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Cognitive style and anxiety as related to the P300 component of the event related potential waveform in eleven and twelve year old males

Kapahi, Ranju Malhotra, Ph.D.

The Ohio State University, 1987

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COGNITIVE STYLE AND ANXIETY AS RELATED TO THE P300
COMPONENT OF THE EVENT RELATED POTENTIAL WAVEFORM
IN ELEVEN AND TWELVE YEAR OLD MALES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

Ranju M. Kapahi, M.A.

The Ohio State University

1987

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Adviser
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To the memory of my parents,
Harbans Lal and Prakash Vati Malhotra
ACKNOWLEDGMENTS

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CHAPTER I
INTRODUCTION

In the words of Piaget and Inhelder (1969) "There is no behavior pattern, however intellectual, which does not involve affective factors as motives; but reciprocally, there can be no affective states without the intervention of perceptions or comprehensions which constitute their cognitive structures. Behavior is, therefore, of a piece, even if the structures do not explain its energetics and if, vice versa, its energetics do not account for its structures. The two aspects, affective and cognitive, are at the same time inseparable and irreducible" (p. 158).

Until recently, the differences in cognitive style and affect and the interrelationships between these two major dimensions of human individuality have been typically measured through the examination of overt behaviors. Covert mental processes underlying these two aspects of individual psychological differences have been inferred from behavioral measures, such as reaction time. However, this is an indirect way of studying the differences in the mental processes that
characterize cognitive style and affect. As Callaway (1975) puts it, "the knowledge of mental individuality is far more rudimentary." The underlying complex forms of mental information processing have yet to be clarified using only the conventional measures (Callaway, 1975).

For ages now, the brain has been considered the central organ of behavior that controls our ability to think, learn, move, create or perform any of the complex functions that are associated with human endeavors (Andreassi, 1980). Such a notion leads naturally to attempts to explain behaviors and mental phenomena in neurological terms and to apply psychological concepts to brain functions (Vanderwolf, 1983). In recent years, through the application of computer-science, there have been significant technological advances in our ability to measure directly aspects of the brain's function by analyzing its spontaneous or evoked electrical activity. There have been innumerable experiments utilizing brain electrical activity to study different mental processes, especially cognition. By looking at the covert processes of the brain as they relate to overt behavior, researchers are gaining insights which go beyond the traditional behavioral approach. Such technological advances permit us to investigate the possibility that the study of brain electrical potentials elicited under controlled conditions will tell us something more about human individuality. Perhaps such a study will provide a new understanding of individual differences
in cognition and affect that cannot readily be available through the use of conventional measures. Tyler and Tucker (1982) stated that "if a workable neuropsychological model of emotional and cognitive processes could be developed, it might be possible to understand how specific emotional processes lead to predictable alterations in information processing strategy" (p. 210).

In addition to the brain wave frequency patterns of the ongoing electroencephalograph (EEG), the other basic method of assessing brain activity is the Event-Related Potential (ERP) Method. This is a method by which a large number of short epochs of EEG, time-locked to the presentation of a target stimulus, are collected and computer analyzed. The event-related potential waveform is viewed as a series of components each of which is thought to be a manifestation of the summated electrical field of large numbers of neuronal membranes acting in synchrony (Hillyard & Woods, 1979; Regan, 1972). Components of event-related potential are studied by noting the changes in duration (latency) and amplitude over time.

Callaway (1975) delineates three justifications for examining the possible relationships between the event-related potentials and individual psychological differences. First, brain potential measures reliance on prior experience and on voluntary responses is far less than more measurable forms of behavior. Second, brain potentials provide convergent data. A set of brain potentials, when examined in correspondence with a set of
behaviors, is more likely to indicate a characteristic brain state than either set alone. Third, brain potentials may be a more immediate and elemental reflection of internal brain states at the instant of performance than the performance or external behaviors.

The event-related potential component that has been most extensively researched is the P300 waveform. This waveform reflects subjective responses to unexpected, rare, novel, but relevant stimuli which deliver significant information. The P300 may be related to the "amount of prior uncertainty resolved by a stimulus" (Ruchkin & Sutton, 1973), and in a general sense, this component indexes a decision-making process within the brain. Donohin (1981) believes that his research using the P300 component shows that the human brain is a complex organ which responds to task demands rather than just to specific stimuli. He states that the brain is "a dynamic system that continuously generates hypotheses about the environment that are then validated against input information." The implications this can have in the selection and training of people for high-risk jobs, such as atomic reactor operators, is intriguing. In the present computer age, with the ever-increasing use of computers in home, office, and school, in computerized strategy games and in academic programs, research using the P300 component can shed light on "the active processing of stimulus information" (Beck, 1975). Hence, the examination of the P300 can provide new
insights into the neural mechanisms of specific aspects of mental processing.

The heuristic which merges neurological functions and psychological constructs has been boosted by advances in computer technology. A few studies have encouraged the investigation of the relationship between specific psychological variables such as individual differences and brain functions.

Researchers (Tyler & Tucker, 1982) have provided experimental evidence that individual differences in anxiety and different approaches (global/analytic) to perceptual structuring of the stimulus information were reflected not only in the behavioral data (accuracy level) but also in the neurophysiological processes (cerebral activation). The results of this study provide support for the utility of a neuropsychological model in studying the effects of individual differences in anxiety and perceptual structuring on the performance of cognitive tasks.

There is also some evidence that extremely field-dependent individuals may have many features which appear common to an anxiety-prone group of individuals (Witkin, Dky, Faterson, Goodenough & Karp, 1962) and that they may perceive, or learn or remember, the same environmental stimulus differently than the extremely field-independent individuals in varied task situations. Some of the electrophysiological studies (Knott, VanVeen, Miller, Peters & Cohen, 1973; Knott & Irwin, 1968;
Tecce, 1972) have suggested the possibility of differential effects on the event-related potentials of normal populations with varied cognitive styles (field dependence/independence) and levels of anxiety (high-low) during the performance of certain types of tasks.

The present study was designed to examine the functional significance of the P300 event-related potential waveform, measured on 11-12 year old subjects who have different cognitive styles and different levels of anxiety during their performance on specific cognitive tasks in an evaluative situation. The principal question posed in this study was, "Are there any reliable P300 event-related potential signs established when high and low anxious 11-12 year old subjects who have varied modes of cognitive processing are required to perform certain cognitive tasks?" The study was designed in such a way as to allow discrimination between the relationship of a neurophysiological measure (P300 waveform at central and lateral brain sites) to cognitive style on the one hand, and to anxiety on the other. Also, the design allowed a discrimination of whether or not this neurophysiological measure could be regarded as an index of an interaction between cognitive style and anxiety. While this was the primary focus of the study, the relationship of cognitive style and anxiety to accuracy of performance of the tasks in question and to reaction time in making task decisions were also of interest.
NEED FOR THE PRESENT STUDY

The use of the P300 component of the event-related potential, in understanding the mode of cognitive processing of the stimulus, has drawn considerable attention during the past few years. Donchin (1979) has opined that the P300 event-related potential reflects "active, contextually-induced cognitive processing of stimuli". Other studies of the P300 component also seem supportive of the specific cognitive view of P300 (Tueting, 1978; Pritchard, 1981). However, very little research work has been done in the evaluation of event-related potential as the neurophysiological index of differences in cognitive styles. This significant facet of mental individuality, cognitive styles, has been observed and measured extensively using conventional measures. The relationships of cognitive styles and other individual differences, such as abilities and motivational direction, have been validated with behavioral measures. However, electrophysiological research has not been going on long enough to clarify all of these lines of relationship.

Based on research evidence reflecting some trends in the relationships between field dependence/independence and brain electrical activity, Oltman (1980) suggested the usefulness of further electrophysiological explorations to better understand the mechanisms underlying these pervasive psychological characteristics. This suggests a possibility that the extent of differentiation in the P300 component of event-related potential
may indeed predict individual differences in modes of cognitive processing and indicates a need to investigate this relationship.

It is also noted in the literature that little or no attention has been paid to the role of affective factors and how they may influence by modifying and, at times, even controlling inter- and intra-individual differences in information processing, as reflected in the magnitude or latency of P300 (Begleiter et al., 1983). As long ago as 1940, Sherrington asserted that "every cognition has, potentially at least, an emotive value, and along with that, conative effort as a further factor." "Complex cognitive processes, therefore, involve differing degrees of emotionality" (Begleiter, Projesz & Chou, 1983). However, a close scrutiny of the related literature (Andreassi, 1980) on the P300 event-related potential in both normal and abnormal populations also indicates a neglect of non-cognitive processes as potentially important determinants of P300 amplitude and latency. Hence, there is a need to investigate this relationship.

P300 waveforms elicited in a number of paradigms have been significantly smaller for schizophrenics than for controls (Roth, Pfefferbaum, Hovrath, Berger & Kopell, 1980). These results have been interpreted as a deficiency of cognitive processing which is associated with the inability to attend selectively to particular stimuli (Torello, 1983). However, Venables (1977) explained that schizophrenics often failed to respond to unexpected stimuli with
electrodermal responses which is usually interpreted as a lack of orienting responses or failing to react to low probability stimuli with surprise. According to Roth et al. (1980), "It is possible that schizophrenics perceive stimulus probability accurately but do not respond to low probability stimuli with either a P300 or autonomic responses. In that case, the deficit would be more an affective than a cognitive one" (p. 503).

Differences in the magnitude of the P300 were also noted by Chattopadhyay, Cooke, Toone and Lader (1980) between patients suffering from primary anxiety states and normal subjects with low and high levels of anxiety. A considerable body of research is available which describes human anxiety and its development and unanimously confirms the detrimental role of high, and not necessarily pathological, anxiety in many types of performances (Hamilton, 1985). It then appears that differential P300 event-related potential effects may be obtained in normals showing different levels of anxiety when required to perform certain types of cognitive tasks in an evaluative situation. Hamilton (1985) also emphasizes that the interaction of anxiety with external situations is governed by cognitive mediating processes such as cognitive styles, "which integrate external-temporary and internal-more pervasive goal-directed processes." Such a model further encourages one to explore the electrophysiological correlates of cognitive style and anxiety to better understand the underlying mechanisms of these two major dimensions of human
individuality. Therefore, the present study examines the electrophysiological manifestations (P300 event-related potential) along with behavioral data when these are measured on individuals who have different cognitive style (field dependence/independence) and varied levels of anxiety (high/low).

Kurtzberg, Vaughan, Courchesne, Friedman, Harter and Putnam (1984) brought to our attention that although research using event-related potentials as measures on adults is extensive, nevertheless, there is a paucity of such research on normal children. They emphasize that event-related potential studies can be important analytic and evaluative tools with children because they record the brain activity without needing an observable response from the child. Better understanding may be attained in terms of mental processing and brain activity mapping once the relationship between different event-related potential components and task manipulations and alternative problem-solving strategies can be established. "Since different components may represent different neurophysiological activity involved in cognitive processing, examination of age-related differences in these components could provide a rewarding means of mapping developmental trends and transitions" (Courchesne, 1983). Clautour and Moore (1969) and Levine (1983) have specified a number of adjustment difficulties which have been noted in 11 and 12 year old normal children. According to them, children at this age may fear being different from their peers and struggle with
They are faced with variation in physical maturation but uniform expectations. In a setting of much TV, computer games and multiple-choice tests, children who do better at encoding and who learn best by writing may have difficulty adapting to the cultural norms. Consequently, the result is delayed output and poor work efficiency. Hence, the present study emphasizes assessing the electrophysiological correlates of cognitive style and anxiety along with behavioral data when these are measured on 11 and 12 year old children.

This research may provide new insights in neurophysiological terms on how the differences in cognitive styles and anxiety levels may produce changes in information processing strategies or variations in the surge of attention and curiosity, coding processes and memory function, when an element of surprise or novelty is introduced in the learning environment. A study of this kind may provide greater understanding of the effects of individual differences and may help to identify pertinent areas of aptitude--treatment interaction as defined by Cronbach and Snow (1977).
CHAPTER II
LITERATURE REVIEW

The present study dealt with the functional significance of the P300 event-related potential waveform, when this is measured on 11-12 year old male subjects who have different levels of anxiety and cognitive styles during their performance of specific cognitive tasks in an evaluative situation. The related literature is reviewed in four sections. The first section presents a basic review of theory and general research findings on the P300 event-related potential waveform. The second section deals with the review of current electrophysiological research and cognitive styles (field dependence/independence). The third section contains a review of the literature on electrophysiology and anxiety with the presentation of current research work in this area. The fourth section reflects upon the relationship between cognitive styles (field dependence/ independence) and anxiety.

