CORTICAL AROUSAL IN RUSSIAN PARANOID SCHIZOPHRENICS AS A FUNCTION OF A WORD ASSOCIATION TASK

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This is to certify that the

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ABSTRACT

CORTICAL AROUSAL IN RUSSIAN PARANOID SCHIZOPHRENICS AS A FUNCTION OF A WORD ASSOCIATION TASK

By

Diane M. Silvert

This investigation examined the relationship between patterns of cortical arousal and schizophrenia and whether these patterns of cortical arousal relate to avoidant thought in the schizophrenic.

Ten words from the Kent-Rosanoff list having cross-culturally high response commonality were presented as a single word association task to 25 Russian paranoid schizophrenics and 25 Russian normal controls while the subject was monitored for arousal by a monopolar EEG hookup. Patients were selected in order of admission with representation of both sexes (11 males; 14 females) and two levels of severity of the disorder resembling the distinction of process vs. reactive schizophrenia. Although matching was not possible with the normal subjects, who were recruited from the hospital staff (8 males; 17 females), correlations between demographic variables and the dependent measures proved insignificant. Trials were counterbalanced for word order and pre-stimulus photic stimulation within groups defined by diagnosis plus sex. Trials affected by artifact

were not included in the analyses and only subjects who showed no signs of EEG abnormality were included in the study.

Utilizing a Drohocki integrator, EEG recordings were assessed for degree of cortical arousal by inferring amount of alpha from the sum of the mean energy content of each record during each pre-stimulus, latency, and post response period. Response commonality was scored according to the percent incidence of the response in a reference sample of Russian medical students. Differences in EEG activity and verbal responsivity among the four subject groups (Normal Males, Normal Females, Schizophrenic Males, and Schizophrenic Females) were assessed by means of Student's _t_ test and where test data was taken from the same subject at different times, by using the correlated _t_. Where changes over time were of interest, regression equations were used.

The hypothesis that schizophrenic and normal subjects differ in their patterns of electrocortical arousal both at rest and under conditions of a single word association task did find support in the data. The EEGs of schizophrenic subjects, examined with the Drohocki integrator, showed less alpha in all time periods measured: pre-task; pre-stimulus, latency period, and post response. Thus schizophrenics as compared to normals were more highly aroused in all periods of the experiment. Normals varied more within and between trials in amount of alpha and Schizophrenic Males, who were less severely ill, showed greater variability than

their female counterparts. Within a post response period equal in length to the preceding latency period almost all subjects showed electrocortical under-recovery as compared to their pre-stimulus levels. By contrast the Schizophrenic Females over-recovered on the average.

The hypothesis that schizophrenic and normal subjects differ in their verbal responsivity and in the relationship between verbal behavior and electrocortical indices under conditions of a word association task received only partial support. Schizophrenics give fewer common responses than normals, and their uncommon responses are less appropriate to the stimulus as ranked by ten Russian judges. For the most part there were no general relationships between electrocortical arousal and recovery with kind of verbal response for either normal or schizophrenic subjects; only Normal Females showed stronger recovery associated with less common responses.

Additional analysis revealed that the schizophrenics failed to show adaptation to the experimental situation both verbally and electrocortically. Schizophrenics showed a longer mean reaction time which by contrast to the increasingly shorter latency among the normals, remained relatively stable through trials. Response commonality scores showed a similar stability of low commonality for the schizophrenic subjects whereas the responses for normals became somewhat more original with time.

Diane M. Silvert

Low commonality and low quality of verbal responses given in a single word association test, higher electrocortical arousal, reduced variability, and a general failure to habituate, distinguish the schizophrenic from the normal subjects in most cases. These differences increase with severity of the disorder. These findings underline the growing concensus that describes the schizophrenic as suffering from chronic physiological hyperreactivity. Notwithstanding the methodological issues of a somewhat restricted and unmatched sampling, the value in considering psychophysiology in diagnosis and possible prevention of thought disorder development is suggested here. The greater severity of disorder among the females and the relationship between recovery, commonality, and sex argue for a closer examination of sex as a variable of importance in the study of schizophrenia. While this study does not offer support for an anxiety theory of schizophrenia, the absence of any demonstrable relationship between commonality of response and degree of physiological arousal is consistent with the theoretical position espoused by Broen and Storms which says that behavioral deficit in schizophrenia is the result of arousal apart from any necessarily defensive significance of the behavior.

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To Sarnoff, Costia, and Valeria

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

In his review of "Brain Dysfunction in Schizophrenia", Brackbill (1956) concluded that one of the major sources of error in research on schizophrenics is the assumption that schizophrenia is a homogeneous process as diagnosed; in fact the group labeled "schizophrenic" is a quite heterogeneous one in composition and in responsivity on most measures. One source of this wide variability may be found in the fact that much of the literature is dominated by subject groups which might be characterized as chronic as opposed to acute. This may elicit data relevant only to the "scars" of the dysfunction rather than to the dysfunction itself. The effects of long term hospitalization which involve general stimulus deprivation, social isolation, and drug therapy effects are all special burdens of the chronic patient and are likely to affect his functioning in a structured research investigation (Mednick-Schulsinger, 1967). Other reports fail to take into consideration some measure of severity and it is significant that recognition of the existence of subgroups of differing degrees of disturbance has been a major determinant of increased understanding of schizophrenia.

The validity of nosological distinctions within schizophrenia is questionable in that the classification of paranoid schizophrenia alone remains viable when compared to others. On the average, paranoid schizophrenics appear less "ill" when compared to other schizophrenics. Assessing a broad spectrum of measures of psychological functioning Shakow (1962) summarizes findings from studies carried out at three institutions over a period of three years and finds the paranoid individual to be closer to normal subjects in 31 of 58 measurements; the non-paranoid schizophrenic resembles the normal more closely than the paranoid in only seven instances, using measures only where normals were scored at one or the other extreme of the distribution.

This heterogeneity among persons diagnosed as "schizophrenic" is responsible for the inconclusive and conflicting findings in the research literature and testifies to the need for more objective measures in diagnosis and prognosis of schizophrenia. Venables (1966) concurs in his criticism of undue reliance upon the Kraepelinian diagnostic system based primarily on description of manifest behavior. He recommends recognition of distinct subgroups among schizophrenics based on a broader assessment of patient functioning. The subtlties and complexities of normal and abnormal behavior demand an equally complex assessment procedure and investigations have frequently been too simplistic, involving a single dependent variable at the expense of assessment of the interaction between several relevant measures. The growing recognition of the importance of affective factors associated with schizophrenia argues for a wholistic assessment of the person, both psychological and physiological, if all the relevant factors are to be identified.

Psychological Deficit in Schizophrenia

On most measures of behavior schizophrenics perform more poorly than their normal or nonpsychotic comparison groups. Lang and Buss (1965) feel that a sensori-motor defect underlies this psychological deficit, or performance decrement, in schizophrenia. In their review of theories of deficit involving social motivation, drive, arousal and interference, they conclude that what is typically observed is a reduction in *overt* responsivity suggesting that these findings may be partly the result of higher initial basal levels which would predict lower comparative size of response upon stimulation.

The literature shows high agreement with regard to the apathetic picture characteristic of schizophrenics. By contrast to manic-depressive psychosis which shows a major affective involvement, schizophrenia is classified as a syndrome marked by the loss of affective intensity.

Lange (1939) in his introspective account of affective aspects of schizophrenia, states that the actual decrement in affective responsivity is less than it appears outwardly. Rather the mode of affective discharge becomes translated increasingly into ideation. The stimulus quality of this ideation gives rise to affective qualities varying from euphoria to deep depression and additional suppression occurs by a conscious attempt to block the affective response from showing outwardly by further avoidant ideation. Lange suggest that the extent of cortical dominance in a patient predicts the amount of this outward "apathy." He proposes that "the dominant factor underlying the development of the psychosis is the over-emphasis of the idealogical aspect of the psychological organization at the expense of the sensory and motor aspects."

Reaction time studies involving schizophrenic subjects almost invariably conclude that schizophrenia is characterized by hyporesponsivity. Rosenthal *et al.* (1960) found a correlation of $r = .89$ ($p < .01$) between reaction time and ratings of mental health *within* schizophrenic subjects. Even when the experimental situation is made simple, including foreknowledge of what the stimulus and the response will be and exact length of time of preparatory intervals, the schizophrenic subject consistently responds more slowly than the normal control. Apparently a schizophrenic is able to take advantage of this information only for short intervals of time. Fedio, et al. (1961) were concerned with the relationship between reaction time impairment in schizophrenia (as measured by releasing a Morse Telegrapher Key) and resistance to alpha blocking. Using twenty schizophrenic subjects and a matched group of normal subjects they found normals showed significant improvement in reaction time ($p<.005$) under conditions of a preparatory signal, while schizophrenics performed significantly more slowly ($p<.01$) than they had initially.

General disturbance in adequacy of overt expressiveness is noted in most studies involving voluntary, environmentally responsive behavior in the schizophrenic subject. Where a demand is made for new responses, (e.g., learning), or self-initiated behavior, (e.g., finger-tapping), deficit in performance is often not observed (Shakow, 1962).

Theoretical Background

One theoretical position entertained to explain schizophrenic deficit is that which presumes an organic, anatomically demonstrable basis for development of seriously disturbed psychological functioning. Brackbill (1956) reviews a number of studies of brain dysfunction in schizophrenia and comments that the difficulty with histopathological studies is that it is difficult to get normal material; in fact most research must rely exclusively on individuals with demonstrated central nervous

(CNS) disease. Even so, if cell loss is the cause of a progressive disorder characterized by schizophrenic behavior, then one should expect the longer the illness the greater the cell loss. Rowland and Mettler (1949) in comparing a group which had been hospitalized more than twenty-two months with another hospitalized for less time, found no difference between the two. However, methods of counting cells tend to be unreliable and this alone may account for differing reports in the literature. Another source of error is the possibility that various researchers may have misjudged the limits of normal variation in cell tissue. These authors discount the thesis of a specific organic factor in schizophrenia with the present evidence available.

Biochemical studies for the most part have not revealed consistent findings. Using a physiological approach, Hoskins (1946) suggests that the adrenal mechanism in the Autonomic Nervous System (ANS) is altered in its functioning thereby producing a changed metabolism. The main finding in support of this position is that schizophrenics show a subnormal response to stress. Altschule (1949), however, feels that most physiological disorders reported are a consequence rather than a cause of the psychosis.

Much difficulty with the psychological approach derives from the trouble in differentiating between organics and schizophrenics, and especially between organic-schizophrenics and funtional schizophrenics. Brackbill and Fine (1956) using the process-reactive classification system, gave the Rorschach to a number of organic, process and reactive schizophrenic patients. They found that the organic and process patients could not be distinguished by their Rorschach responses although reactive patients showed fewer Rorschach organic signs. Meadow and Funkenstein (1952) categorized fifty-eight schizophrenics according to their ANS pattern and found that abstract thinking was most deteriorated in the group with the "release" from cortical inhibition pattern. The group with normal ANS patterns showed no disturbance in abstract thinking.

Lang and Buss (1965) in their examination of four theories of deficit, find support for the psychological theories of positive and negative drive equivocal but conclude that research findings involving the covert responses of ANS and CNS functioning are somewhat more promising than the usual assessment of overt behavior.

Typically researches have favored either the position of hyporeactivity or hypereactivity as characteristic of schizophrenia. Studies involving motor responses and some measure of reaction time have generally concluded in support of the position that hyporeactivity characterizes schizophrenia. By contrast, many investigations of autonomic variables in recent years have produced results consistent with the position of hypereactivity.

Lacey (1956) feels that many of the ANS studies which concluded in support of a hyporeactive picture were probably affected by the contribution of higher basal levels in the schizophrenics as reduced response size would be anticipated when baselines are already near homeostatic limits. Then by inference, the finding of greater reactivity in acute and/or reactive patients as compared with chronic and/or process patients suggests that the latter, who are used most frequently as the schizophrenic subjects in research, behave from a baseline considerably higher and therefore closer to homeostatic limits than their control comparisons (Malmo and Shagass, 1951).

Broen and Storms (1966) suggest that behavioral deficit in schizophrenia is the result of arousal apart from any necessarily defensive significance of the behavior such as reduction of anxiety (Mednick, 1958). Their theory states that the strength of habitual tendencies to respond in a given stimulus situation, normally dependent upon amount of previous training, interacts multiplicatively with arousal level to yield response strength. In the case of competing responses response strength is a function of the differences in response strengths between the dominant and competing responses. However, the response strength ceiling may be lower than the product of maximum arousal and maximum habit strength in which case further increases in arousal will only facilitate competing responses. This leads to a decrease in the relative dominance of the dominant response with an increasing probability of competing responses, thus creating a deterioration of the original hierarchical order of response. It is this disorganization of normal response hierarchies which seems common to much of schizophrenic behavior.

Emotion and Physiology in Schizophrenia

Physiological responses paralleling the experience of human emotion include the sympathetically determined behavior of an increase in emptying time of the stomach, inhibition of paristaltic movement in the GI tract, and augmentation of blood pressure, pulse rate, and palmar sweating (GSR). Parasympathetic expressions of emotional discharge include an increased frequency of urination, weeping, and a fall in the pulse rate. Both these branches of the ANS system are activated simultaneously in emotional experience, but which subsystem predominates varies according to the individual and the emotive situation. In his review, Gellhorn (1953) notes that for the most part, fear experiences seem to be related to reactions that are primarily sympathetic; hostility, and anxiety tend to be primarily parasympathetic physiologically. The "upward discharge" of these ANS experiences, mediated by the hypothalamus, results in cortical areas which are affected by a change in the nature of the group potentials in these areas characterized typically by a lowering of amplitude and an increase in frequency and irregularity which may replace the normally larger, slow (8-13 cps), and regular alpha wave configuration. These changes may be reflected in any or all parts of the cerebral cortex. Likewise the downward discharge may involve the whole or part (for example sympathetic excitation may show an increase in blood pressure without sign of change in pulse rate) of the sympathetic or parasympathetic systems.

Autonomic nervous system changes are paralleled by endocrine changes in the context of emotional excitement. Thus the basic physiological pattern of the emotional process seems to involve (1) the autonomic-endocrine responsivity to the "downward discharge"; (2) the hypothalamic-cortical "upward discharge", representing the bodily expression of emotion in the first instance and the feeling tone in the second and involving activation of the cortex paralleling this subjective experience of emotion.

Hyporeactivity

In his earlier work Gellhorn (1943) concluded that schizophrenics showed ANS hyporeactivity, especially sympathetico-adrenal underexcitability when compared to normals. In support of this conclusion he refers to Finkelman and Stephens (1936) who, in studying heat regulation in schizophrenics after exposure to cold, found that heat production increased less in schizophrenic patients than in normals. From studies of systolic and diastolic blood pressure in schizophrenics, Freeman, Hoskins, and Sleeper (1932) found these measures low in patients and this was interpreted as the result of a diminution in the sympathetically controlled vasomotor tone. Linton, Hamalink, and Hoskins (1934) suggested a deficiency in sympathetic response on the basis of the low score in schizophrenics on the Schneider test which involved studying cardiovascular fitness or observing cardiovascular response to changes in posture and moderate exercise. Freeman and Rodnick (1940) found that if O_2 saturated with water vapor is inhaled at an increased temperature so as to interfere with heat elimination from the lungs, normals show a much greater increase in blood pressure, heart rate and respiration amplitude than do schizophrenics. On the basis of these studies, researchers concluded in favor of schizophrenics showing a decreased reactivity of sympathetico-adrenal functioning compared to the vago-insulin system, thus reflecting a parasympathetic dominance.

Angyal, Freeman, and Hoskins (1940) in their review of the Worchester Studies, also concluded that schizophrenics show autonomic hyporeactivity. Employing a variety of stimulating agents such as dinitrophenol, thyroid extract, and forced breathing of hot, moist O_2, they found reduced autonomic nervous system responses predominated in the schizophrenic subjects used. Nystagmic response to vestibular stimulation, the one CNS variable studies, was also found to be considerably reduced in schizophrenics.

In his discussion of schizophrenia and shock therapy, Gellhorn (1953) refers to further evidence in support of the position that schizophrenics show ANS hyporesponsivity. Even when showing overt hyperemotional behavior, psychotics show no decisive hyperglycemia (Bowman, et al., 1929; Gildea, et al., 1935; Whitehorn 1934). Numerous blood sugar studies have typically explained the diminished reactivity of the sympathetico-adrenal systems as a function of a greater insulin/adrenalin ratio in schizophrenics when under emotional excitement, but direct experimental evidence has come only from animal studies. Endocrine dysfunctions have not been demonstrated to be a prominent contributor to schizophrenia (Gellhorn, 1953).

Hypereactivity

Over the past ten years an accumulating body of research findings has concluded in favor of the orthogonal position: that schizophrenia predicts physiological hyperarousal characterized by unusually high autonomic responsivity especially to pain stimuli (Ax, 1967). This is paralleled by abnormally small and few conditioned responses.

As early as 1951, Malmo and Shagass pointed out discrepancies and evidence against the hyporeactivity hypothesis of schizophrenia. Normal and greater reactivity is reported by Altschule and Sulzbach (1949) in their observation of normal vasodilation and increased vasoconstriction using CO_2 on acrocyanosis in schizophrenics. Cohen and Patterson (1937) using an algesimeter as pain stimulus, report the average heart rate for schizophrenic patients (n = 10) was higher during a ten minute prestimulation period than heart rates obtained as a ward procedure in other investigations.

Malmo and Shagass (1951) recorded EMG, heart rate, blood pressure, and pneumograph data from groups of chronic schizophrenics, psychoneurotics, acute psychotics, and nonpatient controls under three different conditions of stress. Whereas chronics resembled other patients by showing more tension than controls, the change in tension in this group was less than the other groups ($p<.02$). Chronic schizophrenics showed more hyporesponsivity than other groups but during two of the stress conditions, the EMG for the chronic group was higher than for the controls. Pneumograph data was collected in connection with a pain stressor and it was found that chronics were relatively unresponsive especially with higher intensities of temperature (using as a baseline each subject's initial prestimulation respiration rate). Deviations in the direction of decreased amplitude of respiration were more frequent with chronics, that is, they showed more shallow breathing than other groups. A higher mean heart rate was noted in chronics during the pain-stressor test and this was the only group to show a reliable increase in heart rate. This suggests high autonomic arousal in schizophrenics, showing at least normal if not hypernormal behavior physiologically, despite a reduction in overt response amplitude.

Reynolds (1962) in his investigation of the somatic system in chronic schizophrenics hospitalized for a minimum of three years noted that normals have the lowest basal levels and show a typical increase under stress, reactive schizophrenics display a reduced response but show a higher basal level than normals and process patients show the highest basal values and least change with stress. Muscle tension, heart rate, respiration rate, systolic blood pressure, diastolic blood pressure were measures recorded under conditions of three mild stressor stimuli: exercise, a cold pressor test, and a mental arithmetic task failure with verbal criticism by the experimenter. Even though half of the schizophrenics ($n=16$) were taking tranquilizers and showed a significantly higher Manifest Anxiety score than those not taking tranquilizers and normals, this difference in felt anxiety was not accompanied by any significant somatic differences among the groups.

Funkenstein, et al., (1951) noted that as the psychological picture deteriorates in terms of overt behavior, the physiological picture also changes. Observing systolic blood pressure changes from basal values in post-therapy cases (ECT, insulin, psychotherapy, spontaneous, or hospital milieu therapies) where there was behavioral improvement the authors also found a reduction in arousal as indicated by physiological measures. Conversely, if the patient's psychological picture did not change, their physiological profile also did not change. Furthermore, patients with poor prognosis tended to show a nor-epinephrine like state.

Whatmore and Ellis (1958) studied twenty-one schizophrenics and ten normals with regard to their EMG responses under conditions of pain versus comfort. While measures from the leg, forearm, jaw, and the forehand were taken for a period of thirty minutes during these procedures, subjects were questioned about the way they felt. In all comparisons schizophrenics showed much higher residual motor activity than did normals. Further dividing the normals into two groups defined by presence versus absence of psychogenic symptoms, they found that the group with symptoms also showed more muscle tension than the group without.

Ingram (1962) measured respiration (via abdominal movement), EKG, ballistocardiogram, skin temperature, skin resistance, blood pressure in a large group of schizophrenic and non-schizophrenic subjects using the EEG as a monitor. He was interested in examining the hypothesis that schizophrenia is a single versus many diseases. All subjects were submitted to a strict diet one month prior to the testing session and had been off drug therapy for a period of at least two months. Degree of clinical anxiety or emotionality expressed by each patient was rated independently from behavior prior to testing, during psychological testing and during the polygraph recording. An eight-point clinical rating scale was utilized and results compared to EEG data. Comparing these findings with a group of non-schizophrenic subjects, Ingram noted that whereas paranoid schizophrenics showed a greater respiratory irregularity in depth and rate of breathing than the other schizophrenic groups ($p<.01$), all schizophrenics had higher skin resistance ($p<.01$) when compared to non-patients. All schizophrenics showed a greater fall in skin resistance under stress conditions other than shock, but paranoids showed a greater respiration rate under stress than all other groups of schizophrenics ($p<.01$). Before drug use, schizophrenics showed a smaller rise in blood pressure when compared to normals when nor-epinephrine was administered. Ingram concludes from this that there are no marked differences among schizophrenics, either in resting level of ANS activity or response to stress and drugs; but what few differences did occur tended to discriminate paranoid schizophrenics from other groups of schizophrenia. Resting ANS activity reflected higher arousal in schizophrenics when compared to non-schizophrenic patients. Reactivity to stress, too, seemed to be greater among schizophrenics when observing changes in GSR.

Venables and Wing (1962), like the Ingram study, used ratings on the ward by the charge nurse of the degree of social withdrawal shown by the subjects in the pretest period. They found that the increase in physiological arousal as measured by skin potential response was highly associated with increased ratings of social withdrawal.

Using a methodology similar to that of Ingram, Ax *et al*. (1961) were concerned with ANS responses to the experimental stressors of pain apprehension, a psychodynamic stress interview, and insulin injection. Ten male chronic schizophrenics were compared to ten male non-psychotic patients maintaining controls for age, diet, absence of drug therapy and length of hospitalization. The instructions were to call "help" when the subject thought the intensity of the stimulus was becoming "harmful"; the number of "Helps" served as a behavioral index of stress. Two psychiatrists, one conducting the interview and the other observing the interview through a one-way mirror made independent ratings immediately after the interview of the patients' visible degree of emotional arousal. Applying insulin intravenously, blood samples were taken fifteen minutes afterward and were analyzed for amount of epinephrine versus nor-epinephrine (epinephrine causes a greater rise is systolic blood pressure, heart rate, ballistocardiogram values, and respiration rate; nor-epinephrine causes a greater rise in muscle tension and number of GSR's and produces a greater fall in heart rate).

