. This learning takes place early in life. Sustained high anxiety (drive, arousal) experienced at this time will interfere with intensity learning. (Epstein's approach can predict both under and overactivity of autonomic systems in the same subject.).

Psychophysiological findings in neurotic subjects have led to much less theorizing of the type seen in studies of schizophrenia. Most neurotic behaviors are attributed to learning (Dollard & Miller, 1950; Wolpe, 1958). Neurotic psychophysiological overresponsivity has been regarded as a result of conditioning. Some British researchers however have pointed to a physiological substratum in neurotic behaviors as well. Eysenck (1957, 1963) and Claridge (1967) present a great deal of evidence to suggest that depressed and anxious neurotics (the "introverted" or "dysthymic" neurotics) are highly activated, whereas patients who display hysterical and acting out behaviors are not.

Among patients suffering from chronic high anxiety, high levels of psychophysiological activity have in part been attributed by Lader & Wing (1966) to genetic factors which result in some form of impairment in the feedback mechanisms between the ARAS and the cerebral cortex. This hypothesis is similar to those advanced to explain schizophrenic deficit. Claridge (1967) who hypothesizes a two-factor arousal system (a "tonic" long-term activating system and a modulating system) suggests that an introverted (anxious and depressed) neurotic has a high level of tonic arousal and a "strong" (active) modulating system. This schema incorporates the findings of high basal activity level and overreactivity to stimulus input.

On the basis of the studies and theoretical formulations reviewed above the case for psychophysiological abnormality in chronic schizophrenics and in highly anxious neurotic patients appears plausible. There are, however, problems of methodology as well as conceptualization which raise basic questions. The majority of studies of psychophysiological function in "abnormal" subjects have dealt with central and peripheral changes which accompany the performance of a task, or are associated with a manifestly threatening stimulus or are related to the presentation of complex ideational stimuli (such as the viewing of a film). These studies emphasize the effects of complex stimulus parameters on autonomic functioning. They do not examine central and peripheral functioning per se under minimal stimulus input. When stimuli and instructions to subjects are complex, it is difficult in practice to distinguish between truly "basal" or resting levels of activity and levels altered by equipment stress or preparatory set induced by instructions. Duffy's observation is relevant here: "It is of course erroneous to suppose that the individual is in a truly "basal" state of activation until the experimenter introduces the stimulus which serves as the independent variable... The rest period usually required before physiological measurements are made does not in fact reduce the degree of activation to a level which might be considered 'basal'." (Duffy, 1962, p. 29). Also under complex stimulus conditions, the differentiation of orienting response, defensive reflex and phasic adaptive reactions becomes difficult. When simple, non-ideational stimuli are employed in a non-noxious range the above problems are less important. However, other questions remain pertinent.

1. Stimulus modality

What are the effects of stimulus modality on psychophysiological responsivity to simple stimuli in psychiatric subjects? Very few studies tried to assess this difference in psychiatric populations.

2. Sex effects

Sex differences in GSR habituation reported in normal subjects have not been investigated in psychiatric patients. Do such differences exist among "abnormal" as well as in normal groups?

3. Subdivisions among diagnostic categories

A number of studies, particularly those employing simple sensory stimuli did not make use of a neurotic control group when comparing schizophrenic and normal subjects. Furthermore, meaningful subdivisions among schizophrenic or neurotic subjects were frequently not observed. Contradiction between reports describing increased and those finding decreased psychophysiological responsivity in the same categories of psychiatric groups may have been partially due to this lack of subdivisions within the major psychiatric categories. Evidence for the need of such subdivision among neurotics comes from Eysenck (1957) and Claridge (1967). They have presented evidence that psychophysiological and perceptual functioning of anxious and depressive neurotic (dysthymics) differs from those neurotics who exhibit somatic complaints and overt behavioral disturbances. The differences are in the direction of high activation among the dysthymics. The inclusion of a dysthymic neurotic group in studies of schizophrenic autonomic activity becomes highly relevant.

Similarly, interpretation of findings in ungrouped schizophrenic samples is also difficult. Silverman (1964, 1967) has presented evidence that certain perceptual behaviors (particularly "scanning") divide schizophrenics along three dimensions: "paranoid - non-paranoid", "process-reactive" and "good-premorbid - poor-premorbid". The "good-premorbid reactive" paranoids are "hyperscanners", very alert to events in the perceptual field, and the "poor-premorbid" "process" non-paranoids show decreased scanning of their environment. As mentioned earlier, this latter group is most likely to show "ideational gating" and "sensory enhancement" as defined by Silverman (1967). It has also been reported that when non-paranoid schizophrenics are separated into good-prognosis - poor-prognosis groups (Bernstein 1967) or are divided along the behavioral dimension of activity-withdrawal (B.D. Smith, 1967; Spain, 1966; Venables, 1963) withdrawn patients and those with a poor prognosis show more autonomic abnormality in the direction of high activation than do active patients, and patients with good prognostic outlook.

4. Drug status

As noted previously psychoactive drugs used in the treatment of the "mentally ill" - depending on dosage and chemical structure - do affect central and peripheral psychophysiological activity in the direction of lowered arousal (Ban, 1969; Elkes, 1961; Lader & Wing, 1966). Studies of psychiatric patients, particularly schizophrenics, on autonomic variables vary in their concern for medication effects. Many of the earlier studies did not report the drug status of their subjects. Results of these studies are difficult to interpret.

5. Psychophysiological activity and diagnostic specificity

Another question frequently asked is whether diagnostic specificity need exist on a neurophysiological basis. According to the position of Gellhorn (1953, 1965, 1968) and Wenger (1966) both neurotic and psychotic disorders may show the same type of imbalance between sympathetic and parasympathetic dominance of autonomic responsiveness. In addition, both Bernstein (1967) and Lang & Buss (1965) suggest that the OR and habituation abnormalities of the same type may occur in neurotics as well as in schizophrenics. Also the comment of Lader & Wing (1966) on autonomic feedback disturbances in high anxiety patients appears similar to suggestions reviewed by Broen (1968) concerning autonomic abnormality in chronic schizophrenics. Finally, Crooks & McNulty (1966) have shown that autonomic response stereotypy (Lacey & Lacey 1958) is not significantly different in neurotics, normals and schizophrenics.

6. Psychophysiological activity and personality traits

Considering the above suggestions one may prefer to look at personality traits, or long-term behavioral characteristics rather than diagnostic categories, as possible and meaningful correlates of autonomic dimensions.

In normal subjects differences in autonomic reactivity were found related to such major personality dimensions as "repression-sensitization" (Byrne 1964), repressors being more reactive under stress than sensitizers.

Anxiety (often used synonymously with arousal or drive) as measured by questionnaire type tests, however, does not correlate with autonomic indices (Katkin & McCubbin, 1969; Raphelson, 1957; Roessler, Burch,& Childers, 1966). In addition, Roessler et al. (1966) were unable to find significant correlations between a large battery or personality inventories and electrodermal responsivity under a variety of stimulus schedules. It should be noted however, that scales of personality inventories cover a variety of behaviors which lie along different dimensions, and may therefore cancel out potential correlations with specific autonomic behaviors. Breaking down a scale to specific subdivisions may result in significant correlations between autonomic variables and specific "subscales" as was shown by Epstein & Fenz (1970).

Certain behavioral dimensions may be readily identified in objective terms among psychiatric subjects as well. On the dimension of "activity-withdrawal" - as mentioned previously - autonomic abnormality in the direction of high arousal and reduced phasic responsivity was found to be related to behavioral withdrawal. Since "withdrawal" occurs clinically in both schizophrenics <u>and</u> in anxious-depressive neurotics, one may expect that an autonomic abnormality present during simple, low-stress stimulus conditions will correlate with behavioral withdrawal in <u>either</u> group and in a sample combining both groups.

The aim of the present investigation therefore is to determine a) whether diagnostic categories and autonomic activity differences are meaningfully related, and b) whether behavioral dimensions also correlate significantly with autonomic indices.

Method

Subjects

In choosing psychiatric subjects for a study like the one proposed, it is important to consider:

1. the dysthymic-hysteric distinction now generally applied to neurotics. The presence of "anxiety" alone is not a sufficient criterion for considering a neurotic "dysthymic". In fact, many high anxiety subjects of Lader & Wing (1966) were found to be extroverted. The presence of anxiety and depression as well as certain premorbid personality features such as high levels of aspiration in the presence of a self-critical attitude, persistence in and liking of detailed "finicky" work, selectivity in seeking social stimulation (Eysenck 1957) in combination describe the "introverted" neurotic.
2. subgroupings of schizophrenics based on pre-morbid history and course of illness in addition to classical clinical classification. It is important to compare relatively acute, "reactive" cases to the frequently used chronic, long-term hospitalized samples. The psychiatric patient groups consisted of 24 chronic non-paranoid schizophrenics, 24 acute non-paranoid schizophrenics, and 24 anxious-depressive neurotics respectively. They were between twenty and fifty years of age, without known or apparent visual, auditory, or neurological dysfunction. Half of each group were women. The chronic non-paranoid schizophrenic patients were residents of a large mental hospital in the Montreal area. Only patients with more than two years and less than ten years of continuous hospitalization were included. Only those patients were considered whose diagnosis remained unchanged during the course of their hospitalization. Each patient was reviewed by his staff psychiatrist and nurse. All chronic schizophrenics selected had a long history of poor pre-

morbid adjustment (poor academic and work performance and impoverished interpersonal relationships) and had demonstrated little improvement over at least two years of continuous treatment including long-term phenothiazine medication. The acute schizophrenics and neurotics were drawn from the in-patient and day-hospital services of a Montreal general hospital. Criteria for selection of acute schizophrenics were: (a) a recorded diagnosis of "acute schizophrenic reaction"; (b) non-paranoid symptoms; (c) hospitalized for less than six months; and (d) a history of adequate school and work performance prior to onset of psychiatric disturbance. For the neurotics, those who at any time had carried a diagnosis of psychosis, sociopathy, or alcoholism were excluded. The neurotic patients were characterized by staff as anxious and depressed. Psychotic potential or symptoms were judged to be absent.

Drug status:

Since it has been shown earlier that tranquilizing drugs have an effect both on tonic levels of autonomic and central activity and on habituation patterns as well, it is difficult to see how valid results can be obtained if subjects remain on medication. The markedly different kinds of drugs given to neurotics and schizophrenics would further confound the results. Withdrawal of phenothiazine medication also poses a problem. It may take up to 30 weeks for a patient's urine to be clear of metabolites of drugs of this type after administration is discontinued and it is often not feasible to withhold treatment from patients for such long periods of time. Lykken & Maley (1968) suggest that certain autonomic differences between patients and controls may have been due to the restlessness of patients who "missed" their medication. However, major reviews of studies dealing with the distribution, metabolism and excretion of phenothiazine drugs in animals as well as humans (Ban, 1969; Shepherd, Lader,& Rodnight, 1968) conclude that well over half of the daily dose is excreted in bodily waste within 48 hours. The rest is stored mainly in keratinous tissue, (hair) and in the lungs with relatively little residual remaining in the CNS. Therefore the use of a shorter "off medication" period which may not be long enough to render a subject entirely drug free in the biochemical sense may nevertheless contribute to more valid psychophysiological results. All subjects were, therefore, taken off medication for 72 hours prior to the first test.

Patient samples were restricted to those who did not show undue apprehension or hostility when the procedures (including removal of medication) were explained to them. The control group consisted of 24 subjects recruited from administrative and maintenance personnel of the two hospitals where the study took place. Control subjects were matched as closely as possible to the psychiatric groups on age, sex, and educational level. However, the mean age of the acute schizophrenic group remained significantly below that of the other groups. In attempting to match educational levels, the chronic schizophrenic group was found to have a significantly lower level of formal education than that of the other groups. No other significant differences were found. (Tables 1 and 2, Appendix A lists the means and standard deviations of age and educational level of the groups.)

Choice of measures:

Simultaneous monitoring of all central and autonomic variables involves a great deal of instrumentation including the placement of numerous electrodes on different parts of the body. This procedure by itself may be a source of differentially strong initial stress for psychiatric patients. If one attempts to achieve a low-stress stimulus environment, placement of equipment including electrodes on the body surface should be kept at a minimum. Consequently instead of taking simultaneous readings of all major psychophysiological variables, it may be preferable to concentrate on one or two variables having relatively easy "monitorability". For the purposes of the present study the basal skin conductance level (BSCL) and the galvanic skin response (GSR) as tonic and phasic components of the electrodermal system were selected. Both practical and theoretical considerations suggest this choice.

I. The nature of the system is such that both tonic and phasic responses are clearly interpretable. A rise in the BSCL is seen as an increase in activation. A sudden rise of the BSCL along with its return toward the baseline is regarded as a GSR.

II. There is no evidence of spontaneous manifest perceptual or motor feedback of the electrodermal response which might influence the probability of the next response occurring.

III. The phasic element (GSR) is easily evoked by simple stimuli and it has all the clear-cut characteristics of an OR and its habituation. (Kimmel & Kimmel, 1965; Montagu, 1963). The tonic component (BSCL) shows a long-range (across-sessions) habituation pattern as well. (Duffy & Lacey, 1946; Galbrecht et al., 1965).

IV. At a practical level, measurement of the skin conductance level and GSR can be accomplished with little annoyance to the subject. The record is easily scorable. (Hume, 1965; Martin & Venables, 1966).

As a second measure, rate and variability of respiration were selected. Respiration seems to be a neglected variable in psychophysiological research in spite of its relevance to both arousal and psychopathology.

Respiration seems less responsive to small changes in stimulus conditions than other psychophysiological measures. It shows little habituation over time (Galbrecht, et al., 1965) suggesting a rather stable basal output - at least under low-stress conditions. Three features of this measure argued for its conclusion in the study.

A. Previously demonstrated abnormality in both neurotic and schizophrenic groups.

B. Relatively few recent data.

C. Ability to record without placing the equipment on the body surface.

Physiological recording apparatus:

Electrical resistance of the skin and respiration were recorded on a Sanborn 296, two-channel portable polygraph utilizing heat-sensitive (inkless) paper for continuous recording. Chart speed was set at 2.5 mm/sec.

Skin resistance:

Electrical resistance of the skin was recorded with Beckman-type, Ag - AgCl2, electrodes (Miller 1968). These are flat discs, 12 mm in diameter. (Manufacturer: Biocom Co.). The surface of the electrodes was covered with Grass electrode paste Type EC-2 and placed over the central whorl of the distal phalanx of the first and third finger of the right hand of the subject. A custom built DC power source delivered a constant current of fifty micro-amperes through the electrodes. A Sanborn 350-1300 type preamplifier was used to magnify signal strength. The recording instruments were so calibrated that a one mm deflection of the recording pen on a rectilinear chart paper represented a change of one Kiloohm in resistance.