P300 COMPONENT OF EVENT-RELATED POTENTIALS

In the past fifteen years, a great deal of research has been devoted to studying the relationship between evoked cortical potentials or event-related brain potentials and human behavior.
and performance. Researchers have demonstrated the usefulness of
the study of event-related potentials as an analytic tool to
compare processing styles of different populations (normal,
learning disabled, brain-injured and schizophrenics) and to
better understand the relationship between mental processing and
human performance.

**Event-Related Potential—ERP**

Two types of brain electrical activity can be recorded
through the scalp. One is the on-going electroencephalogram (EEG)
while the other is the event-related potentials (ERP) which are
time-related to some event. The term "event-related potentials"
was proposed by Vaughan (1969) to refer to a variety of brain
responses that show time-locked relationships to actual or
anticipated stimuli. The event-related potential waveform is
viewed as a series of components each of which is a manifestation
of the summated electrical fields of large numbers of neuronal
membranes acting in synchrony (Regan, 1972; Hillyard & Woods,
1979). The event-related potentials were classified by Vaughan as
(a) sensory evoked potentials; (b) motor potentials; (c) steady
potential shift; and (d) long latency potentials. Whereas the
sensory evoked potentials are generated by visual, auditory,
somato-sensory and olfactory stimuli, the motor potentials are
produced by voluntary movements. The latter two types viz., the
steady potential shift and the long latency potentials, are
endogenous event-related potential components and are evoked by
the processing demands of a task. These components are not obligatory responses to external stimuli and as such the same external stimulus may or may not elicit a particular endogenous event-related potential component depending upon information processing demands imposed by a task. When elicited, the amplitude and the latency of the event-related potential components serve as important indicators of the information processing patterns in individuals.

Donchin, Ritter and McCallum (1978) attempted analyses of endogenous components and came to the conclusion that each event-related potential waveform could serve as an indicator to the information processing system. Processes of selective attention, decision making and comprehension have been associated with specific event-related potential waveforms (Picton & Hillyard, 1974; Hillyard & Woods, 1979; Kutas & Hillyard, 1980; Pritchard, Coles & Donchin, 1982).

**P300 Component—The Cognitive Trend**

Sutton, Braren, Zubin and John (1965) discovered that a late positive event-related potential was elicited to task-relevant stimuli that delivered important information. It was labeled "P300" because it occurred at about 300 msecs. after the stimulus presentation and was positive-going. At the time P300 emerged on the psychophysiological scene, information theory was playing an important role in both psychology and neuropsychology (Dember & Warm, 1979). The information theory model of human
behavior considered the human organism as a communication channel (Shannon, 1949) and explained that the amount of information in a message is equivalent to the reduction of uncertainty. The influence of information processing theory and the cognitive approach is reflected in the interpretation of research findings on P300 component as a relationship between this component and uncertainty resolution. Since its discovery, the P300 has been widely studied as an index of cognitive processing and the factors that influence its amplitude and latency have become the main focus of interest for researchers in the field.

**P300—Amplitude**

The amplitude of P300 is the greatest at the midline over the parietal regions of the scalp. The mean size of the amplitude is related to the subject’s anticipation of whether the stimulus will or will not occur. If the chance that a target stimulus will occur is low and if the individual is confident about his decision in discriminating the target stimulus, the amplitude of P300 will be the largest (Squires, Squires & Hillyard, 1975; Rohrbaugh, Donchin & Ericksen, 1974; Squires, Hillyard & Lindsay, 1973). The amplitude may be associated with the amount of prior uncertainty resolved by selectively attending and detecting the rare and task-relevant stimulus (Andreassi, 1980). Languis and Wittrock (in press) state that in a general sense “the P300 amplitude indexes a decision-making process within the brain."
Duncan-Johnson and Donchin (1982) related the production of the P300 to the "acquisition and evaluation of information rather than to the specific response selection mechanisms activated by a given event" (p. 24). They postulate that once a stimulus is identified and categorized, it triggers several classes of processes. One of these processes evaluates the encoded stimulus in relation with the existing hypotheses. If the event that occurs is expected, then little change results in the existing model of the operating context. However, if the event that occurs is unexpected and mismatches with what the subject expects, the existing context model and hypotheses is revised. It is stated by Duncan-Johnson et al. (1982) that "this contextual updating may be manifested by the process of the P300." The general finding is that greater amplitude increases appear to be related to increased confidence in the decision whether a target stimulus will occur.

It is noted, however, that the studies on the P300's functional role of updating and decision making in terms of neurocognitive models concerning future events as reflected in the mean size of the amplitude do not indicate clearly whether reliable event-related potential differences are available in school age populations. These studies also do not delineate clearly where, in terms of brain regions, these differences occur. Although these studies emphasize the cognitive processing of information, nevertheless the effects of cognitive stylistic
dimensions have not been evaluated nor has significant attention been paid to individual differences in terms of affect.

P300—Latency

As has been stated above, latency of the P300 is also of interest. Donchin and his colleagues suggested that the P300 latency reflects "stimulus evaluation time". The P300 latency as stated by Duncan-Johnson et al. (1982) depends upon the time it takes for stimulus evaluation to be completed and is largely independent of response selection and execution time (reaction time).

There is evidence supporting different views about the locus of effect of stimulus probability on reaction time. The changes in reaction time have been interpreted as a consequence of facilitation of perceptual factors by some researchers (Miller & Pachella, 1976; Stanovich & Pachella, 1977) and as a consequence of facilitation of response factors by others (Biederman & Stacy, 1974). Magliero, Bashore, Coles and Donchin (1984) postulate that

the controversies in the literature derive from the result of the reliance of mental chronometry on the timing of overt responses for its dependent variables when many of the processes it is trying to elucidate are covert.

Donchin and his colleagues have opined that a combined analysis of changes in the latency of components of event-related potential, recorded at the scalp with measurements of reaction
time, can enhance our understanding of the timing and duration of information processing activities.

The assumption is that the P300 amplitude relies on the probability of the category into which the eliciting event is classified by an individual, and that the probability of a category cannot be assessed before the event has been categorized. Based on this assumption, it is concluded that "the latency of the P300 must be at least as long as categorization time and the index stimulus evaluation process must be independent of processes that mediate response selection and execution" (Duncan-Johnson & Donchin, 1982).

Support for the hypothesis that the P300 latency represents a manifestation of stimulus evaluation was provided by several studies. McCarthy and Donchin (1981) manipulated stimulus discriminability and stimulus-response compatibility and assessed the effects of these two manipulations on reaction time and on the P300 latency. They concluded that processes involved in response selection and execution have little, if any, effect on the latency of the P300. Similar data were obtained by Duncan-Johnson and Kopell (1981) in the context of the Stroop task. Results showed that the P300 latency remained stable but response time varied with the congruence between the stimulus word and the color in which it was printed. Pachella (1974) explains the dissociation between these two measures in terms of changes in the performance strategies used by an individual. Kutas, McCarthy and Donchin (1977) presented their subjects with different
instructional sets in a task to discriminate stimuli. The results showed that single-trial measures of reaction time and the P300 latency highly correlated when accuracy of performance was emphasized but slightly correlated when speed of performance was stressed.

The latency of the P300 can reflect, in a significant manner, the determination of timing and duration of information processing activities. Hence, instead of inferring cognition from behavior responses like reaction time which succeed the performance of some task requiring cognitive activity, such as behavioral measure can be supplemented by evaluating the covariation of reaction time and the P300 latency, the latter reflecting brain electrical activity as related to on-going behavior rather than an inference from an overt response.

In summary, a number of studies have indicated that variations in the amplitude and the latency of P300 components of event-related potential are related to the performance of various cognitive and information processing activities such as in decision-making tasks. In the opinion of Donchin (1979), "P300 reflects active, contextually induced cognitive processing of stimuli rather than a passive transmission of sensory information." The cognitive strategies of the subject are therefore important in determining the P300 amplitude and latency and provide support for a specific cognitive view of the P300 (Pritchard, 1981). Such associations lead to intriguing
implications in terms of better understanding of neurophysiological processes and behavioral manifestations in terms of cognitive and affective individual differences and under different situations. As stated by Donchin (1979), "The subject's overt response is only one of many possible consequences of stimulus presentation, rather than an end point of the sequence of information processing activities invoked by a stimulus."

The influence of the information-processing model on P300 research has led to the formulation that the P300 component indexes a measure of cognitive processing of the stimuli (Donchin, 1979). Research using these measures has contributed to our understanding of the complexities of human abilities but has paid very little or no attention to the cognitive mediating processes such as cognitive styles (especially with the school-age population). The construct of cognitive style refers to the consistent mode in which an individual filters, processes and organizes objective stimuli and translates these into meaningful dimensions. Perhaps evaluation of the P300 event-related potential as the index of differences in cognitive style will better explain the question, "Why do different individuals perceive or learn or remember the same environmental stimulus differently?" Perhaps such an investigation will give us data on mental processes underlying stylistic differences which cannot be readily gathered using more conventional measures.
Cognitive styles are defined as "dimensions of individual differences involving the form of cognitive functioning with expressions in a wide array of content areas including perceptual, intellectual, social interpersonal, and personality-defensive processes" (Goodenough, 1976). In the theory of psychological differentiation (Witkin, Dyk, Faterson, Goodenough & Karp, 1962), field dependence/independence represents "one expression of a more general individual difference dimension, which reflects the degree to which people perform autonomously of the world around them" (Witkin & Goodenough, 1977a). Field independent individuals are relatively autonomous, use a more articulate/analytic mode of field approach, and have the ability to overcome embedding contexts in perceptual functioning. By contrast, field dependent individuals are more affected by distracting stimuli (Bloomberg, 1965) and are more attentive to social information (Witkin & Goodenough, 1977b), use a global/holistic mode of field approach, and their experiences are governed by the organization of the field.

Witkin and Asch (1948) first formulated the concept of field dependence to refer to a graded ability to separate the stimulus field into salient and irrelevant cues in a figure-ground task. Two major instruments most commonly used to assess the dimension of field dependence/independence have been the Rod
and Frame Test (RFT) and the Embedded Figures Test (EFT). The RFT requires an individual to set a rod surrounded by a tilted frame to the true vertical. Some individuals tend to rely more on internal referents, set the rod close to the vertical and are called field independent. Others orient the rod in relation to the tilted framework. They are influenced in their judgements of rod position by the external surroundings and are called field dependent. On the EFT, the subject is required to locate simple geometric figures within a complex background. The relationship between performance on the EFT and measures of personality led Witkin to conceptualize an underlying dimension of differentiation, greater differentiation implying relatively greater segregation and specialization of various functioning abilities from each other. The more differentiated the individual, the more articulated and the more field independent the person. The less differentiated the individual, the more global and more field dependent the person. "The more differentiated person perceives the field as more discrete and structured, has a more definite sense of body boundary, a sense of individuality, internalized standards, and is less likely to use primitive, indiscriminate defense, such as massive repression and primitive denial" (Witkin, Oltman, Raskin & Karp, 1971).

Witkin et al. (1962) regarded his notion broadly, as reflecting differences in body concept, the nature of the self, and defense. Field independent subjects are able to attend to
significant elements in a visual field, inhibit irrelevant information (Gardner, 1961), and avoid distraction (Bloomberg, 1965). Also, field independent subjects are generally more active (Vinicki, 1974) and have shown superior ability in accuracy of motor responses and in simple reaction time (Barrett & Thornton, 1968). Rotella and Bunker (1978) did a study on the relationship of field dependence and reaction time of tennis players. They found that the experimental group comprised of national super-senior tennis players, as compared with a similar aged heterogeneous control group, were significantly more field independent (as measured on RFT) and had much more rapid simple reaction times and total-body response time than their counterparts. The former exhibited a better ability to attend selectively to a stimulus.