The expectation of the authors was that chronic schizophrenics would show more nor-epinephrine kinds of responses and that the nonpsychotic subjects would show a predominance of epinephrine-like responses. GSR and ballistocardiogram measures alone tended to remain stable and differentiated between the psychotic and nonpsychotic groups even during resting states, in that the schizophrenics reflected a greater sympathetic arousal and showed more disturbance by the test situation and a slower adaptation to it. Whereas nine out of ten nonpsychotics showed an epinephrine pattern, seven out of ten chronic schizophrenics showed a nor-epinephrine dominance among the variables and Ax suggests that perhaps two types of chronic schizophrenics are included in this sample: The more hostile and less responsive schizophrenics showing a nor-epinephrine-like pattern; and the more responsive schizophrenics showing an epinephrine-like pattern. Interpreting the physiological data into emotional terms, it appears that the larger sized group of chronic schizophrenics in this study show an emotional pattern dominated by experiences of anger as opposed to anxiety. In support of this interpretation, Gellhorn (1963) finds that with exercise, active aggressive behavior, and hostile emotion, more nor-epinephrine is produced in normal subjects. Conversely with the experience of passive, fearful anxiety, more epinephrine is produced. Thus the finding of more nor-epinephrine-like physiological behavior in these schizophrenics suggests the interpretation that the experiential correlate of such findings is an angry state. With other subjects, Ax (1967) found variables such as heart rate, diastolic blood pressure and GSR also discriminate well between epinephrine and nor-epinephrine-like groups. Nor-epinephrine dominated subjects show a high blood pressure whereas epinephrine-like subjects show high heart rate and ballistocardiographic index of stroke force. GSR shows a marked increase in number of responses during the experience of anger whereas the phenomenological experience of fear produces much larger increases in skin conductance and respiration rate. These findings, (1) that autonomic responsivity to pain stimuli is often abnormally high; (2) that conditioned responses are abnormally small and few; and (3) that the majority (82 per cent) of schizophrenics in this sample had a nor-epinephrine-like (anger-like) psycho physiological response pattern to the cold pressor stress in contrast to only 28 per cent of the normals agree well with some findings of Mednick (1966). Reporting on "high-risk" children, he finds that they (1) make larger GSR responses to a loud buzzer; (2) have shorter latency to noxious stimuli; (3) generalize more; (4) show faster recovery from discrete stimuli; and (5) resist extinction of conditional GSR longer than do the members of a healthy matched group. The chief differences here between the findings on the high-risk children and the findings on chronic adults is the greater responsivity of the high-risk children compared to their matched normals, as compared to the adult schizophrenic versus healthy adults, and the apparent readiness of the high-risk children to respond to a conditioning situation. Ax interprets this discrepancy as one of the major adaptations of the schizophrenic as he adjusts to his unrewarding environment--that is, he behaviorally withdraws through time, and in this way partially succeeds in protecting himself from his oversensitivity.

CNS and ANS Measures in Schizophrenia

Darrow *et al.*, (1942) studied the relationship between autonomic nervous system responses and brain electrical potential data. Examining ten subjects including some normal, some improved schizophrenics and "normal" records from suspected epileptic cases, the investigation looked at seventy-eight reactions to specific stimuli while GSR and blood pressure were also measured post-stimulation. Results for the entire group were that beta potentials increased while alpha potentials decreased and GSR increased parallel to beta increase (r=.51) and decrease of alpha (r=-.50). A small inverse correlation (r=-.24) was noted between blood pressure and beta wave incidence. Thus in general it appears that increased activity of the sympathetic nervous system predicts an increase in beta and a decrease in alpha potentials.

In another study, Darrow (1943) addressed the problem of determining whether an observed peripheral event is due to *increase* of activity in one branch of the autonomic nervous system or to decrease of activity in the other. A rise in blood pressure, for example, is too often assumed a function of increased sympathetic activity; conversely a fall in blood pressure is generally interpreted to mean an increase in parasympathetic activity. Yet, a rise in blood pressure can be due to a *decrease* in parasympathetic tone with sympathetic nervous system activity remaining stable. This oversight may account for some of the literature which suggests opposite relationships between blood pressure and other measures of autonomic nervous system activity. Pulse rate, like blood pressure, is the resultant of a balance between the sympathetic and parasympathetic nervous systems. In addition there tends to be a compensatory slowing of the heart when there is a rise in blood pressure and an acceleration in pulse rate when there is a fall in blood pressure. Even though hyperglycemia occurs only with strong emotion in humans, absence of hyperglycemia which is a finding often reported in schizophrenics, may not suggest a defect in the sympathetico-adrenal function, but may be the consequence of an increased vagal activity and insulin secretion instead. Thus blood sugar level is not a simple reflection of autonomic influences but, too, depends on a balance of opposed autonomic factors. This often overlooked interdependency of autonomic factors argues for the measurement of CNS variables as less ambiguous correlates of emotional experience.

EEG work done at the same lab with the same subjects that Ax used (1967) suggested that generally measures of sympathetic activation such as digital vasoconstriction to pain and epinephrine-like arousal to a cold pressor test consistently had negative correlations with EEG amplitude. Thus it appears that low sympathetic arousal is accompanied by higher amplitude rhythmic activity in all frequencies of the EEG, whereas psychophysiological activation (tension and anxiety) are more related to desynchronization at all frequencies rather than to low voltage high frequency alone as most of the previous literature reports. Much of the difficulty with earlier research has been the lack of sophisticated equipment but in the Ax study a frequency analyser was used and so some of this information became manifest.

Electroencephalography and Schizophrenia

General Considerations

A normal waking adult electroencephalogram is composed of alpha and beta waves, some low voltage random activity, and a small amount of delta waves. Although records from different parts of the cerebral cortex show somewhat different patterns, alpha is found in all areas of the cerebral cortex but is produced in greatest amount in the occipital region.

All electrocortical wave activity is thought to be a result of the polarization and depolarization of the neurons. Polarization is generally assumed to arise either from metabolic oxidation and reduction processes, from interface (boundary) potentials, or from subliminal action potentials (Cohn, 1946). Depolarization is attributed to volleys of incoming action potentials of sufficient voltage to trigger the stored charge. Although there is debate as to the exact mechanism responsible for these potentials, much is known about the conditions which influence potential differences.

Strauss, et al., discuss some physiologic concepts useful in the interpretation of the EEG (1952). If a large number of cells under one electrode show a deviation in the same direction from the zero line of potential at the same moment while the remaining cells show no deviation, at least not a synchronized deviation, then a potential will be picked up by the electrode. This synchronization of the activity of many cells is thought to be responsible for the origin of brain waves. An inherent function of the cerebral cortex, it has been suggested that this synchronization is controlled by a "pacemaker mechanism" situated probably in the diencephalon, and may be disturbed by factors such as emotional tension, sensory stimuli, and concentration. Through hyposynchrony or asynchrony, these activities will tend to suppress alpha activity, which is the modal wave form for most normal waking adults.

Wave kinds are defined primarily by frequency, and alpha, the most prominent frequency range, regardless of the region of the cortex, is usually defined as those waves showing eight through twelve cycles per second (cps). The beta wave range is roughly from thirteen through thirty cps and amplitudes usually reflect less than twenty microvolts. Voltage level may vary according to distance between electrodes and whether monopolar or bipolar methods are used. A typical bipolar mean occipital (alpha) voltage is twenty-four millivolts having a range of 9-48 millivolts; monopolar recordings elicit a somewhat higher average voltage.

Although alpha may not be seen in the newborn infant, it gradually appears in increasing incidence until a constant rhythmic pattern appears by late adolescence. There are large interindividual differences, but in any individual the frequency regulation in a sample record is well maintained within 1/2 wave per second under standard awake conditions. Waves less than eight cps (theta and delta) indicate interference with cell metabolic function and may be evidence of an organic lesion.

The EEG record may be evaluated according to frequency, amplitude, per cent time or amount of time of certain types of waves, and variability of wave behavior.

In normal subjects per cent time alpha, which has been the most common unit of comparison, varies from 0 to about 100 per cent. The blocking of alpha waves--that is, the cessation of the appearance of alpha correlates with measures of attention and is preferred by most researchers as the criterion of electrocortical arousal.

Parameters of Alpha Blocking

Adrian and Matthews (1934) confirmed Berger's observation that the occipital lobes seemed to be the area where alpha wave behavior was most predominant. In addition, they demonstrated the alpha wave's responsivity to light and concluded that the essential condition for the presence of alpha was the absence of patterned stimuli. In administering an arithmetic problem to subjects, they noted that this problem, which required the whole attention of the individual, abolished the alpha rhythm even though the eyes remained closed.

Jasper and Cruikshank (1936) studied the effect of variation in stimulus intensity and duration upon alpha blocking. They concluded that blocking time (time between appearance of light and attenuation of alpha wave) varies inversely with intensity of the light stimulus when duration is held constant.

Redlich, Callahan, and Mendelson (1946) noted that the presentation of visual stimuli is not sufficient in all cases to produce alpha blocking. Of 100 subjects tested with a standard clinical EEG procedure, twelve of these showed no alpha blocking on eye opening and exposure to a visual stimulus. In an earlier study, Jasper and Cruikshank (1937) concluded that the significance of the alpha blocking appears to be associated with the attention value or the arousal value of the stimulus for the organism rather than with the modal or the intensity attributes of the stimuli as such. Povarinsky _et al_. (1955) noted that when direct conditioned stimuli were substituted by their verbal designations changes immediately appeared in the EEG similar to those evoked by direct stimuli; alpha rhythm was depressed and beta rhythm intensified. In cases where preliminary verbal instruction is used, there is less alpha than with verbal conditioning procedures without preparatory verbal stimulation (Christian, 1960).

One of the few studies that has examined, although only by eye judgment, the amount of increase post-stimulation of alpha behavior is that by Cruikshank (1937). Here, using a series of intensity levels of light and recording the occiput EEG behavior with up to four pairs of electrodes, data from a selection of five normal students showed a variation of increase in per cent alpha behavior poststimulation between 20 and 40 per cent of the prestimulation variable. This is reported for the maximum intensity used, ten millilamberts the amount of increase in frequency following stimulation decreases to only one or two per cent at near threshold intensity.

The frequently observed finding in schizophrenics' EEGs of dysrhythmic and/or low amplitude fast activity is complemented by Jasper's (1936) exploration of normals using varying degrees of excitation. He reports that a loss of rhythmic activity occurs with extreme excitation and an increase in low amplitude fast activity is noted with the application of a stimulus producing moderate excitation. These findings with induced moderate excitation in normals agree with many of the reports reflecting a non-manipulated resting EEG of schizophrenic subjects.

If the subject is experiencing strong emotion, the amount and amplitude of alpha waves diminishes and an increased frequency appears (Darrow, et al. 1942). Darrow suggested that alpha may be an important factor in neurophysiological homeostasis. Low incidence of alpha may permit an increase of emotion and increased alpha may act to reduce low voltage fast activity and terminate excitation. External and internal sources of cortical excitation are characterized typically by a low voltage fast EEG, and it is this low potential fast activity which corresponds to the integrative processes of the cortex.

Sherman and Jost (1942) state that EEG and ANS measures provide a better index of emotional reactivity than overt behavior, verbal or other. They conclude that the best measure of emotional stability is the duration of the dominant alpha frequency.

Jasper (1936) in his application of different levels of excitation involving the ANS so as to produce feelings of fear, anxiety, and worry, reported that changes in the ANS variables predicted marked changes in the frequency and regularity of brain rhythms. Loss of rhythmic activity occurred with extreme excitation and an increase in low amplitude fast activity appeared under circumstances of moderate excitation. Loomis _et al_. (1936) were primarily interested in long term recordings of normal subjects between seventeen days and seventy-four years of age with regard to individual variation in the waking state and characteristic population changes during sleep. In agreement with Berger (1929) these researchers found conditions leading to alpha blocking included: (1) sleep; (2) the attempt to perceive objects; (3) emotional disturbances; and (4) concentrated attention. Jasper noted that many of his subjects showed relatively little alpha behavior in the first hour or so of recording, yet when they were apparently accustomed to the electrodes and the strange surrounds alpha behavior began to appear. He concluded that this reflected a change in emotional state of perhaps apprehension or embarrassment initially to one of greater relaxation and acceptance of the strange circumstances of the machinery. Asking the subjects at a given signal to try to imagine themselves in a terrifying situation also produced consistant alpha blocking.

Cohn (1946) examined patients with histories of headaches and various forms of emotional disturbance related to domestic difficulties and interference with work and compared them to patients who clinically showed symptoms of vomiting, dizzy spells, and digital tremors. Although the author does not mention the size of these two groups, he found that the former group reflects an EEG pattern characterized by low amplitude, random high frequency oscillation in all regions of the head. The second group emitted an EEG pattern characterized by <u>rhythmic</u> high frequency oscillation (usually 18-22 cps), predominantly in the frontal and parietal region. This is a pattern similar to that reported by Finley and Campbell (1941) in affect disorders of the major psychoses. Cohn thus concludes that in hyperemotional states two characteristic types of EEG patterns may be found. He compares the first pattern, where all regions of the head showed an equal low amplitude random high frequency behavior, to the pattern characteristic of the brain when receiving protracted afferent stimuli. The pattern of the second group characterized by rhythmicity and high frequency of wave behavior, is found to be usually stable and uninfluenced by afferent stimuli of ordinary intensity when applied to the subject.

In his review of the effects of certain forms of emotion on the normal EEG, Thiesen (1943) points out that the major problems in researching the effect of emotional stimuli upon EEG is the difficulty of producing emotional reactions in any standard way in the laboratory. Attempting to resolve this problem, he presented a mixture of standardized stimuli including verbal and visual forms of presentation. Using the EEG as a monitor, ten subjects were examined who gave only normal baseline EEG records and showed no family history of intracranial pathology or mental disorder. Both clinical and quantitative assessments were made of the EEG data, but whereas the effects of the emotional excitement of the subjects did not produce clinical discriminations between emotive and nonemotive stimuli, quantitative assessment of the EEG record showed a depression of alpha and a decrease in rhythmic activity associated with onset of emotional excitement. Conversely increase in non-serial slow activity and a tendency toward a flatter (high frequency, low amplitude) record was noted ($p<.01$). Great individual variation was noted, however, and three of the four most reactive subjects showed a <u>depression</u> of fast activity. Thus, change in the direction of a flatter and more desynchronized record was associated with emotion-producing stimuli, but quantitative assessment was necessary to make the change visible.

Gastaut <u>et al</u>. (1951) were especially interested in the relationship between EEG measures of excitability and clinical measures of "calmness" versus excitability. "Nervous" subjects showed by contrast to "calm" subjects a dominant rhythm in the upper half of the alpha range, therefore, of less amplitude. The "nervous" subjects tended to show a low voltage picture to the "calm" subject's high voltage alpha of 8-10 cps. No indication was given of the measures of excitability used for the psychological comparison, however.

Lange et al. (1960) selected subjects from a group of normal persons according to the relative dominance of beta, alpha, or theta waves. Using an eight-channel EEG recorder and two frequency analyzers, twenty-four normal adults, about even for each sex, were tested with the Rorschach, the Bourdon, Kraepelin, the Passalong, the Wiggly Blocks, and the Four Pictures Test. EEG's were examined for mono- versus poly-rhythmia and degree of frequency fluctuation in the rhythm, alpha index, per cent of fast and slow alpha variance, and the dominant frequency. Subjects were secondarily categorized, without reference to their EEG records, according to a number of dimensions related to drive and feelings of self-confidence. Those with little beta and theta and relatively high alpha tended to show monorhythmic alpha with a moderately high amplitude, and psychological characteristics of extensity, activity, self-confidence, and generally an absence of tension and anxiety. Subjects with a little theta and alpha but much beta showed a polyrhythmic alpha record, and psychological characteristics of intensity, tenseness, anxiety, and unfavorable reactions to feelings of social insecurity.

Test conditions involving some degree of emotional arousal such as apprehension, startle, or anxiety and personality dimensions assessing reactivity and tension predict a depression of alpha and an increase in low amplitude dysrhythmic wave behavior. This represents the consensus of the literature to date.

EEG and Personality

Some authors report relationships between character traits and EEG parameters. Lemere (1936) found "good alpha" in cyclothymic individuals and "poor alpha" in schizoid subjects. He, as Darrow (1942), suggested that the capacity to produce a predominance of alpha waves related in some way to the affective capacity of the individual. Using a psychoanalytical method to obtain psychological data, Saul *et al*. (1949) separated seventy non-psychotic patients into two groups according to high versus low alpha index. Persons with a high alpha index were found to be passive, inhibited, and dependent. Patients with low alpha indexes exhibited a consistent, well-developed activity orientation and were often described as frustrated, agressive, and impatient.

Abnormality and EEG in Schizophrenia

Attempting to see if the EEG could differentiate between psychotics and normals, as well as predict change clinically, Davis and Davis (1939) examined "alpha index" in schizophrenics and manic-depressives in comparison to a group of normal subjects. Although the fundamental pattern of psychotics could not be distinguished from normal, there appeared to be a large proportion of patients showing variation outside of the normal range of variability. These authors were particularly concerned with variations bordering on CNS pathological indices, waves resembling brain lesion patterns, epileptic forms, and sleep wave profiles in the waking and/or cyanotic state.

McMahon and Walter (1938) were among the earlier researchers to address the question of whether schizophrenics showed EEG deviation from normals. Using a two-channel EEG they examined thirty cases, including eleven catatonics, three hebephrenics, three chronics of undifferentiated type, and seven others of equivocal diagnostic classification, all of whom had been under hospital care between three and ten years. They examined the EEG records for differences with the normal EEG and noted that eye movements (REM's) and blinking produced artifacts, which they concluded had probably contributed to findings of earlier research using the delta index as a measure of degree of abnormal activity. Even though these artifacts produced delta waves, they noted that unlike typical CNS pathological cases, the delta behavior was not localized. Without reporting statistical data, the authors indicate that a "certain number of the patients" displayed a true delta discharge having a focus in the frontal lobe. Two

of the catatonics showed an unusually high incidence of alpha. On the basis of these observations, the authors suggest two conclusions: (1) that there is a variation within the physiological range and prominence of alpha rhythm; and (2) that there may be a truly pathological delta discharge, primarily in the frontal lobes, but lacking the focal quality of epileptic discharges. They emphasized that, while neither of these is diagnostic of schizophrenia, they may be found in a certain incidence among schizophrenics.

Furthering her interest in classificatory schemes for EEG in psychiatric disturbance, Pauline Davis (1940) grouped 132 schizophrenic patients into three EEG categories: (1) "Normal," essentially a normal pattern; (2) "Dysrhythmic," resembling patterns of convulsive disorder patients; and (3) "Choppy," characterized by little or no alpha but much low activation of the cortex by subcortical mechanisms. She found that of the patient group, more paranoids gave records belonging to the "normal" group. Most of the patients, however, fell into the second group suggesting the incidence of minimal brain dysfunction resembling epilepsy. The patients falling into "Choppy," a pattern which tends to exclude a high incidence of alpha, showed some evidence of past or present organic brain disease. The dysrhythmic patients were more often catatonics and persons who showed unpredictable behavior in their clinical histories. Thus, the relatively "healthy" schizophrenics, the undeteriorated paranoids, showed the healthiest EEG records. However, those patients undergoing ECT treatment, if they had previously shown a normal record, became abnormal during and after ECT; if they had shown a baseline abnormal record, ECT predicted a worsening EEG record. Stability of the EEG pattern correlated with clinical stability (Davis makes a distinction between stability and normality here). Dysrhythmic patterns, on the other hand, correlated with unstable behavior.

Walter (1942) studied a group of psychiatric patients, including six catatonics, sixteen non-catatonic schizophrenics, two manic-depressives (manic phase), and ten manic-depressives (depressive phase). Using a three-channel amplifier and Grass ink-writer, standard clinical EEG records were collected for all subjects, including eye opening and closing, mental activity, and hyperventilation procedure. In an attempt to classify the records according to the broad spectra of "normal, abnormal, or doubtful" he found only two schizophrenics that gave records definitely outside the normal range. Both of these were catatonic schizophrenics.

Kennard and Levy (1952) found "psychological deterioration" as measured by duration of symptoms predicted the presence of an abnormal EEG. This finding was used to support their theory that schizophrenia is a progressive disorder which ultimately affects all organic systems including the cerebral cortex. However, Barker et al. (1950) in recording the EEG from epileptics during interviews which included significant stress materials selected from the patient's history, found that subcortical EEG discharges were associated with distress in recall of the experiences. These authors conclude that these discharges provide some psycho-social distress warning, therefore negating the premise that abnormal discharges are to be taken as evidence only for the existence of an organic pathological process.

Lindsley (1944) concludes that there are no distinctive abnormalities in the EEG associated with a particular type of disorder. Generally, findings of definite abnormality in the EEG of schizophrenics have been inconstant and minor (Strauss, et al., 1952). Yet while there are no consistent characteristics of the EEG to clearly differentiate schizophrenics from normals or other psychotic patients, a subgroup of schizophrenics do show a variety of abnormalities--mainly of low amplitude, irregular, high frequency rhythm variations.

Kiloh and Osselton (1966) suggest two conclusions about the body of data relating EEG and schizophrenia to date: (1) no particular EEG pattern can be regarded as typical of schizophrenia; and (2) in the overall majority of cases the EEG of the schizophrenics is within normal limits. Even in cases where there is some evidence of CNS pathology, the abnormalities are relatively slight in degree. On the other hand, these authors report that in response to physiological variables schizophrenics show a wider scatter about the mean of normality than do controls.

Normality and EEG in Schizophrenia

Whereas most of the recent literature would agree with the first two points here, that there is no typical pattern and that most schizophrenics show an EEG within normal limits, there seems to be greater debate about the schizophrenics range of physiological response to stimuli including variability of the EEG pattern. Relative incidence of alpha versus beta waves, alpha blocking, and conditionability of alpha have all been examined with regard to this issue.

Davis and Davis (1936) reported a mean alpha index above 50 per cent on a large group of normal controls and most other authors conclude in the same general area of 50 or greater per cent time alpha for a normal population. Yeager and Baldes (1937), using Davis's EEG classification scheme, reported a high per cent of their schizophrenic patients showing EEG's of "rare" (0-25 per cent) or "mixed" (25-50 per cent) alpha incidence in contrast to the higher level of alpha in manic-depressive and involutional depressive patients. Additionally the authors collected a standard EEG from each of seventy adult, primarily male, organic and nonorganic psychiatric patients, (including thirty-three schizophrenics, twenty-four of whom were catatonic). Analyzed for per cent time alpha, these records revealed no significant variations with regard to abnormality of the EEG among the nonorganic psychotic patients. Although the beta wave data were of no diagnostic value, in all cases of the psychotic records beta waves were found to be more prominent under absence of alpha wave behavior than they were noted in the records of normals under similar conditions. Unfortunately, no statistical data were reported in this study and this is a problem with many of the earlier reported findings.

Davis and Davis (1937), using their scale of per cent time alpha in assessing the records of seventy patients diagnosed as psychotic, also found that manic-depressive patients showed a nearly normal distribution interindividually in terms of per cent time alpha; schizophrenics, however, show a significant trend toward low incidence of alpha wave behavior. Further, the clinically quiet and cooperative patients show a more nearly normal distribution of alpha wave incidence in comparison to chronic, or disturbed patients who show a scarcity of prominent alpha waves.