Respiration:

Respiration cycles were recorded by means of a bellows-type pneumograph attached to a Sanborn Model 270 GF pressure transducer having a differential range of 400 Hg/mm. Signals from the pressure transducer were received by a Sanborn type-350-3000 preamplifier. The instrument was placed on the subject's chest and was secured in place by an adjustable strap on subject's back. This was done when subject exhaled so that the instrument fit loosely across the chest.

Presentation of stimuli:

The stimulus sequences were delivered automatically by means of a 1 mm per sec. standard speed 125 V, 1/2 HP tape-timer. The sequences were punched on a 16 mm film leader with a special size puncher resulting in a standard stimulus length of 1.5 sec. The tape-timer was operated via a commercial circuit-breaker switch.

Visual stimulation:

The visual stimuli consisted of flashes of a 300 W commercial electric bulb housed in a wooden box of ten cubic inches fitted in front with an opaque glass. The box was placed at a distance of seven feet in front of the subject at eye level on a simple table. Intensity of the stimulus could be varied by rendering the voltage continuously variable through a custom-built Variac device. The intensities of light stimuli (as measured by a Weston model 703-60 light meter ten inches from the light source) were set at 1/4, 3/4, 3, 7, 15, 30, 50, and 108 foot candles.

Auditory stimulation:

The auditory stimuli consisted of 1000 cps tones generated by a custom-built audio-oscillator delivered through a commercial loudspeaker. (Phillips, 5-8 ohms, 6 W frequency range 50 - 5000 cps). The loudspeaker was placed on the wall behind the subject's head at a distance of three feet. The auditory stimuli (as measured in decibels by a General Radio Co. Type 1551 C sound level meter at the height of subject's head) had the following intensities: 60, 70, 74, 79, 84, 82, 100, and 108 decibels in the presence of approximately 54 db levels of masking noise. The instruments controlling stimulus intensity (the Variac device and the audio-oscillator) could be connected to the tape timer, which in turn was connected to the event marker of the polygraph. Stimulus intensity was set manually on the pre-calibrated instruments. The hum of the polygraph and the air-conditioning provided a background masking noise of about fifty-four decibels at subject's ear level.

Behavioral measure:

The MACC Behavioral Adjustment Scale, Form II, (Ellsworth 1962) was selected. This scale provides a rating of four areas of observable behavior without reference to psychiatric concepts or diagnostic labels. This enables persons who spend a considerable amount of time with patients to give a description of patients on the basis of long-term everyday observations rather than on the basis of an interview or a lengthy inventory. The scale consists of four sub-scales; Mood, Cooperation, Communication, Social Contact, and a fifth composite Total Adjustment rating. The four scales are not independent of each other; reported intercorrelations range from ˙19 to ˙87, depending on rater and the pairs of scales being correlated. Test-retest correlations (one week apart) have been reported ranging from ˙84 for Mood, to ˙91 for Total Adjustment when the same rater was used; and ˙79 for Mood, to ˙87 in Communication when independent raters were employed. (Ellsworth 1962).

Although the scales were not meant to measure behavioral dimensions such as activity-withdrawal directly, the Social Contact Scale is made up of items dealing with withdrawn behavior; items of Scales Cooperation and Communication deal both with withdrawal and cognitive confusion. Mood deals with a negative versus positive affective response tendency. The Total Adjustment Scale describes the "overall level of the patient's adaptability to the demands of the hospital community". It seems to be a measure of behavioral adaptation to the kind of stimulation typically present in the ward environment.

Procedure:

The experimental setting was a spacious room with the subject seated in a comfortable chair having an arm rest covered with a rubber foam pad. The room was partially sound-proofed, humidity and temperature controlled. E and the recording equipment were shielded from S by a dark screen. All instruments were in sufficient proximity so as to be operated easily by one person. A ten-watt shielded bulb illuminated the equipment; otherwise the room was darkened with some diffuse light filtering through the window covers.

E met the psychiatric Ss on the ward to escort them to the laboratory at which point they had already been reassured that they would undergo a non-stressful procedure; "no shocks are given and no questions asked". Ss had also been told that there were to be three test sessions on three consecutive days. The Ss did not know in advance the nature of the stimuli nor the manner in which they were to be presented. Control subjects were instructed to avoid sleeping pills, tranquilizers or analgesic medication for three days prior to testing and during the period of subsequent sessions. Control subjects received ten dollars upon completion of the procedure.

When S entered the testing room (all subjects were tested by E) E gave the following instructions slowly but in a natural voice. "Please sit down there, (indicating chair). I am going to put these (indicating electrodes) on your fingers. This (indicating pneumograph) I will put around your chest. Tell me if it is comfortable". After the electrodes and the pneumograph were placed, E continued: "Do you have any questions?" If the S had questions, E answered them in a quiet, neutral manner reassuring them that nothing disturbing was going to happen to them. E then said: "I am going now behind the screen and am turning off the main light. Nothing harmful will happen. Would you please keep your eyes open and look in that direction" (indicating vaguely the stimulus box). E then turned off the light and started recording.

The experimental session; characteristics of stimulus sequences.

As Duffy (1962) pointed out, behavior shows variations in two aspects: direction and intensity. It seems reasonable that a study of psychophysiological activity and reactivity using only simple stimuli would "build in" these dimensions on the stimulus side. Stimuli can be presented in sequences of gradually increasing or decreasing intensity instead of the common design of presenting stimulus blocks each of a different intensity.

Another factor to be taken into account is the habituation delay reported among high anxiety neurotic and chronic schizophrenic subjects. This points to a time element in the presumed "arousal pathology" of such subjects. A study of psychophysiological changes in psychiatric subjects should include a long enough single session as well as more than one session involving the same subject.

A four-minute "stabilization" period or "pre-stimulus" period preceded the introduction of the first stimulus. A two-minute "rest" or "post-stimulus" period followed the last stimulus of a sequence. The stimulus sequences consisted of seventeen stimuli distributed randomly over an eleven-minute period. Time between stimuli ranged from eight to seventy seconds. Three sequences were used; one in which stimulus intensity was held constant; one in which stimulus intensity increased; and one in which stimulus intensity decreased. The distribution of stimuli over the eleven-minute period varied from sequence to sequence. However, the same three sequences were used during visual as well as during auditory stimulation. Only one sequence was administered in a single session. The three sessions were spaced twenty-four hours apart.

The stimulus strength of the "constant intensity" sequence in the visual modality was set at seven footcandles; in the auditory modality at 79 decibels. In the "increasing intensity" sequence the intensity of the first stimulus was set at the lowest level of calibrated intensity in both modalities, to be followed by eight pairs of stimuli; each pair having greater intensity than the preceding pair.

In the "decreasing intensity" sequence the first stimulus was set at the highest calibrated intensity, followed by successive decrements of intensity through eight pairs of stimuli. These sequences constituted a stepwise arrangement of the intensity variable <u>within</u> one experimental session.

The recorded length of a session was 17 minutes; no subject spent more than 25 minutes in the experimental room during any one session. One half of the men and one half of the women subjects within each group were assigned at random to visual the other half to auditory stimulation. Each subject in turn was assigned in a counterbalanced order to one of six possible arrangements of the three stimulus sequences. This generated 16 identical blocks of testing sequences. (Two for each stimulus modality within each group containing six subjects each.) One block within each stimulus modality comprised women Ss, the other block males.

Behavioral rating:

The nurse in charge of a particular psychiatric S rated him or her on the MACC Behavioral Adjustment Scale Form II (Ellsworth 1962).

Treatment of the data:

1. Sampling (See Table 3, Appendix A for descriptive summary of autonomic and behavioral data).

a) Respiration rate:

Rate of respiration was defined as the number of respiratory cycles (inhalation and exhalation) within a given time period. Six one-minute samples were taken during any one testing session consisting of the first and last minutes of the pre-stimulation period; the first, sixth and eleventh minutes of the stimulation period, and the second (last) minute of the post-stimulus period.

b) Respiratory Amplitude Variability:

This measure was introduced in order to estimate the degree of irregularity of respiration. In each one-minute sample of respiration rate (described above) means and standard deviations of respiratory cycle amplitudes (measured within one-sixteenth of an inch) were computed. The coefficient of variation (v) was then derived from the formula $\frac{SD}{\bar{x}}$.

When $\bar{x}$ is restricted in range, the value of v is mainly a function of the SD, which is a measure of variation. Thus, the coefficient of variation within each one-minute respiration sample served as the respiratory amplitude variability score.

c) Tonic electrodermal activity (Basal skin resistance):
Averages of skin resistance readings taken ten seconds apart at the beginning and the end of the pre-stimulation period, at the beginning, middle, and end of the stimulation period and at the end of the post-stimulation period expressed in Kiloohms served as estimates of tonic electrodermal activity.

d) Phasic electrodermal activity (galvanic skin response - GSR):
A deflection of the recording pen representing a drop of at least 500 ohms in electrical skin resistance was scored as a GSR if it occurred within 1·2 - 5·0 seconds following the onset of a stimulus. The amplitude of the response was read as the vertical distance between the basal skin resistance level just prior to the rise of the GSR curve and the inflection point of its primary wave.

e) Parameters of the response to the first stimulus (startle response):
In addition to the usual amplitude measure, two other parameters of the startle response, latency and duration were also sampled. Latency was defined as the time elapsed between the onset of the stimulus and onset of the response. This measure (see scoring of a GSR above) had a restricted range of 1·2 - 5 seconds. Duration was defined as the time it took a GSR to reach the inflection point of its primary wave from its

point of onset. The measure was taken as the horizontal distance between these two points, 2.5 mms equalling one second.

Data analysis:

Statistical transformation of autonomic response data

Skin conductance scores:

All electrical skin resistance scores were converted into conductance units (mho-s) by taking the reciprocal value of a resistance reading. Basal skin conductance levels were computed as the average between two conductance values measured 10 seconds apart. A formula introduced by Lykken, Rose, Luther,& Maley (1966) was then applied to all basal skin conductance scores in order to correct for individual differences in range; i.e., to remove the effect of the observed skin conductance range on a single measurement. The formula is given as:

$$RBSCL_{IX} = \frac{Bix - Bi\ (min)}{Bi\ (max) - Bi\ (min)}$$

where RBSCL is the range-corrected value of the basal skin conductance level; Bix is the uncorrected value of the skin conductance level for subject i on a given measurement. The value of (Bi (max) - Bi (min) is the difference between the highest and lowest observed skin conductance level for subject i. Another formula, also introduced by Lykken et al. (1966) was used to remove the effect of the basal skin conductance level on the amplitude of the GSR. This formula corrects the basal skin conductance level for range at the lower and upper inflexion points of the GSR primary wave. It is given as

$$RGSR_{ix} = \frac{Cix\ (post)}{Bi\ (max)-Bi\ (min)} - \frac{Cix\ (pre)}{Bi\ (max) - Bi\ (min)}$$

where RGSR is the galvanic skin response expressed in conductance units corrected for range of subject i on trial X; Cix (post) is the basal skin conductance value at the upper, and Cix (pre) at the lower inflexion point of the GSR primary wave.

Formation of RGSR response blocks:

RGSR's to stimuli from No. 2 through 17 were grouped into four consecutive blocks, each block containing four responses. Means of RGSR amplitudes within each block were computed; these block means were treated as scores to be used in the statistical analyses.

Behavioral data:

Raw scores on the MACC scales were converted into centile scores provided by the profile summary on the evaluation sheet.

Handling of Irregularities:

In recording the respiratory cycles, movement artifacts made scoring difficult in a few one-minute samples. Where this occurred, the average score of the group on the given sample was entered as the subject's score on that sample. In computing the coefficient of variation for the RAV a few unusually large and irregular cycles were recorded due to sudden movements, on the part of the subject.

As these irregular cycles occurred infrequently (1 - 2 times per record) they were simply omitted from the computation of mean respiratory amplitude for the sample in which they occurred.

One chronic schizophrenic woman subject had to be replaced by another subject of the same age and educational level after she became anxious during the first testing session. A neurotic male and a control female subject also had to be replaced with other subjects matched for age and education for reason of physical illness.

Statistical treatment of the data:

Psychophysiological data of the pre-stimulation, stimulation and post-stimulation periods were analyzed separately. The data were subjected to a six-way analysis of variance with repeated measures on the last two factors. (Programme BMD08V Health Sciences Computing Facility UCLA). The basic design of this analysis along with the brief description of the factors is reported in Table 4 Appendix A. In cases when only one measurement was analyzed at a time a 5 way ANOVA was utilized. F ratios yielded by this analysis were considered significant at or better than the .05 level. F ratios between .10 and .05 were considered as indicating a tendency. Significant F ratios are reported in subsequent tables for main effects and interaction effects, up to and including three-way interactions. - Preliminary analysis indicated that order of presentation effects as main effects were not significant for any variables because of the counterbalanced order of the design.

Other analyses:

Chi square tables were prepared to test the significance of the presence versus absence of the GSR startle response across the groups.

Trend analysis:

Non-parametric analyses of monotonic trend (Ferguson 1965) were performed on consecutive scores of the range-corrected basal skin conductance level within the stimulation period and on the mean amplitude scores of consecutive RGSR blocks, in order to test for significant monotonic habituation trends among groups across modalities and during different stimulus sequences.

Correlational analysis:

Product-moment correlations were computed between psychophysiological response data and behavioral ratings. (Table 5 Appendix A lists the variables of this analysis). The variables included Ferguson's (1965) statistic S - a rough estimate of the regularity of increase or decrease: i.e., habituation or adaptation in the consecutive scores of a subject. A constant was added to each S score to remove negative values. - Age and education levels were also included in this analysis.

RESULTS

I. Group Differences:

A. Group differences in respiratory behavior

1. Rate of respiration:

A significant difference was found in the rate of respiration (RR) among groups. The chronic schizophrenic group breathed most rapidly, followed by the acute schizophrenics, depressive neurotics and control Ss in that order (Figure 1). This difference among groups appeared in the pre-stimulus period and was sustained during and after stimulation (Tables 6,7,8, Appendix B). The Newman-Keuls method of comparison of pairs of group means after obtaining a significant overall F ratio demonstrated that for each of the time periods (pre, during, and post-stimulation) only the difference in mean breathing rate between control Ss and chronic schizophrenics reached significance at the .05 level. Compared to the other groups, the chronic schizophrenic group also tended to exhibit consistently higher RR during and after auditory stimulation than during and after visual stimulation.