The initial impetus for the Witkin studies came from an interest in how normal adults perceive the same elements in a variety of contexts, but the research eventually expanded to include subjects of different ages, backgrounds, pathologies and cultures. In general, the many empirical reports from a variety of areas, including cognitive, educational, emotional, physiological and social psychological, have been congruent with the theoretical basis of this dimension (Goodenough, 1976).
Neurophysiological Correlates of Cognitive Style (FD/FL)

This differentiation concept has also been applied to the neuropsychological domain. Zoccolotti and Oltman (1978) refer to Palmer's view that there is a developmental specialization of different parts of the brain leading toward greater functional localization. If the extent of neural and psychological differentiation are related, then groups varying in the functional capacities of the different parts of the brain would also differ in ways predictable from Witkin's psychological differentiation model. (p. 155)

Perhaps the most influential aspect of neuroscience research has been a series of "split brain" operations conducted by Sperry and his colleagues in the 1960's. Subtle post-operative psychological testing suggested that in most righthanded individuals, the left hemisphere which controls the right side of the body specializes in the logical-analytical, categorical thinking and verbalization. The right hemisphere, on the other hand, controls the left side of the body and houses visual-spatial transformations, holistic understandings, perceptual insights, configuration and intuitive ability (Gazzaniga, Bogen & Sperry, 1962; Bogen, 1969; Kimura & Durnford, 1974; Sperry, 1974; 1982; Kinsbourne, 1974; Galin & Ornstein, 1974; Levy, Trevarthen & Sperry, 1972; Nebes, 1971). It was further suggested that it may not be the differential processing of verbal versus perceptual information that characterizes the hemispheres but that each is equipped with a different cognitive or processing style. The left hemisphere was seen as an analytical, logical
processor because it manipulates information in a linear or sequential fashion. The operation of the right hemisphere was recognized as "gestalt" or holistic since it processes information in a more simultaneous or parallel manner.

A number of studies have shown evidence that groups differing in degree of lateralization would also differ in directions predictable from Witkin's model of psychological differentiation. In their studies, Silverman, Adevai and McGough (1966) and Pizzamiglio (1974) found that non-righthanded subjects were more field dependent than were clearly righthanded individuals and explained this relationship with the view that non-righthanded individuals exhibit ambilaterality, consistent with the assumption that persons with less specialized cerebral hemispheres are likely to be relatively field dependent. Other studies using dichotic listening techniques have provided evidence that subjects showing a greater right ear advantage in dichotic listening have been found to be more field independent that those showing smaller ear differences (Dawson, 1972; Pizzamiglio, 1974). Zoccolotti and Oltman (1978) report that field independent subjects showed a greater right hemispheric specialization for configurational processing than did field dependent subjects. Hence, in both hemispheres, each according to its predominant mode of information processing, greater differentiation is expected to be associated with greater specialization of function.
Recently, neuropsychological research has presented evidence that contradicts the theory of hemispheric lateralization in cognitive processing. In an extensive review, Searleman (1977) stated that the right hemisphere has a "fairly well developed language capability." Heeschen and Jurgens (1977) used a dichotic listening task and presented evidence that two cerebral hemispheres are equally responsible for semantic representation. Recent research (Freides, 1977; Heeschen & Jurgens, 1977; Levy & Trevarthen, 1976) showed that both the hemispheres can process verbal and visuo-spatial information, and both can process that information in an analytic as well as global manner.

Despite the evidence for asymmetry, hemispheric symmetry or interaction cannot be ignored. Popper and Eccles (1977) underscore the importance of "cross-talk" or "impulse traffic" across the corpus callosum. Sperry (1974) concluded,

Regardless of the indications for the interhemispheric antagonism between the verbal and spatial modes of thinking, the two modes apparently integrate quite harmoniously under normal conditions, i.e., in the presence of the corpus callosum.

Luria (1973) postulated an interactive nature of the hemispheres and maintained that "integrated activity of both hemispheres governs psychological activity." Das, Kirby and Jarman (1975) and Goldberg and Costa (1981) developed models of cognitive processing that reflect the "whole brain" or the interactive nature of hemispheres. Research using the model of successive-
simultaneous processing of cognitive function indicated that any task could be approached using either style of information processing or perhaps both styles (Das, 1973). Clark and Frisby (1980) operationalized the differences in modes of cognitive processes in terms of analysis-synthesis and postulated that for more efficient responses to complex tasks "an interplay of these two strategies is important."

As expressed by Dunn (1985), research (Heeschen & Jurgens, 1977; Freides, 1977) shows that varied interactions or mixtures of the hemispheres rather than lateralized functions of each result in analytic and holistic modes of processing. Studies that have monitored brain activity of individuals who are performing complex tasks provide evidence that "the whole brain is used for perception and cognition" (Dunn, Singer & Gould, 1981; Reddix & Dunn, 1984).

Cognitive Style—Event-Related Potential

More recently, the two modes of cognitive processing, verbal/analytic style (field independence) and spatial-global/integrative style (field dependence) for learning, problem solving and decision making, have been assessed not only by electroencephalographic (EEG) techniques but specifically by event-related potential (ERP) records.

On the basis of the results of their previous studies (Buchsbaum & Silverman, 1968) which related individual differences on psychophysiological judgment tasks to individual
responses and on an analogous averaged evoked response procedure, Buchsbaum and Silverman (1970) postulated that the presence of relatively stable individual differences in test performance suggested that the Rod and Frame Test might well be adapted to an averaged evoked potential study. Subjects in this study were 15 male and 15 female volunteer students ranging in age from 18 to 22 without known pathologies. EEGs were recorded both from the right occipital zone and from the vertex with reference to the right earlobe. Lines of different degrees of tilt produced evoked potentials with different waveforms. The results indicated that the differences between evoked potentials were more pronounced in individuals with low errors on the classic Rod and Frame Test and less in individuals with high errors on the Rod and Frame Test. This discrimination was best noted quite late in the evoked potential, specifically over the interval from 334 to 512 ms. The results of this study reflect a relationship between the theoretical model of cognitive style (field dependence/independence) and the neurophysiological dimension. This suggests implications for the differential effects of field dependence/independence dimension on the variations in the amplitude and the latency of P300 component.

In exploring different types of associations between different aspects of human information processing and brain electrical activity, Lewis (1982) postulated that increase/
decrease in event-related potential activity over the left or right hemisphere may be considered an index of increased/decreased information processing within that hemisphere. He assessed that the differential information processing styles of individuals which he refers to as use of predominantly verbal-analytic cognitive style versus a spatial-global cognitive style for task performance, will affect the performance of verbal/spatial tasks and be reflected by the amplitude differences of event-related potential. In his study, 50 right-handed subjects (Caucasian male recruits undergoing basic military training) were administered a battery of paper and pencil tests to assess their cognitive styles, aptitudes and abilities. On the basis of cluster analysis of the cognitive styles, aptitudes and abilities, the 50 subjects were divided into two groups, a verbal processing group and a spatial processing group. Visual, auditory and bimodal event-related potentials were also recorded at four brain sites (frontal, temporal, parietal, occipital) over each brain hemisphere during the same testing session but not concurrently. Overall, results showed that the greatest amplitude asymmetry in response to visual stimuli was noted in the spatial group and the greatest asymmetry in response to auditory stimuli was seen in the verbal group. The spatial group showed increased information processing as reflected by event-related potential activity in the right hemisphere while the verbal group exhibited the same in the left hemisphere. This study suggested that ERP
records are better able to discriminate and classify performance groups than paper-pencil scores. However, this study focused at the differential effects of field dependence/independence on the event-related measures among adult populations and did not give any indication whether these relationships may be valid for, or generalized to, school age populations. This suggests the need to explore for reliable signs of event-related potentials among children who are varying on cognitive style dimension (field dependence/independence).

In another research project, Federico (1984) attempted to establish whether ERPs are valid indicators of individual differences in not only abilities and aptitudes, but also cognitive styles. The issue addressed in this study was whether measurement of event-related potentials may be useful for estimating the cognitive characteristics of Navy trainees. If such a relationship is established then it may be feasible to develop instructional procedures that accommodate the difference between individual trainees. The results indicated significant canonical and product-moment correlations which suggest that brain electrical activity evoked visually or bimodally in the left hemisphere or right hemisphere may be related to complex information processing as measured by some customary tests of cognitive styles, abilities and aptitudes. Cognitive style (field independence/dependence) as well as abilities and aptitudes were associated with visual and bimodal event-related potential
amplitudes in the right hemisphere at temporal, parietal and occipital sites and/or in the left hemisphere at frontal and parietal areas.

In summary, results of several studies demonstrate the construct validity of brain event-related potentials as indicators of human cognitive processing. Research (Goodenough, 1976; Witkin & Goodenough, 1977; Goodenough, 1978) has differentiated the characteristics of relatively field dependent and independent individuals. Field dependence when compared with field independence is related to lesser ability in perceptual and cognitive restructuring; use of an intuitive (spectator) rather than a hypothesis-testing (active) approach in problem solution; lesser ability to overcome embedding context and to separate salient from irrelevant cues in perceptual tasks; lesser ability to remain task-oriented and more functional fixity in problem solution; lower level of accuracy and a tendency to be slower in perceptual closure tasks (Barrett & Thornton, 1968; Vinicki, 1974; Rotella & Bunker, 1978). Considering the cognitive style characteristics of field dependency/independency, and reflecting upon the theoretical paradigm of the P300 waveform that this indexes decision making and context revision process, it is reasonable to explore the possibility that the P300 waveform identified by amplitude and latency will be differentially related to field dependent and field independent individuals. Based on research findings discussed earlier in this section, it
is expected that P300 amplitude will be significantly smaller and P300 latency will be significantly longer for field dependent individuals as compared with field independent individuals. Differences will also be expected in the reaction time and the level of accuracy on the Stroop task and the Color-Block task between field dependent and field independent individuals. Field dependent individuals will demonstrate longer reaction time and lower accuracy level as compared with field independent individuals (Barrett & Thornton, 1968; Rotella & Bunker, 1978). Hence, the relationship of brain event-related potential and field independence/dependence as one facet of mental individuality merits attention.

P300 NON-COGNITIVE PROCESSES

From the foregoing it becomes clear that great emphasis has been given to the study of cognitive processes, although not to cognitive mediation processes such as cognitive styles, in relation to the P300 component. It is also apparent from the review of the related literature that the generation of appropriate responses in a particular environmental situation which essentially incorporate thinking and learning in cognitive actions may be quite different between two individuals. The variations in response to identical situations may be due to variations in affective and motivational levels. Sherrington (1940) asserted that "every cognition has, potentially at least, an emotive value and along with that, conative effort as a
further factor." According to Begleiter et al. (1983), "Complex cognitive processes, therefore, involve differing degrees of emotionality." In relation to the P300 waveform, it has not been demonstrated how much cognitive processes can be clearly delineated from other critical processes such as motivation, anxiety, or stress occurring simultaneously in the organism. Greater emphasis on cognition has virtually neglected the study of affective processes as potentially important determinants of the P300 amplitude and latency. In fact, as Begleiter et al. (1983) state, "the cognitive process of determining the 'meaning' or 'significance' of stimuli must of necessity possess a fundamental and critical emotive aspect."

**P300 and Motivational Direction**

During the last two decades, efforts have been made to designate the brain areas responsible for the analyses of the motivational content of the stimuli. Fuster and Uyeda (1971) associated such a function with limbic system activity. Other neuropsychological investigations (Heath, 1976) have shown beyond any question that the limbic system is the seat of emotional control in the brain. A theoretical view that relates attending behavior and effort to task expectancies and a theoretical impact that led to a conceptual and cognitive turn in physiological psychology was brought forth by Pribram and McGuiness (1975). They postulated a hippocampus-centered effort system that modulates the electrocortical arousal. Support for Pribram's view
has come from the work of Halgren, Squires, Wilson, Rohrbaugh, Babb and Crandall (1980) who have reported that the hippocampus is a possible generator of scalp recorded P300 component. Similar evidence has been presented by Okada, Kaufman and Williamson (1983) who found hippocampal formation to be the active source of the endogenous potentials at the scalp.

From the available literature, Begleiter et al. (1983) postulated that the P300 late positive component "indexes the subjective motivational properties of environmental stimuli." Various studies (Hombert, Gerhard, Gruenwald, & Gruenwald-Zuberbier, 1981; Begleiter et al., 1983) examined the relationship of stimulus incentive value such as different levels of monetary payoff on the P300 component. The results indicate that the P300 was significantly larger in the higher than in the lower payoff conditions. Based on the evidence that a P300 is generated in the hippocampus and associated brain structure (Okada et al., 1983) and its functional role in human neurocognition is that of updating memory (Donchin, 1981) and indexing the subjective motivational properties of stimuli, Begleiter et al. (1983) hypothesized that events that elicit a P300 will be recalled better than those events which do not elicit a P300.