From a total of 3,100 patients, Stevens and Derbyshire (1958) selected the twenty-one catatonic schizophrenic patients showing the most severe symptom pictures. Comparing the EEG record before and after administration of sodium amobarbital the authors noted that those patients who showed an initial baseline of more than 38 per cent time alpha showed a fall post medication in alpha per cent time. Those patients showing an initial per cent time alpha less than 38 per cent, conversely, showed an increase in alpha post medication. Thus even though there was wide variation in the patient's behavioral manifestation of hyper- as opposed to hypo-activity, the physiological picture was congruent in that all patients showed a hyperalert state and responded differently to sodium amobarbital in terms of the degree of internal arousal. Again, by comparison with normals the schizophrenic subjects in this study showed a low alpha baseline.

Grinker and Serota (1938) noted that, whereas the EEG's of normals responded by either a more slow or more fast range of amplitude upon stimulation by various stressors, e.g., external cold, electric shock, intravenous epinephrine, and emotional disturbance by verbal provocation, the EEG's of schizophrenics showed no discernible change upon impact of these stimuli. However, Grinker and Serota do not note the character of the baseline EEG in the schizophrenic subjects. If in fact the schizophrenic initially showed a higher level of physiological arousal, one would expect less change with stimuli which typically produce increased arousal in the EEG record.

Rubin and Wall (1938b) examined the EEG records of sixty schizophrenic subjects (no subdiagnostic information was indicated) and sixty normals, observing whether there were differences in per cent time alpha, number of alpha bursts, and/or average length of alpha bursts. Using a monopolar lead from the occipital lobe, they observed a mean of 38 per cent time alpha for normals as opposed to 34 per cent time alpha for the schizophrenics, thus showing a trend toward a lower incidence of alpha in the schizophrenic group, but one which did not reach statistical significance. In comparison to other studies observing per cent time alpha in normals, this normal group shows an unusually low incidence of alpha.

Jasper, Fitzpatrick, and Solomon (1939) examined the records of fifty-one epileptics, sixty normals, and eighty-two schizophrenics (twenty-eight catatonics, twenty-two hebephrenics, eighteen paranoids, and eight simple) for per cent time alpha. Using recordings from frontal, central, parietal, and occipital leads, the schizophrenics showed about an equal distribution from 0 to 100 per cent alpha, while the majority of normals gave a per cent time alpha above 50 per cent with a mode at about 70 per cent for the frontal and central regions and a mode of 50 per cent for the occipital lobe lead. For all lead distributions, schizophrenics showed more cases in the 0-20 per cent class and fewer cases in the 80-100 per cent class than the normal or epileptic subjects. Thus the schizophrenic records, by contrast to the other groups were characterized by "flat", higher frequency activity. Although no quantitative data are reported, it is mentioned that the paranoid subjects tended to show more cases with higher incidence of alpha than did the other subgroups of schizophrenics. At the time of recording, each patient was assessed for "degree of contact with the environment." There was a contingency r correlation of .50 between the four classifications, per cent of degree of contact and the per cent time alpha. More paranoids were rated in good contact and conversely, more hebephrenics and catatonics in poorer contact. These authors used an alpha category extending from 8-15 cps, somewhat higher in the upward range in defining alpha behavior than other researchers use. Again, schizophrenics showed a much greater incidence of EEG abnormality, (25 per cent) than normals (8 per cent), but there was no single specific form of EEG activity which could discriminate the psychiatric patients from the non-psychiatric patients and normals.

Davis (1942) again compares the EEG record of schizophrenics (non-differentiated as to subtype) and manic-depressive patients. Comparing 129 schizophrenics with eighty-one manic-depressive subjects, she notes further that the schizophrenic group shows more records characterized by the "B" type pattern whereas the manic-depressive patients show a prominence of "A" pattern. She interprets this finding as a reflection that schizophrenics as a group appear to be dominated by internal overactivity, overstimulation, or lack of organization within the CNS.

Blum (1957) tested the hypothesis that schizophrenics would resemble brain-damaged patients in their failure to show normal responsiveness of the alpha rhythm to visual, auditory, and photic stimulation. Twenty-four normals, twenty schizophrenics on tranquilizers, and twenty schizophrenics without drug treatment, and twenty chronic brain syndrome patients subjects were categorized according to how much responsiveness to the stimuli they showed (alpha blocking). No differences were noted between groups with regard to normal resting alpha rhythm, and no differences between schizophrenic groups were noted. Normal subjects, however, showed significantly greater alpha responsiveness (alpha blocking) to stimuli than schizophrenics ($p<.05$). Normals showed this same difference from brain-damaged patients, thus suggesting that schizophrenics resemble brain-damaged patients in their lack of brain wave responsiveness to stimulation and tranquilizer drugs seemed to have no or minimal effect on this responsivity.

Variability in Cortical Measures

Jasper *et al*. (1939), concurring with the findings of Davis, also finds wide variation within schizophrenics on EEG records compared to normals. However, Travis and Knott (1936), found greater inter-individual differences among normals in time lapse between the removal of a light stimulus and the appearance of the potential rhythm (alpha). Yet in the second half of the trial run, it was noted that there was a general decrease in perseveration time for individuals as well as for the entire group; this refers to the process of adaptation. There is some indication that schizophrenics do not show this same process, or at least, in the same degree. They seem, by contrast, to not show this same capacity for adaptation to stimuli. Hill (1957) criticizes some of these earlier studies from the point of view of their lack of control for age; thus some of the variability reported among schizophrenics may be due to physical factors related to aging rather than to the disease process itself. In a somewhat more carefully controlled study, Rubin and Wall (1938b) found both normals and schizophrenics to show insignificant variation between groups in per cent time alpha, number of alpha bursts, and average length of alpha burst within an experimental session and found only slightly greater deviation between groups from day to day. These authors found that normals showed variation 122 times greater between individuals than within the subsequent records of the same individuals.

Acute schizophrenics showed inter-individual variation forty-five times greater than intra-individual variation and chronic schizophrenics (also no n given) showed an inter-individual variations twenty-seven times greater than intra-individual variation. While on any one session the normals were more heterogeneous, the patients showed much more intra-individual variation from day to day (p<.05). Thus it appears that schizophrenia makes individuals more similar to each other.

In Lindsley's review of the literature on "Electroencephalography in Personality and the Behavior Disorders" (1944) he concurs in reporting that, whereas there are large inter-individual differences among normals, intra-individual variability is relatively low.

Shakow (1952) points out that variability becomes a problem in EEG studies of schizophrenics compared to normals. Some schizophrenic patients consistently show coefficients of variation three times that of normals (Sugarman et al., 1964), although the general finding is that schizophrenics give a coefficient of variation considerably less than that of normals.

More recently, Goldstein, et al. (1965), using the Drohocki technique and taking standard clinical EEG records from chronic schizophrenics, have found that the coefficient of variation, figured on the basis of mean energy content (MEC) of the Drohocki integrator data, is much less among patients than among normals (p<.001). In contrast to earlier investigators (Rubin and Wall, 1938b; Lindsley, 1944) these authors found schizophrenics to be somewhat less variant than normals in week to week comparisons.

Regardless of the incidence of MEC, neither the patients nor the normals in the Goldstein et al. study showed any consistent relationship of coefficient of variation with level of MEC. Thus differences between coefficients of variation of normals and patients were independent of their alpha indices (alpha index and MEC being closely related). Furthermore this low variability of schizophrenics does not seem to change under different conditions of recording such as lying down, lying down with eyes open, closed, or sitting with eyes open. The authors suggest that this lesser variability in the records of the schizophrenics is related to a higher arousal level and absence of periods of drowsiness both in behavioral and EEG criteria. Length of institutionalization did not seem to be an important factor, as no differences were noted between patients who had been hospitalized two as opposed to twenty years. Likewise, no differences were apparent in a group of inmates studied some of whom had been incarcerated for two and some for as long as twenty years. Furthermore, no significant trend for either age or number of years of illness could be noted with MEC or coefficient of variation findings. Thus differences appeared to be due to hyperarousal in the schizophrenics.

This position is supported by a number of drug studies relating EEG variability to stimulant and sedative drugs (Murphree et al., 1962; Goldstein et al., 1963a; Pfeiffer et al., 1963). These studies noted that barbiturates and tranquilizers in varying quantities showed increases in EEG variability as a by-product and that conversely LSD tended to reduce the coefficient of variation in normal subjects. Thus it appears that the coefficient of variation is inversely related to level of activation of the cortex.

Although early studies which relied primarily upon clinical assessment of EEG data often reported a difference in incidence of normal wave behavior in schizophrenics, examination of EEG parameters in psychiatric subjects has only regained attention in the last several years. Much ambiguity still remains in the literature as to the degree of difference between EEG behavior in schizophrenics and normals, but the growing consensus is that schizophrenics show a more dysrhythmic, unusually aroused, cortical state which increases with chronicity. Reported sex differences are rare, and this at least reflects the disinterest in sex as an independent variable by most researchers. Variability, however, is much lower between schizophrenics than among normals and this may reflect the intensity and consistency of the over-aroused physiological state of the chronic patient.

Habituation and Recovery

Habituation or diminution of response strength over time, occurs as a result of repeated stimulation of the same neuronal pathway or when a novel but similar stimulus is introduced (Jus and Jus, 1960). Gastaut and Bert (1961) report habituation of alpha blocking to occur fastest when either a weak light or tone stimulus was applied in normal subjects. And the higher the baseline alpha level, the faster the habituation. Attempting to manipulate activation level in fifteen normal subjects by exposing them repeatedly to a perceptual conflict situation, Frankenhaeuser et al. (1966) found a progressive decrease in physiological and subjective indices of activation as performance improved. As the subjects became more successful at naming the color of cards in a color-word task, measures of subjective arousal, skin conductance, and adrenalin excretions decreased, and this linear relationship was especially strong between the first two test trials. The authors concluded that similar and parallel changes characterize the response patterns for these different measures.

As early as 1937, Cohen and Patterson reported schizophrenics showed a diminished heart rate change over the course of ten successive pain stimulation trials. Using an algesimeter and applying it as a pain stimulus at five-minute intervals and recording via a cardiochronograph the heart rate of the subject simultaneously they examined ten normals and ten schizophrenics. Whereas the schizophrenics tended to maintain their initial heart rate of eighty beats per minute, the normals decreased to about seventy-four beats per minute over the ten trials. This was interpreted as a failure for the patients, on the average, to show adaptation to the pain stimulus; the schizophrenics showed much variability in reaction pattern, however. This failure to show habituation in schizophrenia points out how the experimental situation itself may induce changes in the particular phenomenon under investigation. The fact that the average heart rate during the ten trials was higher than those heart rates obtained as a regular ward measurement procedure also suggests that the experimental situation itself may induce changes in the particular phenomenon under investigation. Yet even if the experimental situation may produce an unusual baseline level of the variable being studied, the failure to show adaptation in the schizophrenics stands independent of this possible experimental effect.

Gastaut et al. (1951) reported that their "calm" subjects showed a recuperation time from neuronal post-excitatory excitability longer than that of the "nervous" subjects. Most of the earlier findings in psychophysiological research of schizophrenics have stated that the schizophrenic requires a longer recovery period from autonomic disturbance than does the normal individual (Williams, 1953; Ax et al., 1962). More recent work, however, has suggested that the assumption of slower recovery in schizophrenics is not descriptive. Examining children with "high risk" for schizophrenia, Mednick

(1967) has found an unusually fast recovery rate on measures of GSR. Zahn (1966) has come to a parallel conclusion using adult schizophrenics, i.e., schizophrenia is apparently characterized by faster recovery and failure to show response habituation. He observed that the GSR to a repeated noise stimulus dropped less in his schizophrenic subjects than in his normal controls and that the schizophrenics remained at essentially the same high general arousal level throughout the experimental period, whereas in normal subjects the level gradually diminished.

Travis and Knott (1937) examined normals for perseveration time to twenty words, twenty nonsense words, and a control ten blank cards, while varying emotionality of the words and controlling for size and configuration of the nonsense words by using the same letters as contained in the words. With repeated presentations, words seemed to lose their arousal value as assessed by EEG changes, however, meaningful and nonsense words were associated with longer perseveration times than light alone.

Thus normal subjects show a parallel between improved performance through familiarity with the stimulus materials and a reduced internal arousal level. Habituation and recovery are altered as a function of schizophrenia, with less of the former and more of the latter found among schizophrenic patients.

Severity of Disorder and Psychophysiology

A number of studies using physiological variables in the examination of schizophrenia have noted differences in the performance of patients diagnosed as acute vs. chronic, process vs. reactive. To mention just a couple, Gellhorn (1963) noted that a number of ANS factors indicating sympathetic arousal increased in normal subjects with overt expression of emotion and decreased in schizophrenic patients when increases in emotionality were reduced (r=.26; p<.01). He further reports that metholyl test responses measured in blood pressure changes discriminate chronics from acutes. However, both groups looked hyperreactive compared to normals. Shagass and his colleagues have noted a number of differences regarding sedation threshold, including a difference between chronic and acute cases of schizophrenia (1958; 1958a). Shagass tested the hypothesis that individual differences in drug tolerance may reflect significant aspects of affect and personality. Using a 0.5 milligram/kg intravenous injection of amobarbitol, he noted at what point speech slurring began to occur in a group of forty-five non-patients, 308 psychoneurotics, and 350 psychotic patients. Frontal EEG records were monitored simultaneously. With a reliability of r=.83 for the total group, sedation threshold increased with degree of manifest anxiety in normal and psychoneurotic patients, but the normals showed a lower sedation threshold than all of the psychoneurotics with the exception of the hysterics. Acutes had significantly lower thresholds than chronics, and after one year of illness as defined by hospitalization, schizophrenics' thresholds tended to be generally high.

More recently Gromoll (1961), in his comparison of process and reactive schizophrenics with regard to level of cortical activation and arousal, concurred that, while this difference did not reach significance, the process rather than the reactive patients manifested evidence of prolonged electrocortical response to stimulation. Process patients continued to show fairly high levels of activation across experimental conditions of rest, visual-auditory stimulation, auditory stimulation, and auditory-stress.

The growing concensus of psychophysiological research with schizophrenics is that they tend to be over-aroused, and this physiological hyperactivity varies with chronicity. Performance deficit also varies with chronicity. These two sources of data support a drive theory of schizophrenia, wherein schizophrenic deficit may be explained as the result of the disruptive effects of an excessively high arousal or generalized drive state.

Paranoid vs. Non-Paranoid Subjects in Studies of Schizophrenia

Most studies which have taken into account subcategory differences have reported discrepancies between paranoid and non-paranoid subjects examined for differences in perception. Venables and Tizard (1956) find that non-paranoid chronic schizophrenics show faster reaction to visual than to auditory stimuli, whereas normals and intact paranoid schizophrenics show the reverse relationship. Johannsen (1961) found paranoid schizophrenics, non-paranoid schizophrenics, and normals behaved differently depending upon the presence or absence of the experimenter in the room when the subject was being tested. Each subject was required to learn a repetitive double alternation pattern under conditions of presence or absence of the experimenter seated beside them and saying "right" or "wrong" according to the correctness of their response. Normals showed better performance with feedback and non-paranoid schizophrenics showed the reverse. All subjects did equally well under conditions of non-social feedback and paranoid schizophrenics did equally well under both conditions. One interpretation suggested is that, as supposed by Mednick (1965), social feedback arouses anticipation of censure and thus an increased drive level among the non-paranoid schizophrenics. The paranoid subjects' behavior is more puzzling.

Stimulus threshold data (Venables, 1966) indicates that the more withdrawn the patient (among non-paranoid schizophrenics), the lower the threshold tended to be (Venables and Wing, 1962). But among coherent paranoid patients the relationship between two-flash and two-click thresholds was as for normals.

Ingram (1962) measured several ANS variables under conditions of rest, stress, and drug administration in 107 male schizophrenics and a comparison group of non-schizophrenic psychiatric patients. Paranoid schizophrenics showed greater respiration rate and irregularity than others, although there were no other differences within schizophrenics for any of the other variables under any of the three test conditions. Autonomically, paranoids tend to resemble non-paranoid schizophrenics according to these results. It may be significant that all patients here were chronic schizophrenics.

Of fifty-eight measurements made over a wide range of psychological functions, Shakow (1962) found the paranoid schizophrenics to be nearer the normal in thirty-one instances as compared to the hebephrenic's seven instances of similarity to the normals. On twenty measures, however, paranoid and non-paranoid subjects fell on either side of the normals. Shakow interpreted these findings to mean that the paranoid overreacts to the underlying trend toward disorganization, whereas the non-paranoid submits to manipulation by his environment more readily.

In their studies of EEG activity in schizophrenic and non-psychotic subjects, Goldstein <u>et al</u>. (1965) found catatonic subjects showed least variation when compared to other subcategories of schizophrenia, subjects incarcerated in a state reformatory, and normal controls.

This reinforces the point of view which describes schizophrenics as showing physiological hyperarousal, especially among more severely disturbed schizophrenics.

Ax (1967), in his investigation of the psychophysiology of schizophrenia, found his patients included two extreme types: fairly intact paranoids who rated low on disintegration but high on tension and deteriorated hebephrenics with low tension.

The majority of these studies reinforce the position that paranoid schizophrenics behave in ways, psychological and physiological, different from the other members of the schizophrenic population. An obvious implication for research is cognizance of this heterogeneity and care in selection of subjects.

Sex Differences in Schizophrenia

Research among psychiatric groups has been almost exclusively with male subjects. The assumption of no difference between the sexes, even on physiological measures, may result in a serious oversight. Goldstein, *et al*. (1965) found at least one sex difference on a measure of arousal and suggest that ovulation may predict this variation.

Hill (1957) reports that Gastaut finds females show a higher incidence of a photomyoclonic response (rhythmic clonis of the periorbital musculature) when exposed to high intensity light under the influence of metrazol. He interprets this as susceptibility of subcortical mechanisms to the production of epileptic-like responses to a light stimulus. Although this reaction is commonly found in emotionally tense subjects of all descriptions, the higher incidence in females is noted by comparison to males, although there are no statistical data reported for this finding. Visser (1961) examined sex as a possible source of difference in psychiatric patients versus normal subjects' susceptibility to alpha conditioning. Although a high alpha frequency was associated with high susceptibility to alpha conditioning, there were no sex nor age differences noted.

Mednick (1967) in his longitudinal, multi-variate comparison of high-risk to schizophrenia and low-risk children, noted that among the differences distinguishing the two groups from each other, the female subjects of the high-risk group appeared to be more highly tense and nervous, more dysphoric, compulsive, and negative in their self-evaluation according to the interviewing psychiatrist. He further found that the girls in the high-risk group, by contrast to the boys, were positively related to their sick mothers and were described by their teachers as being relatively passive and responding with withdrawal when upset. By contrast, high-risk males were more often described as aggressive and disturbing in the class. These findings suggest that the schizophrenia of the mothers affects the females somewhat more than the male offspring.

Rosenthal (1962) has pointed out that the family members of the same sex as the schizophrenic parent are more likely to be concordant for schizophrenia. The fact that schizophrenic women are more fertile than schizophrenic men and that psycho-developmentally mothers presumably play a greater role in shaping children, would suggest that females might be expected to fall ill with schizophrenia at a higher rate than males (Goldfarb, and Erlenmeyer-Kimling, 1961).

Malzberg, reported by Arieti (1959), gives figures showing essentially no difference between males and females in first admission rates up to the year 1950. Although the rate of admission for diagnoses collectively subsumed under Dementia Praecox has increased between the years 1910 and 1950, the proportion between males and females has remained fairly close (1950: 31.5 males and 31.0 females per 100,000 population).

Although the literature is equivocal as to the presence of sex differences in per cent time alpha (Brazier and Finesinger, 1944; and Short 1951, find no association; Ellis and Last, 1953, do) beta waves are reported by Mundy-Castle (1951), Ellis and Last (1953), and Kennard _et al_. (1955) to be in greater incidence in females than in males. Goldstein (1965) reports a difference on their measure of electrographic variation for males and females.

Although the findings are sparse, evidence for behavioral differences on the basis of sex continues to mount as incorporation of sex as a variable becomes a more common procedure in research designs.

Perception Methodology in Research on Schizophrenia

Although there is little evidence that there is any true deficit in sensory threshold in the functional disorders (Maher, 1966), schizophrenics do show a difference from normals when classical refractory phase experimental methodology is used (Venables, 1968). Using very short delay intervals (50-500 milliseconds) in order to control against the possible interference of sex and expectancies, Venables pursued the suggestion of Lang and Buss (1965) that because schizophrenics show more checking and monitoring of their responses, one might expect them to show an exaggerated delay in responding to the second signal in the refractory phase experiment. Venables reports a number of concepts and methods in current use in the study of perception, attention, and memory but notes that work done in this area has usually excluded abnormal subjects. He finds that, in general, schizophrenics show spatial narrowing of the visual field, narrowing of attention to relevant aspects of the total input, and temporal narrowing to more immediate aspects of the stimulus situation. Temporal narrowing is found especially in states of high cortical arousal. This finding is complemented by Venables' (1966) findings showing schizophrenics to have a relatively higher two-click threshold than a two-flash threshold, and Venables concludes that there is some disturbance in normal sensory modality dominance as a function of schizophrenia.

In light of these results the methodology of perception seems a fruitful approach to questions of psychopathology. The primary rationale in studying sensory processes with regard to psychopathology is that they may clarify the processes and etiology of malfunctioning of more central processes.

Soviet Research on Psychophysiology in Schizophrenics

In Lynn's review of Russian theory and research on schizophrenia (1963) the evidence as a whole suggests two types of schizophrenics: the majority who show a low sympathetic tone and reactivity; and a minority where sympathetic tone and reactivity are unusually high. Breaking down these two groups into sub-diagnostic categories, it appears that the first group is primarily composed of catatonics and simple schizophrenics whereas the smaller group contains acute and agitated patients, especially paranoid schizophrenics. This observation in the Soviet Union is congruent with Gellhorn's conclusions (1957) that high as compared to low sympathetic reactivity seems to follow lines of severity and chronicity. Venables' (1960) findings for high and low arousal patterns and Mednick's high and low anxiety (1958) hypothesis about schizophrenics are also paralleled by these findings. However, Russian EEG research has reported patterns typically showing low arousal and drowsy states characterizing schizophrenia. Rusinov and Rabinovitch (1958) find a "diversity of the EEG pattern" (unexplained) which they attribute to the different clinical forms and stages of the disorder according to A. Snezhnevsky's schemata (see Figure 1). There are no studies translated in the western literature comparing psychiatric patients with normal controls, however. Russians have used many conditioning approaches in studying schizophrenics, and with the recent and major exception of Ax's work, researchers have not generally used these techniques in the West. The general Russian findings using conditioning have been that schizophrenics tend to show slow and retarded reactions.