2. Respiratory amplitude variability:

The psychiatric groups differed significantly from the control Ss on the measure of respiratory amplitude variability (Tables 9,10, Appendix B). In the pre-stimulation period RAV (respiratory amplitude variability) was high in all psychiatric groups as compared to control Ss (Figure 2). The Newman-Keuls procedure indicated that only the control and chronic schizophrenic means differed from each other at the .05 level of significance. In addition, the difference in RAV prior to visual stimulation as compared to RAV before auditory stimulation varied significantly among the groups. Control Ss and chronic

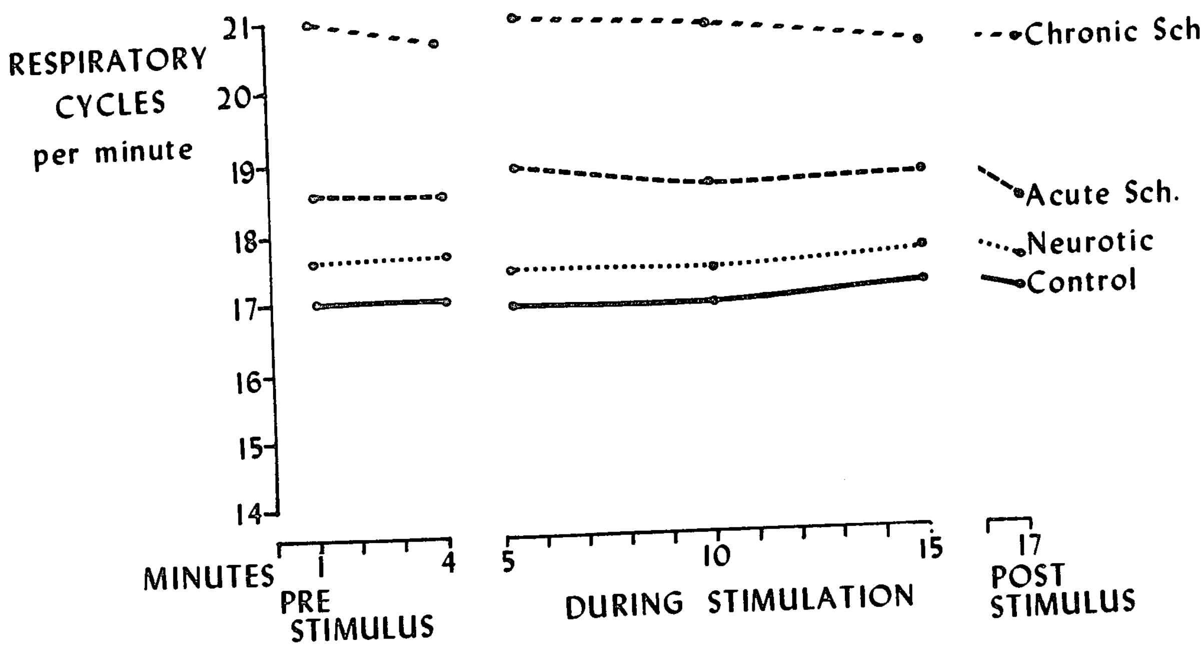

Figure 1. Respiration rate in four groups, (N = 24 for each group), averaged over sessions and modalities.

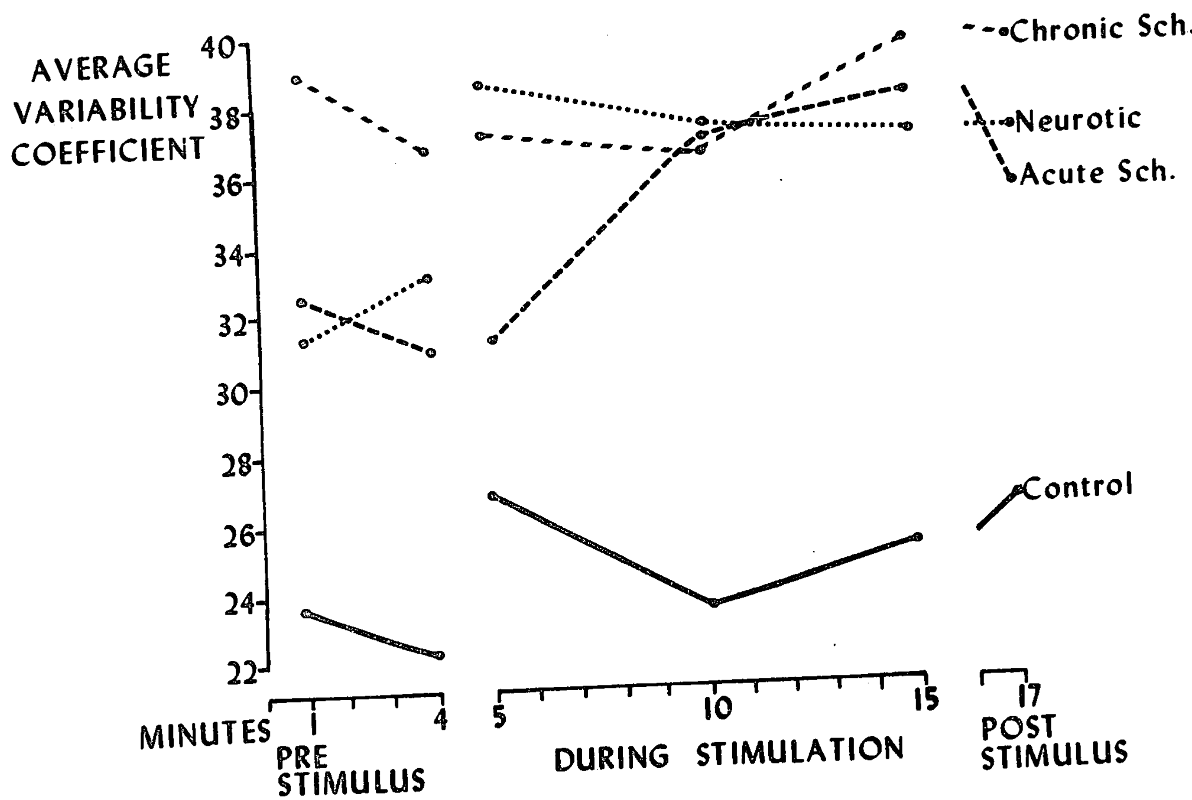

Figure 2. Respiration amplitude variability (N = 24 for each group) averaged over sessions and modalities.

schizophrenics exhibited higher RAV before onset of auditory rather than visual stimulation. Depressive neurotics showed the reverse trend. The smallest difference in RAV prior to visual as compared to auditory stimulation was obtained in the acute schizophrenic group.

During stimulation, RAV was again found to be high in all psychiatric groups as compared to control Ss. The Newman-Keuls procedure demonstrated that during stimulation control Ss differed from both depressive neurotics and chronic schizophrenics at better than .05 level of significance on this measure.

RAV in the post-stimulus period showed a similar trend, but the group differences fell short of statistical significance. There was also no significant difference in RAV among the groups during and after stimulation which could be associated with changes in stimulus intensity and modality.

In summary, irregular breathing patterns (as measured by amplitude variability) occurred in all three types of patients more frequently than in control Ss. Rapid breathing on the other hand (i.e., a high number of respiratory cycles per time unit) was characteristic only of the schizophrenic groups - particularly the chronic schizophrenic group.

The high RR among chronic schizophrenic subjects suggested the possibility that this finding may have been due to a "rebound" effect associated with the removal of medication in these patients. The RR and RAV of a group of chronic schizophrenics (N=24) all receiving the same type of phenothiazine medication, pipothiazine palmitate (Ayd 1972) similar in its action to chlorpromazine (Jain, Ananth, Klingner, Ban,&

Lehmann, 1972) were therefore measured over a four-minute period. The averages of the first and fourth minute RR and RAV respectively of this medicated group were then compared to the similarily derived scores during the pre-stimulus period of the first session of the original experimental groups (Table 11, Appendix B). A one-way analysis of variance of the RR scores yielded an overall F ratio of 4.94, which is significant at better than the .002 level. Newman-Keuls' comparisons of the individual means showed that the difference between controls and chronic schizophrenics was significant at the .01 level; between controls and medicated chronic schizophrenics at the .05 level and between neurotics and chronic schizophrenics at the .05 level. One may conclude from these data that there is no significant difference in RR between medicated and non-medicated chronic schizophrenics.

A one-way analysis of variance of the RAV data yielded an F ratio of 2.13 which falls just short of significance ($.05 > p < .10$). Table 12 (Appendix B) shows that the mean RAV scores of medicated chronic schizophrenics are of the same order as the control subjects, with the non-medicated psychiatric groups showing a tendency toward higher RAV scores. Scores derived from the pre-stimulus period of the first session only, while showing the same trend, do not significantly differentiate the groups. Stimulation appears to enhance RAV differences between control subjects and psychiatric groups.

B. <u>Group differences in the range-corrected basal skin conductance level (RBSCL)</u>.

Throughout the pre-stimulus period, the stimulation period and the post-stimulus period, there were no significant group differences in

RBSCL, although chronic schizophrenics tended to show the highest RBSCL values during and after stimulation. Group differences which did occur on this measure were associated with stimulus modality and habituation factors.

1. In the pre-stimulation period the depressive neurotics displayed a higher average RBSCL value before auditory than before visual stimulation. All other groups showed an opposite trend. In addition, depressive neurotics started at their highest level of RBSCL at the beginning of the four-minute pre-stimulation period and showed the steepest drop (most habituation) of RBSCL by the fourth minute. In contrast, the chronic schizophrenic group exhibited the least amount of RBSCL decrement during the pre-stimulus period (Table 13, Appendix B). The Groups x Measures interaction is illustrated in Figure 3.

2. During stimulation there was also evidence of differential habituation of the RBSCL among groups. In the control group, basal skin conductance level decreased during visual stimulation and increased during auditory stimulation irrespective of changes in stimulus intensity. Among depressive neurotics, a marked drop over successive RBSCL measures continued to occur only in the presence of auditory stimulation and irrespective of changes in stimulus intensity. The schizophrenic groups showed only a slight decrease of RBSCL during all three types of stimulation in both modalities (Table 14, Appendix B). The Groups x Modality x Measures interaction is seen in Figure 4. A non-parametric trend analysis was then done for each group. The procedure examined the successive RBSCL scores obtained (Tables 15 and 16, Appendix B) during stimulation for each of the three stimulus sequences

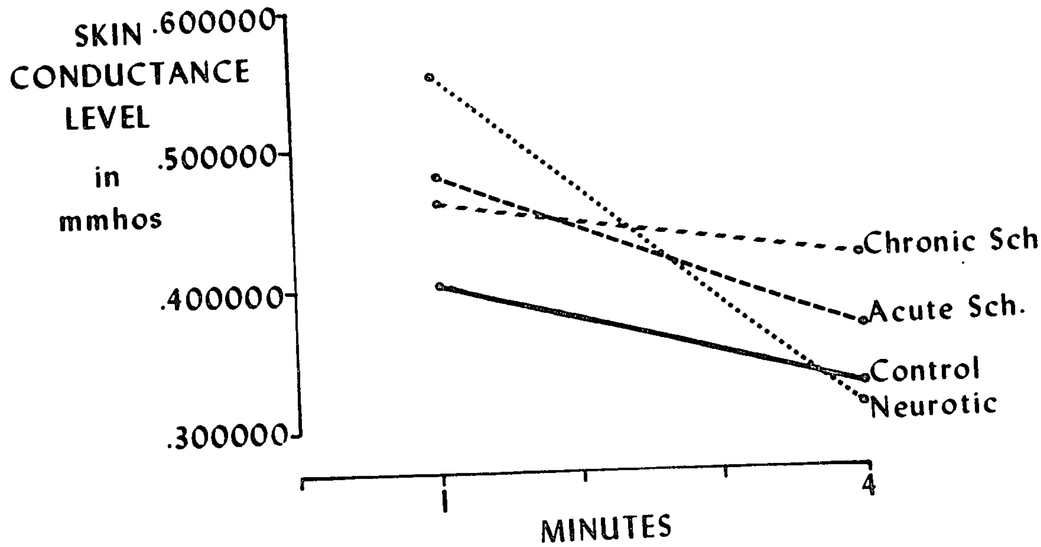

Figure 3. Habituation of the range-corrected basal skin conductance level prior to stimulation; averaged over sessions. (N = 24 for each group.)

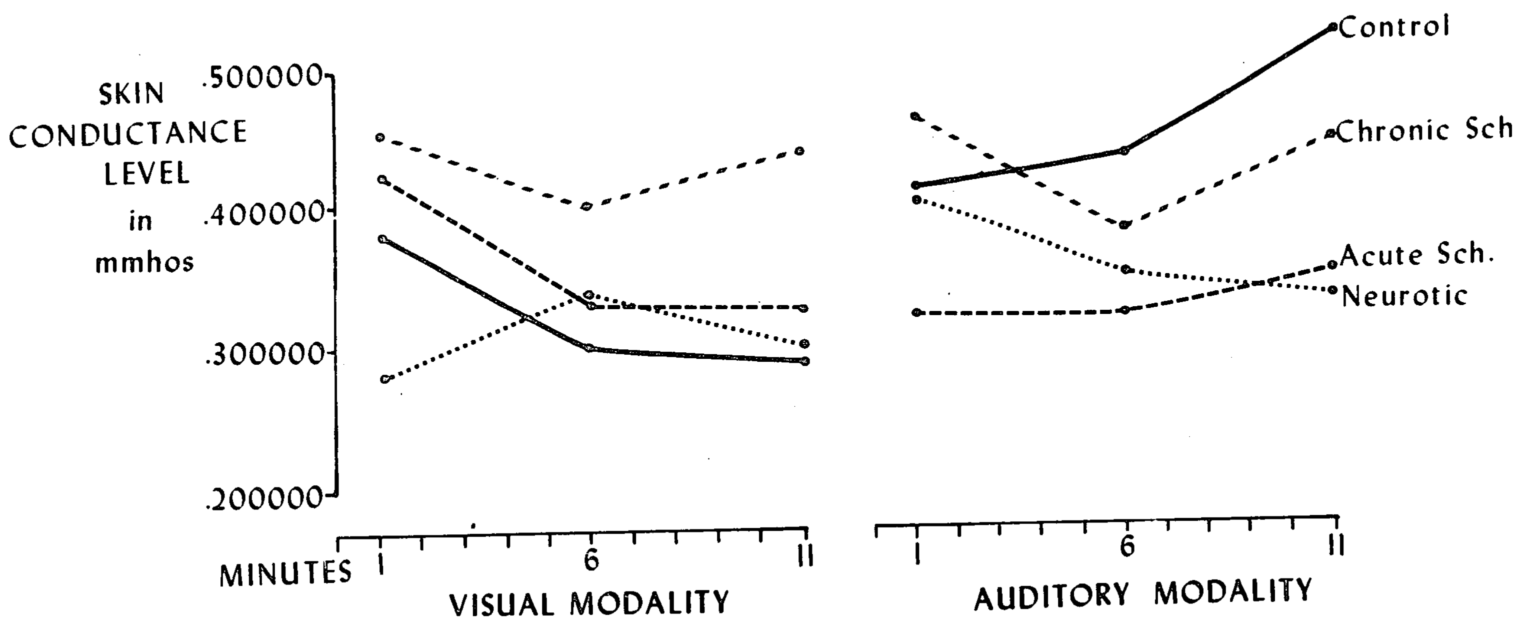

Figure 4. Habituation of the range-corrected skin conductance level during stimulation averaged over stimulus sequences. Differential response to stimulus modality. (N = 12 for each group in each modality.)

and in both visual and auditory modalities to determine:

a. Whether changes across successive RBSCL measures followed a significant monotonic trend (habituation) in each group;

b. Whether these changes were also related to the direction (increase, constancy or decrease) of stimulus intensity;

c. Whether there was a relationship between systematic monotonic change in RBSCL scores and the sensory modality in which stimuli were received. Results revealed that when stimulation was given in the visual modality, a significant monotonic decrease occurred in two instances. As seen in Table 15, during the visual sequence of increasing intensity the acute schizophrenics paradoxically decreased their basal skin conductance level. Also, among the groups only the control _S_s showed a significant monotonic decrease during decreasing visual stimulation.