Since the neurophysiological measure of the P300 waveform is reported to be sensitive to aspects of information processing as they occur in the brain, there have been studies done using the P300 amplitude and latency measures as indicators of
differences in information processing abilities between populations of different cognitive and motivational levels (Roth, Pfefferbaum, Hovrath, Berger & Kopell, 1980; Simons, 1982). Taken collectively, these studies indicate that smaller P300 amplitude in populations with aberrant motivational levels (anhedonics, schizophrenics) as compared to normal populations represents a deficit in general mobilization to react to, selectively attend to and identify unexpected, significant stimuli. The consistent demonstration of differences in the amplitude and latency of a P300 between the populations with affective disorders or clinical anxiety states, and the normal subjects may encourage one to hypothesize that affective variations may be playing a significant role. Butler and Mathews (1985) showed that with normal subjects "a generalized inflation of subjective risk across a range of events is particularly characteristic of those with high trait anxiety" somewhat similar to that experienced by the individuals experiencing clinical anxiety states. This raises the possibility of differential effects in terms of the electrophysiological endogenous measures in normal subjects showing high levels of anxiety as compared to those with low levels of anxiety. Research (Hamilton, 1985) on human anxiety confirms the detrimental role of high, and not necessarily pathological, anxiety in many types of performances. It, therefore, appears that differential P300 event-related potential effects may be obtained in normal subjects with varied levels of
anxiety when these subjects are required to perform certain types of cognitive tasks in an evaluative situation. Hence the relationship of the P300 event-related potential and high/low levels of anxiety merits attention.

**Anxiety and Electrophysiology**

Anxiety is a complex phenomenon that has been studied extensively and refers to a mood, an affect, a personality trait, a symptom, a syndrome and an illness. The variations in the intensity, frequency or persistence of anxiety determines its level of normality, as experienced by all of us at some time or another, or abnormality. It is generally believed that pathological abnormal anxiety differs from induced anxiety in normally calm individuals only with respect to degree and not in a qualitative way (Butler & Mathews, 1985).

The current psychological literature proposes that anxiety is a cognitive process with expectancy as a primary element (Epstein, 1972; Mandler, 1974). Anxiety occurs when a subject is unable to anticipate and control relevant stimuli. Several attempts have been made to establish the manner and the cause of changes, mostly in terms of deficits in information processing and in the utilization of signs, signals, and cues or messages. Easterbrook (1959) interpreted results on the restriction in the range of cues utilized with increases in emotions in terms of motivational concentration. He hypothesized that high anxiety reduces the range of cue utilization.
Text anxiety theory (Sarason, 1975) has specifically attributed an anxiety deficit to self-preoccupation during the study with monitoring of task irrelevant events interfering with the study of task relevant material.

The individual sees himself or herself as ineffective in handling or inadequate to the task at hand. The individual focuses on undesirable consequences of personal inadequacy. Self-deprecatory preoccupations are strong and interfere or compete with task relevant cognitive activity (Sarason, 1975).

With this limited capacity system, the relevant information is processed or it is encoded in a more superficial manner perhaps with less elaboration. The outcome would be a functional reduction in the range of attention. Wine (1971) proposed an attentional interpretation of the adverse effects that test anxiety has on performance. She suggested that highly test anxious subjects perform poorly during task performance because they tend to divide their attention between self-relevant and task-relevant matters. In contrast, low test anxious subjects focus more of their attention on the task at hand. The differences in performance among high- and low-test anxious individuals are enhanced if the task in question is difficult or complex, and/or if the test is taken under conditions that increase subject's evaluation apprehension.

Spielberger (1966; 1972) has distinguished between two different anxiety constructs: state anxiety (A-state) and trait anxiety (A-trait). A-state is defined as a transitory emotional
state that varies in intensity, fluctuates over time and is characterized by feelings of tension and apprehension and by heightened activity of the autonomic nervous system. A-trait refers to relatively stable individual differences in anxiety proneness, that is, to differences in disposition to respond to situations perceived as threatening with elevations in the intensity of state anxiety (Spielberger, Gorsuch & Lushene, 1970).

As Spielberger has demonstrated, two important classes of stressors can be identified which have different implications for the evocation of A-state reactions in individuals differing in A-trait: situations that pose direct or implied threats to self-esteem, and situations characterized by physical danger. According to Spielberger, fear of failure is a major characteristic of high A-trait people. They would, therefore, be likely to perceive stress situations which involve failure or threats to self-esteem as more threatening than would low A-trait people. Thus, differential elevations in A-state would be expected for people who differ in A-trait when exposed to ego-involving situations. On the other hand, situations characterized by physical danger usually do not pose any threat to self-esteem and, therefore, should produce differential A-state elevations for individuals who differ in A-trait.

Hamilton points out the necessity of clarifying the interference of anxiety with an externally presented task. He
points out that highly anxious individuals are predisposed towards:

(a) low retrieval thresholds for these data; (b) excessive elaboration of these structures through autonomous self-stimulation; (c) external scanning for subjectively aversive stimuli rather than objective relevance; (d) excessive deployment of matching processes for the identification and recognition of short-term memory input (Hamilton, 1979, p. 396).

Hence, the amount of processing space and time available for "objective situational requirements" is curtailed by high anxiety. The capacity to process adaptively relevant cognitive data becomes reduced when effort to cope simultaneously with anxiety absorbs the spare processing capacity of the system. According to Hamilton (1979), additional demands are made on the information processing system at the short-term memory stage and at the response selection and execution stage. There is an excessive load in information processing due to stimulus and response uncertainty. Hamilton (1979) postulates that the range and amount of information encountered in an information processing system is increased rather than decreased by high anxiety. The explanation is that relevant and irrelevant, central and peripheral cues, task relevant and "affect" relevant information, are simultaneously present and scrutinized and this hampers uncertainty resolution. The usual indicators of anxiety effects have been increased reaction time and numbers of errors of omission or commission. In a study (Hamilton, 1976) with 7-9 year old low and high test anxious children, it was demonstrated
that on the task of visual reaction time and simultaneous digit rehearsal and recall, high test anxious children performed significantly worse than low anxious children.

As was stated previously, the amount of electrocortical arousal is regulated by the hippocampus via the midbrain which maintains internal stability by diminishing the response to most repeated events in the internal and external world (Pribram & McGuiness, 1975). This recognition of a state of mismatch between actual input and expected input by the hippocampal formation and consequent changes in hippocampal output, implies that there is some sort of storage of information about stimulus matches and mismatches. This division of effort and attention to simultaneous matching/recognizing processes according to Kahneman (1973) would place a strain on available capacity, and high anxious people should demonstrate, therefore, a greater impairment with all problems of regulation.

In recent years, investigators have looked at electrophysiological changes, anxiety states and attention (Sayer & Torres, 1966). Proulx and Picton (1984) in a study on the effects of anxiety on the event-related potentials conclude that high anxious subjects had some inherent difficulty in perceiving extrinsic stimulus organization and establishing appropriate expectancies and would experience anxiety before discovering the appropriate response strategy.

In another study, Chattopadhyay, Cooke, Toone and Lader (1980) looked at the effects of threat-of-shock and no-threat
condition with respect to low and high anxiety levels on P300 event-related potential. An "oddball paradigm" in which 288 frequent and 32 infrequent tones (pure tones of 1000 or 1400 Hz of 50 msec duration with an interstimulus interval of 2 secs) were delivered in random order. For the elicitation of auditory evoked responses, bilateral temporoparietal placements were used, Cz-C3 and Cz-C4 respectively.

The results indicated that the amplitude of the P300 component to both frequent and infrequent stimuli was greater in the high anxious than in low anxious subjects. The effects were much more marked on the P300 waves elicited by the infrequent (p<0.05) than the frequent stimuli (p<0.01). It is pertinent to emphasize here that this study used threat-of-shock as a stressor, which according to Spielberger (1972) can be more threatening to low anxious subjects than to high anxious subjects. The latter, on the other hand, are threatened more by ego-involving instructions. Saltz (1970) also supported that low anxious subjects tend to perform more poorly under threat of physical pain than do high anxious subjects. As stated by Chattopadhyay et al. (1980), the results of their own study do not present clear-cut patterns, perhaps because the experimental techniques and stimulation procedures were of necessity complex. Nonetheless, studies involving the P300 component of the average evoked potential seem worth pursuing.

According to these authors, perhaps the central correlates of the orienting response are affected by different levels of anxiety.
In recapitulating this section, it appears that in high anxious individuals, the interference and distraction caused by ego-involvement and task irrelevant information, competing for finite processing, results in additional loads on short-term processing and/or response integrating components and intrusion by less dominant stimuli from external and internal sources of information. The consequences of distraction appear to be impaired concentration, and this in return may result in reduction of the size of evoked potentials. In other words, high anxiety places limitations on the capacity to process relevant and irrelevant information. The task-irrelevant self-monitoring that the high anxious subjects are said to do (Sarason, 1975) ought to interfere with deep and elaborate encoding and retrieval of information, and selection and execution of responses and this reflects a qualitative difference between high and low anxious subjects (Mueller, 1979). Looking at this conceptual basis, one may hypothesize that in high anxious individuals, the size of the P300 event-related potential component which is associated with relevance of stimuli, selective attention, confidence in decision making and uncertainty resolution in a discrimination task, will be significantly smaller in high anxious than in low anxious individuals. Also, the latency of P300 will be significantly longer for high anxious as compared with low anxious individuals. Differences will be also expected in the reaction time and the level of accuracy between high anxious and low anxious individuals.
individuals. High anxious individuals will demonstrate longer reaction time and lower accuracy level as compared with low anxious individuals (Hamilton 1976, 1979).

**RELATIONSHIP BETWEEN COGNITIVE STYLE AND ANXIETY**

Hamilton (1985) attempted to develop a cognitive model of anxiety and made an effort to give a dynamic interpretation of the relationship between cognition and emotion; that is, on the interdependence of cognition and emotion. According to him, anxiety should be considered as a particular set or network of connotative data, which on the basis of past experience and autonomous elaboration of their cognitive structures, provide a store of long-term memories. The interaction of one particular personality and motivational system—anxiety—with external situations is governed by cognitive mediating processes which integrate external-temporary and internal-more durable goal-directed processes. (p. 19)

One such mediating process which may be a potential guide to explain the question "Why do different individuals perceive (or learn or remember) the same environmental stimulus differently?" is termed "cognitive style". As indicated earlier, this construct refers to the consistent mode in which an individual filters and processes and organizes objective stimuli and translates these into meaningful dimensions. One of the most extensively studied approaches to cognitive styles which continues to be a prominent variable in personality research is that of field dependence/independence as developed by Witkin and his colleagues (Witkin, Dyk, Faterson, Goodenough & Karp, 1962). According to
Witkin et al. (1962) persons who are "field dependent have many features which seem common to the anxiety prone group."

In reviewing different studies on the relationship between anxiety/stress and field dependence/independence, Goodenough (1976) concluded that the adverse effect of stress on memories was noted to be greater in field dependent subjects than field independent subjects. The latter are less affected by changes in the affective atmosphere created by the experimenter in respect to positive feedback and criticism (Cooperman, 1974). Externally imposed stress conditions in testing tend to cause a greater performance decrement for field dependents than field independents possibly because they may have difficulty screening out irrelevant aspects of the perceptual field (Sarris, Heinken & Peters, 1976).

In examining the studies done by Knott and Irwin (1968), Tecce (1972), Knott, VanVeen, Miller, Peters and Cohen (1973) and Froehlich and Glanzmann (1984) on the relationship of anxiety and the event-related potentials, differential effects were noted as a result of different levels of anxiety and stress. These investigators suggest that further study will show a relationship between "distraction" and "stress"; "distraction" and "anxiety"; and possibly between "anxiety", "distraction" and "field dependency". Hence, they hypothesized that these constructs may have some electrophysiologically common features along with overt behavioral manifestations. It is possible that differential
effects of these constructs may be reflected in the variations of
the magnitude and latency of the P300. This may encourage one to
explore the predictive contributions of cognitive style and trait
anxiety to P300 amplitude and latency as well as reaction time
during the performance of perceptual discrimination tasks.