Much of the Soviet literature shows schizophrenics unusually sensitive to stimulants, showing behavioral improvement with small quantities or substantial regression of behavior produced by large dosages. Venables and Tizard (1956), and Venables (1960) report similar findings when observing arousal level changes as a function of intense stimuli and level of background stimulation. Most of these findings then can be used to support the interpretation that schizophrenics can only operate efficiently within a narrower range of arousal than normals (Venables, 1960).

Most of the Soviet literature presumes Pavlov's concept of "protective inhibition" as subsuming the phenomena of schizophrenia; however, there is to date no known physiological evidence verifying this explanatory construct. The tendency in the West has been to use the construct "deficit" to describe the differences in behavior, both overt and physiological, noted between schizophrenics and normals.

Verbal Association in Schizophrenia

In his coinage of the term "Schizophrenia", Bleuler recognized the plurality of the groups of disorders but defined them together as

> characterized by a specific type of alteration of the thinking, feeling, and relation to the external world, (Kline, 1952).

The process of normal association, which involves "integration of thought, completion of logical pursuit and conceptual integrity," is altered in schizophrenics by its decreased predictability and often bizarre quality. Primary disturbances of perception, orientation and memory do not typically occur, but in more severe cases emotional and affective expression seem muted if not absent.

Bleuler described the fundamental symptoms as: (1) disturbances in association; (2) progressive deterioration of affectivity; and (3) a reliance upon fantasy as compared to reality--an inclination toward autism. Disturbance in association may occur in terms of loss of continuity, tangential thinking, concreteness, time disturbances of verbal production, place disturbances, etc. Disturbance of affect was seen to occur in distortion of degree of expressiveness; in severe cases, affectivity is reduced, in milder cases there may appear a heightened but often shallow affectivity. (Severity here is defined in terms of the patient's capability of functioning independent of hospitalization).

Kretschmer (1934) similarly to Bleuler felt dissociation, or the tendency for mental activity to occur in isolation, to be one of the main characteristics of psychotic states. He pointed out that an abnormal amount of dissociation could produce a schizophrenic thought disorder characterized by a "fragmentation of mental activity and a lack of logical relationships between systems of ideas." The concept of dissociation is also used to explain inappropriate affect and maintenance of delusional ideas.

Babcock (1930) suggested thought disorder in schizophrenia is a result of extreme intellectual slowness and based his conclusion primarily upon observations of reaction time in schizophrenics. Chronics are very slow, acutes are less slow. However, this explanation fails to account for the parallel behavioral retardation noted in depressed patients, thus reducing its power to distinguish schizophrenics from other patient populations.

Cameron (1947) holds that schizophrenic thought disorders are due to overgeneralization of concepts. In this way, schizophrenics are seen to include a number of categories at one time. Although there is much in the literature to support this viewpoint, overinclusion is not specific to schizophrenic conditions alone.

More recently, Mednick (1958) provides an explanation of the schizophrenic's associational disturbance as a function of anxiety. Using a Hull-Spence concept of drive, this learning theory approach proposes that the random contiguity of irrelevant thoughts with moments of anxiety predicts the recurrence of irrelevant thoughts under similar circumstances of high psychophysiological arousal. As these conditioned avoidant responses help the individual avoid the arousal stimulus, this will result in a momentary reduction in arousal level. The reinforcement value of this reduction in arousal will reinforce the association between the arousal stimulus and the avoidant thought, thereby increasing the probability of an avoidant associate response to future stimulation. Through subsequent generalization of stress cues, irrelevant thinking becomes expanded and gradually results in a chronic state. Mednick (1967) suggests that the individual most likely to be susceptible to this learning of avoidant thought shows extreme hyperresponsivity, excessive generalization and fast recovery from autonomic imbalance.

Payne and Hewlett (1960) were concerned with determining whether retardation, overinclusion, or concreteness are abnormalities specific to schizophrenia or general characteristics of psychotic patients. Their measures of overinclusion elicited high scores only among schizophrenics, although retardation was characteristic of all psychotic patients compared to normal and neurotic controls, and retardation did not discriminate between schizophrenic and depressive patients. Concreteness seemed to be almost entirely a product of low general intelligence. Even though overinclusion discriminated schizophrenics from other groups, half of the schizophrenics tested were not overinclusive. The authors note this as indicating the heterogeneity of the schizophrenic sample and suggest the presence of a specific set of symptoms; paranoids show more overinclusion than other patient groups for example.

Johnson et al. (1964) found the responses of psychotic patients to verbal stimuli to be more idiosyncratic than those of normals. This supports Moran's (1953) finding that the responses of VA chronic paranoid schizophrenics in a word association test show less meaningful relationship to the stimulus words than those of nonpsychiatric patients. Although these schizophrenics could define words about equally well as normals, their use of them revealed conceptual misunderstanding.

Spence and Lair (1964) attempted to test Mednick's theorizing which deals with abnormal associative interference in schizophrenics as exhibited in paired-associate learning. Mednick proposed that early stage or acute schizophrenics have a heightened susceptibility to associative interference of this type (1958), but these authors found both the acute schizophrenic group and the nonpsychiatric patient controls to show similar significant interference of extralist words upon presentation of the experimental list. The major difference between the groups was that on both experimental, control, and practice lists the schizophrenics gave a significantly higher proportion of incorrect overt responses as compared to errors of omission. This was interpreted to say that normals exercise greater control over their overt behavior, inhibiting inferior or incorrect responses more.

Kent and Rosanoff (1910) noticed from a massive survey of verbal association material that the one tendency which appears to be almost universal among normals is to give a small group of common reactions in response to many high frequency words in everyday usage. This is more true for some stimulus words than others. By contrast this characteristic is reduced in psychiatric patients, many of whom were found to give more than 50 per cent of individual responses. The Kent-Rosanoff frequency tables provide a list of 100 words selected with care taken to avoid words liable to stimulate intense emotional responses and presented as a single word association task to 1,000 normals covering a broad demographic range. The tables include all 100,000 responses for all stimulus words compiled separately. Comparing the responses of 1,000 normal subjects to responses collected from a group of 247 psychiatric patients, 147 of whom were diagnosed as having "Dementia Praecox" or "Paranoic Conditions", incidence of common responses, responses which occurred at least 1 per cent of the time, was compared to incidence of individual responses, responses occuring less than 1 per cent of the time. Normals gave 92 per cent common responses to the patients' 71 per cent. There were no notable differences determined by age or sex although the proportion of individual reactions given by subjects with a college education was slightly higher than the average for normal subjects.

Sommer _et al_. (1960) studied a group of twenty-three acute, twenty-six chronic, and twenty-three non-schizophrenic mental patients using the Kent-Rosanoff word list and scoring responses according to their frequency tables. They found that more than 90 per cent of their subjects most frequent associations were among the three most frequent associations of the Kent-Rosanoff norms; apparently commonality of verbal behavior had remained highly stable over a period of fifty years. Again schizophrenics gave fewer common responses (28 per cent) than either normals (35 per cent) or the other psychiatric patients (45 per cent). When asked to rate the commonness of their responses, all subjects did equally well. Thus the schizophrenics not only give more individual responses but they are aware of their individuality as well.

Babcock (1930) states that the Kent-Rosanoff words seem to have the quality of a "core language" in that they consist of words for the most part learned fairly early in life, they are thus not as likely to be affected by schizophrenic disturbances as words which occur less frequently in the language and are learned later in life. Maltzman *et al*. (1962) were interested in seeing if common as well as uncommon word associations could be induced in normals by administering verbal reinforcement for the appropriate type of response. The group reinforced for common responses gave more of them, but the groups reinforced for uncommon responses did not give more than a control group which received no special reinforcement. Apparently normal subjects can learn to give more common associations but not less common ones. Using a similar approach with normals compared to schizophrenics, Wynne (1963) found normals gave more common responses under instruction whereas schizophrenics did not. There were no differences in proportion of common responses elicited under conditions of free association, however.

Statement of the Problem

Whereas many studies comparing schizophrenic and normal subjects have reported an underresponsivity where behavior is measured overtly, the covert and internal state of the schizophrenic has been described variously as tending to show either physiological hypo- or hyper-arousal. The equivocality of the literature can be in part assigned to early reliance upon ANS variables, many of which behave interdependently and therefore artifactually in response to reduction or increase in the complementary subsystem. Depending upon the variable, the size of the measure may or may not reflect the functioning of that variable alone. GSR has remained as one enduring exception to this difficulty, and most recent studies attending to GSR have concluded in favor of a hyperarousal viewpoint as descriptive of schizophrenia. EEG research using schizophrenics provides a closer check on the degree of physiological arousal in that it lacks the complication of opposing and interdependent subsystems such as exist within the autonomic nervous system.

From very early in the history of EEG research reports of differences in level of arousal as reflected by level of alpha and beta waves have been noted but many of these first endeavors suffer from reliance upon assessment by clinical impression to the exclusion of quantification or mechanical measurement of wave parameters. Only with the introduction of the Drohocki integrator has it been possible to mechanically quantify the energy expenditure of brain wave behavior including a continuous expression through time of wave energy changes.

The earlier impressions of higher CNS arousal in schizophrenics have in recent years gathered increasing support, contradicting the view of schizophrenia which contends that these individuals suffer from an underactive physiology. Not only does it appear that most schizophrenics experience a continuous state of hyperarousal, but there is some evidence to suggest that chronic individuals show less adaptation to stimuli and decreased variability through time when compared to less severely ill patients and normal controls.

The presence of labile autonomic nervous system reactivity at the time preceding onset of habitual avoidant thinking is posited by Mednick (1966) as one of the critical factors responsible for a spiraling reliance upon avoidant thought finally resulting in a diagnosis of "schizophrenia". He further posits that reinforcement of avoidant thought under original conditions of stress is enhanced by failure to habituate to distressing stimuli and by faster recovery to pre-stimulus physiological baseline.

This study attempts to examine the possibility that the schizophrenic (paranoid) differs from the nonschizophrenic in physiological reactivity and that these differences, if confirmed, relate to the presence of avoidant thought processes in the schizophrenic. If, as Mednick suggests, there is a relationship between ANS lability and the development of avoidant thinking, it may be wondered if adult schizophrenics show evidence of association between avoidant thinking and electrocortical arousal.

In view of the accumulating body of literature which suggests the schizophrenic suffers from a chronically hyperaroused internal state, it is predicted that paranoid schizophrenics compared to normal controls will show higher cortical arousal as measured by Mean Energy Content of the EEG under conditions of rest and performance of a single word association task.

It is hypothesized that large (alpha) wave activity will be significantly less among schizophrenics during resting, pre-stimulus, latency period, and immediate post-response recordings. By contrast, overt behavioral indices such as reaction time, response commonality and response quality are predicted to show deficit of performance as compared to normals. Both overt (behavioral) and covert (electrophysiological) data will be examined with reference to theory of thought disorder development in schizophrenia.

CHAPTER II

METHOD

Setting

An opportunity to work at the Institute of Psychiatry, located on the grounds of the Kashchenko Hospital in southeastern Moscow, provided the occasion for researching this experimental design. Kashchenko is one of the largest Soviet psychiatric centers with approximately 2,500 beds and a staff of 2,300. Of the nearly 200 physicians, about half are qualified psychiatrists and most of the physicians are women. Although there are no psychiatric aides, patient care by the many nurses is done with apparent warmth and concern.

Of the 12,000 yearly admissions to Kashchenko, nearly 90 per cent are readmissions and the hospital functions largely as an acute service in that patients are not usually maintained there longer than a year. Those who are not among the 80 per cent discharged to return home are transferred to chronic hospitals.

The present study was conducted at the Psychiatric Research Institute of the Academy of Medical Sciences of the USSR, housed in a building located within the grounds of the Kashchenko complex. Here Professor A. V. Schnezhnevsky, the director, heads a multi-disciplinary staff in the exclusive research of schizophrenia. The approach of the institute is thus monoproblematic utilizing a team effort involving the separate but exchanged efforts of clinical psychiatrists, psychologists, physiologists, biochemists, biologists, and neuropathologists. The clinic involves four laboratories including: (1) Clinical psychiatry; (2) Abnormal Psychology and Neurophysiology; (3) General Pathophysiology; and (4) Pathomorphology.

The predominant view of schizophrenia is Pavlovian in theory and emphasizes description and classification of the dynamics of the illness. Contrasting with Slutzensky in Leningrad, Schnezhnevsky, whose views are reflected by the institute's research, assumes schizophrenia to be a unitary disease process without hypothesizing about etiology. Figure 1 depicts the scheme used to understand the possible routes of development and course of schizophrenia as conceptualized by Schnezhnevsky and his colleagues. Essentially the focus is upon exploration of whether the person has sterotypic ways of decompensating in terms of mental and/or higher nervous activity and how to understand these ways in psychological and phenomenological terms.

The Abnormal Psychology and Neurophysiology Laboratory, headed by Dr. C. C. Monakhov, devotes much of its research energies to exploration and discovery of EEG correlates of schizophrenia. The presence of EEG machinery and the warm invitation by Dr. Monakhov to participate with his staff made it possible to undertake this investigation concurrent with the laboratory's own research activities. Data was gathered jointly with the aid of V. G. Puskina, the second most senior member of the laboratory and assistance for attending and preparing subjects for the EEG apparatus was made available on request by the regular research staff.

Design

The original experimental randomized design included four factors: Sex (2) x Diagnosis (2) x Light (4) x Time Periods (3). A preliminary analysis proved Light to be of no influence upon the dependent measures and so this factor was dropped from further consideration in the data analysis.

Measures

Physiological Measures

The one consistent significant relationship between EEG pattern and psychological state is that between electrocortical wave frequency and level of consciousness: decrease of frequency is associated with somnolence and inattention and increase of frequency with alertness and attention (Hill, 1957). For this reason, physiological arousal was monitored by means of a standard clinical electroencephalogram integrated for mean energy content (MEC) in order to infer incidence of alpha waves, a relatively low frequency large wave, the primary dependent variable. As preliminary analysis of lobe data indicated no significant differences in MEC, the final measure of arousal utilized MEC data summed over all five lead pairs. MEC data, noted as blips on the raw integration record, was used as an equivalent to incidence of alpha waves; all records were carefully screened to assure exclusion of any subject with presence of abnormal slow wave activity, primarily delta waves, which would otherwise violate the assumption that alpha waves were the major source of electroencephalograph pen displacement which, summated, produced integration data. Striking off equal portions of the record dependent upon the length of each latency period, this data was examined for pre-stimulus (PS) alpha/second, latency period (LP) alpha/second, and post-response (PR) alpha/second for each subject. Blocking of alpha waves, measured as a significant ($p<.05$) drop in MEC, was used as the operational definition of electrocortical "arousal", while return to background alpha wave incidence from a preceding state of arousal defined electrocortical "recovery".

In addition latency period length, summated within trials using word stimuli alone, and within trials including variable frequency photic stimulation just preceding the word stimulus, was analyzed for each subject and for each trial.

Psychological Measures

As the major concern of this work was the investigation of relationship between electrocortical arousal and recovery and associative behavior, the task for each subject was to respond with the first association subsequent to each of a list of twelve stimulus words. These were selected from the Kent-Rosanoff word list (1910) for their tendency to elicit common responses in American normal subjects and for their apparent absence of emotive acconotation. Goldstein and Jones (1964) note that persons who give a large number of remote associations to emotional stimuli also give a large number of remote associations to neutral stimuli. Thus controlling against emotionality in stimuli should elicit a clearer picture of basic disturbance in the association process of the subject. These words were: table, dark, man, slow, girl, high, sour, hard, bread, long, black, and loud (Appendix A). While these words all produce a single common response 60 per cent of the time or better among American subjects (Kent and Rosanoff, 1910), the assumption of cross-cultural similarity in eliciting common responses was not met for the two words "girl" and "bread" for the standardization subjects, who were of Great Russian heritage.

A group of 100 medical students were asked to respond to each stimulus word with their first response (Appendix B). Whereas even this limited sample reflected results congruent for American norms for ten of the words, "girl" and "bread" received a much wider spread of first response words than did the other words. As a result data associated with these words were eliminated from the final analysis. The per cent response given for each word by the Russian standardization sample was then used as the commonality score for that response; responses not given by the standardization sample but produced by the subject uniquely were accorded a score of "1".

Apparently "bread" connotes "salt" most frequently as a function of the traditional association of these two foodstuffs in rural tsarist Russia. At the arrival of a visitor the wife of the house would respectfully offer him a fresh loaf of bread upon which rested a small cup of salt--the symbols of Russian welcome and hospitality. Although "girl" elicited "boy" most often, as in American norms, "woman" appeared with comparable frequency. Perhaps this is a reflection of the observation that women seem to maintain girlfriend relationships more intensively and extensively in Soviet Russia than in the United States. For example, it is a common sight to observe two adult women arm in arm on the streets of Moscow; the same is rare between men and women.

Subject Characteristics

Age, marital status, and socio-economic status was recorded for each subject. Socio-economic status (SES) was coded by use of a ranked scale of one through five, from unskilled worker down through professional status. Each schizophrenic subject was coded as more (1) or less (2) severe in the degree of disturbance he demonstrated using the guidelines for describing process vs. reactive schizophrenics as suggested by Kantor, Wallner and Winder (1953) and Brown's distinction of more or less than two years' hospitalization (1960).

Subjects

Twenty-five normal controls and twenty-five patients hospitalized in the Institute of Psychiatry with a diagnosis of "paranoid schizophrenia" comprised the subjects of the study. Appendix C contains admission histories of all patients. Approximate counterbalancing for sex was maintained within diagnostic groups and all schizophrenic subjects were fresh admissions except for seven who were removed from drug therapy a week before inclusion in the study. Selection of only patients with diagnosis of "paranoid schizophrenia" was precipitated by the observation (Brackbill, 1956; Lang and Buss, 1965; Venables, 1968) that the diagnostic category of schizophrenia is heterogeneous in its membership. Paranoid schizophrenics seem distinguishable from other subdiagnoses in that paranoids are usually less disturbed than other schizophrenics (Payne and Hewlitt, 1960; Shakow, 1962; Lang and Buss, 1965) and show fewer differences from normals on both psychological and physiological tests (Shakow, 1962; Ingram, 1962). And Johannsen (1963) finds the acute-chronic, process-reactive, and good-premorbid-poor-premorbid scales all correlating highly; only the dimension paranoid-non-paranoid remained independent of these. This greater similarity of paranoid schizophrenics to normals on both psychological (Shakow, 1962) and physiological (Ingram, 1962) measures in contrast to other subclassifications of schizophrenia suggests that patient-normal differences, if found for paranoids, would be of greater value in clarification of differences between "schizophrenic" and normal status. That paranoids are often more cooperative and that it is suggested by at least one researcher that they show a higher incidence of alpha waves (Jasper, Fitzpatrick, Solomon, 1939) than other schizophrenics further encouraged using patients with this diagnosis.

Males have been the subject sample in most studies of schizophrenia cited in the literature (Schooler, 1963). The present study attempts to compensate for the omission of sex as a variable in the literature by inclusion of groups representing both sexes: eight normal males, seventeen normal females, fourteen paranoid schizophrenic males, and eleven paranoid schizophrenic females. Spontaneous order of fresh admission was the main criterion for inclusion in the study and so analysis of the data by severity was made later. Normal subjects were recruited from the hospital staff attempting to use only staff members who were naive about the purpose of the study at the time of testing.

Demographic variables of age, socio-economic status, marital status, and severity of disorder were examined by correlation to determine if any subject characteristics not controlled for homogeneity related to any of the dependent measures (Appendix F).

The higher age of the schizophrenics and higher SES of the normals is explained by the difficulty in obtaining normal-schizophrenic matches on demographic variables. This was in part due to the difficulty in communicating the importance of this procedure to the Soviets who are accustomed to much less concern about controlling against artifactual influence upon results due to subject heterogeneity. In addition, schizophrenic subjects were recruited as they appeared as admissions and if matches were not available from the research staff occupying the institute building, the Soviets were reluctant to seek elsewhere for these; no explanation was given for this position, however.

Apparatus

The experimenter used a twelve-channel electroencephalograph built in Leningrad and copied after an Italian machine; exact specifications were not available. However, it resembled in most respects Grass twelve-channel machinery and channel specifications were standard. Frequency and intensity control apparatus for the stroboscope adjoined the electroencephalograph machine. Contact with the subject in the experiment room was maintained with an intercom system operated in the machinery room. Attached to the electroencephalograph machine was a Drohocki-like integrator (Drohocki, 1948) whose output appeared as a series of pulses on each of the five channels used.

The experimental setting included a suite of three contiguous rooms separated from each other by thick walls containing copper shielding (see Figure 2). All doors were heavily padded to effect sound proofing and two of these doors separated the subject from the experimenter. The test room was entered by passing through a small anteroom which separated the experimental from the machinery room.

Recording speed was three centimeters per second and amplification was set at maximum deflection for a five microvolt input. Amplification range included frequencies of one-half cycle upward to sixty cycles per second. Requirements for linearity of response, the deflection of the pen being directly proportional to the voltage applied at input to within 10 per cent, and amplification standards of five microvolts giving a deflection not less than two millimeters, were met. Noise level of the machinery was 2.5 microvolts. Calibration of the electroencephalograph machine was set to have a fifty microvolt signal produce a six millimeter deflection in all channels. A preliminary recording was made to determine whether all electrodes were making good contact and to ensure against artifactual interference with the recording.

Five channels were used for cortical recording including frontal, percentral, parietal, temporal, and occipital areas. One channel recorded onset and termination of verbal material, and another indicated onset, frequency, and termination of stroboscope stimuli.

The Drohocki integrator was preset to register a pulse at the moment when a certain cummulative energy level (microvolts) had been reached. The frequency of these deflections is then proportional to the size and number of the electroencephalograph deflections, and by summing the number of pulses over a number of successive time periods, the mean energy for that sum time can be obtained. As alpha waves, the larger slow wave characteristic of a normal relaxed waking state, was the implicit criterion of interest in this study, the integrator mean energy was used as a reflection of incidence of alpha wave behavior.

Electrodes used were silver disks about 0.5 centimeters in thickness having a slight depression on the undersurface for the application of electrode paste. A two-meter length of insulated wire of multi-strand copper connected each electrode with a plug. The electrodes were applied with collodian paste, plus a dash of chloroform to hasten drying, and were removed with acetone after the test procedure.

Recording was monopolar in that each of the cortical leads situated over the left cerebral hemisphere compared to a single non-cerebral and presumably neutral electrode located in the lobe of the left ear (Figure 3). The frontal electrode was placed centered on the forehead directly above the left eye. The precentral electrode placement was three centimeters anterior to the vertex and three centimeters lateral to the midline of the skull whereas the temporal parietal area was measured by placing an electrode in this same position posterior to the vertex. Electrode placement was at the level of the upper edge of the pinna of the ear above the auditory meatus. Occipital electrode placement was 0.5 centimeters above the inion.

Procedure

The attending nurse or nurses (in the case of patients) escorted the subject to the EEG laboratory where he was introduced to the procedure as part of the admission regimen. Both as a means of establishing rapport and as an opportunity to observe the subject clinically, the nurse asked the subject for a brief history of himself and inquired as to his feelings of the moment as he was being hooked up to the electroencephalographic apparatus.