When stimulation was carried out in the auditory modality, the one significant monotonic change in RBSCL scores was registered by the control subjects. The control group showed a paradoxical increase of RBSCL scores during auditory stimulation of decreasing intensity. In no other groups did the monotonic component of the habituation slope of the RBSCL reach significance.

3. No significant group differences emerged on this measure in the post-stimulation period.

C. <u>Group differences in parameters of the startle response</u> (Response to the first stimulus)

No statistically significant startle response was recorded on respiratory measures.

In contrast, a highly significant startle response was noted on the RBSCL measure by comparing the last pre-stimulus RBSCL score with the first during-stimulus score of the range-corrected basal skin conductance level (Table 17, Appendix B). An increase in the RBSCL was defined as the startle response on the continuous (tonic) electrodermal variable. It occurred mainly as a response to auditory stimulation, and was highest in the control subjects, followed by the chronic schizophrenics, depressive neurotics, and acute schizophrenics in that order. The chronic schizophrenic group showed about as much responsivity as the depressive neurotic group despite its higher base level of skin conductance (after correction for range). Acute schizophrenics showed relatively little startle response on this measure.

Three parameters of the phasic startle response were subsequently examined: latency, duration, and amplitude of the first range-corrected galvanic skin response (RGSR).

1. Latency: (Table 18, Appendix B). There were no statistically significant group differences in latency of the first RGSR.
2. Duration:(Table 19, Appendix B). Duration of the RGSR startle response was significantly different among the groups. Depressive neurotics led with the longest startle responses, followed by control Ss, acute schizophrenics and chronic schizophrenics in that order. These group differences were related to the modality in which the stimulus was given. Control Ss first responses to visual and auditory stimulation were of approximately equal duration. In contrast, all psychiatric groups showed a differential response to stimulus modality. As seen in Figure 5, the high

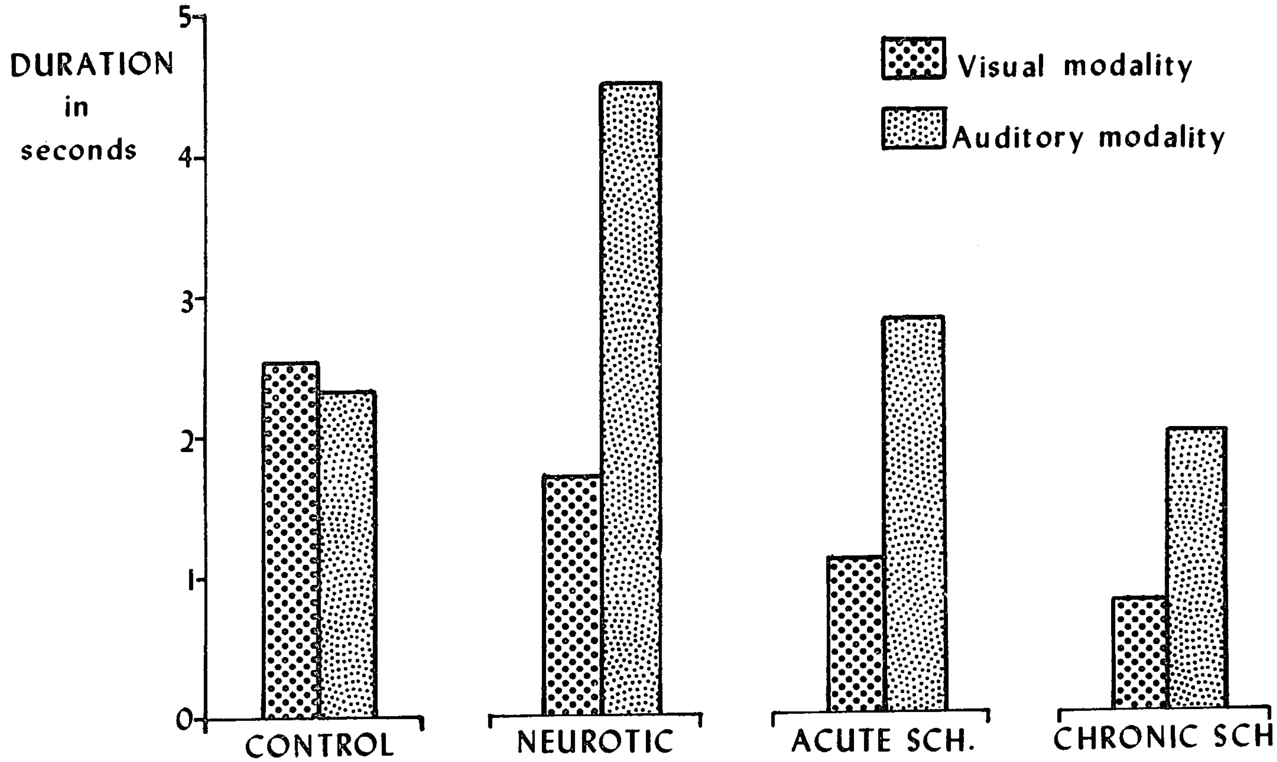

Figure 5. Duration of the primary wave of the GSR startle response averaged over stimulus intensities. Differential response among groups to stimulus modality.

average score of the depressive neurotic group was due to its very long response to the first auditory stimulus. Both schizophrenic groups, however, gave very short-lived responses to the first visual stimulus.

3. Amplitude and frequency: Groups also differed with respect to the amplitude and frequency of the RGSR startle response (Table 20, Appendix B). All psychiatric groups showed smaller RGSR startle amplitude than did Control Ss. Matching of the amplitude of the RGSR to the first stimulus (startle response) was related to stimulus modality. The amplitude of the RGSR response to the first auditory stimulus was reasonably well matched to stimulus intensity in all groups; the louder the first stimulus the higher the RGSR amplitude. This was not the case when the first visual stimulus was introduced. In the chronic schizophrenic group it was the medium intensity stimulus which evoked the highest amplitude startle response. Figure 6 illustrates the Groups x Modality x Intensities interaction.

   Inspection of the data from the chronic schizophrenic group suggests that they either reacted strongly to the medium intensity first visual stimulus - or did not respond at all. Acute schizophrenics on the other hand tended to respond less frequently to the first medium and high intensity visual stimulus than to the low intensity stimulus. This absence of the startle response was further examined by means of chi-square analyses in order to determine whether presence or absence of the RGSR startle response was related to group membership.

   In the visual modality, the combined percentage of "startle

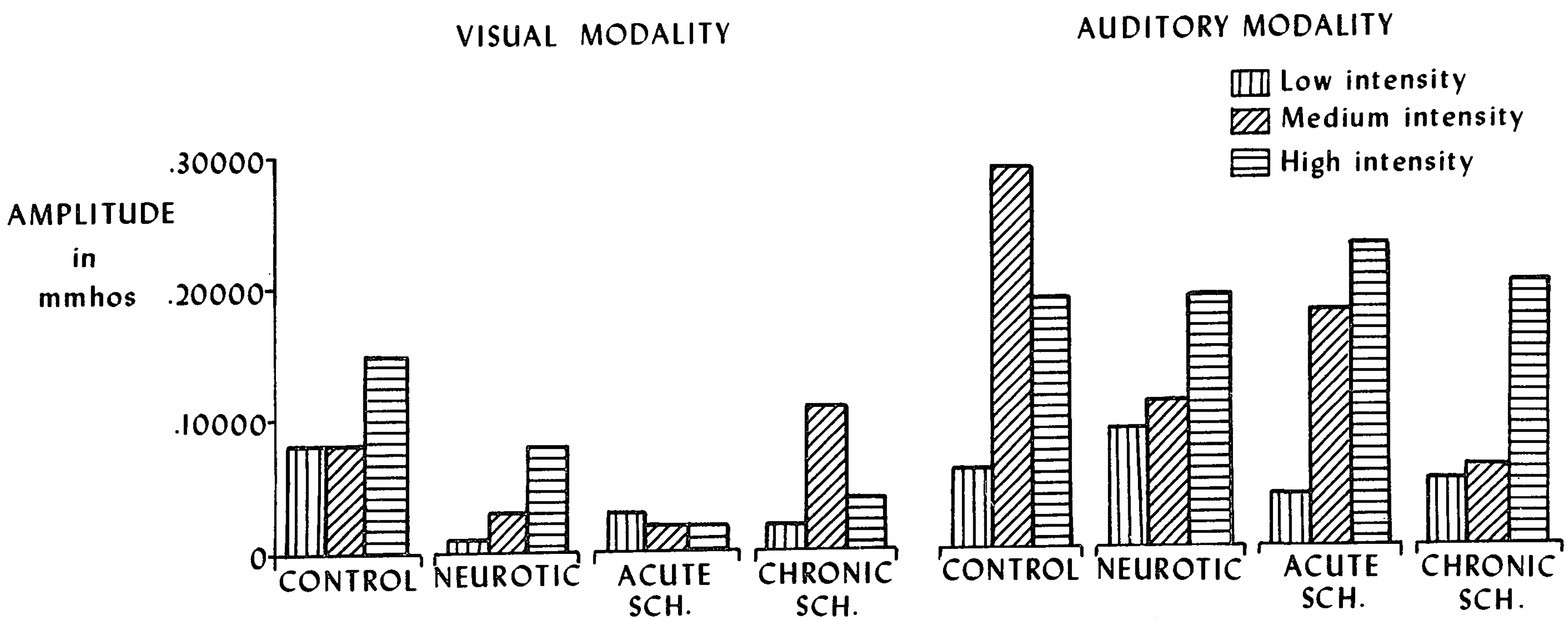

Figure 6. Relationship of the mean amplitude of the range-corrected GSR startle response to stimulus intensity. (N = 12 for each column.)

response absent" was 8.5 percent among controls, 33.3 percent among depressive neurotics, 35.8 percent among acute schizophrenics and 50 percent among chronic schizophrenics. The results indicated that absence of the RGSR startle response to the first visual stimulus is significantly related to group membership under conditions of low and high stimulus intensity. A similar trend in the medium intensity condition fell short of statistical significance (Table 21, Appendix B).

The lack of response was most marked in the schizophrenic groups and least marked among control _Ss_, with the depressive neurotics in between. In the auditory modality control _Ss_ and depressive neurotics both showed 11.1 percent absence of the expected RGSR startle response. There was a 27.7 percent absence of the startle response among acute schizophrenics and 19.4 percent among chronic schizophrenics. Since the control _Ss_ and depressive neurotics were identical on this measure, they were compared as one group with the acute and chronic schizophrenics constituting the other. The data were rearranged in 2 x 2 tables. The RGSR startle response to the first auditory stimulus was significantly more absent among schizophrenic _Ss_ than among control _Ss_ and depressive neurotics under the condition of medium stimulus intensity. (Table 22, Appendix B). Frequency of absence of the startle response in the combined sample was not significantly related to stimulus intensity in either modality.

D. Group differences on three parameters of phasic electrodermal responsivity

1. Total number of GSR's emitted

A significant general group difference in total GSR output (Table 23, Appendix B) indicated sustained responding in the control group in contrast to lower general output in all psychiatric groups. The Newman-Keuls procedure demonstrated that in comparing group means two at a time the difference between the control and all other group means reached significance at the .01 level. The other group means did not differ significantly from each other. This difference was associated with the performance of control male Ss who almost doubled the total GSR output of female control Ss and both male and female Ss of all other groups.

2. Mean RGSR amplitude: (Table 24, Appendix B)

As described previously (see Method), following the first stimulus and startle response, the GSR's associated with the subsequent sequence of 16 stimuli were divided into four consecutive blocks of four responses each. The measure of mean RGSR amplitude was established for each block by taking the average amplitude of the four GSR's (corrected for range) within each block. Analysis of the mean RGSR amplitude based on the means of the four consecutive blocks revealed a significant group difference of the kind noted in the previous paragraph, i.e., overall mean RGSR amplitude was reduced in all psychiatric groups relative to controls. This result was due to the high mean amplitude shown by the men of the control group (Figure 7).