SUMMARY/HYPOTHESES

A considerable body of literature dealing with electrophys­
iology and cognitive styles (field dependence/independence) and
anxiety suggests the possibility of differential effects in terms
of electrophysiological endogenous measures in normal populations
with varied levels of anxiety (high-low) and styles of cognitive
processing (field dependence/independence) performance of certain
types of tasks. The literature reviewed specifically indicates
that a relationship exists between the P300 waveform (amplitude
and latency) and cognitive processing. P300 amplitude and latency
are affected by the complexity of the stimulus and the level of
probability of its occurrence by the subject. It is noted from
this review that the decision confidence and uncertainty
resolution in context revision process of an individual's
cognitive expectancies concerning future events may be manifested
in the P300. This waveform reflects the relative duration of
stimulus evaluation processes while being independent of the
duration of response processes. Theory and research (Sutton et
al., 1965; Rohrbaugh et al., 1974; Squires et al., 1975; Duncan­
Johnson & Donchin, 1982) lead us to believe that the lesser the
decision confidence in contextual updating, the smaller the P300 amplitude; the longer the time required to categorize an event for contextual updating, the longer the P300 latency. Scrutiny of these covert responses (P300 amplitude and latency) will supplement the knowledge of different stages of information processing currently assessed by overt responses (reaction time and levels of accuracy). This additional information may provide the bases of describing when (latency), where (brain location), and how much (amplitude) such differences are reflected and how performance accuracy is affected by such differences (Strandburg, Marsh, Brown, Asarnon & Guthrie, 1984, p. 236)

Evidence has been presented to establish the idea that electrophysiological changes of brain functioning are probably correlated with cognition and affect. References (Goodenough, 1976; Witkin & Goodenough, 1977a; Goodenough, 1978) have been made to cognitive style characteristics of field dependence/independence and their possible differential effects on the P300 amplitude and latency. That is, it would be expected that P300 amplitude will be significantly smaller and P300 latency will be significantly longer for field dependent individuals as compared with field independent subjects. The implication of qualitative differences between high and low trait anxiety (Mueller, 1979) may lead to differences in the neurophysiological responses as indicated in the variations in P300 amplitude and latency. It would be expected that P300 amplitude will be significantly
smaller and P300 latency significantly longer in high anxious individuals as compared with low anxious individuals.

Cognitive psychologists typically rely on information processing models and cognitive styles dimensions to explain cognitive functioning. Research is on the threshold of combining what have, heretofore, been diverse areas of inquiry; personality dimensions reflected by anxiety; cognitive stylistic approaches to problem solving; and neurophysiology. Research on the relationship of cognitive style and anxiety (Goodenough, 1976; Sarris et al., 1976) and some of the electrophysiological studies (Knott et al., 1973) have suggested the possibility of differential effects in terms of event-related potentials in normal populations with different stylistic cognitive processing (field dependence/independence) and varied level of anxiety (high-low) during the performance of certain types of tasks. It is possible that differential effects of both these constructs may be reflected in the variations of the magnitude and latency of the P300. This theory and research encourages us to investigate and evaluate the following hypotheses:

I. There will be significant differences in the P300 waveform amplitude scores and latency scores at each of the four scalp locations (Pz, Cz, LW and RW) as a function of cognitive styles and/or trait anxiety (smaller P300 amplitude scores and longer latency scores for field dependence and high anxiety as compared with field independence and low anxiety) during the performance of the Stroop task.

II. There will be significant differences in the P300 waveform amplitude scores and latency scores at each of the four scalp locations (Pz, Cz, LW and RW) as a function of cognitive styles and/or trait anxiety (smaller P300 amplitude scores and longer
latency scores for field dependence and high anxiety as compared with field independence and low anxiety) during the performance of the Color-Block task.

III. There will be significant differences in the reaction time scores during the performance of the Stroop task and the Color-Block task as a function of cognitive style and/or trait anxiety (longer reaction time scores for field dependence and high anxiety as compared with field independence and low anxiety).

IV. There will be significant differences in the level of accuracy (number of false positives and number of misses) during the performance of the Stroop task and the Color-Block task as a function of cognitive styles and as a function of trait anxiety (lower level of accuracy for field dependence and high anxiety as compared with field independence and low anxiety).

The present study, then, attempts to examine in an exploratory fashion the functional significance of the P300 event-related potential waveform when this is measured on 11-12 year old subjects who have varied cognitive styles (field dependence/independence) and different levels of anxiety (high-low) during their performance on cognitive tasks in an evaluative situation. As is noted in this chapter, the literature review provides support for a specific cognitive view of the P300 event-related potential waveform, emphasizing that this component reflects active contextually-induced cognitive processing of stimuli. However, little attention has been given to the effects of different affective inclinations of the subjects who have varied cognitive modes of processing information. This study is an effort to assess the cognitive-affective effects in terms of electrophysiological manifestations (P300 event-related potential waveform) at central and lateral brain sites. Taken collectively,
the theory and research presented in the four sections of this chapter encourages us to investigate the hypotheses listed above.
CHAPTER III

METHODODOLOGY

THE SAMPLE

The final sample of subjects consisted of twenty volunteer males age 11-12 years (mean age: 11 years 5 months; range: 11 years 1 month - 12 years 6 months) from schools located in a middle class rural and suburban neighborhood, contiguous to a large midwestern city. To obtain the volunteers for this investigation, the directors of the school were approached. The procedures and the requirements for the study were explained to them. In order to obtain this final sample the following paper-pencil instruments were administered to seventy-nine subjects.

INSTRUMENTATION

1. State-Trait Inventory for Children (Spielberger, 1973) (Appendix A)

The State-Trait Inventory for Children measures two anxiety constructs: State and trait anxiety. This was developed as a research tool for the study of anxiety in elementary school children.
The State-Trait Inventory for Children—Anxiety State scale consists of 20 item statements that ask children how they feel at a "particular moment in time". This scale is designed to measure transitory anxiety states. The State-Trait Inventory for Children—Anxiety Trait scale consists of 20 item statements that ask subjects how they "generally feel". This scale measures relatively stable individual differences in anxiety proneness. This inventory was designed for self-administering and has no time limits. Generally it requires eight to twelve minutes to complete either scale and less than 20 minutes to complete both. This can be administered to a group and requires scaled responses. For example, the respondent may choose either hardly ever, sometimes or often, which are assigned values of 1, 2 or 3. Hence, the scores on either the A-State scale or A-Trait scale can range from a minimum of 20 to a maximum of 60. A high score indicates high anxiety whereas a low score is indicative of low anxiety.

2. The Group Embedded Figures Test (Oltman, Raskin & Witkin, 1971) (Appendix B)

This instrument is an adapted form of the original Embedded Figures Test to enable group testing. This test requires the subject to find a simple form when it is hidden within a complex pattern. This is a test of field dependence/independence in perception, a measure of non-verbal analytic ability which assesses the subject's ability to select relevant information.
assesses the subject's ability to select relevant information, ignoring the distracting elements, disembedding the specified simple form from the complex figure. This test contains three sections. The first section consists of seven very simple items primarily for practice (time limit two minutes). The second and third sections, each of which contains nine more difficult items, have a time limit of five minutes for each of the two sections. The score is the total number of simple forms correctly traced in the second and third sections combined. In order to receive credit for an item, all lines of the simple figure must be traced, no extra lines added and that all incorrect lines have been erased.

3. Edinburgh Handedness Test (modified version)
(Appendix C)

The original handedness questionnaire consisting of 23 items was published by Raczkowski, Kalat and Nebes (1973). In the present study the hand dominance of the subjects was ascertained by the administration of the modified version of this test as used at the Brain Behavior Laboratory at Ohio State University. Demonstrated use of the same hand for 13 out of 16 performance items served as the criterion for hand preference. Only subjects who demonstrated firm righthanded preferences in at least 13 out of 16 performance items were included in this study.
SAMPLE SELECTION

Phase I:

Letters (Appendix D) explaining and seeking consent for participation in the study were sent to the parents of 285 male students between the ages of 11 and 12, attending school located in a middle class suburban neighborhood, contiguous to a large midwestern city. Eight-one students received permission from their parents to participate in Phase I of the study. In accordance with the school criterion levels, 79 of these students were classified as "normal students" participating in the regular curriculum and were therefore chosen to participate in Phase I. School medical records indicated that these children have vision and hearing within normal limits.

All 79 students were gathered in the school multi-purpose room for administration of the group tasks. Procedures and requirements for the entire study were explained to the students and their consent to participate in the study was indicated by their signature on the Subject Consent Form (Appendix F). The State-Trait Inventory for Children and the Group Embedded Figures test were administered to all 79 children. Upon completion of these tasks children were individually administered the Edinburgh Handedness Test.

In order to establish high and low trait anxiety an extreme group design was implemented. According to Cronbach and Snow (1977), "treating upper and lower thirds of the population, or
upper and lower quarters is appreciably more powerful than a study with the same distributed over the full aptitude range." According to them, "The median split wantonly discards power." Subjects were selected based on their inclusion in either the upper or lower third of the anxiety distribution.

This selected sample of high and low trait anxious subjects were further grouped according to their cognitive styles (field dependence/independence). Once again, those scoring in the upper and lower thirds of the Group Embedded Figures Test distribution were considered as representatives of the two extremes of field dependence/independence (high scores reflecting field independence and low scores indicative of field dependence).

Hand dominance was determined through the administration of a modified Edinburgh Handedness Test (adapted by Raczkowski, Kalat & Nebes, 1973). Only subjects who demonstrated firm righthanded preferences in at least 13 out of 16 performance items were included in this study.

Using the above stated criteria, a total of 33 male subjects were selected who were righthanded, of normal intelligence (per school records) and who fell under one of the following categories:

1. Low Anxious - Field Independent
2. High Anxious - Field Independent
3. Low Anxious - Field Dependent
4. High Anxious - Field Dependent
These 33 subjects were then eligible to participate in Phase II of the sample selection.

Phase II Sample Selection:

A second letter (Appendix E) was sent to the parents of the 33 students selected. This letter explained in detail the data collection procedures and the purpose of the study. The final sample consisted of 20 male subjects, between 11 and 12 years old who were right hand dominant and could be classified according to anxiety (high or low) and cognitive style (field dependence-independence). Thus, five subjects represented each of the following categories:

- Low Anxious - Field Independent n = 5
- High Anxious - Field Independent n = 5
- Low Anxious - Field Dependent n = 5
- High Anxious - Field Dependent n = 5

**INSTRUMENTATION FOR DATA COLLECTION IN THE FINAL PHASE**

During data collection the following tasks were presented by an Apple II microcomputer via an Amdek color monitor.

The Stroop Color-Word Test originally used by Comalli, Wapner and Werner (1962) as "a measure representative of the capacity to maintain a course of action in the face of intrusion by other stimuli" was adapted for presentation by computer. The Stroop presents color words (Red, Blue, Yellow) printed in the same or different ink colors. The subject is required to respond to a particular color-word disregarding the ink color in which
the word is presented. For example, the word "blue" may be printed in red ink. The Stroop has been suggested as reflecting cognitive style as well as cognitive attitudes (Comalli, Wapner & Werner, 1962). In the "oddball" design version used for this study, the three color-words "blue", "yellow" and "red" were used. Each of these color-words was presented in the different ink colors, e.g., the word "red" displayed in "yellow" ink color.

The colors changed with each presentation of the stimulus. The "infrequent", "task relevant" stimulus was the word "blue", regardless of the ink color. The subject was required to press the response button whenever the target stimulus flashed on the screen. This task was interpreted as a measure of verbal analytic ability and selective attention processing by picking out relevant information and ignoring the distracting elements. The subject who is able to attend to the color-word rather than be distracted by the ink color itself would make fewer errors than the one who could not disregard the intrusion.

2. Color-Block Task

The second "oddball" paradigm administered, the Color-Block Task, consists of two 12.5 cm by 12.5 cm colored blocks, one red and the other blue, presented separately. This task has also been modified for presentation by computer. The subject was required to press the response button whenever the infrequent task-relevant stimulus (red block) appeared on the screen. This task
was interpreted as a non-verbal analytic measure since the task required discriminative configurational processing.

Two event-related potential tasks of "oddball" design which elicit the P300 waveform were administered in this study. In the case of each task (Stroop and Color-Block), stimuli were presented in random order, one frequently and the other infrequently. The subject was required to press a button with the dominant hand (right hand in the present study) whenever the infrequent (task relevant) stimulus was presented. The infrequent stimulus was presented 20% of the time in each of these tasks. It is the identification of the infrequent stimulus which accounts for the use of the term "oddball" to describe this paradigm.