This information was later checked and expanded in conference with the patient's attending psychiatrist. Each subject was requested to recline on a couch as a supine position elicits greater relaxation and reduces interference from muscle tension. In the event of any verbal expression of anxiety on the part of the subject, he was reassured that the procedure was entirely harmless and painless, and that it would produce no ill effects.

When the patient had been properly prepared in the test chamber, all lead pairs were checked on the oscillograph and integrator machinery for adequacy of lead attachment and machine functioning. Damping of the pen was checked by the experimenter to insure wave input would be neither peaked nor rounded in a distorted fashion on the subsequent record. Leads (a pair of two electrodes) were subsequently checked in a trial recording to insure proper electrode contact with the scalp to insure against any machine failure or difficulties. After the damping had been checked, and the channels were matched by connecting each to the same pair of electrodes adjusting for the degree of amplification and filtering necessary, survey records were obtained from the relevant leads. In the event of any unusual verbal or motor behavior evidenced by the subject during the recording, a note was made on the record at the time. If the subject's record gave evidence of sleepiness or motor potential interference, he was reminded by the intercom to remain relaxed but awake and this procedure was maintained throughout the test session. When all adjustments had been completed, the experimental chamber door was closed and the test session begun.

After an adaptation period of approximately ten minutes, a word association task was presented with instructions to answer with the first response that came to mind upon presentation of each stimulus word. A list of twelve words (translated into Russian) with reliable American norms showing high response commonality--eliciting a single response 60 per cent or more of the time--were presented counterbalancing for list placement and precedence of stroboscopic light, between subjects within each diagnosis (see Appendix D). These words were later checked with a small standardization group of 100 medical students to confirm their cross-cultural high response commonality. Electrographic recording was done concurrently with presentation of verbal and photic stimuli.

Statistical Treatment of the Data

The following hypotheses were examined by statistical analysis:

H_1: Schizophrenic (Paranoid) and Normal subjects are the same in their patterns of electrocortical arousal, both at rest and under conditions of a single word association task. This hypothesis will be tested by the following measures:

a. Baseline Mean Energy Content (MEC)
b. Pre-stimulus (PS) MEC (background)
c. Latency Period (LP) MEC
d. Post-response (PR) MEC
e. Interindividual variability of MEC/second
f. Electrocortical arousal
g. Electrocortical recovery

H_2: Schizophrenic (Paranoid) and Normal subjects are the same in their verbal responsivity under conditions of a word association task and this does not relate to patterns of electrocortical arousal. This hypothesis will be tested by the following measures:

a. Response Commonality (RC)
b. Response Quality (RQ)
c. Verbal Reaction Time (RT)
d. Cortical Arousal associated with Verbal Responsivity
e. Cortical Recovery associated with Verbal Responsivity

Each variable was correlated with all other variables with the use of a Missing Data Basic Statistics program processed by CDC computer to determine whether relationships existed between subject characteristics and dependent variables and among the dependent measures themselves.

Student's t test was used to examine differences between subjects and the correlated t test was used to examine differences between data collected from the same subject at different times. Regression equations were applied to data where changes over time were of interest. Incidence of high commonality responses for normals vs. schizophrenics was tested by Chi Square. The presence of unequal n's made analysis of variance by computer for more than one factor impracticable. In some cases product-moment was used where Pearson's point biserial correlation would have been more appropriate. However, the high relationship between these two r's and the availability of only MD BASTAT by product-moment r prompted the consistent use of product-moment r. Where questionably significant differences were found, examination by X^2 was done.

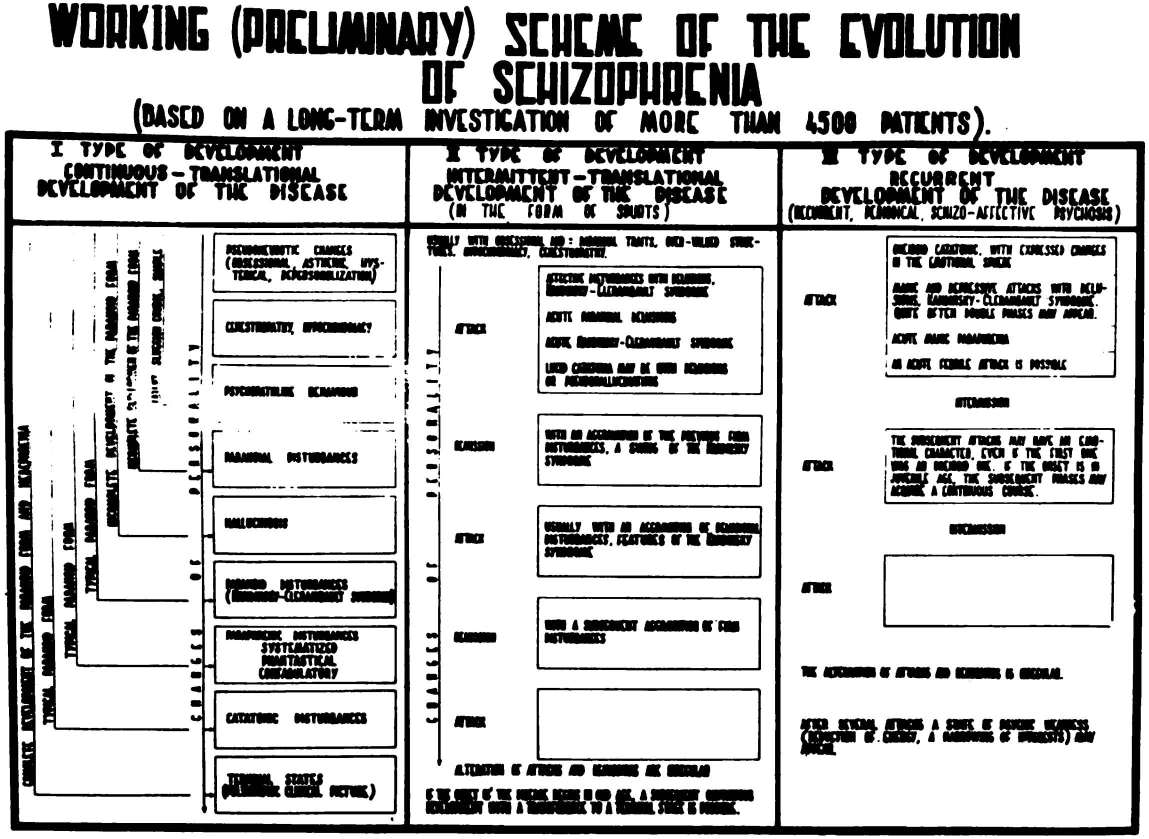
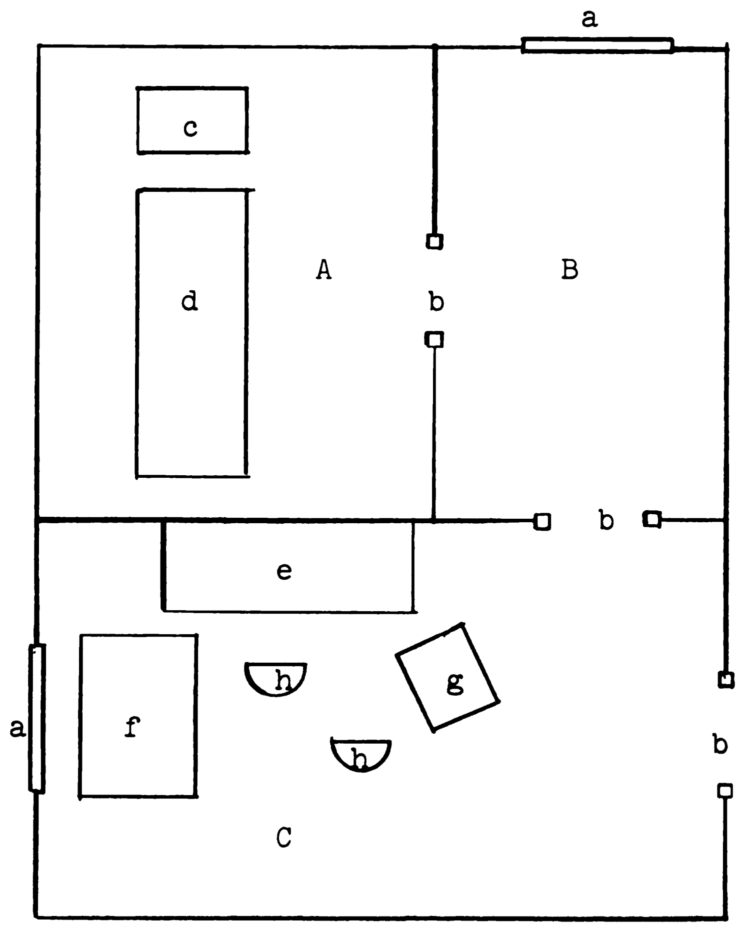


Figure 1. Soviet Working (Preliminary) Scheme of the Evolution of Schizophrenia (Based on a long-term investigation of more than 4,500 patients).



A = Experiment Chamber
B = Anteroom
C = Machinery Chamber
a = window
b = door
c = stroboscopic light
d = subject couch
e = electroencephalograph
f = integrator
g = stroboscopic light control
h = experimenter position

Legend: 1 inch = four feet

Figure 2. Diagram of the Electroencephalographic Experimental Chambers (Institute of Psychiatry, Moscow).

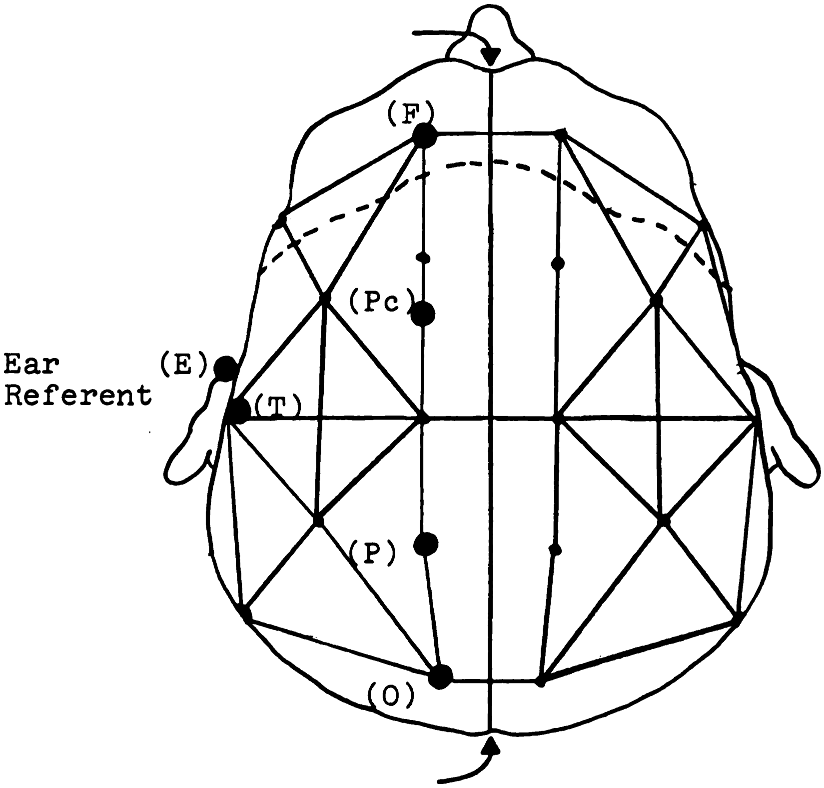


Figure 3. Diagrammatic Representation of Electrode Placements: Frontal (F); Pre-Central (Pc); Parietal (P); Temporal (T); Occipital (O); and Ear Referent (E).

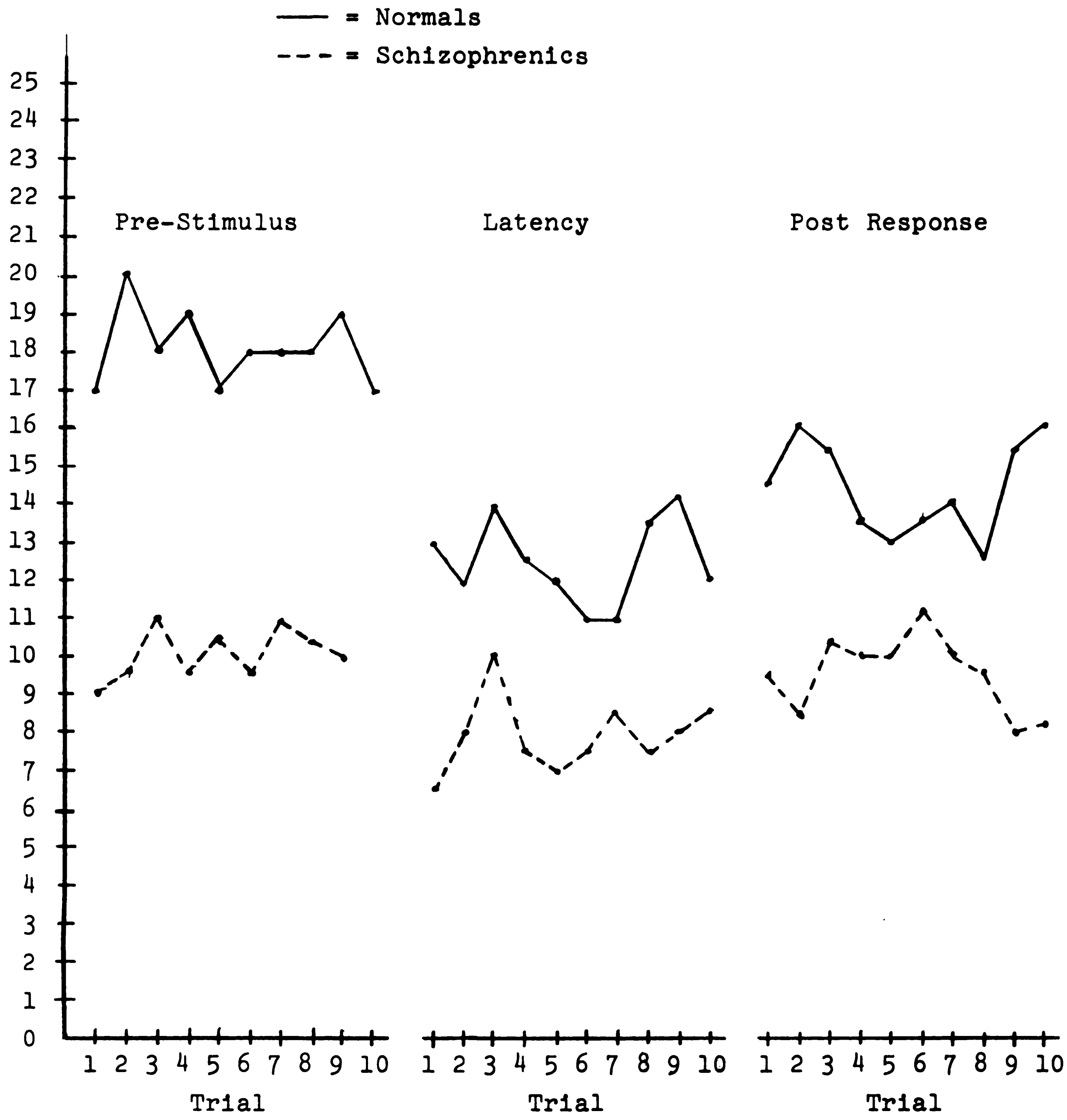


Figure 4. Mean MEC/Second Values for Normal and Schizophrenic Subjects for Each Trial and Each Time Period: Pre-Stimulus, Latency, and Post Response.

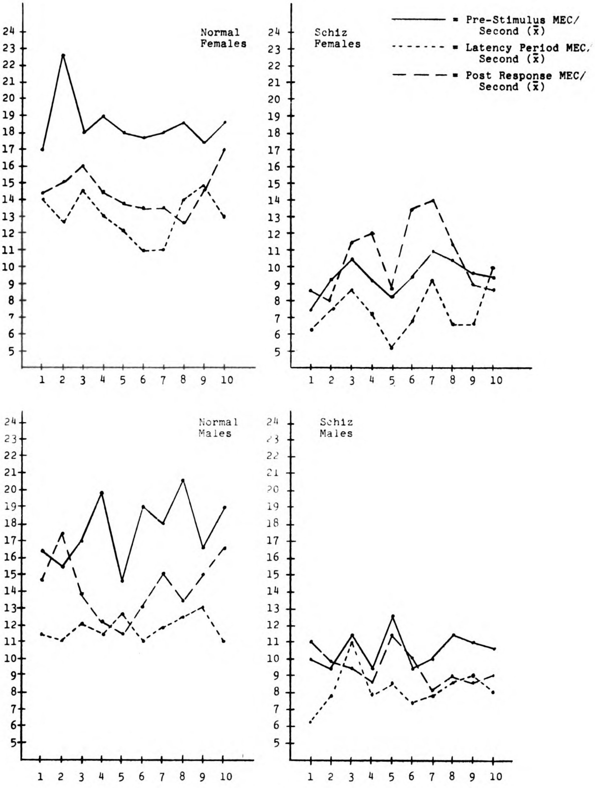


Figure 5. Mean MEC/Second Values for Subgroups Differentiated by Diagnosis Plus Sex for Each Trial and for Each Time Period: Pre-Stimulus, Latency, and Post Response.

TABLE 1.--Student's t and F Statistics Between Groups Differentiated by Diagnosis and Diagnosis Plus Sex: MEC/Second by Time Period[1]

Measures	Comparison[2]	Statistic		Significance	
		F[3]	t	F	t
Baseline	Normals vs Schizs	1.72	3.39	N.S.	.01
MEC/Second	Normals: Males vs Females	2.90	0.11	N.S.	N.S.
	Schizs: Males vs Females	3.52	1.27	.05	N.S.
Pre-Stimulus	Normals vs Schizs	2.98	3.83	.01	.01
MEC/Second	Normals: Males vs Females	2.52	0.29	N.S.	N.S.
	Schizs: Males vs Females	4.50	0.69	.01	N.S.
Latency Period	Normals vs Schizs	1.83	4.64	N.S.	.01
MEC/Second	Normals: Males vs Females	3.50	0.66	.05	N.S.
	Schizs: Males vs Females	6.76	0.73	.01	N.S.
Post-Response	Normals vs Schizs	1.22	4.11	N.S.	.01
MEC/Second	Normals: Males vs Females	2.10	0.18	N.S.	N.S.
	Schizs: Males vs Females	1.46	0.20	N.S.	N.S.

[1] All Comparisons use two-tailed tests

[2] Normals n=25; Schizs n=25; Normal Females n=17; Normal Males n=8; Schiz Females n=11; Schiz Males n=14.

[3] Where F is significant t is calculated with Welch's Test.

TABLE 2.--**Analysis of Variance for** Overall Regression and Multiple Correlation Coefficients for Independent Variables Sex, Diagnosis, Trial and Response Commonality Per Trial With Dependent Variable Latency Period Length (Reaction Time).

Analysis of Variance for Overall Regression

	Sum of Squares	df	Mean Square	F	Significance
Regression (about mean)	1900086.19	4	475021.55	11.72	$p<0.0005$
Error	20064010.09	495	40533.35		
Total (about mean)	21964096.28	499			

Multiple Correlation Coefficient, R = 0.29

Variable	Regression Coefficient	Standard Error of Coefficient	Partial Correlation Coefficient	Significance
Constant	382.15	53.57		
RC per Trial	- 25.37	7.50	-0.15	$p<.001$
Sex	- 24.58	18.72	-0.05	N.S.
Diagnosis	35.34	18.63	0.08	$p<.05$
Trial	- 19.72	3.28	-0.26	$p<.0005$

TABLE 3.--Product-Moment Correlations Between Latency Period Length (Reaction Time) and Variables Which Reach Significance at p<.05.

Subjects	Comparison Variable	Product-Moment r	Significance
Overall Normals (df=23)	No Significant Correlations		
Overall Schizs (df=23)	No Significant Correlations		
Overall Females (df=26)	Pre-Stimulus MEC/Second	0.45	.02
	Post-Response MEC/Second Associated with Hi RC	-0.39	.05
	Latency Period MEC/Second Associated With Lo RC	-0.41	.05
Overall Males (df=20)	Post-Response MEC/Second	-0.44	.05
	Mean Response Commonality	-0.53	.02
Normal Females (df=15)	Post-Response/Latency Period MEC/Second (Recovery	-0.48	.05
	Latency Period MEC/Second Associated with Lo RC	-0.52	.05
Normal Males (df=6)	No Significant Correlations		
Schiz Females (df=9)	No Significant Correlations		
Schiz Males (df=12)	No Significant Correlations		

TABLE 4.--Student's t and F Statistics Between Groups Differentiated by Diagnosis and Diagnosis Plus Sex: Latency Period Length (Reaction Time)

Measures	Comparison[2]	Statistic		Significance	
		F[3]	t	F	t
Latency Period Length Word Alone	Normals vs Schizs	5.45	4.69	.01	.01
	Normals: Males vs Females	1.39	1.44	N.S.	N.S.
	Schizs: Males vs Females	1.01	2.18	N.S.	.05
Latency Period Length Word + Light	Normals vs Schizs	4.66	4.48	.01	.01
	Normals: Males vs Females	1.25	0.12	N.S.	N.S.
	Schizs: Males vs Females	1.89	0.78	N.S.	N.S.
Latency Period Length Overall	Normals vs Schizs	6.05	4.92	.01	.01
	Normals: Males vs Females	1.49	0.58	N.S.	N.S.
	Schizs: Males vs Females	1.73	1.18	N.S.	N.S.

[1] All comparisons use two-tailed tests.

[2] Normals n=25; Schizs n=25; Normal Females n=17; Normal Males n=8; Schiz Females n=11; Schiz Males n=14.

[3] Where F is significant, t is calculated with Welch's Test.

TABLE 5.--Analysis of Variance for Overall Regression and Multiple Correlation Coefficients for Independent Variables Sex, Diagnosis, Time Period, and Trial With Dependent Variable Pre-Stimulus, Latency Period, and Post-Response MEC/Second for Each Trial.

Analysis of Variance for Overall Regression

	Sum of Squares	df	Mean Square	F	Significance
Regression (about mean)	1587496.63	4	396874.16	56.33	p<0.0005
Error	10195619.69	1447	7046.04		
Total (about mean)	11783116.32	1451			

Multiple Correlation Coefficients, R = 0.37

Variable	Regression Coefficient	Standard Error of Coefficient	Partial Correlation Coefficient	Significance
Constant	186.49	14.43		
Sex	1.89	4.56	0.01	N.S.
Diagnosis	- 59.30	4.53	-0.33	p<0.0005
Time Period	- 0.98	3.06	-0.01	N.S.
Trial	1.59	0.29	0.14	p<0.0005

TABLE 6.--**Analysis of Variance for Overall Regression and Multiple Correlation Coefficients for Independent Variables Sex, Diagnosis, and Time Period With Dependent Variable Average MEC/Second for All Ten Trials Averaged.**

Analysis of Variance for Overall Regression

	Sum of Squares	df	Mean Square	F	Significance
Regression (about mean)	124430.68	3	41476.89	8.83	p<0.0005
Error	685506.49	146	4695.25		
Total	809937.17	149			

Multiple Correlation Coefficients, R = 0.39

Variable	Regression Coefficient	Standard Error of Coefficient	Partial Correlation Coefficient	Significance
Constant	236.25	32.57		p<0.0005
Sex	- 2.48	11.62	-0.02	N.S.
Diagnosis	- 52.51	11.53	-0.35	p<0.0005
Time Period	- 26.35	11.87	-0.13	p<.03

TABLE 7.--Analysis of Variance for Overall Regression and Multiple Correlations Coefficients for Independent Variables Sex, Diagnosis, and Time Period With Dependent Variable Pre-Stimulus, Latency Period, and Post Response MEC/Second for Each Subject.