3. Habituation and adaptation of the RGSR amplitude:

The RGSR habituation pattern as measured by successive changes in mean RGSR amplitude over the four blocks also reflected a significant group difference: neurotic depressives decreased mean RGSR amplitude

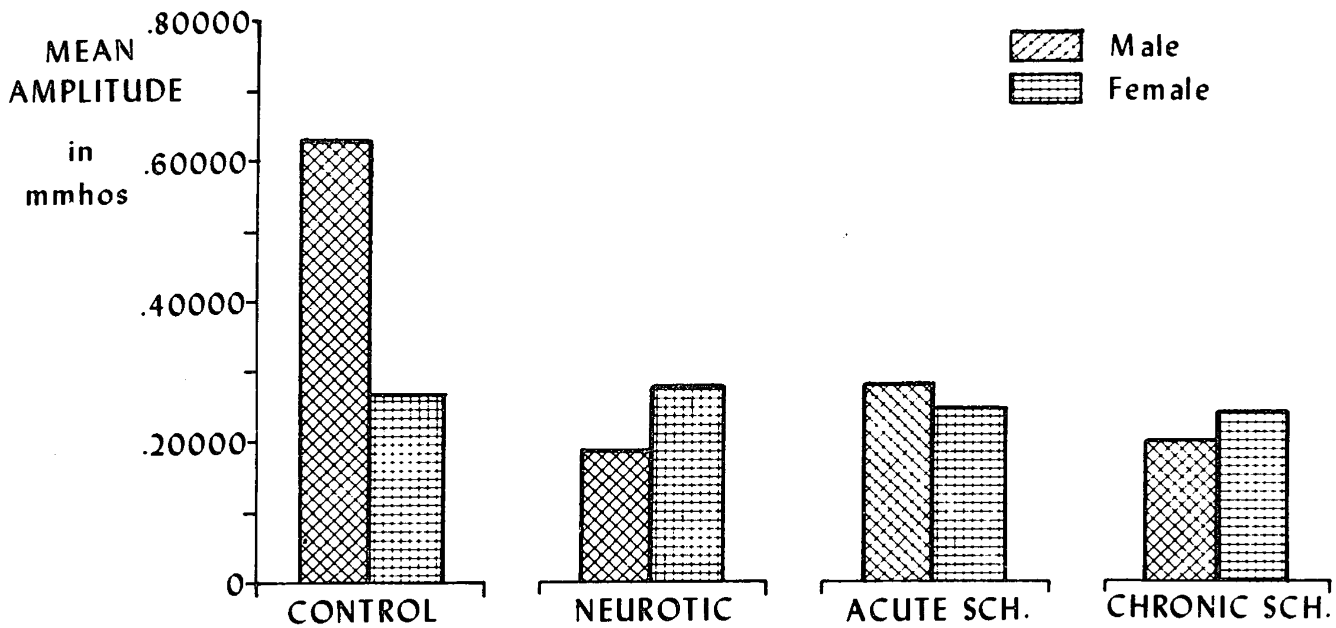

Figure 7. Sex differences in mean range-corrected GSR amplitude averaged over blocks, stimulus sequences and modalities. (N = 12 for each column.)

quickly whereas all other groups showed only a moderate decrease followed by a rise in the last block. This pattern was associated with stimulus modality; during visual stimulation overall mean RGSR scores tended to increase rather than decrease in all groups. Figure 8 describes the Groups x Modality x Measures interaction during increasing stimulus intensity. Habituation did occur, however, among schizophrenic subjects during auditory stimulation. It was also noted that groups followed a differential habituation pattern related to the order in which stimulus sequences were given. For example, when the stimulus sequence was one of increasing intensity for the first session, overall mean RGSR amplitude was high when averaged for all sessions for depressive neurotics and acute schizophrenics.

A non-parametric analysis of monotonic trend was then applied across the mean RGSR amplitudes of four successive blocks. This was done in order to examine whether habituation and adaptation of the RGSR amplitude followed a simple pattern.

As seen in Tables 25 and 26 (Appendix B), during stimulus sequences of constant intensity, the changes in successive mean RGSR amplitudes followed no significant monotonic trend in any group. Table 25 indicates that under conditions of increasing intensity of visual stimulation, a corresponding increase in mean RGSR amplitude scores followed a significant monotonic trend only in the acute schizophrenic group. Under the same condition of increasing stimulation in the auditory modality the depressive neurotic group unexpectedly decreased its RGSR amplitude scores in a significant monotonic trend. Sequences of decreasing stimulation significantly enhanced the monotonic decrease

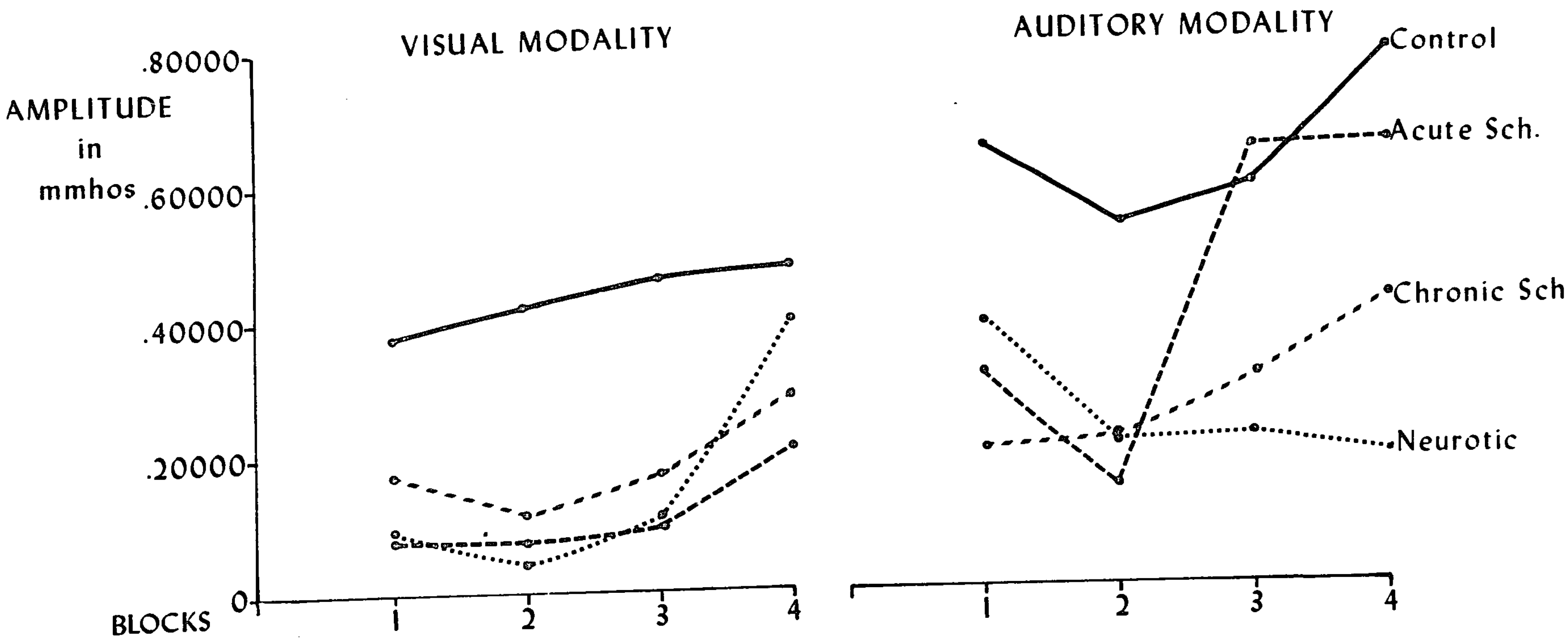

Figure 8. Adaptation of the range-corrected GSR to stimuli of increasing intensity. (N = 12 for each group within each modality.)

of RGSR amplitude across blocks. In the auditory modality this monotonic trend reached significance in all groups (Table 26). In the visual modality, however, only the control Ss and the acute schizophrenics demonstrated a significant decreasing monotonic trend (Table 25).

Summary of group characteristics

1. Control Ss

Compared to psychiatric groups, control Ss were characterized by low respiratory amplitude variability and relatively slow breathing throughout all phases of the experimental procedure. They showed the highest amplitude startle responses of the range-corrected galvanic skin response in both visual and auditory modalities as well as the largest startle response of the range-corrected basal skin conductance level. In addition, a high number of GSR's was emitted by the men of the control group. This accounted for the overall difference on this measure between the psychiatric groups on the one hand, and the control group on the other. Habituation of the range-corrected basal skin conductance level among control subjects was related to stimulus modality; in this group visual stimulation was accompanied by a decrease, and auditory stimulation by an increase in RBSCL regardless of direction of intensity change of the stimulus sequence. In addition, only among controls did the stimulus sequence of decreasing intensity produce a significant monotonic change of the RBSCL, including a paradoxical increase during the auditory sequence. Finally, control subjects did not differ significantly from any other group on measured values of the RBSCL at any phase of the experiment.

2. Depressive neurotics

The respiratory behavior of depressive neurotics was characterized by relatively low rate and high amplitude variability of respiratory cycles. The range-corrected basal skin conductance level (RBSCL) decreased (habituated) markedly during the pre-stimulation phase. During auditory stimulation and irrespective of direction of intensity change the RBSCL decreased significantly. The decrease did not follow a simple monotonic direction, and did not occur during visual stimulation. While the amplitude of the range-corrected galvanic skin response (RGSR) to the first stimulus (startle response) was smaller than that of the control Ss, it lasted longer among the depressive neurotics than among all other groups. The paradoxical decrease of RGSR amplitude during increasing auditory stimulation was in accord with the RBSCL changes occurring under the same condition. Only in this group and only in this condition was such a close positive relationship found between basal skin conductance level and GSR output. Other RGSR habituation patterns were not significantly different from those of other psychiatric groups.

3. Acute schizophrenics:

In this group both variability and rate of respiratory cycles were high relative to control subjects. Basal skin conductance level, while in the same range as that of the control Ss, showed a paradoxical monotonic decrease during increasing visual stimulation. The startle response to both visual and auditory stimuli was more frequently absent in this group than in control subjects and depressive neurotics. On the whole, the startle response to visual stimulation was markedly diminished as compared to the group's startle response to auditory stimulation. The startle response in terms of the basal skin conductance level ("tonic" startle response) was smallest in the acute schizophrenics as compared to other groups. Only in the acute schizophrenic group was visual stimulation of increasing intensity followed by a significant monotonic increase in mean

RGSR amplitude scores.

4. Chronic schizophrenics:

The chronic schizophrenic group showed a pattern of high rate and amplitude variability of respiration and electrodermal functioning similar to the acute schizophrenic group. The respiratory amplitude variability was particularly high in this group before the onset of auditory as compared to visual stimulation. Also in the pre-stimulation period, habituation of the range-corrected basal skin conductance level was smallest in the chronic schizophrenic group. Paradoxically large GSR's occurred in this group when the first visual stimulus presented was of medium intensity. During stimulation the chronic group appeared more sensitive to auditory as compared to visual input in general. This was suggested by the higher respiration rate during auditory stimulation and by the more frequent occurrence of the tonic (basal skin conductance level) startle response in this group compared to the acute schizophrenics. Chronic schizophrenics, unlike the acute group, did not show paradoxical response patterns (either respiratory or electrodermal) under any stimulus conditions.

II. Significant findings not related to group differences:

In this section significant effects and trends not dealt with under Group Differences are considered as follows:

a. Comparison of effects of auditory versus visual stimulation (Modality effects)

b. Comparison of differential effects of stimulus sequences (Treatment effects)

c. Systematic changes over successive measures

(Habituation, adaptation, recovery)

d. Sex differences

(All significant F ratios pertaining to these main effects and their interactions are listed in the tables in Appendix B. These tables have already been referred to in Section I.)

A. Comparison of effects of visual versus auditory stimulation

1. Respiratory rate and variability:

In general, rate of respiration was not significantly affected by stimulus modality. A slightly elevated breathing rate was observed across all groups only when the loudest auditory stimuli were presented. This trend reached borderline statistical significance. Respiratory amplitude variability (RAV) appeared more consistently influenced by stimulus modality, but the association again was of borderline significance. During auditory stimulation of any intensity the RAV tended to be higher than during visual stimulation.

2. Range-corrected basal skin conductance level (RBSCL):

RBSCL was associated with stimulus modality throughout all phases of the experiment.

   a. In the pre-stimulus phase the RBSCL prior to visual stimulation was higher during each session than prior to auditory stimulation. Relatively high RBSCL values were obtained at the beginning (pre-stimulation) of the second or third sessions when high or medium intensities of visual stimulation terminated the previous session. In the auditory modality it was the low and high terminating stimulus intensities which were associated with high RBSCL at the beginning of the next session.

b. During visual stimulation RBSCL was highest in the sequence of decreasing intensity. During auditory stimulation the highest RBSCL was associated with the sequence of constant intensity.

c. This differential effect of visual auditory stimulation continued in the post-stimulus phase. In Ss receiving visual stimulation, RBSCL at the end of a session was highest when the stimulus sequence was one of decreasing intensity for that session. In Ss receiving auditory stimulation, RBSCL was highest following a sequence of constant (medium) intensity.

3. Response to the first stimulus (startle response):

As stated previously, almost all the difference between the second pre-stimulus and first during-stimulus measurement of the RBSCL (the tonic electrodermal startle response) was associated with the initial auditory stimulus. (Visual stimulation produced no measurable startle response in most Ss on this measure). The range-corrected galvanic skin response (RGSR) - the phasic electrodermal startle response - to the first auditory stimulus appeared earlier, lasted longer, and was of higher amplitude than one following the first visual stimulus. In addition, amplitude of the auditory RGSR startle response was matched to the intensity of the first auditory stimulus; low intensity going with small amplitude; high intensity with high amplitude. However, the relationship between intensity of the first visual stimulus and RGSR response parameters was not clearly demonstrated.

4. Phasic electrodermal responsivity; (RGSR) - Its habituation and adaptation:

The total number of GSR's emitted to auditory stimuli was significantly greater than the number emitted to visual stimuli. The mean RGSR amplitude averaged over four blocks of responses to auditory stimulation was significantly higher than that obtained during visual stimulation. Auditory stimulus sequences also generated more clearly defined mean amplitude changes (habituation patterns) across response blocks than did visual sequences. Mean amplitude changes between blocks were larger during auditory stimulation than during visual stimulation.

B. Comparison of differential effects of stimulus sequences (constant, increasing and decreasing intensity) on psychophysiological variables

1. Constant intensity:

   a. Measures of respiration rate, amplitude variability and range-corrected basal skin conductance level showed no specific patterns during the constant intensity stimulus sequence in either modality.

   b. When stimulus intensity was held constant, the mean RGSR amplitudes kept decreasing over three consecutive blocks and showed an unexpected rise in the last block.

2. Increasing intensity:

   a. Upon termination of a stimulus sequence of increasing intensity the RBSCL kept increasing for at least two minutes (i.e., to the end of the session).

   b. Increase in stimulus intensity was accompanied by an initial dip of mean RGSR emplitude (from the first to the second block) with a successive rise in the two last blocks.

3. Decreasing intensity:

Only in the habituation of mean RGSR amplitude across blocks did stimulus sequences of decreasing intensity have a specific effect. Under this condition an overall progressive decrement of mean RGSR amplitude scores is seen from the first to the last block.

C. <u>Systematic changes over successive measures</u>

(Habituation, adaptation, recovery; within the same session and between sessions).

1. Rate of respiration and respiratory amplitude variability showed no habituation effects.
2. Range-corrected basal skin conductance level (tonic electrodermal arousal) showed marked habituation in the four-minute period preceding stimulation. RBSCL for the same period also showed a significant decrease going across sessions. During stimulation periods RBSCL tended again to decrease across sessions regardless of type of sequence of stimulus intensity change. Finally, changes of the RBSCL during stimulation were associated with the order of sessions. In the first session regardless of direction of stimulus intensity sequence, RBSCL dropped and then levelled off. In subsequent sessions there was a rise during the first half of the stimulation period followed by a drop.
3. Startle response

The RBSCL (tonic electrodermal) startle response diminished from the first to subsequent sessions. In each session, however, the mean amplitude remained proportionate to the intensity of the session's first stimulus (i.e., more intense stimuli evoked larger responses in all sessions). The RGSR (phasic electrodermal) startle response showed similar across-sessions decrements in duration, and amplitude. A slight increase in latency across sessions did not reach significance.