EQUIPMENT

The oddball paradigms, as used with the Stroop Color-Word and Color-Block measures, were presented by an Apple II microcomputer via an Amdek color monitor. This computer and its controller box were used to signal an Apple IIe microcomputer with a Cyborg Isaac A/D convertor to collect data. The two computers operated synchronously through connections between the annunicator output of the former computer and the analog input of the latter. This system allowed for a summation into a composite waveform of raw EEG data collected from five polygraph channels each time an infrequent "task relevant" stimulus was presented to the subject. Data were digitized and stored on diskettes for later analysis. The data were collected in epochs of one second
duration. In addition, the Apple IIe microcomputer monitored eye artifact in order to ensure that the data were due to brain activity and not eye muscle movement.

Scalp electrical activity was recorded with non-polarizable electrode sensors from Pz (parietal zone) and Cz (central zone) brain sites in accordance with the International 10-20 system (Jasper, 1958) (Appendix J) and at scalp locations over Wernicke's area and the right hemisphere homologue with reference to linked mastoids. Approximate locations of Wernicke's (language zone of the left hemisphere, and right homologue) as per the system (Appendix J) followed at the Brain Behavior Laboratory, Ohio State University, were used since the International 10-20 system does not specify these. These two electrode sites will be referred to as left and right Wernicke's or left and right temporoparietal electrodes (LW and RW). Vertical and horizontal electroculograms (EOGs) were recorded to facilitate editing the results for eye artifact. Electrodes were placed at the outer canthus of the right eye and supraorbital ridge of the left eye. Grounding was achieved through a central forehead electrode. Brain electrical response data were collected and amplified using a Beckman Accutrace eight channel polygraph from each of the specified scalp locations in one second epochs which began 240 msecs before the presentation of the "task relevant" stimulus and with 760 msecs post-stimulus interval. Electrode impedance was checked to be below five KOhms. Rejection of artifact was accomplished by setting low and high bandpass filters at
0.5 Hz and 35 Hz, respectively. The data on a total of 39 task relevant stimuli were collected and stored on floppy diskettes for off-line analyses. The artifact free epochs were averaged to generate average event-related potentials for each of the four active EEG channels. Most average waveforms consisted of 20-30 epochs and none had less than 19 epochs. In addition to the recording of brain electrical activity from the four locations, the stimulus markers (corresponding to the stimulus presentation on the screen) and button press response were produced on the polygraph write up to the two types of stimuli stated above.

DATA COLLECTION PROCEDURES

After parental consent (Appendix F) to record brain activity had been obtained, each subject in this select sample was requested to come to the Brain Behavior Laboratory in the Nisonger Center at the Ohio State University.

On the lab premises, initially a brief explanation was given to each of the subjects and his accompanying parent regarding the aims, requirements and the apparatus to be used and any risks involved in the second stage of this study to each of the subjects and their accompanying parent. Both the subjects and the parents were free to ask questions about the apparatus and the study itself. Then the parent was required to complete a consent form (Appendix G) before the procedure began. The subject was also required to sign a form giving consent to record brain activity with scalp electrodes. After the electrodes were placed
on the scalp in accordance with the standard procedures of electrode application, the subject was seated in a quiet room directly in front of a video color monitor (approximately 36 inches from screen to eyes). A response panel with a button was given to the subject with the instructions to press the button with the thumb when the target stimuli appeared on the screen.

After the experimenter had explained the specific requirements for each of the two tasks, the subject was generally instructed that this was an important test of his ability level and it was important that he perform extremely well. The subject was also instructed to look at the center of the screen, avoid blinking as much as possible especially while responding to the stimulus, avoid speaking and avoid any sudden sharp movements of the head and/or body. A demonstration session was held before each test session. Any questions regarding the protocol were answered at this time. Once the subject was ready a pair of headphones equipped with "white noise" were placed over the subject's ears to eliminate extraneous noise. Overhead lights were turned off to eliminate screen reflections. Each of the stimuli was centered on the TV screen. A three minute rest was given between the administration of the two tasks. The appropriate demonstration, requirements and instructions were given for the second task. Lastly, the subjects were debriefed after the data collection and any questions were answered.
An A-State scale of the State-Trait Anxiety Inventory for Children (Appendix A) was completed after the electrodes were placed on the scalp but before the general instructions to perform extremely well. This was then re-administered immediately after all the tasks were completed. This scale was administered twice in order to note the situationally induced anxiety before and after the task performance.

**ANALYSIS OF WAVEFORM**

The electroencephalographic (EEG) data were collected over a selected period of time (i.e., the timing for the stimuli presentation and behavior responses) in relation to specific synchronization pulses that time lock the averaging processes to these events. This was done in accordance with the experimental logic and timing modules used at the Brain Behavior Laboratory, Ohio State University. The amplified and filtered EEG data were stored along with the synchronization pulses on floppy diskettes for later analysis. The electrical brain activity which occurred after each signal marker which designated target stimulus onset and was artifact free, was summed, averaged and added to any previous target waveform. A maximum of 39 waveforms on each task for each subject were averaged in this manner using the Apple-Isaac computer system. A graph was generated for each subject on an Epson (Mx80-Ft) printer. The importance of controlling for eye blink and other muscle artifact was placed in this design. Rejection of artifact was accomplished by setting low and high
band pass filters at 0.5 Hz and 35 Hz, respectively. The final waveform that was transferred onto the diskette was displayed and manipulated by means of a cursor for each of the four brain locations (Pz, Cz, LW and RW) on the Stroop and Color-Block Tests. Waveform measurements of the amplitude and latency of P300 component of event-related potentials for each subject were obtained. The P300 waveform was identified as the most positive-going peak between 250 and 500 msecs after the target stimulus onset. The amplitude measure used was the height of the peak with respect to baseline. The baseline was established by taking an average of the beginning and end points, of the most positive peak greater than 250 msecs. The mean value in microvolts between these two points was subtracted from the microvolts value obtained at the mid-point of peak of the positive-going curve. The latency (or time after the stimulus presentation) was measured to the mid-point of this positive-going peak (values that appeared on the graph as per experimental logic used at the Brain Behavior Laboratory, Ohio State University.)

**STATISTICAL ANALYSES**

For each of the 20 subjects, five allocated to each of the four blocks (high anxious-field dependent; low anxious-field dependent; high anxious-field independent; low anxious-field independent, allocated on the basis of their scores on the State-Trait Anxiety Inventory for Children and the Group Embedded Figures Test) the P300 waveform amplitude and latency scores on
each of the four brain locations (Pz, Cz, LW and RW), reaction
time scores and level of accuracy (number of false positives and
misses) for the two types of stimuli presentations, Stroop task
and Color-Block task, were obtained.
I. The scores were analyzed to determine whether there were
significant differences in the P300 waveform amplitude and
latency at each of the four scalp locations (Pz, Cz, LW and RW)
as a function of cognitive style and/or anxiety (smaller P300
amplitude scores and longer latency scores for field dependence
and high anxiety as compared with field independence and low
anxiety) during the performance of the Stroop task.
II. The scores were analyzed to determine whether there were
significant differences in the P300 waveform amplitude and
latency at each of the four scalp locations (Pz, Cz, LW and RW)
as a function of cognitive style and/or anxiety (smaller P300
amplitude scores and longer latency scores for field dependence
and high anxiety as compared with field independence and low
anxiety) during the performance of the Color-Block task.

Data were analyzed using a two factor ANOVA. The two
independent variables were cognitive style (field dependent,
field independent) and trait anxiety with two levels (high
anxiety, low anxiety). The dependent variables were amplitude
scores and latency scores at each of the four scalp locations
(Pz, Cz, LW and RW) on the Stroop task and Color-Block task.
Separate ANOVAs were computed for each of the dependent variables, amplitude and latency on each of the two tasks.

This design produced information regarding significant differences for main effects (field dependent vs. field independent; high anxiety vs. low anxiety) and interaction effects. Post hoc or follow up tests were employed to determine which of the pairwise comparisons contribute to the significant F-test if significance was obtained in the interactions.

III. The scores were also analyzed to determine whether there were significant differences in the reaction time scores during the performance of the Stroop task and the Color-Block task as a function of cognitive style and/or anxiety (longer reaction time scores for field dependence and high anxiety as compared with field independence and low anxiety).

The data were analyzed as for I and II above, but this time reaction time was the dependent variable.

IV. The frequency data were analyzed to determine whether there were significant differences in the level of accuracy (number of false positives and number of misses) during the performance of the Stroop task and the Color-Block task as a function of cognitive style and/or anxiety (lower level of accuracy for field dependence and high anxiety as compared with field independence and low anxiety). In this case since the focus was on nominal data, these were analyzed using a non-parametric test of significance of a difference between uncorrelated proportions of
equal sample size. The statistical analysis involved a pairwise comparison of proportions. Separate results were calculated for each of the dependent variables.

A paired t-test was used to assess the differences between 1) State Anxiety scores of pre-task performance, and 2) State Anxiety scores of post-task performance.

All major analyses were performed using the SAS computer program. The significance level of $p<.05$ was set for rejecting the null hypotheses.
CHAPTER IV
RESULTS

The present chapter is concerned with the analysis and presentation of data pertinent to this study. The main purpose of this study was to examine the functional significance of the P300 component of event-related potential when this is measured on 11-12 year old subjects who have different levels of anxiety (high-low) and cognitive style (field dependent/independent) during their performance of specific cognitive tasks in an evaluative situation. The balance of this chapter will address each of the research hypotheses stated for this study and present the findings from specific statistical analyses.

Hypothesis I
There will be significant differences in the P300 waveform amplitude scores and latency scores at each of the four scalp locations (Pz, Cz, Lw and Rw) as a function of cognitive styles and/or trait anxiety (smaller P300 amplitude scores and longer latency scores for field dependence and high anxiety as compared with field independence and low anxiety) during the performance of the Stroop task.
For the purpose of testing this hypothesis, data were analyzed by using a two factor ANOVA. The two independent variables consisted of two modes of cognitive processing (field dependent-field independent) and trait anxiety with two levels (high anxiety and low anxiety). The dependent variables were 1) P300 waveform amplitude scores at each of the four scalp locations (Pz, Cz, LW and RW) on the Stroop task; 2) P300 waveform latency scores at each of the four scalp locations (Pz, Cz, LW and RW) on the Stroop task. Separate ANOVAs were computed for each of the dependent variables, P300 amplitude scores and latency scores.

Results for Amplitude

Table 1 summarizes the results of the two factor ANOVA of P300 amplitude scores at the scalp location Pz on the Stroop task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 5.
TABLE 1

ANOVA of P300 Amplitude Scores at Scalp Location Pz on the Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>61.952</td>
<td>61.952</td>
<td>3.02</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>147.425</td>
<td>147.425</td>
<td>7.18*</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>6.272</td>
<td>6.272</td>
<td>0.31</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>328.371</td>
<td>20.523</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>544.020</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05

Inspection of Table 1 shows that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) the significant main effect of trait anxiety was obtained for the P300 amplitude scores at the scalp location Pz on the Stroop task.

Main Effect of Anxiety at Scalp Location Pz

The main effect of this variable (anxiety) was significant, F(1, 16)7.18; p<.05, indicating there was significant difference in the mean values of the P300 amplitude scores at the scalp location Pz, on the Stroop task with differences in levels of anxiety (low anxiety—17.61 comparatively larger P300 amplitude...
mean score, and high anxiety—12.18 comparatively smaller P300 amplitude mean score).

Table 2 summarizes the results of the two factor ANOVA of the P300 amplitude scores at the scalp location Cz on the Stroop task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 5.

**TABLE 2**

ANOVA of P300 Amplitude Scores at Scalp Location Cz on the Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>12.800</td>
<td>12.800</td>
<td>1.72</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>85.698</td>
<td>85.698</td>
<td>11.50*</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>23.328</td>
<td>23.328</td>
<td>3.13</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>119.219</td>
<td>7.451</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>241.045</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.005

Inspection of Table 2 indicates that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) the significant main effect of anxiety was obtained for the P300 amplitude scores at the scalp location Cz on the Stroop task.
Main Effect of Anxiety at Scalp Location Cz

The main effect of this variable (anxiety) was significant, \( F(1, 16) = 11.50; p < .005 \), indicating there was significant change in the mean value of the P300 amplitude scores at the scalp location Cz, on the Stroop task with change in the level of anxiety (low anxiety—8.87 comparatively larger P300 amplitude mean score, and high anxiety—4.73 comparatively smaller P300 amplitude mean score).