Analysis of Variance for Overall Regression

	Sum of Squares	df	Mean Square	F	Significance
Regression (about mean)	210.70	3	70.23	13.05	p<0.0005
Error	786.00	146	5.38		
Total (about mean)	996.71	149			

Multiple Correlation Coefficients, R = 0.46

Variable	Regression Coefficient	Standard Error of Coefficient	Partial Correlation Coefficient	Significance
Constant	6.35	1.10		p<0.0005
Sex	-0.09	0.39	-0.02	N.S.
Diagnosis	-2.23	0.39	-0.43	p<0.0005
Time Period	0.91	0.40	0.18	p<0.02

TABLE 8.--Product-Moment Correlations Between Pre-Stimulus/Latency Period MEC/Second (Arousal) and Variables Which Reach Significance at $p<.05$.

Subjects	Comparison Variable	Product-Moment r	Significance
Overall Normals (df=48)	No Significant Correlations		
Overall Schizs (df=23)	Post-Response MEC/Second Associated With Hi RC	0.63	.01
	Post-Response MEC/Second Associated With Lo RC	0.66	.01
Overall Females (df=26)	Socio-Economic Status	0.41	.05
	Post-Response/Latency Period MEC/Second (Recovery)	0.37	.05
Overall Males (df=20)	Socio-Economic Status	0.46	.05
	Response Quality	-0.43	.05
	Post-Response/Latency Period MEC/Second (Recovery)	-0.60	.01
Normal Females (df=15)	Age	0.59	.02
	Socio-Economic Status	0.72	.01
Normal Males (df=6)	No Significant Correlations		
Schiz Females (df=9)	Age	-0.66	.05
	Post-Response/Latency Period MEC/Second (Recovery)	0.66	.05
Schiz Males (df=12)	Post-Response/Latency Period MEC/Second (Recovery)	-0.75	.01

TABLE 9.--Correlated *t* and $\bar{D}$ Statistics Between Pre-Stimulus and Post-Response MEC/Second For Each Analysis Group Defined by Diagnosis Plus Sex.

Measure	Comparison	$\bar{D}$	*t*	Significance
Pre-Stimulus vs Post-Response MEC/Second	Normal Females (df=14)	32.00	5.11	.02
	Normal Males (df-32)	42.00	2.75	.01
	Schiz Females (df=20)	-62.00	4.10	.01
	Schiz Males (df=26)	27.00	3.70	.01

TABLE 10.—Product-Moment Correlations Between Response Quality and Response Commonality Which Reach Significance at p<.05.

Subjects	Product-Moment r	Significance
Overall Subjects (df=48)	0.73	.01
Overall Normals (df=23)	0.69	.01
Overall Schizs (df=23)	0.65	.01
Overall Females (df=26)	0.77	.01
Overall Males (df=20)	0.67	.01
Normal Females (df=15)	0.79	.01
Normal Males (df=6)	0.93	.01
Schiz Females (df=9)	0.83	.01
Schiz Males (df=12)	0.58	.05

TABLE 11.--Student's t and F Statistics Between Groups Differentiated by Diagnosis and Diagnosis Plus Sex: Response Commonality, Response Quality, and High Response Commonality Frequency[1]

Measure	Comparison[2]	Statistic F[3]	Statistic t	Significance F	Significance t
[4]Response Commonality	Normals vs Schizs	2.16	3.03	.05	.01
	Normals: Males vs Females	1.13	0.24	N.S.	N.S.
	Schizs: Males vs Females	1.12	0.56	N.S.	N.S.
[5]Response Quality	Normals vs Schizs	1.38	5.19	N.S.	.01
	Normals: Males vs Females	5.87	1.40	.05	N.S.
	Schizs: Males vs Females	1.44	1.31	N.S.	N.S.
High Response Commonality Frequency	Normals vs Schizs	0.72	-2.77	N.S.	.01

[1] All comparisons use two-tailed tests.

[2] Normals n=25; Schizs n=25; Normal Females n=17; Normal Males n=8; Schiz Females n=11; Schiz Males n=14.

[3] Where F is significant t is calculated with Welch's Test.

[4] Commonality scores are the per cent frequency of the response as given by a reference group of 100 medical students.

[5] Quality scores are the means of the ranks assigned by ten medical students asked to judge "goodness of fit" of each of the subjects' responses.

TABLE 12.--Analysis of Variance for Overall Regression and Multiple Correlation Coefficients for Independent Variables Sex, Diagnosis, and Time Period With Dependent Variable Pre-Stimulus, Latency, Period and Post-Response MEC/Second Associated With High Response Commonality.

Analysis of Variance for Overall Regression

	Sum of Squares	df	Mean Square	F	Significance
Regression (about mean)	2057.72	3	685.91	10.25	$p<0.0005$
Error	9766.91	146	66.90		
Total (about mean)		149			

Multiple Correlation Coefficients, R = 0.42

Variable	Regression Coefficient	Standard Error of Coefficient	Partial Correlation Coefficient	Significance
Constant	24.36	3.77		
Sex	- 0.29	1.39	-0.02	N.S.
Diagnosis	- 7.22	1.38	-0.40	$p<0.0005$
Time Period	- 1.17	0.82	-0.12	N.S.

TABLE 13.--Analysis of Variance for Overall Regression and Multiple Correlation Coefficients for Independent Variables Sex, Diagnosis, and Time Period With Dependent Variable Pre-Stimulus, Latency, Period and Post-Response MEC/Second Associated With Low Response Commonality.

Analysis of Variance for Overall Regression

	Sum of Squares	df	Mean Square	F	Significance
Regression (about mean)	1141.14	3	380.38	6.99	$p<0.0005$
Error	7934.08	146	54.34		
Total (about mean)	9075.22	149			

Multiple Correlation Coefficients, R = 0.35

Variable	Regression Coefficient	Standard Error of Coefficient	Partial Correlation Coefficient	Significance
Constant	21.36	3.39		
Sex	0.06	1.25	0.00	N.S.
Diagnosis	- 5.33	1.24	-0.33	$p<0.0005$
Time Period	- 0.84	0.73	-0.09	N.S.

TABLE 14.--One-Way Analysis of Variance for Response Commonality vs. Trial for Normal and Schizophrenic Diagnostic Groups.

		Normals			
Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Between trials	9.32	9	1.04	3.07	p<.01
Within trials	81.04	240	0.34		
Total	90.36	249			
		Schizophrenics			
Between Trials	1.64	9	0.18	0.79	N.S.
Within trials	55.12	240	0.23		
Total	56.76	249			

TABLE 15.--Product-Moment Correlations Between Response Commonality, Response Quality and Post-Response MEC/Second.

Subjects	Response Commonality Product-Moment r	Significant	Response Quality Product-Moment r	Significance
Overall Subjects (df=48)	.17	N.S.	.20	N.S.
Overall Normals (df=23)	-.07	N.S.	-.20	N.S.
Overall Schizs (df=23)	.10	N.S.	-.06	N.S.
Normal Females (df=15)	-.11	N.S.	-.18	N.S.
Normal Males (df=6)	.10	N.S.	.13	N.S.
Schiz Females (df=9)	.06	N.S.	-.26	N.S.
Schiz Males (df=12)	.13	N.S.	.45	N.S.

TABLE 16.--Student's *t* and F Statistics Between Groups Differentiated by Diagnosis, by Sex, and by Diagnosis Plus Sex: High and Low Response Commonality Associated With Post-Response/Latency Period MEC/Second (Recovery)[1].

Measures	Comparison[2]	Statistic F[3]	 *t*	Significance F	 *t*
High Response Commonality Associated With Post-Response/Latency Period MEC/Second (Recovery)	Normals vs Schizs	5.60	-1.56	.01	N.S.
	Normals: Males vs Females	1.65	1.87	N.S.	N.S.
	Schizs: Males vs Females	8.63	0.85	.01	N.S.
	Males vs Females	3.89	0.21	.01	N.S.
Low Response Commonality Associated With Post-Response/Latency Period MEC/Second (Recovery)	Normals vs Schizs	3.62	-0.14	.01	N.S.
	Normals: Males vs Females	1.61	-1.29	N.S.	N.S.
	Schizs: Males vs Females	5.27	0.99	.01	N.S.
	Males vs Females	3.34	-1.41	.01	N.S.
[4]High vs Low Response Commonality Associated With Post-Response/Latency Period MEC/Second	Normal Females	NA	-2.49	NA	.05
	Normal Males	NA	1.12	NA	N.S.
	Schiz Females	NA	0.96	NA	N.S.
	Schiz Males	NA	0.75	NA	N.S.

[1] All comparisons use two-tailed tests.

[2] Normals n=25; Schizs n=25; Normal Females n=17; Normal Males n=8; Schiz Females n=11; Schiz Males n=14.

[3] Where F is significant *t* is calculated with Welch's Test.

[4] Correlated *t*.

CHAPTER III

RESULTS

All raw data, both physiological and psychological, was coded numerically and analyzed by Missing Data Basic Statistics (MD BASTAT) in a CDC computer. Appendix E presents the names and descriptions of these variables and notes those where transformations were incorporated in the data analysis. The data was examined for all subjects summed, for subjects grouped by diagnosis, by sex, and by sex plus diagnosis. The sum, mean, sum of squares, standard deviation, sum of squared deviation from the mean, skewness, and kurtosis were calculated for each variable and simple correlations with all other variables were obtained for each of the analysis groups.

Subject Characteristics

The first step in data analysis was to examine variables where subjects were not matched for correlations with dependent measures (Appendix F). Although the schizophrenics were older and had predictably lower socioeconomic status than the normals, these measures on the overall did not correlate meaningfully with the dependent measures. However age correlates differently with electrocortical arousal for females depending upon diagnosis: the older the normal female, the higher the arousal level; the older the schizophrenic female, the lower the arousal. Within schizophrenics presence of marital history did not relate significantly to other measures except to predict a longer latency period length for the males. There are more female schizophrenics who are more chronic than the males but this difference does not reach significance ($X^2 = .083$, 1 df).

Electroencephalographic Findings

Figure 4 contains mean MEC/second values for all normal and all schizophrenic subjects, respectively, for each trial and each time period separately. Figure 5 depicts subgroup mean MEC/second values for each trial successively and each time period comparatively. (As there are no differences between the sexes within each diagnostic category, like-sexed but different diagnostic groups have been assembled contiguously for purposes of visual comparison.)

Table 1 presents the data of Figure 4 and 5 in statistical terms showing schizophrenics to be more highly aroused at all times during the study. Baseline MEC/second (Mean MEC/second preceding the onset of the *first* stimulus only), PS, LP, and PR MEC/second all discriminate between normal and schizophrenic subjects with the latter showing significantly less MEC/second on each measure.

As trials progress, RT decreases (Table 2), and response commonality decreases through trials for normals but not for schizophrenics (Table 2). The shorter the RT, the higher the initial state of arousal for overall females (Table 3). In all t comparisons schizophrenics show longer latency periods and F statistics, when significant, show schizophrenics to be far more variable as a group in their latency period length than are normal subjects (Table 4).

Normals show greater variability from trial to trial summed over time period in the incidence of MEC/second than do schizophrenics (Table 5); and when all trials are averaged, normals show greater incidence and greater variability of MEC/second than do schizophrenics (Table 6).

There is an absence of any significant t findings between groups differentiated by diagnosis and diagnosis plus sex for the dependent variable ratios PS MEC/second to LP MEC/second (arousal) and PR MEC/second to LP MEC/second (recovery). This suggests that the analysis groups show similar arousal and recovery when proportional data are considered, i.e., taking into consideration the subgroup baselines. Thus, with respect to their beginning incidence of MEC/second, all subjects show a similar post-stimulus decrease and a PR increase of MEC/second. Schizophrenic females, however, show a significantly greater incidence of PR MEC/second, being the only group to show not only full recovery to average PS alpha levels, but to show overrecovery (Table 9). The other three groups fail to recover PS levels on the average through all trials.

The higher the arousal, the lower the response quality and MEC/second recovery. Age predicts arousal differently for females depending upon their diagnosis: a positive correlation coefficient of 0.59 for normal females and a negative value of -0.66 for schizophrenic females. As in the overall sex findings, schizophrenic males show a negative relationship between recovery and arousal and schizophrenic females a positive one.

Other Electroencephalographic Findings

Greater variance is noted among schizophrenic males when compared to their female counterparts on Baseline, PS and LP MEC/second. Normal subjects show greater variance than schizophrenics on PS MEC/second data and normal females reflect a higher variance of MEC/second behavior during the latency period from normal males (Table 1). Significant variation is noted for variables of RC per trial, diagnosis, and trial alone when related to RT (Table 2).

The one significant sex plus diagnosis difference in variation reveals schizophrenic males have more variable latency periods than do schizophrenic females.

A finding of lesser strength is noted for time period ($p < .03$) in that least MEC/second is noted during the latency period. The dependent variable of PS + LP + PR MEC/second for each subject is found to be related to diagnosis in Table 7. Here where trial is excluded as a variable, normals again show higher incidence of MEC/second ($p<.03$) as well as higher variability in MEC/second incidence (Table 6).

Reduced PR MEC/second is associated with High RC, and low LP MEC/second is found with low RC in overall females, although the latter reflects normal female data primarily. For males faster reaction time means higher Response Commonality and a greater incidence of PR MEC/second, regardless of its commonality. Normal females also show greater recovery the shorter the reaction time. There were no significant relationships as a function of diagnosis alone and examination of data for subgroups normal males, schizophrenic females, and schizophrenic males revealed no significant findings.

Analysis of variance of trial against MEC/second within each time period for all subjects, normal subjects, and schizophrenics, respectively, was done and found not significant. The absence of significant F statistics points out that the incidence of MEC within each time period (PS, LP, PR) does not vary significantly as a function of trial within each of these analysis groups.

Significant product-moment correlation coefficients between arousal and other measures are presented in Table 8. Although no findings are noted for overall normals, overall schizophrenics show a positive relationship between arousal and PR MEC/second for both High and

Low RC. Overall females are more aroused the lower their SES and high arousal predicts strong recovery. Overall males, too, show a similar relationship between SES and arousal but show an inverse relationship between recovery and arousal and response quality and arousal.

Verbal Association Findings

The original experimental design included light as a stimulus preceding presentation of the stimulus word on one-half the trials for each subject. As an attempt to discover whether a reduced level of background MEC/second by presence of photic stimulation on some trials affected Response Commonality, the data was examined by product-moment correlation for relationship with mean trial Response Commonality for each of the four diagnostic subgroups. Although there is no relationship between PS photic stimulation and Response Commonality, the middle and the end of the trial series seem to be associated with an inverse relationship between light and level of MEC/second, for normals. Light predicted decreased alpha levels at these points for these subjects.

Subject groups were tested for correlation between measures of Response Quality and Response Commonality (Table 10), and apparently there is a consistent and high relationship between commonality and quality of subject responses with some decreased relationship noted for schizophrenic males.

In Tables 12 and 13 diagnosis is the source of significant variance for both F statistics in that normals show more MEC/second associated with both High and Low Response Commonality than do schizophrenics and this stands independently from variables of sex and time period.

Table 14 shows that while normal subjects show a decrease in Response Commonality over trials, there is no relationship between trial and Response Commonality for the schizophrenics.

There are no significant relationships between level of PR MEC/second and Response Commonality or Response Quality for any of the subject groups listed in Table 15 although one trend ($p<.10$) exists between Response Quality and PR MEC/second for schizophrenic males. Table 16 takes into account the specific LP baselines for change in level of MEC/second PR (recovery). Here student's t and F statistics show that there are no relationships between proportional size of recovery and commonality of the response word to the stimulus word. Greater variation is found within schizophrenics than normals, females than males, and schizophrenic females than male schizophrenics. However, the absence of any differences in variation between normal males and females and the large variance of the schizophrenic females suggest that the significant F comparisons are a result of the schizophrenic females' variance. Within group comparisons reveal that normal females alone show greater recovery associated with Low

RC responses; thus the further the response word from the stimulus word (as judged statistically) the greater the reinforcement value of that word in terms of reduction of cortical arousal.

CHAPTER IV

DISCUSSION

Subject Characteristics

Age: Of seventeen possible product-moment correlations with other measures, for normal females there are three; of nineteen possible findings for schizophrenic females, two are noted. If chance were operating alone, there would be an average expectation of somewhat less than one finding for each group of analyses. These few findings suggest that age is not an important factor affecting other measures.

Socio-Economic Status (SES): Out of a possible 136 findings, only eight are noted: chance alone would predict six of these. As with age, the significant correlations involving SES are limited in number and possibly affected by chance. If chance is presumed not a factor, normal females show greater physiological arousal the lower their SES and verbal reaction time decreases with increase in SES for males.

Marital History: Marital history was assessed among the schizophrenic subjects as this has been a reliable objective measure predicting prognosis among hospitalized schizophrenics (Meehl, 1954). The only significant correlations of note are found between latency period length (RT) for schizophrenic males and with LP MEC/second associated with High RC for schizophrenic females. Presence of marital history (including divorced status) is associated with longer reaction time in the males and more MEC/second during the latency preceding a High RC response for females (Table 3).

Severity: There are more females more severely ill than males in the study sample although this does not reach significance, and severity also predicts low SES. Schizophrenic males show greater electrocortical recovery the more severely ill they are. There is a trend relating arousal to severity for schizophrenic males ($r=.34$; $p<.15$).

Despite statistically significant differences in SES for all three comparison groups ($p<.01$) the range of difference varied between schizophrenics and normals. Most of the normal males, who are scarce within the primarily female-run facility, were physicians having completed their training. Although many of the normal females tended to be in medically-related positions, there were fewer who had completed their educational requirements and two who were of relatively limited education. Most of the male schizophrenics had worked and several had been working immediately prior to hospitalization but most of the schizophrenic females were either invalid occupationally or functioning in the most menial of work capacities. Thus the sex differences in SES within each diagnostic subgroup reflect somewhat different origins.

Subject characteristics exclusive of the selective criteria of sex and diagnosis do not appear to contribute importantly to the dependent variable data. Patient selection by order of fresh admission, however, involved a shortage of female schizophrenics with paranoid symptomatology as compared to males. When sufficient numbers had not occurred spontaneously in the referral population as the data collection period drew to a close, it was necessary to recruit five female schizophrenic subjects, sustained from medication for a period of one week, from those already hospitalized in another sector of the Kaschenko Hospital complex. The spontaneous character of the patient referral pattern suggested a differential incidence of patient referrals related to sex: fewer but more severely disturbed females appeared as compared to males. If this sample is indicative, Soviet females may be more severely disturbed before they come to the attention of psychiatric care. Thus if a difference in incidence of schizophrenia among males and females exists, it does not become reflected in the statistical data _per se_. (Malzberg, in Arieti, 1959). On the other hand, one might expect that females would, by their tendency to occupy occupations of lesser demand and stress than males, be absorbed in the community more readily than males. Then for a male and female schizophrenic showing the same degree of dysfunction, the male would be more likely to be identified and subsequently hospitalized than would the female. From this hypothesis, Malzberg's first admission data giving the picture of equal admission for both sexes would suggest that the females admitted are more "sick" than the males; this in turn would predict an actual greater proportion of females showing schizophrenic disturbance than males in the overall population.

Mednick reports a complementary finding for differences in the incidence of schizophrenia as a function of sex (1967). As compared to males in the still healthy "high-risk" group, early adolescent females were positively related to their disturbed mothers, failed to see their mother's symptoms as strange or abnormal, and gave many more negative self descriptions on the Adjective Check List. Teachers described the "high-risk" girls as being especially passive, as more nervous and prone to withdrawal as their response to upset. Thus the presently healthy but "high-risk" females showed more signs of morbid prognostication than did the males, probably as a function of their greater susceptibility through identification with the pathology of the schizophrenic mothers.

Electroencephalographic Findings

Figures 5 and 6 present graphically the raw data of Table 1 including mean MEC/second values for each trial and time period for subgroups differentiated by diagnosis (Figure 5) and diagnosis plus sex (Figure 6). In all time periods, normals have higher MEC/second than do schizophrenic subjects and this includes a baseline measure of pre-task MEC/second. Arousal, which is a desynchronization of alpha waves and an increase in high frequency, low voltage wave activity is here measured by a decrease in MEC/second and is greater among schizophrenic subjects in all phases of the experimental period. Greater PS variability is found among normals when compared to schizophrenics ($p<.01$) and among male schizophrenics when compared to their female counterparts on Baseline ($p<.05$), PS ($p<.01$) and LP ($p<.01$) measures. Normal females show greater variability than normal males during latency period alone ($p<.05$). This reduced variability of the schizophrenic subjects adds to the growing body of data which describes schizophrenia as a condition involving reduced physiological variation (Rubin and Wall, 1938b; Lindsley, 1944; Goldstein, <u>et al</u>., 1965). The significantly lower variation among schizophrenic females as compared to males suggests the former are even more "schizophrenic" in this respect.

<u>Reaction Time (RT)</u>: Assessment of reaction time as a function of sex, diagnosis, trial and RC (per trial) suggests that trial affects RT (Table 2). The size of the partial correlation coefficient ($r=0.26$; $p<.0005$) is much greater than other significant relationships between RT and diagnosis ($r=0.08$; $p<.05$) and per trial ($r=0.15$; $p<.001$). Trial better than diagnosis or RC per trial

accounts for most of the variability here. As trials progress RT decreases and so does RC as a function of RT. This varies with diagnosis in that normals show a decrease through trials whereas schizophrenics remain approximately the same in their RC scores. Schizophrenics show no decrease in their comparatively longer RT nor increase in their low mean RC through time; thus habituation fails to occur for schizophrenics on both psychological measures of reaction time and response commonality.

There are no simple relationships between RT and other variables as a function of diagnosis alone (Table 3). There are different patterns of relationship between the sexes for reaction time. The greater relaxation pre-stimulus, the longer the RT for females. RT is shorter when followed by strong recovery associated with High RC for this group and normal females contribute most to the finding that females show shorter RT when this period is characterized by relatively high MEC/second and is followed by a response of low commonality. Males show a generally high level of PR MEC/second exclusive of quality of response when the RT is short in duration. And the shorter the RT, the higher the commonality of the succeeding response. This relationship does not appear for females. The other significant finding is an inverse relationship between RT and recovery for normal females.