4. RGSR habituation

Mean RGSR amplitude across the four consecutive blocks showed a progressive decrement from block to block - except for a rise in the last block - when averaged over all other variables. The initial session produced the highest amplitude RGSR's as compared to subsequent sessions under all three stimulus intensity sequences.

D. Sex differences

1. Tonic electrodermal arousal (RBSCL) at the beginning of a session was higher in women than in men. The difference diminished by the end of the four-minute pre-stimulation period.
2. The phasic startle response (RGSR to the first stimulus) lasted longer in women than in men. The sex difference varied according to group membership. Control males and acute schizophrenic men showed higher amplitude than women of their respective groups. The converse was the case for depressive males and females. The difference between sexes in amplitude of the RGSR startle response was smallest in the chronic schizophrenic group.
3. As previously noted in the section on Group Differences high phasic electrodermal responsivity (RGSR) was noted in male control Ss.

III. Correlational analysis:

As described previously under Method, the correlational analysis consisted of four sets of correlations between psychophysiological measures (as listed in Table 5, Appendix A) and the MACC scales representing rated observable behaviors. The first set of correlations was based on the scores of all psychiatric cases in the study (N = 72) on the premise that overt "abnormal" behaviors and patterns of psychophysiological functioning can cut across psychiatric diagnostic categories. The remaining three sets of correlations were obtained from each of the three diagnostic groups. It should be noted that the directionality of scores is such that negative correlations of respiration rate with rated overt behaviors express a positive relationship between slow RR and socially favored (adaptive) behaviors as defined by the MACC scales. Similarly a negative correlation between "S" scores (representing steepness of habituation slope) and rated overt behaviors express a positive relationship between adaptive behaviors and steepness of habituation.

a. <u>Correlations for all psychiatric cases</u>

In this sample, correlations based on the first psychophysiological measures of the first session indicated that <u>S</u>s who breathed more slowly were rated as easier to communicate with ($r = -\cdot 301$, $p < \cdot 02$) showed better social contact ($r = -\cdot 234$, $p < \cdot 05$) and were rated as generally better adjusted ($r = -\cdot 270$, $p < \cdot 05$) than those <u>S</u>s who breathed more rapidly. When correlations were based on the second measures of the first session (immediately prior to stimulation) <u>S</u>s breathing more slowly were rated to be in a better mood ($r = -\cdot 283$, $p < \cdot 02$), easier to communicate with and were generally better adjusted ($r = -\cdot 258$, $p < \cdot 05$) than <u>S</u>s showing more rapid breathing. These correlations remained significant after the effects of age on breathing rate had been partialled out. At the end of the last session following auditory stimulation slower rate of respiration remained significantly associated with ratings of better mood ($r = -\cdot 356$, $p < \cdot 05$). Ratings of better mood were positively associated (in this set) with steepness of habituation slope of the basal skin conductance level during the auditory stimulus sequence of constant intensity ($r = -.357$, $p < .05$).

b. <u>Depressive neurotics</u>

In the depressive neurotic group, behavioral ratings correlated with two psychophysiological measures. Rate of respiration measured during the first minute of the first session correlated negatively with the Communication factor of the MACC scale ($r = -.416$, $p < .05$). Those depressive neurotics who were rated as easy to communicate with showed slower respiration rates than those who were rated as difficult to communicate with. This correlation remained significant after the effect of age had been partialled out. A negative correlation was obtained between the steepness of RGSR habituation slope during auditory stimulation of constant intensity and the Mood factor of the MACC ($r = -.708$, $p < .01$). Patients showing marked habituation (i.e., a graded decrease of initially strong RGSR responses) were described as friendlier and easier to get along with than either those who showed minimal habituation or very little GSR responsivity. Electrodermal variables for this group correlated with level of education. Raw-score skin resistance measures prior to stimulation in the first session correlated positively with education level ($r = .511$, $p < .05$). A similar relationship was found at the end of the last session after auditory stimulation ($r = .776$, $p < .01$). Level of education was also positively associated with continuing GSR responsivity (minimal habituation to visual stimuli of constant intensity). ($r - .585$, $p < .05$). (Those who were better educated showed less diminution of GSR amplitude.) Finally, the better educated Ss of this group tended to show a steep habituation of RBSCL during auditory stimulation of decreasing intensity ($r = -.592$, $p < .05$). In general, the higher the level of education in this group, the more flexible was the RBSCL and under visual stimulation the more sustained was the orienting behavior.

c. Acute schizophrenics

In the acute schizophrenic group there were no significant correlations between behavioral ratings and electrodermal variables. However, respiration rate following the final session of visual stimulation correlated positively with readiness to initiate and maintain social contact ($r = .737$, $p < .01$). Irregular breathing was associated with ratings of grouchiness and unfriendliness ($r = -.415$, $p < .05$). Level of education in this group was related to degree of habituation of the RGSR following decreasing auditory stimulation ($r = -.599$, $p < .05$). The higher the level of education the steeper the slope of habituation. In general, respiratory measures and educational level show some relationship to overt behavior in this group.

d. Chronic schizophrenics

In the chronic schizophrenic group, fast breathing prior to stimulation in the first session was associated with ratings of grouchiness and unfriendly behavior ($r = -.437$, $p < .05$). After auditory stimulation in the final session a similar relationship was found between rapid breathing and ratings of withdrawal behavior in social situations ($r = -.583$, $p < .05$). Among electrodermal variables, the average amplitudes of the RGSR startle response to auditory stimulation showed a significant correlation with two of the four MACC scales and with the general adjustment score. High amplitude startle responses were associated with cooperative behavior ($r = \cdot677$, $p < \cdot05$) and with less social withdrawal ($r = \cdot600$, $p < \cdot05$). Patients in this group showing a stronger startle response were also judged to be generally better adjusted to the daily ward routine than patients with a poor initial response to auditory stimuli ($r = \cdot723$, $p < \cdot02$). Habituation of the basal skin conductance level in the presence of auditory stimulation of constant intensity was significantly and positively related to ratings of friendly mood ($r = - \cdot695$, $p < \cdot02$), cooperative behavior ($r = - \cdot610$, $p < \cdot05$), and overall adjustment ratings ($r = - \cdot583$, $p < \cdot05$). A similar relationship for this group was found between RBSCL habituation during the auditory stimulus sequence of decreasing intensity and degree of observed social contact ($r = - \cdot620$, $p < \cdot05$). Age and education were associated with psychophysiological measures in this group as well. Older Ss showed more irregular breathing after the final session of visual stimulation ($r = \cdot624$, $p < \cdot05$). They showed more habituation of the basal skin conductance level during visual stimulation of constant intensity ($r = - \cdot634$, $p < \cdot05$), auditory stimulation of decreasing intensity ($r = - 712$, $p < \cdot02$), and auditory stimulation of increasing intensity ($r = - \cdot610$, $p < \cdot05$). Older Ss of this group generally showed more tonic electrodermal habituation than did younger Ss.

Finally, higher education levels in this group were related to less habituation of RBSCL during visual stimulation of decreasing intensity ($r = -\cdot787$, $p < \cdot01$). Changes in RBSCL did not match diminishing visual input in better educated chronic schizophrenics.

Discussion

Diagnostic specificity

One of the major aims of the present study was to determine whether a meaningful relationship exists between peripheral psychophysiological indices on the one hand and psychiatric diagnostic categories on the other. There are a number of findings which point to such a relationship.

1. The difference in pre-stimulation respiration rate between neurotics and chronic schizophrenics - with the same trend continuing during and after stimulation - appears to represent a difference in basal activation level. It is likely that this difference was maximized in the present study by the relative simplicity and non-threatening nature of the stimulus situation. Under stressful conditions, or those requiring overt responses there may well be no group differences (Jurko et al., 1952). Both fast breathing rate and fast heart rate have frequently been found among chronic schizophrenics (Fenz & Velner, 1970; Reynolds, 1962; Williams, 1953). Rickles (1972) has pointed out the need for more concern with respiratory variables because these affect heart rate. If fast heart rate is secondary to rapid breathing, complex theorizing about the role of heightened cardiovascular activity in chronic schizophrenia such as that offered by Reynolds (1962) and Broen (1968) appears in need of revision. It may well be that a) respiration rate is a more direct measure of activation level than heart rate, and b) the homeostatic feedback from cardiovascular baroreceptors lowering cortical activity level is indirectly initiated by fast breathing.

2. The differential habituation of the basal skin conductance level (BSCL) prior to stimulation indicates that habituation patterns in low-stress

situations are different in neurotics and schizophrenics. Anxious-depressive neurotics habituate more, and schizophrenics habituate less than control subjects. It is possible to interpret the results as follows: The neurotic Ss once made familiar through instruction with the stimulus situation as a whole, could believe that nothing disturbing was going to happen to them. Subsequent sessions helped to confirm this belief. In contrast, the initial apprehension of the schizophrenic patients was difficult to dispel; subsequent sessions also did not reinforce the harmless nature of the procedure for these subjects. It is as if the experience of increasing familiarity with a stimulus (habituation in a general sense) did not register or generalize "normally". This is reminiscent of Shakow's (1962) concept of "segmental set", used to explain schizophrenic performance on reaction-time tasks. This interference with the continued maintenance of a set in schizophrenic Ss may well be present even when no preparation for an organized response is required. The feeling of unfamiliarity when perceiving familiar situations is a frequently reported early complaint of schizophrenic patients (McGhie & Chapman 1961).

In the neurotic group a quick and vigilant appraisal of the situation appears to have led to a rapid diminution of alertness with regard to the general procedure. The stimulus conditions actually induced drowsiness in some of these patients once the non-threatening nature of the procedure and setting were made apparent. Many of the anxious-depressive neurotic patients suffered from chronic sleep-disturbance and appeared rather sedated by the semi-dark, quiet, air-conditioned room once past the initial phase of the procedure.

3. During stimulation, the BSCL was a function both of group membership

and of stimulus modality. It will be recalled that the control subjects showed higher overall BSCL in response to auditory than to visual stimulation as well as a tendency to increase BSCL regardless of direction of auditory stimulus change. In this context, the psychiatric groups presented differing patterns of tonic electrodermal activity. The anxious-depressives showed paradoxically accelerated BSCL habituation or lowered arousal in the face of increasing auditory stimulus intensities, as if a "defensive" or counteracting inhibition of arousal were in operation; acute schizophrenics showed a similar paradoxical decrement in BSCL with increasing stimulus intensities, but in the visual modality and not in the auditory. Here the concept of the "protective" or "transmarginal" inhibition of Pavlovian theory (Gray, 1964; Lynn, 1963) might again be applied. The chronic schizophrenics showed a) little differential response in terms of stimulus modality, and b) a comparatively limited range of habituation changes. It would appear, therefore, that anxious-depressive neurotics are psychophysiologically "defensive" in non-ideational auditory stimulus situations; early or acute schizophrenics show a similar pattern with visual input; and tonic arousal levels of chronic non-paranoid schizophrenics are "stuck" to such an extent that there is limited adaptive manoeuvering possible in either the visual or auditory modality. This particular sub-group of schizophrenics appears to demonstrate a profound adaptation deficit of the CNS which extends even to the modulations of response to essentially neutral stimulus situations. Such a group appears distinguishable at the psychophysiological level from neurotics as well as from other types of patients diagnosed as schizophrenic.

4. Group differences are also seen on the phasic orienting (startle) response. "Matching" both frequency and amplitude of the GSR to intensity

changes of the first visual stimulus was difficult for both acute and chronic schizophrenic groups. This difficulty appeared in addition to an apparent attention problem (reduced frequency of the visual startle response) which was seen also in the neurotics. The difficulty of matching psychophysiological response magnitude to stimulus intensity changes in "early" schizophrenics as compared with anxiety neurotics was noted by Malmo & Shagass (1949) who used thermal pain as a stimulus variable. The aim of their work, in contrast to the present study, was to investigate reactions of psychiatric patients under stress. This intensity discrimination difficulty among schizophrenics may be specific only to certain classes of stimuli and sense modality of stimulus presentation. In the present study, for example, both schizophrenic groups matched the amplitude of their GSR startle responses to auditory intensity changes more closely than did the control subjects. We can postulate that inhibitory processes are operating in a different manner for schizophrenics than for normal subjects. This effect is contributing to the difference between normals and schizophrenics in their respective response to stimulus intensity change. The effect then leads to a discrimination deficit in the schizophrenics which may be further exacerbated when presented stimuli have strong ideational components or require some form of scanning. In this respect, the position of Silverman (1964, 1967) concerning scanning difficulty, the "chronic high activation" hypothesis of Venables (1964, 1966) and the "anticipatory physiological set" concept of Broen (1968) - all of which try to account for the response deficit seen in non-paranoid schizophrenics appear complementary. Reduced scanning may prevent adaptation of tonic psychophysiological activity to environmental demands because clues are ignored, while reduced "mobility" of the tonic levels may in turn interfere with scanning behavior.

5. The groups differed on the parameter of continuing phasic responsivity (GSR adaptation) in the face of increasing stimulus intensity. There was again a modality difference (as in the case of tonic reactivity). The neurotic group showed a paradoxical decrease of GSR amplitude in the auditory modality along with the BSCL - commented on earlier. The acute schizophrenic group behaved in a more "normal" manner under this condition. In the visual modality the acute schizophrenics demonstrated a monotonic increase of mean GSR amplitude; in the auditory modality, after an initial low responsivity, they "caught up" with the control group. The chronic schizophrenic group could not "match" the mean GSR amplitude of the control subjects even at high intensities of auditory input when the high intensity stimuli appeared at the end of the sequence. By contrast, their startle response amplitude to the high intensity auditory stimulus was equal to that of the control subjects. The adaptation difficulty in phasic responsivity appears to be similar in chronic schizophrenics to that described previously concerning their tonic adaptation deficit. In general, acute schizophrenics appear to show a more appropriate relationship between stimulus intensity and GSR output than do chronic schizophrenics.

6. A final observation suggesting diagnostic group differences concerns the "on and off" pattern of GSR responding among chronic schizophrenic subjects particularly in response to visual stimuli and regardless of direction of stimulus intensity sequence. This pattern consisted of a random disappearance and reappearance of the GSR during stimulation. It has previously been noted by Zahn, Rosenthal,& Lawlor (1968). In terms of Sokolow's interpretation of habituation as neuronal model building, the "on and off"

response pattern may signify an instability of the neuronal model in chronic schizophrenics.