Table 3 summarizes the results of the two factor ANOVA of P300 amplitude scores at the scalp location LW on the Stroop task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 5.

### TABLE 3
ANOVA of P300 Amplitude Scores at Scalp Location LW on the Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>96.888</td>
<td>96.888</td>
<td>9.60**</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>133.025</td>
<td>133.025</td>
<td>13.19***</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>64.369</td>
<td>64.369</td>
<td>6.38*</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>161.418</td>
<td>10.089</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>455.700</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\* p < .05  
** p < .01  
*** p < .005
Inspection of Table 3 shows that significant main effects of cognitive style, anxiety and significant interaction of cognitive style and anxiety were obtained for the P300 amplitude scores at the scalp location LW on the Stroop task.

**Main Effect of Cognitive Style at Scalp Location LW**

The main effect of this variable (cognitive style) was significant, F(1, 16) 9.60; p < .01, indicating there was significant change in mean values of the P300 amplitude scores at the scalp location LW on the Stroop task with change in mode of cognitive processing (field independent—12.53 comparatively larger P300 amplitude mean score, and field dependent—8.13 comparatively smaller P300 amplitude mean score).

**Main Effect of Anxiety at Scalp Location LW**

The main effect of this variable (anxiety) was significant, F(1, 16) 13.19; p < .005, indicating there was significant change in mean values of the P300 amplitude scores at the scalp location LW on the Stroop task with change in levels of anxiety (low anxiety—12.91 comparatively larger P300 amplitude mean score and high anxiety—7.75 comparatively smaller P300 amplitude mean score).

**Interaction Effects of Cognitive Style and Anxiety at Scalp Location LW**

The interaction effects of the variables cognitive style and anxiety were significant F(1, 16) 6.38; p < .05. In order to determine which of the pairwise comparisons contribute to the significant F-test obtained in the interaction effects of anxiety
and cognitive style, Tuckey's HSD Test was employed. The analysis showed that for the P300 amplitude scores at the scalp location LW on the Stroop task, there were significant differences between the subjects who have characteristics of field independence–low anxiety (mean 16.90) and those who have characteristics of field dependence–high anxiety (mean 7.34); between the subjects who have characteristics of field independence–low anxiety (mean 16.90) and those who have characteristics of field independence–high anxiety (mean 8.15). The means for this analysis appear later on in Table 6.

Table 4 summarizes the results of the two factor ANOVA of the P300 amplitude scores at the scalp location RW on the Stroop task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 5.
TABLE 4
ANOVA of P300 Amplitude Scores at Scalp Location RW on the Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>45.150</td>
<td>45.150</td>
<td>4.14</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>12.090</td>
<td>12.090</td>
<td>1.11</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>58.653</td>
<td>58.653</td>
<td>5.38*</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>174.368</td>
<td>10.898</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>290.261</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05

Inspection of Table 4 indicates that of the three principal effects (cognitive style, anxiety and cognitive style x anxiety), the significant interaction effect for cognitive style and anxiety was obtained for the P300 amplitude scores at the scalp location RW on the Stroop task.

**Interaction Effects of Cognitive Style and Anxiety at Scalp Location RW**

The interaction effects of the variables cognitive style and anxiety were significant $F(1, 16)=5.38; p<.05$. In order to determine which of the pairwise comparisons contribute to the significant $F$-test obtained in the interaction effects of anxiety and cognitive style, Tuckey's HSD Test was employed. The analysis showed that for the P300 amplitude scores at the scalp location...
RW on the Stroop task, there were significant differences between the subjects who have characteristics of field independence–low anxiety (mean 14.60) and those who have characteristics of field dependence–low anxiety (mean 8.17). The means for this analysis appear in Table 6. This table also presents the standard deviations for the P300 amplitude scores at the four scalp locations (Pz, Cz, LW and RW) on the Stroop task by cognitive style and level of anxiety. Inspection of the cell-means reported in this table reflects a significantly greater positivity of P300 amplitude for field independence–low anxiety as compared with field dependence–high anxiety. In terms of the brain locations, there is a general pattern of greater positivity of the P300 amplitude noted at Pz in comparison with the other three brain sites, namely, Cz, LW and RW.
TABLE 5

Means of P300 Amplitude Scores at Four Scalp Locations (Pz, Cz, LW and RW) for Main Effect of Cognitive Style and Anxiety on the Stroop Task

<table>
<thead>
<tr>
<th></th>
<th>FI</th>
<th>FD</th>
<th>LA</th>
<th>HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pz</td>
<td>(A) 16.66</td>
<td>(A) 13.14</td>
<td>(A) 17.61</td>
<td>(B) 12.18</td>
</tr>
<tr>
<td>Cz</td>
<td>(A) 7.60</td>
<td>(A) 6.0</td>
<td>(A) 8.87</td>
<td>(B) 4.73</td>
</tr>
<tr>
<td>LW</td>
<td>(A) 12.53</td>
<td>(B) 8.13</td>
<td>(A) 12.91</td>
<td>(B) 7.75</td>
</tr>
<tr>
<td>RW</td>
<td>(A) 12.11</td>
<td>(A) 9.11</td>
<td>(A) 11.39</td>
<td>(A) 9.83</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location and variable, separately, are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious
TABLE 6

Means and s.d. of P300 Amplitude Scores at Four Scalp Locations (Pz, Cz, LW and RW) for Interaction Effect of Cognitive Style and Level of Anxiety on Stroop Task

<table>
<thead>
<tr>
<th></th>
<th>Pz</th>
<th>Cz</th>
<th>LW</th>
<th>RW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FI</td>
<td>FD</td>
<td>FI</td>
<td>FD</td>
</tr>
<tr>
<td>LA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s.d.</td>
<td>2.75</td>
<td>5.18</td>
<td>3.74</td>
<td>2.69</td>
</tr>
<tr>
<td>HA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s.d.</td>
<td>4.77</td>
<td>4.97</td>
<td>1.12</td>
<td>3.27</td>
</tr>
<tr>
<td>Means</td>
<td>13.38</td>
<td>10.98</td>
<td>4.45</td>
<td>5.01</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location separately, are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious

Results for Latency

Results of the two factor ANOVA of the P300 latency scores at each of the four scalp locations (Pz, Cz, LW and RW) on the Stroop task by cognitive style and level of anxiety yielded no significant findings (Appendix H—ANOVA Tables 27 to 30). The means for this analysis are reported in Tables 7 and 8. This table also presents the standard deviations for the P300 latency scores at the four scalp locations (Pz, Cz, LW and RW) on the Stroop task by cognitive style and level of anxiety.
# TABLE 7

Means of P300 Latency Scores at Four Scalp Locations (Pz, Cz, LW and RW) for Main Effect of Cognitive Style and Anxiety on the Stroop Task

<table>
<thead>
<tr>
<th></th>
<th>FI</th>
<th>FD</th>
<th>LA</th>
<th>HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pz</td>
<td>334.80</td>
<td>331.60</td>
<td>338.40</td>
<td>328.00</td>
</tr>
<tr>
<td>Cz</td>
<td>360.80</td>
<td>352.40</td>
<td>356.80</td>
<td>356.40</td>
</tr>
<tr>
<td>LW</td>
<td>339.20</td>
<td>338.40</td>
<td>350.40</td>
<td>327.20</td>
</tr>
<tr>
<td>RW</td>
<td>367.80</td>
<td>355.20</td>
<td>368.80</td>
<td>354.20</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location and variable, separately, are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious
TABLE 8

Means and s.d. of Latency Scores at Four Scalp Locations (Pz, Cz, LW and RW) for Interaction Effect of Cognitive Style and Level of Anxiety on Stroop Task

<table>
<thead>
<tr>
<th></th>
<th>Pz</th>
<th>Cz</th>
<th>LW</th>
<th>RW</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
</tr>
<tr>
<td>FD</td>
<td>325.60</td>
<td>330.40</td>
<td>359.20</td>
<td>353.60</td>
</tr>
<tr>
<td>LA</td>
<td>s.d.</td>
<td>43.23</td>
<td>46.09</td>
<td>60.69</td>
</tr>
<tr>
<td></td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
</tr>
<tr>
<td></td>
<td>Means</td>
<td>325.60</td>
<td>330.40</td>
<td>359.20</td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>53.78</td>
<td>72.13</td>
<td>79.88</td>
</tr>
<tr>
<td>HA</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
</tr>
<tr>
<td></td>
<td>Means</td>
<td>337.60</td>
<td>339.20</td>
<td>345.60</td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>53.78</td>
<td>72.13</td>
<td>79.88</td>
</tr>
</tbody>
</table>
( ) = Means with the same letter under each location separately, are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious

Hypothesis II

There will be significant differences in the P300 waveform amplitude scores and latency scores at each of the four scalp locations (Pz, Cz, LW and RW) as a function of cognitive styles and/or trait anxiety (smaller P300 amplitude scores and longer latency scores for field dependence and high anxiety as compared with field independence and low anxiety) during the performance of the Color-Block task.

For the purpose of testing this hypothesis, data were analyzed by using a two factor ANOVA. The two independent variables consisted of two modes of cognitive processing (field dependent-field independent) and trait anxiety with two levels (high anxiety-low anxiety). The dependent variables were 1) P300...
waveform amplitude scores at each of the four scalp locations (Pz, Cz, LW and RW) on the Color-Block task; 2) P300 waveform latency scores at each of the four scalp locations (Pz, Cz, LW and RW) on the Color-Block task. Separate ANOVA were computed for each of the dependent variables.

Results for Amplitude

Table 9 summarizes the results of the two factor ANOVA of P300 amplitude scores at the scalp location Pz on the Color-Block task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 13.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>113.050</td>
<td>113.050</td>
<td>4.72*</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>94.395</td>
<td>94.395</td>
<td>3.94</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>15.225</td>
<td>15.225</td>
<td>0.64</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>383.397</td>
<td>23.962</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>606.067</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<.05

Inspection of Table 9 indicates that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) the significant main effect of cognitive style was obtained for
the P300 amplitude scores at the scalp location Pz on the Color-Block task.

**Main Effect of Cognitive Style at Scalp Location Pz**

The main effect of this variable (cognitive style) was significant, $F(1, 16) = 4.72; p < .05$, indicating there was significant change in mean values of the P300 amplitude scores at the scalp location Pz, on the Color-Block task with change in mode of cognitive processing (field independent—17.50 comparatively larger P300 amplitude scores, and field dependent—12.70 comparatively smaller P300 amplitude scores).

Table 10 summarizes the results of the two factor ANOVA of P300 the amplitude scores at the scalp location Cz on the Color-Block task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 13.
Inspection of Table 10 indicates that of the principal effects (cognitive style, anxiety, and cognitive style x anxiety) the significant main effect of cognitive style was obtained for the P300 amplitudes at the scalp location LW on the Color-Block task.

**Main Effect of Cognitive Style at Scalp Location Cz**

The main effect of this variable (cognitive style) was significant, F(1, 16) 6.74; p<.05, indicating there was significant change in mean values of the P300 amplitude scores at the scalp location LW, on the Color-Block task with change in mode of cognitive processing (field independent—12.01 comparatively larger P300 amplitude mean score and field dependent 6.87 comparatively smaller P300 amplitude mean score).

### TABLE 10

ANOVA of P300 Amplitude Scores at Scalp Location Cz on the Color-Block Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>132.355</td>
<td>132.355</td>
<td>10.75*</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>1.035</td>
<td>1.035</td>
<td>0.08</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>13.861</td>
<td>13.861</td>
<td>1.13</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>197.068</td>
<td>12.317</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>344.319</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.005*
Table 11 summarizes the results of the two factor ANOVA of P300 amplitude scores at the scalp location LW on the Color-Block task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 13.

**TABLE 11**
ANOVA of P300 Amplitude Scores at Scalp Location LW on the Color-Block Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>75.777</td>
<td>75.777</td>
<td>6.74*</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>21.362</td>
<td>21.362</td>
<td>1.90</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>4.352</td>
<td>4.352</td>
<td>0.39</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>179.764</td>
<td>11.235</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>281.255</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05

Inspection of Table 11 indicates that of the principal effects (cognitive style, anxiety, and cognitive style x anxiety) the significant main effect of cognitive style was obtained for the P300 amplitude scores at the scalp location LW on the Color-Block task.