When RT is compared between groups defined by diagnosis and diagnosis plus sex (Table 4), schizophrenics show longer and more variable RT compared to normals. On trials involving word stimuli without a preceding photic stimulus, schizophrenic males give significantly longer RT than their female counterparts.

In agreement with the general concensus of schizophrenic behavioral deficit (Rosenthal et al., 1960; Shakow, 1962; Lang and Buss, 1965) the schizophrenic subjects of this work also show greater delays in response, the males somewhat greater than the females, where word stimulation is used exclusively. There tends to be a general relationship between strong recovery and short RT although this is more clearly defined for the males than the females in the study. Females also show more variability in the relationship between RT and RC. These variables reveal a high inverse correlation for males ($r=-0.53$).

Arousal: Normal subjects show greater variability in MEC/second from trial to trial and among the three time periods than do schizophrenics (Tables 5, 6, and 7) a finding analagous to Goldstein et al.'s work (1963a; 1963b; 1965) using the measure "coefficient of variation" as measured from Drohocki integrator data. When all trials are averaged, thus reducing the bias possibly contributed by subject intertrial correlations, the significance of trial alone ($p<.005$) is reduced but not substantially ($p<.03$). There are no significant correlation coefficients relating arousal and other measures for overall normal subjects. But overall schizophrenics show equally significant relationships for High and Low RC as associated with high PR MEC/second. Arousal does not relate to <u>kind</u> of response for schizophrenics but predicts recovery in opposite ways for female vs. male schizophrenic subjects: the greater the arousal, the greater the recovery for female schizophrenics, the less the recovery for male schizophrenics.

The overall sex findings between arousal and recovery seem determined primarily by the schizophrenic subjects' data alone. Age relates inversely to arousal for females dependent upon diagnosis; the older the normal female, the higher arousal ($r=0.59$; $p<.02$) but for the schizophrenic female age predicts <u>less</u> arousal ($r=-0.66$; $p<.05$). Organic factors contingent upon increasing age do not seem then a source of artifactual contamination to the dependent variables under investigation. The correlation between SES and arousal for overall females reflects the high positive correlation found for normal females ($r=0.72$; $p<.01$); arousal is greater as SES decreases in status. The higher the arousal, the lower the quality (and commonality) of response for the male subjects. There are no relationships between kind of response and arousal for females.

The incidence of MEC/second within each trial period does not vary significantly over the total test time period of ten trials when examined by a one-way AOV of trial against MEC/second within each trial period for either normal or schizophrenic subjects. Where diagnosis is included with trial and time period, the presence of a trial effect of variability as a function of time is found (Tables 5, 6, and 7).

The absence of any differences between diagnostic groups in proportional reactivity is probably a reflection of the "law of initial values" (Wilder, 1958). The lower the initial Baseline MEC/second, the less absolute change in electrographic activity upon presentation of a stimulus. This is apparently the case with the present study: schizophrenics show a significantly lower baseline MEC/second than do normals and change less in their absolute levels of MEC/second but show an equal change proportionally when compared to normals.

Using the raw data of MEC/second comparing PS to PR levels, Table 9 presents significant differences within each subgroup. With the exception of schizophrenic females, all subjects show a higher level of PS as opposed to PR MEC/second; these groups then reflect incomplete recovery to PS levels of MEC/second. A residual arousal is retained within the time period (determined by RT immediately following the subject's verbal response. Schizophrenic females show over-recovery in that immediate PR MEC/second level is higher than the PS value and this difference is greater in magnitude than the value for the other three groups, who show the opposite finding. Not only are schizophrenic females recovered to the initial level, they are over-recovered by an amount greater than the under-recovery difference from PS values in the remaining three subdiagnostic groups. This phenomenon only begins to decrease in trend in the latter three trials of the ten trial sessions (Figure 2) where there appears to be a convergence of all three time period values for the schizophrenic females. The lack of further trials precludes knowing if this is a random observance or indication of a trend toward hypoarousal perhaps as a homeostatic response to an initially hyperaroused state.

Psychological Findings

As an alternate way of measuring verbal responses, RQ, or "goodness of fit", was measured by submitting all non-common responses to a group of ten judges for rating on a scale of one to seven. Table 10 confirms the assumption that RC correlates significantly and positively with RQ. Although all groups showed significant relationships between these two measures, the schizophrenic males showed a much lower relationship than the other groups ($r=0.58$; $p<.05$). It is also of interest to note the closeness of the two females subgroups' correlation coefficients with the schizophrenic females showing the slightly higher figure ($r=0.83$, $p<.01$) and the extreme positions of the two male subgroups (normal males, $r=0.93$; $p<.01$; schizophrenic males, $r=0.58$, $p<.05$).

Even when severely ill, when schizophrenic females give a high quality response there tends to be little deterioration in the commonality of their verbal productions even though they may show greater individuality, or less commonality, on the average in these expressions. The schizophrenic males by contrast show a much lower degree of relationship in that adequacy of response more often fails to predict conformity of response.

On all three measures of response characteristics-mean RC, RQ and frequency of common responses, schizophrenics give fewer adequate responses than do normals (Table 11). No differences dependent upon sex are found except for the greater variation of RQ among normal males and greater variability of RC among normals as compared to schizophrenics. These findings agree well with the literature which generally supports the notion that verbal productions of schizophrenics are less conforming (Kent and Rosanoff, 1910; Sommer <u>et al</u>., 1960; Wynne, 1963).

One corollary of Mednick's theory is that avoidant thinking is precipitated by anxiety and the avoidant thought allows the individual "psychological removal" from the source of anxiety. If this is so, then avoidant associations should be found in connection with greater reduction in physiological arousal than non-avoidant responses. However, there is an overall correlation of $r=0.75$ ($p<.01$) between post-response MEC/second for High

RC responses and for Low RC responses indicating that it is the fact of the response rather than its commonality which is associated with physiological recovery. However, schizophrenics show less MEC/second associated with both kinds of response than do normals (Tables 12 and 13). Commonality of a response does not appear to distinguish arousal reduction behavior for either diagnostic group.

Time apparently affects RC level. Normals show a decrease in RC as trials progress through time while schizophrenics do not change from their initial level of Low RC (Table 14). Whereas normal subjects apparently were able to relax more as time progressed as suggested by their change in RC towards greater individuality, schizophrenics retained their same baseline of relatively low RC. They also failed to show electrocortical habituation as evidenced by Table 14.

The absolute level of MEC/second incidence PR also fails to reveal any relationship with RC (Table 15). This further supports the conclusion that the kind of verbal response functions independently of the state of physiological arousal in all subdiagnostic groups. Using a measure of baseline MEC/second in assessing PR MEC/second change (recovery) the data in Table 16 is generally congruent with the preceding measures of association between verbal response and physiological arousal in that, with the exception of normal females, there is no demonstrable relationship or difference in these data to support the suggestion that non-common responses serve as anxiety reducers. Normal females show one significant finding which, if not a function of chance (twenty comparisons would predict the possibility of one significant finding; one of twelve comparisons here reaches significance) would suggest that normal females alone evidence reduction in level of cortical arousal in association with relatively original verbal responses. Recovery then is greater for normal females when they produce a low as opposed to a high commonality response.

Comparisons with the Literature

The general finding of flatter, lower amplitude EEG records from the schizophrenic subjects concurs with a growing trend in the literature (Yeager and Baldes, 1937; Davis, 1940; Lindsley, 1944; Stevens and Derbyshire, 1958). Comparatively less interindividual variability of EEG records among these schizophrenic subjects agrees with Rubin and Wall's (1938b) and Lindsley's (1944) observations of considerably less variability among schizophrenics than among normals. More recent work using mechanical rather than manual EEG assessment techniques (Sugarman, _et al_., 1964; Goldstein, _et al_., 1965) continues to conclude that schizophrenics are more homogeneous in their EEG variation than are normals. The schizophrenics failure to habituate and the relationship between severity and over-recovery agree well with the observations on adult schizophrenics by Williams (1953), Ax _et al_.

(1962), and Mednick's observations in high risk preschizophrenic children (1967). Visser (1961) noted that number of conditioned responses was found to be low among patients with symptomatic psychosis and number of conditioned responses correlates positively with the speed of extinction ($p<.001$). Thus the better the original learning, the more quickly extinction occurs. He also noted a decreased baseline per cent time alpha in the psychotic subjects tested and found that this predicted less complete learning and a greater period of extinction. To the extent that the single presentation of the stimuli in the present study provided an opportunity for some learning to take place. Visser's comments are in agreement with the findings of the present study. The schizophrenic EEG is then more constricted, flat, and consistent in its quality than that for the normal control. This indicates that the schizophrenics are hyperaroused rather than the opposite and the slower and more variable RT noted in the schizophrenics is not inconsistent with this view. Deterioration of performance might be anticipated under conditions of a hyperaroused physiological state precluding adequate ability to focus even upon the most simple of assignments such as reaction time tasks. Gellhorn (1953) notes that electrographic arousal, often fails to predict behavioral arousal, that is, reduced reaction time. Altschule (1953) concurs and notes that the disturbance that appears in all studies of deficit involves the initiation of responses to the selected stimuli and the inhibition of inappropriate responses.

Shakow (1962) postulates that adequate adaptation to environmental demands requires two kinds of response: (1) high arousal with a focus on the relevant aspects of the stimulus situation associated with minimal focus for irrelevancies; and (2) reduced arousal impact of the focal stimulus with repetition of exposure, that is, habituation, both of which the schizophrenic finds difficult. Whereas schizophrenics may not differ from normals with regard to evidence of general physiological arousal (Fedio, 1961), capacity for focalized arousal seems reduced. Perhaps this failure to develop a focus of attention relates to the correlative findings of his difficulty in adapting to the stimulus through time (Ax, 1967; Mednick, 1966). The findings of this study then contradict the hypoarousal theory of schizophrenia and support a description of schizophrenics as electrocortically hyperaroused.

Analysis of the quality and commonality of associations made by the schizophrenic subjects in response to a single word association task reveal significant differences according to diagnosis only; there is no apparent relationship between degree of change in electrocortical arousal and kind of response. Thus the corollary of Mednick's theory, that low commonality responses would precipitate a reduction in arousal level in persons dominated by avoidant thinking, was not supported by these data. Rather the arousal level of the schizophrenics remained relatively stable through trials as did their typically low RC.

As expected, schizophrenics produced fewer common responses and had a mean commonality score less than that for normals; the schizophrenics quality of response was also found to be inferior as rated by ten judges. This agrees well with the original Kent-Rosanoff work (1910) and that of Sommer et al. (1960) where a lower incidence of commonality was found to typify schizophrenic by contrast to normal subjects.

Interference theory offers a somewhat better fit to these data than anxiety theory. Buss and Lang (1965) in their review of "psychological deficit" in schizophrenia, feel that the concepts of arousal and interference best fit the research findings to date. But rather than specify a particular drive state, such as anxiety, these authors suggest that a generalized drive state, which can be measured as physiological arousal, predicts schizophrenia. Schizophrenic deficit is understood as the result of disruptive effects of an excessively high arousal state.

Interference theory, used to account for associational behavior in schizophrenics, contends that the idiosyncracy and inappropriateness of schizophrenic associations attest to the difficulty these persons have in maintaining focus for relevant as opposed to irrelevant stimuli, retaining and shifting a set when needed, and in general, efficiency of performance. As a more broad explanation including perceptual, motor and cognitive variables, interference theory provides a means of integrating the wide range of findings often qualitatively differing but typically concurring in the schizophrenic's generally reduced capacity for adaptation as to the stimulus situation. The schizophrenic's reduced commonality of verbal responses to a single word association task nonspecific to any variables except diagnosis, may then be understood as a function of the overall high state of arousal the schizophrenics displayed during the test session.

These findings best support a learning theory of schizophrenia espoused by Broen and Storm (1966). They suggest that the extent to which hierarchical disorganization will take place is a function of (a) the strength of dominant and competing responses, (b) the level of arousal, and (c) the level of response strength ceiling. With reference to the present study, the level of electrocortical arousal in the schizophrenic sample was, by comparison to the normal controls, unusually high in some cases approaching an almost flat integrator record. This group also gave fewer common verbal responses, thus suggesting a breakdown of the normal associational process. As the theory posits three sources of contributions to hierarchical disorganization of responsivity, the occasional schizophrenic subject who did not show evidence of unusual arousal level can be understood in terms of either the strength of dominant vs. competing responses or in terms of a low response strength ceiling. As the Kent and Rosanoff words consist of words learned fairly early in life and thus are likely to have strong habit strength in association with a limited number of common responses, a lowered response strength ceiling offers the more likely explanation for the presence of irrelevant responses in the absence of an unusual arousal level.

Examination of the kinds of "errors" (scored as low response commonality), made by the schizophrenic subjects reveals further support for the theory of Broen and Storm (Appendix A). Rather than irrelevant errors showing little if any conceptual relation to the stimulus word, by far the majority of non-common responses show conceptual association to the stimulus.

The qualitative correlates of the observed high arousal level in the schizophrenic subjects are less easily discerned. Short and Walter (1954) observed that subjects who had high visual imagery tended to have low alpha incidence, or high cortical arousal. Employing a task demanding the subjects recognize several concrete blocks with grooved patterns by feeling the grooves and drawing their outlines simultaneously, they noted that correct answers occured significantly more often than incorrect ones in subjects who had been previously categorized as low alpha types (0-25%). Thus the finding of low alpha may indicate a higher fantasy preoccupation than when compared to individuals who show a high incidence of alpha.

Reyher and Marishige (1969) found alpha desynchronization associated with waking dream recall. Compared to waking visual imagery, this waking dream recall imagery contained more judged primary process, more kinetic imagery, more frequent and longer sequences of images, and was associated with a higher heart rate. This complements Kamiya's work (1968) where low alpha activity was noted in conjunction with visual imagery in normal subjects and in subjects under the influence of LSD. These studies involve normal subjects only.

Eysenck's Introversion-Extroversion Scale was found to relate to sedation threshold, (Shagass and Kerenyi, 1958a) in that the more introverted the normal subject, the higher the threshold. By contrast psychotics revealed an inverse relation between sedation threshold and degree of impairment of ego functioning in the gross sense of contact with reality. The lower thresholds among the psychotics were among the organic psychotic cases; the higher in the "borderline" group. Expressed anger was noted to produce marked changes in the sedation threshold by increasing the threshold. Although the authors suggest two different kinds of relationships for the subjects according to psychotic versus non-psychotic status, what apparently holds true for all of the subjects is a relationship between the degree of physiological arousal and sedation threshold. Even in the absence of manifest anxiety, the unusually high threshold for psychotics can be understood in relation to the data for non-psychotics by suggesting that it is their state of high physiological arousal that, as with disturbed psychoneurotic patients, predicts a higher sedation threshold.

The finding that anger correlates with sedation threshold is in accordance with Ax's (1967) work showing schizophrenics have a nor-epinephrine physiological pattern. Ax (1967) in a multivariate approach to the study of autonomic nervous system indicators in schizophrenia, concludes that schizophrenics show an unusually consistent nor-epinephrine-like profile when compared to normals and nonpsychotic patients. Neurotics, on the other hand, show a characteristically epinephrine-like pattern of ANS response. Thus, schizophrenic patients reflect an autonomic-endocrine picture consistent with the emotional feeling tones of anger; neurotic subjects appear to be experiencing intense anxiety and fear reactions internally.

These scattered findings converge to suggest that the phenomenology of the low alpha individual is likely to be accompanied by a higher incidence of fantasy experience involving visual imagery. To the extent that alpha desynchronization occurs as compared to a baseline value, this predicts the experience of primary process material, and in schizophrenics, it is suggested by Ax (1967) that the affective quality of this fantasy preoccupation is likely to be anger-ridden rather than characterized by anxiety.

CHAPTER V

SUMMARY OF FINDINGS

The first hypothesis of this study, that the EEG's of paranoid schizophrenic subjects do not differ from those of normal controls, is not supported by the data. EEG records of the schizophrenic subjects as measured by mean Baseline MEC/second, PS MEC/second, LP MEC/second, and PR MEC/second show significantly less large wave behavior than their normal comparisons for each time period. Greater variability of MEC/second within each time period and by trial is associated with normality, and the male schizophrenic subjects who are also less severely ill, show greater variability than their female counterparts.

Schizophrenics show a longer mean RT and, while normals give an increasingly shorter RT as trials progress, schizophrenic RT remains relatively stable through time. The same is noted for RC scores in that they remain stable among schizophrenics but become somewhat more original in normals as a function of time. Schizophrenic males have longest RT's, especially in the absence of preparatory photic stimulation, and short RT predicts strong recovery for the males.

Arousal does not relate to kind of verbal response for either normals or schizophrenics. It does relate in opposite ways to recovery for schizophrenic subjects according to sex: high arousal predicts low recovery for males, strong recovery for females. Age relates orthogonally to arousal for females depending upon diagnosis; normal females show more arousal the older they get while older schizophrenic females show somewhat less arousal compared to younger subjects. Schizophrenic females alone showed over-recovery as compared to strength of arousal contrasting with all other subjects' incomplete recovery as measured in the immediate PR period.

The second hypothesis receives only partial support in these findings. Although there are no significant relationships noted between RC and diagnosis, RQ which correlates strongly with RC shows a trend relationship with arousal in that higher arousal predicts lower RQ for the male subjects alone. There are no relationships between kind of response and arousal for females or for diagnostic groups. As anticipated, schizophrenics give fewer adequate responses when compared to normals in measures of commonality, and quality, verbal productions. These differences of relationship between RC and other variables give only partial support to the null hypothesis of no association between commonality of response and other measures, and there were no general relationships noted between PR mean MEC/second or recovery dependent upon diagnosis or sex.

"Psychological deficit" as measured by overt behavioral indices (RT, RC) is somewhat greater for the male schizophrenic subjects in this study and this is not surprising in view of the male's greater susceptibility to language impairment under stress. However, the female subjects who are more severly debilitated on the average, appear to be more highly reactive physiologically than their male counterparts, and to the extent that hyperarousal correlates with severity it seems that physiological measures are the more reliable in predicting degree of schizophrenic disturbance. Here the most consistent relationship with severity among schizophrenics is strength of recovery; severity of the schizophrenic condition predicts over-recovery. Higher arousal and flatter EEG profiles throughout time periods of measurement and a general failure to habituate either verbally or physiologically through time reliably distinguist the normal and schizophrenic subjects from each other in most cases. This is not to say there is no overlap among individuals, however, and to diagnose differentially exclusively on these bases would be in error.

Whereas there is little support for Mednick's conceptualization of the etiology of thought disorders as a function of a drive to reduce anxiety, there is much to underline the growing consensus that describes the schizophrenic as suffering from chronic physiological hyperreactivity (Mednick, 1966; Venables, 1968; Ax, 1967), and there is some evidence (Ax, 1967) to suggest that the phenomenological quality of this hyperaroused state is anger rather than fear or anxiety.

The value in considering psychophysiology in diagnosis and possible prevention of thought disorder development is suggested here. If the usual idea of learning is modified to include the broader aspects of physiological adaptation rather than simply verbal or manipulative changes in behavior and if schizophrenia is viewed involving a deficit in these emotional and motivational parameters, a more concise understanding of schizophrenia and therefore an increased probability of dealing effectively with the schizophrenic process may be anticipated.

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APPENDICES

APPENDIX A

VERBAL RESPONSES FOR EACH SUBJECT TO EACH WORD STIMULUS

VERBAL RESPONSES FOR EACH SUBJECT

TO EACH WORD STIMULUS

1. Table

	NORMALS		SCHIZOPHRENICS
Subject		Subject	
1	Room	A	Kitchen
2	Bed	B	Furniture
3	Bed	C	Round
4	Dark	D	Clean
5	Chair	E	Peaceful
6	Chair	F	Polished
7	Chair	G	Long
8	Chair	H	Chair
9	Didn't Hear	I	Different Kinds
10	Chair	K	Square
11	Chair	L	Large
12	Oaken	M	Set Out The Tablecloth
13	Pitcher	N	Raised
14	Patient	O	Furniture
15	Chair	P	Floor
16	Chair	Q	Chair
17	Round	R	Worthy
18	Dinner (Table)	S	Table (echolalia)
19	Chair	T	Blue
20	Chair	U	Bed
21	Chair	V	Light (in color)
22	Chair	W	Chair
23	Armchair	X	Couch
24	Chair	Y	The Light is Distrubing
25	Chair	Z	Chair

2. Dark

	NORMALS		SCHIZOPHRENICS
Subject		Subject	
1	Light (adj.)	A	Night
2	Light (adj.)	B	Dark (echolalia)
3	Fish	C	Light (prefix to adj.)
4	Deep (profound)	D	Light (adj.)
5	Night	E	Catastrophe
6	Grass	F	Cooked
7	Light (adj.)	G	Sad
8	Pitch Dark	H	Day, light
9	Light (adj.)	I	Dark (prefix to adj.)
10	Light (adj.)	K	Darkness doesn't depend on me
11	Light (adj.)	L	Night
12	(No Response)	M	Unpleasant
13	Light (adj.)	N	Dark (echolalia)
14	Microscope	O	In The Dark It's better to be afraid of people
15	Light (adj.)	P	Dark (prefix to adj.)
16	Light (adj.)	Q	Light (adj.)
17	Exceptional	R	Worm
18	Room	S	Lightness
19	Light (adj.)	T	Light (adj.)
20	Black	U	Light (prefix to adj.)
21	Light (adj.)	V	House
22	Light (adj.)	W	Light (adj.)
23	Light (adj.)	X	Lightness
24	Light (adj.)	Y	Light (adj.)
25	Night	Z	Light (adj.)