Diagnostic non-specificity

The foregoing findings suggest a relationship between psychiatric group membership and particular psychophysiological patterns of function. Other results, however, point either to the similarity of these groups on certain psychophysiological indices or to a continuum of psychophysiological responsivity when one group is compared with another. For example, it may be noted that no significant difference in mean values was obtained on any psychophysiological measures when the neurotic group was compared with the acute schizophrenics, although the latter tended in general to be more similar to the chronic schizophrenics than to the neurotics. Three particular findings are relevant in this context. In tonic activity, respiratory irregularity was frequent in all psychiatric groups as compared to control Ss. All psychiatric groups showed a significantly more vigorous startle response to the first auditory stimulus than to the first visual stimulus as compared to the control Ss. Finally, the psychiatric groups were similar in overall phasic responsivity including habituation, and adaptation of the GSR to decreasing stimulus intensities. Each of these findings merits some comment.

The respiratory irregularity is very likely related to that aspect of arousal which has been identified as anxiety. The similarity of anxiety neurotics and "early" schizophrenics on this measure has been noted by Jurko et al. (1952) and Malmo & Shagass (1949). Interestingly, the measures on which both neurotics and schizophrenics are reported to be "high" are those about which an anxious person is apt to complain: palpitations (rapid heartbeat), breathing difficulty (irregular breathing), stiff neck (muscle tension) and headaches (vascular disturbances). Data of this type lend support to Wenger's (1966) suggestion that a type of autonomic imbalance associated with overactivity of the sympathetic branch of the autonomic nervous system is common to both neurotics and schizophrenics. Such data also favor Gellhorn's (1965, 1968) view that in many types of psychiatric conditions the "ergotrophic" and "tropotrophic" systems (sympathetic and parasympathetic systems with their central representations) act in a simultaneous rather than "antagonistic" (complementary) manner. This hypothesis avoids the difficulties presented by the formulations of Ax, Beckett, Cohen, Frohman, Tourney,& Gottlieb (1962) who suggest that anger-related psychophysiological patterns (parasympathetic discharge) characterize chronic schizophrenics, in contrast to fear-related patterns (sympathetic discharge) characterizing neurotic patients. If Gellhorn's model is correct, both patterns can occur simultaneously. The simultaneous occurrence of anger and fear is common both in schizophrenics and in depressed-anxious patients and it is unlikely that these groups would be dissimilar in parameters of anger and anxiety.

The reduced response frequency and amplitude of the visual startle response probably represents an attention deficit in all psychiatric groups. It seems easier not to pay attention to simple visual stimuli than to simple auditory stimuli - at least initially. Most psychiatric subjects who did not respond to the first stimulus started responding later during a particular stimulus sequence. Cohen (1970) found a similar response pattern in a group of hyperactive children.

Observations of this type lend support to Bernstein's (1969) hypothetical model of a two-stage orienting response. The first stage would deal with some form of input-processing; the second stage of the process would consist of a "decision" whether or not to discharge an OR. It is possible that this decision is unduly delayed in many individuals suffering from a variety of behavioral disturbances. Such a delay could be the result of a flaw in input-processing, or part of a learned inhibitory response which in turn can be inhibited or "unlearned". For example, Fenz & Steffy (1968) have shown that absent GSR orienting responses can be reinstated in chronic, regressed schizophrenics with behavior therapy.

Finally, similarity among the psychiatric groups and their general dissimilarity to control subjects in overall GSR responsivity were due to a sex difference in the control group on this measure. The male control subjects demonstrated higher frequency of GSR responsivity. This sex difference has been previously reported in normal subjects by Kimmel & Kimmel (1965) and Korn & Moyer (1968). They attribute the discrepancy to possible attitudinal differences between the sexes toward the experimental procedure. In the present study spontaneous remarks of male control Ss suggested that the continued GSR responding of these Ss reflected an attempt to transform a passive, boring experience into an "active" vigilance task. It is possible that motivational factors (motivation deficiencies are frequently noted in both schizophrenics and depressive neurotics) were responsible for the GSR responsivity differences between control male Ss and the remainder of the sample.

One particular measure, the mean basal skin conductance level also failed to distinguish the psychiatric groups from the control group. This finding corroborates a number of recent reports (Goldstein & Acker, 1967; Lykken & Maley, 1968; Smith, 1967; Thayer & Silber, 1971) of no significant differences between normal control subjects and psychiatric patients on this measure. These and similar negative findings, often in the presence of positive results on other autonomic variables, cast doubt on the unitary nature of the arousal concept. They also suggest that the relationship of high central and high autonomic arousal is a very complex one in psychiatric subjects. Finally, they support the observation of Hord, Johnson,& Lubin (1964) who found that the electrodermal system does not follow the Law of Initial Values in the way other psychophysiological variables do. It is, therefore, difficult to account for abnormalities of electrodermal responsivity in terms of differences in the electrodermal base level alone.

In dealing, then, with the question of basic psychophysiological differences among normal, neurotic and schizophrenic individuals, three major factors, often confused in past research, should be delineated.

The first factor comprises the psychophysiological concomitants of high arousal, often experienced subjectively as anxiety and anger by psychiatric patients. Anxious neurotics and certain schizophrenic sub-groups probably contribute to a continuum of relatively high arousal values as compared to control subjects. Neurotic and schizophrenic groups may or may not differ from each other on some or all of these indices. This would depend on stimulus conditions and the momentary internal status of these subjects. The presentation of simple stimuli in a non-threatening setting will minimize certain psychophysiological differences, while stressful stimuli will maximize others.

The second factor covers psychophysiological concomitants of attention and vigilance. Although attentional and motivational disturbances have been typically associated with schizophrenic disorders, the present study suggests that under simple stimulus conditions (meaningless and impersonal stimuli) attention and motivation may be impaired in depressive-anxious neurotics as well. It appears reasonable to conclude, therefore, that stimulus conditions can be manipulated to minimize or maximize differences in attention "pathology" between neurotic and schizophrenic Ss. One would expect the measures of psychophysiological response to co-vary with stimulus changes as well as with group membership.

Psychophysiological (central and peripheral) concomitants of high arousal (anxiety) and attention deficits appear to comprise a dimension of "severity of psychopathology". Knowledge of tonic psychophysiological levels (expressed as averaged scores) or of phasic response omissions to simple stimuli can help determine whether the patient is "more disturbed" or "less disturbed", but not necessarily whether he is neurotic or schizophrenic. That groups of out-patient neurotics and chronic schizophrenics are statistically distinguishable on some of these variables may only reflect degree rather than type of disturbance.

The third factor concerns psychophysiological activity and reactivity in the presence of stimulus change (adaptation). The results of the present study are in line with previous findings (Fenz & Velner, 1970; Goldstein & Acker, 1967; Jurko et al., 1952; Malmo & Shagass, 1949; Reynolds, 1962; Zahn, 1964) where in a variety of stimulus conditions either the acute (early) or chronic schizophrenics, or both tended to "mismatch" their tonic and phasic responsivity to changes in stimulus parameters such as intensity, complexity and meaning. This "visceral-level" disturbance appears to follow the poorly modulated overt behaviors of many disturbed individuals described as "schizophrenic".

The present study indicates that this adaptation or "calibration" difficulty at the autonomic level occurs even under neutral low-intensity stimulus conditions. It emerges as one of the "basic" features of schizophrenic functioning. Using a projective personality test (the Rosenzweig Picture Frustration study) as stimulus material, Jurko et al. (1952) described this deficit as specific to early schizophrenics. They termed it "dysadaptation". However, their theoretical framework, the "energy system pathology" is no longer in use. Claridge's (1967) theoretical construct of high tonic arousal in the presence of "low arousal modulation" appears to deal with the same phenomenon. In Claridge's model, the arousal modulating system is responsible for inhibiting the tonic arousal system and filtering sensory input into both systems. If the activity in the modulating system is low, one expects to find high tonic arousal, and an impaired "match" between stimulus input and response output. However, Claridge characterizes the "active" or "cycloid" psychoses in these terms, but not chronic schizophrenia. It is also quite likely that the intensity discrimination difficulty in chronic schizophrenics postulated by Epstein (1967) is associated with this factor of adaptational deficit. In terms of the model of "protective inhibition" the inhibitory process in schizophrenics appears to operate at lower stimulus intensities and in a random manner.

Drug effects:

In comparing the respiration rates of the on-and-off medication groups of chronic schizophrenics no significant difference was found. High respiration rate, therefore, is not a rebound effect from drug withdrawal. Two other possibilities may be considered: a) rapid breathing in the absence of apparent stress is a characteristic of chronic schizophrenics; or b) long term administration of phenothiazine drugs causes fast breathing. There have been studies reporting high respiration rate in schizophrenic subjects well before the introduction of routine phenothiazine drug treatment (Jurko et al., 1952; Malmo & Shagass, 1949; Williams, 1953). This would support the former possibility. It may well be that rapid breathing in chronic schizophrenics represents an aspect of arousal which is not affected by phenothiazine medication. In contrast, chlorpromazine in stutterers was found to reduce both respiration rate and irregularity (Goldman-Eisler, Skarbek,& Henderson, 1967). This can be regarded as further evidence that the concept of "arousal" comprises several dimensions rather than a single factor. A given drug does not necessarily reduce or increase arousal under all conditions and for all subjects.

Behavioral correlates:

The final section of the present study examined the relationship of respiratory and electrodermal indices to socially adaptive behaviors in the psychiatric groups. The set of significant inverse correlations obtained across groups between respiration rate and these adaptive behaviors provides additional evidence of impaired social behavior in the presence of high tonic levels of arousal. The impairment is seen as a trend towards withdrawal. The correlational data indicate that this relationship is not diagnostically specific, but rather is an association between a type of overt behavior and high respiration rate. The relationship persists when the effects of age are partialled out.

The relationship of electrodermal variables to overt adaptive behavior appears sense modality-specific. All significant correlations occurred with auditory stimulation. The reason for this modality difference is not clear. It can be hypothesized that electrodermal activity in response to visual input is a more complex and non-linear function of the CNS than is responsivity to auditory input. In addition, almost all of the significant correlations between the rated overt behaviors and electrodermal variables were obtained only in the chronic schizophrenic group. The difficulty of the chronic schizophrenics in lowering or habituating tonic arousal is "matched" by difficulty in habituating or adapting to a social environment and by persistent manifestations of dysphoric mood. Similarly, the diminution or absence of the startle response to a simple but well-defined non-ideational stimulus is also related in this group to impairment of overt adaptive behaviors. It would appear that the factors which govern adaptive electrodermal activity (responses of a peripheral-autonomic system) and those which influence the more complex system of overt social behaviors are similar in chronic schizophrenics.

In essence, the correlational analysis yielded a pattern of results similar to that derived from the psychophysiological data alone, i.e., the relationship between behavioral impairment and high arousal extended across diagnostic categories; relationships between behavioral impairment and habituation as well as inadequate response matching appear almost exclusively in the chronic schizophrenic group.

In neuropsychological terms, the question remains as to how and why depressive-anxious neurotics and non-paranoid, long-term schizophrenics can be both similar and different on psychophysiological variables. The prevailing tendency by theorists is to point to the impairment of feedback arrangements between the cerebral cortex and the ARAS as the basis for any behavioral pathology which is associated with central and peripheral indices of high arousal. This model, however, can explain the mismatch and poor calibration of responses in schizophrenic subjects only if it includes some specific additional hypothesis about the modulating role of the ARAS in sensory input. It is possible that impairment is present within the ARAS as well as in the cortico-reticular feedback system to cause an additional and more profound interference on the input side in schizophrenics. Groves & Lynch (1972) have reviewed evidence which suggests the presence of associational neurons in the "small celled" portion of the ARAS dealing with sensory input. These associational neurons could be involved also in habituation processes. Although these authors make no reference to abnormal behavior, their formulations provide a neurophysiological substratum common to cognitive disorders, behavioral deviations, and psychophysiological orienting and habituation difficulties.

Suggestions for further research

It appears that the study of similarities and differences in peripheral psychophysiological activity and reactivity between controls and different diagnostic groups depends on a large number of stimulus and subject variables, some of which (for example the subject's private interpretation of the stimulus situation) cannot be controlled by the experimenter. It may well be that further research of this type utilizing only routine stimuli (tone, electric shock, reaction-time tasks), in laboratory settings, and using comparison of mean scores as statistical techniques will not add to what has already been demonstrated by previous research. Telemetric techniques monitoring autonomic variables in life-like settings - such as in a laboratory disguised as a living room or kitchen and using stimuli which occur with varying degrees of probability in such a setting (ringing of the telephone, slamming of a door, appearance of family members, etc.) may bring us to more valid and more generalizable observations about psychophysiological functioning in the behaviorally disturbed as well as in "normal" subjects.

Another area for future investigation may be the relationship of the psychophysiological parameters - as defined in the present work - to persistent overt behavior patterns (response strategies). One would focus on behaviors which in some way correspond to central and autonomic response parameters, such as curiosity and sustained interest in the environment (orienting) and adaptive behaviors in everyday social situations (habituation and adaptation). This approach would probably lead away from concentrating on discrete categories of "illness" and would focus on what psychophysiological similarities underlie normal and "abnormal" behaviors - without necessarily identifying subjects as "mentally ill". It would be also useful to correlate behavioral measures with autonomic parameters in control subjects. This was not possible within the scope of the present study.

<u>Summary and Conclusions</u>:

The foregoing study has demonstrated both similarities and differences in respiratory and electrodermal parameters of psychophysiological activity and reactivity among anxious-depressive neurotics, acute schizophrenics, and chronic schizophrenics and between each of these groups and a group of normal control subjects. Acute schizophrenics tend to be similar to chronic schizophrenics on most measures - generally falling between the neurotic and chronic schizophrenic groups. The results of the present study along with those of previous research suggest that psychophysiological "malfunctioning" in psychiatric groups varies along at least three continua. One may be described as an arousal continuum on which the relative distance between neurotics and schizophrenics is a function of stimulus intensity and complexity. The second continuum appears to be one of attention and vigilance. The relative position of neurotics and schizophrenics on this factor is also determined by stimulus conditions. The third continuum refers to the covariation or modulation of responsivity with stimulus characteristics (adaptability and habituation). This continuum seems to be diagnostic-specific and corresponds at the visceral level to that which occurs at the level of overt behavior in schizophrenic individuals. The latter demonstrate impaired ability to match responses adequately to stimulus characteristics.

In correlating autonomic variables to ratings of overt, socially adaptive behaviors high rate of breathing correlated significantly with less adaptive, more withdrawn behaviors in the combined patient sample. This suggests a diagnostically non-specific arousal continuum with high arousal related to non-adaptive social avoidance behaviors. In chronic schizophrenics, non-adaptive behaviors were also related to impairment of tonic electrodermal habituation as well as to diminished startle response amplitude with auditory stimulation. This suggests that the more severe the behavioral disturbance, the more involvement there is of the adaptive parameters of an increasing number of peripheral systems.

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Appendix A

Table 1

Age in years: Means and SD-S of Control Ss and three psychiatric groups.