3. MAN

	NORMALS		SCHIZOPHRENICS
Subject		Subject	
1	Woman	A	Tall
2	Woman	B	Sex
3	Student (masc.)	C	Woman
4	Tall	D	Good
5	Woman	E	Music
6	End (noun)	F	Tall
7	Long	G	Tall
8	Woman	H	Woman
9	Woman	I	Could look like a peasant
10	Woman	K	Tall
11	Woman	L	Not always pleasant to be seen as a man
12	Woman	M	Man (echoalia)
13	Woman	N	Man is always seeing woman
14	Office	O	Masculine gender
15	Woman	P	Woman
16	Woman	Q	Woman
17	Interesting	R	Common
18	Tall	S	Woman
19	Woman	T	Skeleton
20	Woman	U	Woman
21	Woman	V	Strong
22	Woman	W	Woman
23	Woman	X	Girl (adolescent)
24	Woman	Y	Not completely
25	Woman	Z	Woman

4. SLOW

	NORMALS		SCHIZOPHRENICS
Subject		Subject	
1	Fast	A	Fast
2	Fast	B	Time
3	Fast	C	Fast
4	To go	D	Fast
5	Fast	E	Undoubtedly
6	Faster	F	Fast
7	To go	G	Leaking water
8	Fast	H	Go By Train
9	Washbasin	I	Fast
10	Fast	K	Fast
11	Fast	L	Fast, slow, no difference
12	Fast	M	Slow (echolalia)
13	Fast	N	Fast
14	Lake	O	Quiet
15	Fast	P	Fast
16	Fast	Q	Fast
17	Train	R	Slow (echolalia)
18	Loud	S	Fast
19	Fast	T	Fast
20	Fast	U	Fast
21	Fast	V	Fast
22	Fast	W	Slow
23	Fast	X	Fast
24	Fast	Y	Often
25	Fast	Z	Fast

5. HIGH

NORMALS		SCHIZOPHRENICS	
Subject		Subject	
1	Little	A	Man
2	Little	B	Increase (noun)
3	High heels	C	Low
4	Fellow	D	Low
5	Low	E	Low
6	Sky	F	Oak
7	Low	G	Man
8	Table	I	High Means Increasing
9	Thick	K	(No Response)
10	Little	L	Natural Creation
11	Low	M	Guy
12	Man	N	Man
13	Tree	O	Long
14	Low	P	Low
15	Low	Q	Low
16	Low	R	Up
17	Oak	S	Low
18	Fellow	T	Beautiful
19	Low	U	Low
20	Red	V	Low
21	Low	W	Low
22	Low	X	Low
23	Low	Y	No Never
24	Average	Z	Low
25	Short		

6. SOUR

	NORMALS		SCHIZOPHRENICS
Subject		Subject	
1	Sweet	A	"Kvas" (A Sour Russian Drink)
2	Bitter	B	Taste (noun)
3	Sweet	C	Sweet
4	Salty	D	Not very
5	Sweet	E	Sweet
6	Grapes	F	Tomato
7	Sweet	G	Milk
8	Sweet	H	Sweet
9	Sweet	I	Greater Sourness
10	Sweet	K	In Milk
11	Sweet	L	Unpleasant
12	Salty	M	"Kvas"
13	Sky Blue	N	Sourness
14	Sweet	O	Bitter
15	Sweet	P	Bitter
16	Sweet	Q	Sweet
17	Lemon	R	Work (Job)
18	Sweet	S	Sweet
19	Sweet	T	Watch (wrist)
20	Sweet	U	Dreamlike
21	Sweet	V	Sweet
22	Sweet	W	It's such, it's I can't know
23	Sweet	X	Sweet
24	Sweet	Y	Light Burns
25	Sweet	Z	Sweet

7. HARD (Surface)

NORMALS

Subject	
1	(improper stimulus used)
2	(improper stimulus used)
3	(improper stimulus used)
4	(improper stimulus used)
5	(improper stimulus used)
6	(improper stimulus used)
7	Soft
8	Crude
9	Soft
10	Soft
11	Soft
12	Soft
13	Black
14	Photography
15	Metal
16	Soft
17	Nut
18	Soft
19	Soft
20	Soft
21	Soft
22	Soft
23	Soft
24	Soft
25	Soft

SCHIZOPHRENICS

Subject	
A	Bread
B	Hardness
C	Soft
D	Soft
E	Soft
F	Antonym Soft
G	Sofa
H	Soft
I	Hard (echolalia)
K	I feel very bad
L	Bread you are current
M	Sofa
N	Brush
O	Hard (syn.)
P	Soft
Q	Soft
R	Sleigh
S	Soft
T	Good
U	Soft
V	Soft
W	Stale
X	Bread
Y	Nothing tastes
Z	Soft

8. LONG

NORMALS Subject		SCHIZOPHRENICS Subject	
1	Little	A	Main Event
2	Short	B	Measure
3	Short	C	Low
4	Short	D	Ruble
5	Short	E	Short
6	Tree	F	Dance (noun)
7	Short	G	Train
8	Short	H	Short
9	Short	I	Tall
10	Short	K	Thread
11	Short	L	Lengthy Poetry
12	Short	M	Long (echolalia)
13	Pigeon	N	Six
14	High Heels	O	Tall
15	Average	P	Low
16	Short	Q	Short
17	Tall	R	Sound
18	Short	S	Short
19	Short	T	Short
20	Short	U	Short
21	Short	V	Short
22	Short	W	Long (echolalia)
23	Short	X	Average
24	Short	Y	Short
25	Short	Z	Long (echolalia)

9. BLACK

NORMALS Subject		SCHIZOPHRENICS Subject	
1	White	A	Fellow
2	White	B	Light (noun)
3	Red	C	White
4	Table	D	Bread
5	White	E	Brown
6	Grass	F	Swan
7	Red	G	Cat
8	White	H	White
9	White	I	And so it is black
10	White	K	Motherly
11	White	L	Special Light (noun)
12	White	M	Bread
13	Lake	N	Suit (clothing)
14	Disgusting	O	Dark (adj.)
15	Soot	P	White
16	White	Q	White
17	Bread	R	Up
18	White	S	White
19	Red	T	Red
20	Red	U	And White
21	White	V	And White
22	White	W	Red
23	White	X	White
24	White	Y	Closed
25	White	Z	Red

10. LOUD

	NORMALS		SCHIZOPHRENICS
Subject		Subject	
1	Quite (adj.)	A	Voice
2	Slowly	B	Sound
3	Quiet (adj.)	C	Silence
4	Loudspeaker	D	Sound
5	Quite (adj.)	E	Weak
6	Scream (noun)	F	Thunder
7	Sound	G	Thunder
8	Quiet (adj.)	H	How? Quietly
9	Sound	I	And so it is loud
10	Weak	K	Thunder
11	Quiet (adj.)	L	High Frequence Sound
12	Thunder	M	Conversation
13	Sun	N	Sound
14	Red	O	Ringing Clear
15	Amplifier	P	Low
16	Quiet (adj.)	Q	Weak
17	Sound	R	Flower
18	Noise	S	Quiet (adj.)
19	Sound	T	Quiet (adj.)
20	Quiet (adj.)	U	White
21	Quiet (adj.)	V	Whistle (noun)
22	Quiet (adj.)	W	Mute (adj.)
23	Quiet (adj.)	X	Weak
24	(No Response)	Y	Don't Hear Anything
25	Low	Z	Quiet (adj.)

APPENDIX B

MOST FREQUENT RESPONSES FOR EACH WORD STIMULUS GIVEN BY A REFERENCE SAMPLE OF ONE HUNDRED MEDICAL STUDENTS

MOST FREQUENT RESPONSES FOR EACH WORD STIMULUS GIVEN BY A REFERENCE SAMPLE OF ONE HUNDRED MEDICAL STUDENTS

1. Table

Chair	52
To Eat	2
Legs	2
Furniture	2
Dishes	2

2. Dark

Light	56
Night	4
(Pitch) Dark	4
Lightness	3
Day	3
Thick	2
Window	2
Deep (Profound)	2
Fearful	2

3. Man

Woman	66
Tall	6
Handsome	4
Girl (adoles.)	2
Interesting	2

4. Slow

Fast	65
Loud	4
To Go	4
Train	2
Quiet	2
To Speak	2
Airplane	2

5. High

Low	45
Short	7
Little	6
Long	5
Fellow	3
Average	3
Table	2

6. Sour

Sweet	54
Salty	11
Bitter	7
Apple	5
Lemon	3

7. Hard

Soft	50
Hard (Syn.)	9
Hard (Difficult)	6
Table	4
Sofa	2
Elastic	2
Metal	2

8. Long

Short	67
Hair	2
Little	2

9. Black

White	50
Red	17
Bread	3
Light	2

10. Loud

Quiet	48
Sound	9
Weak	5
Low	3
Voice	3
Noise	2
Deaf	2
Strong	2
Amplifier	2
Loudspeaker	2

APPENDIX C

PATIENT ADMISSION DATA

PATIENT ADMISSION DATA

Patient A. M. L., a 28-year old male, was admitted in January, 1967. After a previous hospitalization in 1964 he was married and has subsequently divorced. He currently lives with his mother and has worked off and on as a lathe operator. He arrived at Kaschenko on this occasion against his will after his mother reported finding several letters in the home addressed to the Federal Republic of West Germany, the United States of America, and Great Britian complaining of life in the Soviet Union. He complains of strangers who are plotting against him and who intend to do him harm. He currently responds adequately to most questions, although he refuses to state his age and continues to deny that he is ill. Upon admission he appeared moderately anxious, was combative with the attendants on several occasions, and showed moderate disorganization of thought process.

Patient B. An unmarried male of 25 years of age, this is B. C.'s first admission. He speaks openly of his suspicions of people not liking him and shows concern about men who stop him on the street either drunk or sober asking him for cigarettes--feeling that they intend to hurt him in some way. He states that his neighbors do not like him and wish to do something to hurt him, although he is aware there is no evidence for his fears. He does not consider himself ill.

He has worked as an unskilled factory worker in the past but has not been employed in the past three months.

Patient C. C. N. is a 50-year old male divorcee. Six months ago he noted "espionage" in that he feels that his previous wife was a spy and used to spy on him. This is his first admission and he appeared very anxious to admission attendants. According to his family he has exhibited delusions of persecution for the past year and believes he has cancer. He has worked regularly as a taxi cab driver until date of admission.

Patient D. B. K. is a 67-year old male who has a long history of admissions. At the time of this admission he appeared talkative and seemed to be in a good mood although he showed no insight into his illness. He has worked in the past as a ship pilot and in 1956 married for the first time. In 1958 he began to experience auditory hallucinations, ideas of reference, and delusions of persecution. He describes himself as a "consultant on all political questions" and has developed his own theory of the origin of the earth.

Patient E. N. T. is an unmarried male radio engineer. He has not been working in the past several months and this is his first admission. Since 1942 he has been developing his "theory of psychology as a science." He shows little insight and describes himself a superior psychologist. The bizarreness of his theory, which he discusses readily, brought him to the attention of the authorities.

Patient F. A 32-year old married male, A. T. was brought to the hospital by ambulance from the Central Committee Building where he was delivering his theory of the universe on the front steps to passersby. In 1958 he began to be interested in cosmonauts and space theory and since that time has written many letters to various civic organizations about his ideas. He states that he is capable of transmitting "biological waves" and that his sister and brother have tried to kill him on 21 different occasions. He has worked in the past as a foreman in a factory, although relatively calm upon admission, he speaks readily and at length of his "great discoveries" and of his disappointment that the Academy of Sciences has not recognized his work.

Patient G. D. Ṅ., a 37-year old married male, has been admitted for the second time. He complains of hearing noises and male voices in his head. He expresses jealousy of his wife and feels that she wants to kill him. He also feels that physical changes are occurring in his hands. He was a patient in the hospital eight years ago for a period of three months but he has worked relatively steadily as a skilled laborer in the interim.

Patient H. D. C., a married male of 28 years of age, was hospitalized for the first time in January, 1967. He first noticed people had a "strange attitude" toward him shortly before admission. Although he graduated from a technical institute, he has worked only infrequently. During the test procedure he expressed concern that someone was "following his ideas." His twin brother has also been hospitalized in the past with a diagnosis of paranoid schizophrenia.

Patient I. N. B., a married carpenter of 41 years of age, began drinking heavily in 1954. Upon admission in 1961 he complained of hearing voices and expressed multiple fears. His 1967 admission is his second and he continues to complain about voices in his head. He is moderately agitated and refuses to speak about himself or his symptoms in any detail.

Patient K. L. N., a 32-year old unmarried female, has been ill from the age of 16. She has been admitted to the hospital several times since and complains primarily of auditory hallucinations. She hears voices which sometimes threaten her, sees people looking at her who intend to do something harmful to her. She has worked sporadicly as a janitoress in a barber shop.

Patient L. M. P. is a 55 year old female who has been in and out of psychiatric hospitals since 1960. Delusions of persecution first appeared when after changing her apartment she began to speak of neighbors going through her clothes and "spying on her." People on the street look at her strangely, and try to get her to "join their organization." She has worked as an unskilled worker in the past, and is currently living on a pension. She has never been married.

Patient M. B. K., a 50-year old female, has been ill for ten years. The most recent admission, of several, was in May, 1967. She complains of insomnia, of hearing voices which say bad things about her. She has been married in the past and has two living children. Never having been able to maintain a job for any length of time, she is an unskilled worker and is considered an invalid occupationally.

Patient N. B. K., a 58-year old male married secondary school teacher. April 1967 was his first admission. Complaining of "strugglers" he was taken forcibly from a restaurant. He states that the "strugglers" typically disguise themselves as physicians and are especially to be found in hospitals. It is interesting that this patient used to be a private tutor of Litvinov, a former minister under Khruschev.

Patient O. This is M. P.'s first admission to the hospital although he hasn't worked actively in his occupation of taxi driver for the past 2 to 3 years. He denies any need for being here but openly discusses his notions of the "false world." Specifically he is concerned about threatening "voices" which he says have been speaking to him since 1955. He feels his behavior is influenced by "rays" originating in outer space. He is 48 years of age and has never been married.

Patient P. S. C. was hospitalized in 1963 for a short period of time and this is his second admission. A 36-year old male, he is married with two children. His speech reflects many delusions of reference including notions of special calling by the Central Committee. He suspects his wife of spying upon him and reporting his movements to an "enemy agent." He has worked as an unskilled worker all his adult life.

Patient Q. K. G. has had a record of psychiatric disturbance since the age of twelve and has been admitted to the hospital on numerous occasions. He shows disorganization of time and place orientation and hears voices directing "his thoughts." He has never been married and is considered occupationally invalid having never worked steadily.

Patient R. V. K. has had a history of many previous admissions. He is a 27-year old male who has worked in the past as an unskilled worker and has never married. Seeing himself as healthy, he describes everyone around him as spys and acuses them of persecuting him. Upon admission, he was in a state of mild excitation for which he was prescribed a tranquilizing drug. Preceding his inclusion in the study he was kept off drug therapy a period of seven days.

Patient S. B. C., a 32-year old male, has a history of multiple admissions beginning in 1956. He complains of persecution by neighbors, voices in his head, and various somatic complaints not supported by confirmed organic disease. He is reluctant to answer any questions and is generally suspicious although not apparently anxious. He has never been married and has worked only irregularly as an unskilled laborer.

Patient T. R. T. is a 40-year old female who was admitted most recently in April 1967. She has a history of many previous admissions and complains of "physical influences." There are also many references to auditory hallucinations involving the voices of her deceased mother and current neighbors. She has never been married and is considered occupationally invalid.

Patient U. C. B., a 49-year old female, has been ill for more than 15 years. She has a history of several admissions, many for alcoholism. Ideas of reference and auditory hallucinations, voices warning her of her enemies, are prominent in her symptom picture. She feels that her mother wants to kill her by poisoning. A divorcee, she has two children. She is occupationally an invalid.

Patient V. M. O. is a 57-year old female who has been ill for many years. Delusions of persecution, ideas of reference, and some auditory hallucinations characterize her behavior. She complains about how her boss used to spy on her and enlisted co-workers to do the same after working hours. She has worked as an unskilled worker, is a divorcee with no children.

Patient W. P. M. is a 46-year old female whose first admission was in 1950. Since that time she has been admitted many times to the hospital and has complained of ideas of reference, delusions of persecution and complains of prejudicial attitudes expressed toward her by strangers. She is convinced that her neighbors are spying on her. She is a divorcee with no children and is occupationally an invalid.

Patient X. O. K. is a 37-year old female who has been ill since 1957. She has worked as a cloakroom clerk and manages to give fairly adequate responses upon inquiry. She shows marked mannerisms in her behavior, no insight, and delusions of persecution, feeling her relatives are trying to turn her in to the security police. She has not been married.

Patient Y. L. S. is a 39-year old female with a history of many admissions to the hospital. She has worked as an orderly in a nursery, is currently married with one living child. She expresses ideas of reference and auditory hallucinations which have an imperative character. She describes her voices as commanding her to perform nonsensical compulsive acts about the house. She shows no insight and shows only mild anxiety at the time of testing.

Patient Z. N. B. is a 44-year old female with an extensive history of psychiatric disturbance although this is only her second admission. She complains about everyone following her and talking about her and often trying to grab her and threaten her life. She was described by her neighbors as reclusive, almost never leaving her apartment except to go to work and never allowing anyone in for the past year. She had been married, is now divorced, and has worked in her occupation as a janitoress fairly steadily.

APPENDIX D

WORD AND LIGHT STIMULUS PRESENTATION SCHEDULES

WORD AND LIGHT STIMULUS
PRESENTATION SCHEDULES

SCHEDULES

Trial	I	II	III	IV
1	Table	[1]*Table	Sour	[1]*Sour
2	[1]*Dark	Dark	[1]*Hard	Hard
3	[1]*Man	Man	[1]*Bread	Bread
4	Slow	[1]*Slow	Long	[1]*Long
5	[2]*Girl	Girl	[2]*Black	Black
6	[2]*High	High	[2]*Loud	Loud
7	Sour	[2]*Sour	Table	[2]*Table
8	Hard	[2]*Hard	Dark	[2]*Dark
9	Bread	[3]*Bread	Man	[3]*Man
10	[3]*Long	Long	[3]*Slow	Slow
11	Black	[3]*Black	Girl	[3]*Girl
12	[3]*Loud	Loud	[3]*High	High

*Presented with preceding stroboscopic light stimulus.

Note: Trials using stimulus words "Girl" and "Bread" were subsequently eliminated from the data analyses.

[1] Light Frequency = 10/second
[2] Light Frequency = 25/second
[3] Light Frequency = 80/second

APPENDIX E

NAMES AND TRANSFORMATION OF MEASURES CALCULATED FOR EACH SUBJECT

NAMES AND TRANSFORMATIONS OF MEASURES
CALCULATED FOR EACH SUBJECT

Baseline MEC/second ($\bar{x}$) times 10
Pre-stimulus MEC/second ($\bar{x}$) times 10
Latency Period MEC/second ($\bar{x}$) times 10
Post-Response MEC/second ($\bar{x}$) times 10
Latency Period Length (seconds)
Severity of Disorder (Schizs Only: 1=chronic; 2=acute)
Age (to the nearest tenth of year)
Socio-Economic Status (1 downwards to 5)
Marital Status (Schizs only) 1=some marital history; 2=none
Response Commonality ($\bar{x}$)
Response Quality ($\bar{x}$)
Latency Period Length, Trial 1 (SECS) times 10
" " 2
" " 3
" " 4
" " 5
" " 6
" " 7
" " 8
" " 9
" " 10

Pre-Stimulus MEC/second, Trial 1 ($\bar{x}$) times 10
" " 2
" " 3
" " 4
" " 5
" " 6
" " 7
" " 8
" " 9
" " 10

Latency Period MEC/second, Trial 1 ($\bar{x}$) times 10
" " 2
" " 3
" " 4
" " 5
" " 6
" " 7
" " 8
" " 9
" " 10

Post-Response MEC/second, Trial 1 $(\bar{x})$ times 10
" " 2
" " 3
" " 4
" " 5
" " 6
" " 7
" " 8
" " 9
" " 10

Response Commonality, Trial 1 $(\bar{x})$
" " 2
" " 3
" " 4
" " 5
" " 6
" " 7
" " 8
" " 9
" " 10

Pre-Stimulus/Latency Period MEC/second $(\bar{x})$ times 10
Post-Response/Latency Period MEC/second $(\bar{x})$ times 10
Pre-Stimulus MEC/second associated with Hi RC times 10
Latency Period MEC/second associated with Hi RC times 10
Post-Response MEC/second associated with Hi RC times 10
Pre-Stimulus MEC/second associated with Lo RC times 10
Latency Period MEC/second associated with Lo RC times 10
Post-Response MEC/second associated with Lo RC times 10

TABLE E-1.--Product-Moment Correlations Between Age and Variables Which Reach Significance at $p<.05$.

Subjects	Comparison Variable	Product-Moment r	Significance
Overall Normals (df=23)	Socio-Economic Status	.46	.02
Overall Schizs (df=23)	No Significant Correlations		
Overall Females (df=26)	Baseline MEC/Second	-.52	.01
Overall Males (df=20)	No Significant Correlations		
Normal Females (df=15)	Socio-Economic Status	.65	.01
	Pre-Stimulus/Latency Period MEC/Second (Arousal)	.60	.02
	Post-Response MEC/Second Associated With Lo RC	-.50	.05
Normal Males (df=6)	No Significant Correlations		
Schiz Females (df=9)	Pre-Stimulus MEC/Second	.68	.02
	Pre-Stimulus/Latency Period MEC/Second (Arousal)	-.66	.05
Schiz Males (df=12)	No Significant Correlations		

TABLE E-2.--Product-Moment Correlations Between Socio-Economic Status and Variables Which Reach Significance at $p<.05$.

Subjects	Comparison Variable	Product-Moment r	Significance
Overall Normals (df=23)	Age	.46	.02
Overall Schizs (df=23)	Sex	.60	.01
Overall Females (df=26)	Baseline MEC/Second	-.41	.05
	Pre-Stimulus/Latency Period MEC/Second (Arousal)	.41	.05
Overall Males (df=20)	Pre-Stimulus MEC/Second	-.48	.05
	Latency Period Length (Reaction Time)	.45	.05
	Pre-Stimulus/Latency Period MEC/Second (Arousal)	.46	.05
Normal Females (df=15)	Pre-Stimulus/Latency Period MEC/Second (Arousal)	.72	.01
Normal Males (df=6)	No Significant Correlations		
Schiz Females (df=9)	No Significant Correlations		
Schiz Males (df=12)	No Significant Correlations		

TABLE E-3.--Product-Moment Correlations Between Marital History and Variables Which Reach Significance at $p<.05$.

Subjects	Comparison Variable	Product-Moment r	Significance
Overall Schizs (df=23)	Latency Period Length	-.38	.05
Schiz Females (df=9)	Latency Period MEC/Second Associated With Hi RC	-.71	.02
Schiz Males (df=12)	Latency Period Length	-.54	.05

TABLE E-4.--Product-Moment Correlations Between Severity of Disorder and Dependent Variables Which Reach Significance at $p<.05$.

Subjects	Comparison Variable	Product-Moment r	Significance
Overall Schizs (df=23)	[1]Sex Socio-Economic Status	-.55 -.46	.01 .02
Schiz Females (df=9)	No Significant Correlations		
Schiz Males	Post-Response/Latency Period MEC/Second (Recovery)	-.59	.01

[1] Coding for Sex: males = 1; females = 2.

TABLE E-5.--Student's t and F Statistics for Age and Socio-Economic Status of Normal and Schiz Subjects and for These Groups Differentiated by Sex[1].

Subject Characteristic	Comparison[2]	Statistic		Significance	
		[3]F	t	F	t
[2]Age	Normals vs. Schizs	1.33	6.43	N.S.	.01
	Normals: Males vs. Females	5.33	0.45	.05	N.S.
	Schizs: Males vs. Females	2.19	1.28	N.S.	N.S.
Socio-Economic Status	Normals vs. Schizs	1.45	9.91	N.S.	.01
	Normals: Males vs. Females	3.26	2.87	.05	.01
	Schizs: Males vs. Females	NEV	5.50	NEV	.01

[1] All comparisons use two-tailed tests.

[2] Normals, n=25; Schizs, n=25; Normal Females, n=17; Normal Males, n=8; Schiz Females, n=11; Schiz Males, n=14.

[3] Where F is significant, t is calculated with Welch's Test.