One-way analysis of variance comparing group means.

Groups:	$\bar{X}$	SD
Controls:	31.04	7.87
Anxious-depressive Neurotics:	31.92	8.65
Acute Schizophrenics:	24.67	6.20
Chronic Schizophrenics:	35.96	8.92

$F = 9.63$, $df = 3/48$, $p < .01$

According to the Newman-Keuls procedure acute schizophrenic group is significantly younger than all other groups. No other differences reached significance.

Table 2

Level of education: highest grade completed.

Means and SD-S of Control Ss and three psychiatric groups. One-way analysis of variance comparing group means.

Groups:	$\overline{X}$	SD
Controls:	10.29	1.27
Anxious-depressive Neurotics:	10.29	1.92
Acute Schizophrenics:	10.45	1.86
Chronic Schizophrenics:	8.33	1.55

$F = 7.56$, $df = 3/48$, $p < .01$

The Newman-Keuls procedure demonstrated that the chronic schizophrenic group has had significantly less education than all other groups. This was the only significant difference between means.

Table 3

Sampling of Psychophysiological Data

Presumed nature of measure	Measure	Score expressed as
Basal level measures: ("Background" activation level)	a. rate of respiration (RR)	number of respiratory cycles per minute
	b. Respiratory amplitude variability (RAV)	coefficient of variation of respiratory cycle amplitudes per one minute sample
	c. range corrected basal skin conductance level (RBSCL)	average of skin resistance readings taken ten seconds apart; values transformed into conductance units and corrected for range differences
responsivity to discrete stimuli: (phasic responsivity)	Range-corrected galvanic skin response (RGSR)	amplitude of primary wave expressed as difference between two conductance values corrected for range differences
	d. Startle response (first RGSR) - delay	time elapsed between onset of stimulus and onset of response expressed in seconds
	e. Startle response-duration	horizontal length of primary wave of GSR expressed in seconds
	f. Startle response-amplitude;	RGSR measure as described above
	g. RGSR - amplitude; four blocks representing average amplitude of four responses each	RGSR measures as described above averaged over four trials
	h. Total number of GSR responses across all stimulus sequences	as stated

Table 4

General format of the analysis of variance. Main effects *

Source of variation	Between or within Groups		k	df	Error term	df of error term	Results describe:
Groups	(A)	(B)	4	3	G (ABCD)	48	Group differences
Modality	(B)	(B)	2	1	G (ABCD)	48	Differences due to modality of stimulus presentation
Sex	(C)	(B)	2	1	G (ABCD)	48	Sex Differences
Orders	(D)	(B)	3	2	G (ABCD)	48	Effects due to order of sequences across sessions
Intensities	(E)	(W)	3	2	EG (ABCD)	96	Differences due to stimulus sequences
Measures	(F)	(W)	(2,3,4)	(1,2,3)	FG (ABCD)	144	Changes in consecutive psycho-physiological measures; Startle response of continuous variables
Subjects	(G)		2 (within cells)				

* All significant interactions - up to and including two-way interactions - are listed in subsequent summary tables of ANOVA results in Appendix B.

Table 5

Variables of the correlational analysis

Presumed nature of measure	Behavioral ratings (MACC scales)	Score expressed as
Phenomenological description of overt behavior	Mood Co-Operation Communication Social Contact Total Adjustment	Centiles converted from raw scores
	Psychophysiological variables	As stated in Table 3 (All scores computed separately for each modality)
Basal activation; initial and final values	Respiration rate and variability: first session pre-stimulation samples last session post-stimulation sample	
Tonic electrodermal arousal	Basal skin resistance (raw scores): first session pre-stimulation samples last session post-stimulation sample	
Response to sudden change in the environment; degree of autonomic alert	Mean amplitude of the startle response	Mean RGSR amplitude averaged over three stimulus intensities
Phasic responsivity to discrete stimuli	Phasic electrodermal responsivity	Total number of GSR's across all stimulus sequences
Estimation of slope of habituation curve	RBSCL and RGSR habituation across four consecutive blocks	"S" statistic: computed from consecutive RBSCL and RGSR mean amplitude scores in each stimulus sequence
	Level of education	Highest grade completed
	Age in years	

Appendix B

Table 6

Significant sources of variation of Respiration Rate (RR) during pre-stimulus period.

Source of variation	df	df of error term	F.	p.
Groups (A)	3	48	3.17	.05

Table 7

Significant sources of variation of Respiration Rate during stimulation.

Source of variation	df	df of error term	F.	p.
Groups (A)	3	48	3.44	.05

Table 8

Significant sources of variation of Respiration Rate in post-stimulus period.

Source of variation	df	df of error term	F.	p.
Groups (A)	3	48	3.12	.05

Table 9

Significant sources of variation of Respiration Amplitude Variability (RAV) during pre-stimulus period.

Source of variation	df	df of error term	F.	p.
Groups (A)	3	48	4.98	.01
Groups x Modality (AXB)	3	48	4.90	.01
Groups x Modality x Sex (AxBxC)	3	48	3.39	.05

Table 10

Significant sources of variation of Respiration Amplitude Variability (RAV) during stimulation.

Source of variation	df	df of error term	F.	p.
Groups (A)	3	48	3.74	.05
Modality x Intensities (BxE)	2	96	4.58	.01

Table 11

One-way analysis of variance of mean respiration rates (averaged over the first and fourth minutes of the first session pre-stimulus period) of groups including the on-medication chronic schizophrenic group.

Controls	Neurotics	Acute Schizophrenics	Chronic Schizophrenics	On-Drug Chronic Schizophrenics
$\bar{X}$ = 16.77	17.54	19.72	21.27	20.33
F = 4.94				
p < .002				

Table 12

One-way analysis of variance of mean respiratory amplitude variability coefficients (averaged over the first and fourth minutes of the first session pre-stimulus period) of groups including the on-medication chronic schizophrenic group.

Controls	Neurotics	Acute Schizophrenics	Chronic Schizophrenics	On-Drug Chronic Schizophrenics
$\bar{X}$ = .230	.305	.338	.331	.235
F = 2.14				
p < .08				

Table 11

One-way analysis of variance of mean respiration rates (averaged over the first and fourth minutes of the first session pre-stimulus period) of groups including the on-medication chronic schizophrenic group.

Controls	Neurotics	Acute Schizophrenics	Chronic Schizophrenics	On-Drug Chronic Schizophrenics
$\overline{X}$ = 16.77	17.54	19.72	21.27	20.33
F = 4.94				
p < .002				

Table 12

One-way analysis of variance of mean respiratory amplitude variability coefficients (averaged over the first and fourth minutes of the first session pre-stimulus period) of groups including the on-medication chronic schizophrenic group.

Controls	Neurotics	Acute Schizophrenics	Chronic Schizophrenics	On-Drug Chronic Schizophrenics
$\overline{X}$ = .230	.305	.338	.331	.235
F = 2.14				
p < .08				

Table 13

Significant sources of variation of the Basal Skin Conductance level during pre-stimulation period

Source of variation	df	df of error term	F.	p.
Modality (B)	1	48	6.58	.05
Consecutive measures (F)	1	48	23.61	.001
Groups x Modality (AxB)	3	48	3.62	.05
Modality x Intensities (BxE)	2	96	3.48	.05
Orders x Intensities (DxE)	4	96	4.09	.01
Groups x Consecutive Measures (AxF)	3	48	3.52	.05
Sex x Consecutive Measures (CxF)	1	48	6.70	.05

Table 14

Significant sources of variation of the Basal Skin Conductance level during stimulation

Source of variation	df	df of error term	F.	p.
Modality x Intensities (BxE)	2	96	5.32	.01
Order x Intensities (DxE)	4	96	2.66	.05
Groups x Modality x Measures (AxBxF)	6	96	2.35	.05
Orders x Intensities x Measures (DxExF)	8	192	2.35	.05

Table 15

Ferguson's non-parametric trend analysis of consecutive RBSCL scores for monotonic trend during three stimulus sequences during visual stimulation.

Stimulus sequence:

	Constant Intensity				Increasing Intensity				Decreasing Intensity			
Groups: N = 12	Con.	Dep.	AcS.	ChS.	Con.	Dep.	AcS.	ChS.	Con.	Dep.	AcS.	ChS.
$(\Sigma S-1)=$	-7	0	-4	-4	-2	-1	-17	-1	-13	-1	-9	1
z =	1.06	0.0	0.63	0.60	0.30	0.15	2.56**	0.15	1.96*	0.15	1.36	0.15

$\Sigma \delta S^2 = 44.04$ corrected for ties for each group

* - significant at or better than .05 level

** - significant at or better than .01 level

Table 16

Ferguson's non-parametric trend analysis of consecutive RBSCL scores for monotonic trend during three stimulus sequences during auditory stimulation.

Stimulus sequence:

	Constant Intensity				Increasing Intensity				Decreasing Intensity			
Groups: N = 12	Con.	Dep.	AcS.	ChS.	Con.	Dep.	AcS.	ChS.	Con.	Dep.	AcS.	ChS.
$(\Sigma S-1)=$	+3	-9	+8	-4	+11	-9	+1	+12	+13	-5	+5	-11
z =	0.45	1.36	1.22	0.61	1.66	1.36	0.15	1.83	1.96*	0.75	0.75	1.66

$\Sigma \delta S^2 = 44.04$
corrected for ties
for each group

* - significant at or better than .05 level

Table 17

Significant sources of variation of the RBSCL (tonic) startle response

Source of variation	df	df of error term	F.	p.
Consecutive measures * (startle magnitude) (F)	1	48	25.26	.001
Groups x Consecutive measures (AxF)	3	48	3.09	.05
Modality x Consecutive measures (BxF)	1	48	18.05	.001
Intensities x Consecutive measures (ExF)	2	96	5.99	.01
Orders x Intensities x Consecutive measures (DxExF)	4	96	3.28	.05

* The main effect "consecutive measures" expresses the difference between pre- and post-stimulus BSCL: it is the startle response. Only this main effect and its interactions are listed here.

Table 18

Significant sources of variation of the latency of the GSR startle response.

Source of variation	df	df of error term	F.	p.
Modality (B)	1	48	10.48	.01
Modality x Intensities (BxE)	2	96	3.48	.05

Table 19

Significant sources of variation of the duration of the GSR startle response.

Source of variation	df	df of error term	F.	p.
Groups (A)	3	48	3.89	.05
Modality (B)	1	48	14.71	.01
Sex (C)	1	48	5.61	.05
Groups x Modality (AxB)	3	48	3.08	.05
Orders x Intensities (DxE)	4	96	3.41	.05

Table 20

Significant sources of variation of the amplitude of the GSR startle response.

Source of variation	df	df of error term	F.	p.
Groups (A)	3	48	3.42	.05
Modality (B)	1	48	30.40	.001
Intensities (E)	2	96	12.21	.001
Groups x Sex (AxC)	3	48	3.39	.05
Modality x Intensities (BxE)	2	96	4.39	.05
Orders x Intensities (DxE)	2	96	6.94	.01
Groups x Modality x Intensities (AxBxE)	6	96	2.97	.05

Table 21

CHi square analyses of presence vs absence of the startle response to the first visual stimulus of three different intensities.

	Low intensity		Medium intensity		High intensity	
	Response		Response		Response	
	Present	Absent	Present	Absent	Present	Absent
Controls	11	1	10	2	12	0
Neurotics	8	4	7	5	9	3
Acute Schizophrenics	10	2	7	5	6	6
Chronic Schizophrenics	5	7	6	6	7	5
	$X^2 = 8.54$		$X^2 = 3.38$		$X^2 = 8.54$	
	$p < .02$		NS		$p < .02$	

Table 22

CHi square analyses of presence vs absence of the startle response to the first auditory stimulus of three different intensities.

Control and neurotic groups are combined against the two schizophrenic groups.

Low intensity

	Response: Present	Response: Absent
Controls and neurotics	19	5
Acute and chronic schizophrenics	17	7

$X^2 < 1$

NS

Medium intensity

	Response: Present	Response: Absent
Controls and neurotics	23	1
Acute and chronic schizophrenics	18	6

$X^2 = 4.18$

$p < .05$

High intensity

	Response: Present	Response: Absent
Controls and neurotics	22	2
Acute and chronic schizophrenics	20	4

$X^2 < 1$

NS

Table 23

Significant sources of variation of total GSR output

Source variation	df	df of error term	F.	p.
Groups (A)	3	48	4.04	.01
Modality (B)	1	48	7.68	.01
Groups x Sex (AxC)	3	48	3.43	.05

Table 24

Significant sources of variation of mean RGSR amplitude

Source of variation	df	df of error term	F.	p.
Groups (A)	3	48	3.18	.05
Modality (B)	1	48	7.86	.01
Measures (F) (Blocks)	3	144	6.18	.01
Groups x Sex (AxC)	3	48	3.02	.05
Orders x Treatments (DxE)	4	96	2.60	.05
Groups x Measures (AxF)	9	144	2.15	.05
Modality x Measures (BxF)	3	144	7.02	.01
Treatments x Measures (ExF)	6	288	9.31	.01
Groups x Modality x Measures (AxBxF)	9	144	2.03	.05

Table 25

Ferguson's non-parametric trend analysis of consecutive mean RGSR amplitude scores for monotonic trend during three stimulus sequences given in the visual modality. All groups.

Stimulus sequence:

	Constant Intensity				Increasing Intensity				Decreasing Intensity			
Groups: N = 12	Con.	Dep.	AcS.	ChS.	Con.	Dep.	AcS.	ChS.	Con.	Dep.	AcS.	ChS.
$(\Sigma S-1)$ =	+12	-12	0	+12	+14	+17	+21	+3	-27	-16	-2	-23
z =	1.21	1.36	0	1.32	1.45	1.73	2.35*	0.35	2.74**	1.61	0.23	2.64**

$\Sigma \delta S^2$ = 104.04
corrected for ties
for each group.

* - significant at/or better than .05 level

** - significant at/or better than .01 level

Table 26

Ferguson's non-parametric trend analysis of consecutive mean RGSR amplitude scores for monotonic trend during three stimulus sequences given in the auditory modality. All groups.

Stimulus sequence:

	Constant Intensity				Increasing Intensity				Decreasing Intensity			
Groups: N = 12	Con.	Dep.	AcS.	ChS.	Con.	Dep.	AcS.	ChS.	Con.	Dep.	AcS.	ChS.
$(\Sigma S-1)$ =	-4	-16	-12	-14	+13	-24	+5	+14	-21	-33	-33	-29
z =	0.39	1.65	1.39	1.46	1.27	2.51*	0.52	1.39	2.06*	3.56**	3.51**	2.91**

$\Sigma \delta S^2 = 104.04$
corrected for ties
for each group.

* - significant at/or better than .05 level

** - significant at/or better than .01 level