**Main Effect of Cognitive Style at Scalp Location LW**

The main effect of this variable (cognitive style) was significant, F(1, 16)6.74; p<.05, indicating there was
significant change in mean values of the P300 amplitude scores at
the scalp location LW, on the Color-Block task with change in
mode of cognitive processing (field independence—12.87
comparatively larger P300 amplitude mean score and field
dependence—8.98 comparatively smaller P300 amplitude mean
score).

Table 12 summarizes the results of the two factor ANOVA of
P300 amplitude scores at the scalp location RW on the Color-Block
task by cognitive style and level of anxiety. Means for main
effect of cognitive style and anxiety appear later on in Table
13.

TABLE 12
ANOVA of P300 Amplitude Scores at Scalp Location RW on the
Color-Block Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>130.560</td>
<td>130.560</td>
<td>8.31*</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>1.624</td>
<td>1.624</td>
<td>0.10</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>24.420</td>
<td>24.420</td>
<td>1.55</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>251.384</td>
<td>15.711</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>407.984</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.01
Inspection of Table 12 shows that of the principal effects (cognitive style, anxiety, and cognitive style x anxiety) the significant main effect of cognitive style was obtained for the P300 amplitude scores at the scalp location RW on the Color-Block task.

**Main Effect of Cognitive Style at Scalp Location RW**

The main effect of this variable (cognitive style) was significant, $F(1, 16) = 8.31; p < .01$, indicating there was significant change in mean values of the P300 amplitude scores at the scalp location RW, on the Color-Block task with change in mode of cognitive processing (field independence—14.15 comparatively larger P300 amplitude mean score and field dependence—9.04 comparatively smaller P300 amplitude mean score).

Table 14 presents the means and standard deviations for the P300 amplitude scores at the four scalp locations (Pz, Cz, LW and RW) on the Color-Block task by cognitive style and level of anxiety. Inspection of the cell-means reported in this table reflect a significantly greater positivity of P300 amplitude for field independence—low anxiety as compared with field dependence—high anxiety. In terms of the brain locations there is a general pattern of greater positivity of the P300 amplitude noted at Pz in comparison with the other three brain sites, namely, Cz, LW and RW.
TABLE 13

Means of P300 Amplitude Scores at Four Scalp Locations (Pz, Cz, LW and RW) for Main Effect of Cognitive Style and Anxiety on the Color-Block Task

<table>
<thead>
<tr>
<th></th>
<th>FI</th>
<th>FD</th>
<th>LA</th>
<th>HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pz</td>
<td>17.46</td>
<td>12.70</td>
<td>17.25</td>
<td>12.91</td>
</tr>
<tr>
<td>Cz</td>
<td>12.01</td>
<td>6.87</td>
<td>9.67</td>
<td>9.21</td>
</tr>
<tr>
<td>LW</td>
<td>12.87</td>
<td>8.98</td>
<td>11.96</td>
<td>9.90</td>
</tr>
<tr>
<td>RW</td>
<td>14.15</td>
<td>9.04</td>
<td>11.88</td>
<td>11.31</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location and variable, separately, are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious
### TABLE 14

Means and s.d. of P300 Amplitude Scores at Four Scalp Locations (Pz, Cz, LW and RW) for Interaction Effect of Cognitive Style and Level of Anxiety on Color-Block Task

<table>
<thead>
<tr>
<th></th>
<th>Pz</th>
<th>Cz</th>
<th>LW</th>
<th>RW</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
</tr>
<tr>
<td>FD</td>
<td>20.50</td>
<td>14.0</td>
<td>13.07</td>
<td>6.26</td>
</tr>
<tr>
<td></td>
<td>5.96</td>
<td>6.0</td>
<td>4.31</td>
<td>3.11</td>
</tr>
<tr>
<td>LA</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
</tr>
<tr>
<td>s.d.</td>
<td>3.13</td>
<td>3.56</td>
<td>3.73</td>
<td>3.52</td>
</tr>
<tr>
<td>Means</td>
<td>14.41</td>
<td>11.40</td>
<td>10.95</td>
<td>8.41</td>
</tr>
<tr>
<td></td>
<td>2.30</td>
<td>4.35</td>
<td>3.26</td>
<td>2.04</td>
</tr>
<tr>
<td>HA</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
</tr>
<tr>
<td>s.d.</td>
<td>3.21</td>
<td>4.26</td>
<td>2.04</td>
<td>4.70</td>
</tr>
<tr>
<td>Means</td>
<td>15.54</td>
<td>15.54</td>
<td>15.4</td>
<td>9.86</td>
</tr>
<tr>
<td></td>
<td>3.52</td>
<td>3.74</td>
<td>2.04</td>
<td>4.70</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location separately, are not significantly different.

**Results for Latency**

Results of the two factor ANOVA of the P300 latency scores at each of the four scalp locations (Pz, Cz, LW and RW) on the Color-Block task by cognitive style and level of anxiety yield no significant findings (Appendix H—ANOVA Table 31 to 34). The means for this analysis are reported in Tables 15 and 16. This table also presents the standard deviations for the P300 latency scores at the four scalp locations (Pz, Cz, LW and RW) on the Color-Block task by cognitive style and level of anxiety.
TABLE 15

Means of P300 Latency Scores at Four Scalp Locations (Pz, Cz, LW and RW) for Main Effect of Cognitive Style and Anxiety on the Color-Block Task

<table>
<thead>
<tr>
<th></th>
<th>FI (A)</th>
<th>FD (A)</th>
<th>LA (A)</th>
<th>HA (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pz</td>
<td>318.40</td>
<td>301.60</td>
<td>330.40</td>
<td>289.60</td>
</tr>
<tr>
<td>Cz</td>
<td>371.20</td>
<td>350.00</td>
<td>383.60</td>
<td>337.60</td>
</tr>
<tr>
<td>LW</td>
<td>334.40</td>
<td>332.80</td>
<td>353.60</td>
<td>313.60</td>
</tr>
<tr>
<td>RW</td>
<td>353.20</td>
<td>343.20</td>
<td>356.80</td>
<td>339.60</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location and variable, separately, are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious
TABLE 16

Means and s.d. of Latency Scores at Four Scalp Locations (Pz, Cz, LW and RW) for Interaction Effect of Cognitive Style and Level of Anxiety on Color-Block Task

<table>
<thead>
<tr>
<th></th>
<th>FI</th>
<th>FD</th>
<th>FI</th>
<th>FD</th>
<th>FI</th>
<th>FD</th>
<th>FI</th>
<th>FD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pz</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
</tr>
<tr>
<td>Cz</td>
<td>284.4</td>
<td>294.4</td>
<td>343.2</td>
<td>332.0</td>
<td>312.0</td>
<td>315.2</td>
<td>326.6</td>
<td>352.8</td>
</tr>
<tr>
<td>LA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s.d.</td>
<td>26.3</td>
<td>49.1</td>
<td>58.4</td>
<td>77.0</td>
<td>18.7</td>
<td>58.1</td>
<td>48.3</td>
<td>60.5</td>
</tr>
<tr>
<td>Means</td>
<td>318.4</td>
<td>342.4</td>
<td>399.2</td>
<td>368.0</td>
<td>353.6</td>
<td>353.6</td>
<td>360.0</td>
<td>353.6</td>
</tr>
<tr>
<td>HA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s.d.</td>
<td>30.1</td>
<td>88.9</td>
<td>51.2</td>
<td>73.1</td>
<td>70.0</td>
<td>75.1</td>
<td>44.1</td>
<td>58.0</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location separately, are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious

Hypothesis III

There will be significant differences in the reaction time scores during the performance of the Stroop task and the Color-Block task as a function of cognitive style and/or trait anxiety (longer reaction time scores for field dependence and high anxiety as compared with field independence and low anxiety).

For the purpose of testing this hypothesis, data were analyzed by using a two factor ANOVA. The two independent variables consisted of two modes of cognitive processing (field dependent-field independent) and trait anxiety with two levels of anxiety (high anxiety and low anxiety). The dependent variables were 1) reaction time scores on the Stroop task; 2) reaction time...
scores on the Color-Block task. Separate ANOVAs were computed for each of these two dependent variables. Table 17 summarizes the results of the two factor ANOVA of reaction time scores on the Stroop task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 18.

**TABLE 17**

ANOVA of Reaction Time Scores on the Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>7880.450</td>
<td>7880.450</td>
<td>6.52*</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>10904.450</td>
<td>10904.450</td>
<td>9.03**</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>7801.250</td>
<td>7801.250</td>
<td>6.46*</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>19324.400</td>
<td>1207.775</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>45910.550</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *p<.05
**p<.01

Inspection of Table 17 shows that significant main effects of cognitive style, anxiety, and significant interaction of cognitive style and anxiety were obtained for reaction time scores on the Stroop task.

**Main Effect of Cognitive Style**

The main effect of this variable (cognitive style) was significant, F(1, 16) 6.52; p<.05, indicating there was
significant change in mean values of the reaction time scores on the Stroop task with change in mode of cognitive processing (field independent—474.80 comparatively shorter reaction time mean score and field dependent—514.50 comparatively longer reaction time mean score).

**Main Effect of Anxiety**

The main effect of this variable (anxiety) was significant, F(1, 160)9.03; p<.01, indicating there was significant change in mean values of the reaction time scores on the Stroop task with change in levels of anxiety (low anxiety—471.30 comparatively shorter reaction time mean score and high anxiety—518.00 comparatively longer reaction time mean score).

**Interaction Effect of Cognitive Style and Anxiety**

The interaction effects of the variables cognitive style and anxiety were significant, F(1, 16)6.46; p<.05. In order to determine which of the pairwise comparisons contribute to the significant F-test obtained in the interaction effects of cognitive style and anxiety, Tuckey's HSD Test was employed. The analysis showed that the significant differences for reaction time mean values on the Stroop task were obtained between the subjects who have characteristics of field dependence—high anxiety (557.60) and those who have characteristics of field dependence—low anxiety (471.20); between the subjects who have characteristics of field dependence—high anxiety (557.60) and those who have characteristics of field independence—high anxiety
between the subjects who have characteristics of field dependence-high anxiety (557.60) and those who have characteristics of field dependence-low anxiety (471.40). The means for this analysis appear in Table 19. This table also presents the standard deviations for the reaction time scores on the Stroop task by cognitive style and level of anxiety.

TABLE 18

Means of Reaction Time Scores for Main Effect of Cognitive Style and Anxiety on the Stroop Task

<table>
<thead>
<tr>
<th></th>
<th>FI (A)</th>
<th>FD (B)</th>
<th>LA (A)</th>
<th>HA (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroop Task</td>
<td>474.80</td>
<td>514.50</td>
<td>471.30</td>
<td>518.0</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location and variable, separately, are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious
TABLE 19
Means and s.d. of Reaction Time Scores for Interaction Effect of Cognitive Style and Level of Anxiety on Stroop Task

<table>
<thead>
<tr>
<th></th>
<th>FI</th>
<th>FD</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>(B)</td>
<td>(B)</td>
</tr>
<tr>
<td>Means</td>
<td>471.20</td>
<td>471.40</td>
</tr>
<tr>
<td>s.d.</td>
<td>31.67</td>
<td>34.80</td>
</tr>
<tr>
<td>HA</td>
<td>(B)</td>
<td>(A)</td>
</tr>
<tr>
<td>Means</td>
<td>478.40</td>
<td>557.60</td>
</tr>
<tr>
<td>s.d.</td>
<td>20.84</td>
<td>46.72</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter are not significantly different.

FI - Field Independent
FD - Field Dependent
LA - Low Anxious
HA - High Anxious

Table 20 summarizes the results of the two factor ANOVA of reaction time scores on the Color-Block task by cognitive style and level of anxiety. Means for main effect of cognitive style and anxiety appear later on in Table 21.
### TABLE 20

ANOVA of Reaction Time Scores on the Color-Block Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>1377.800</td>
<td>1377.800</td>
<td>0.53</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>980.000</td>
<td>980.000</td>
<td>0.38</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>320.000</td>
<td>320.000</td>
<td>0.12</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>41636.400</td>
<td>2602.275</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>44314.200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 20 shows that of the three principal effects (cognitive style, anxiety and cognitive style x anxiety) no significant differences were obtained for the mean values of reaction time scores on the Color-Block task by cognitive style and level of anxiety. This indicates similarity of the contrasted mean values by cognitive style and anxiety. Table 22 presents the means and the standard deviations for the reaction time scores on the Color-Block task by cognitive style and level of anxiety.
### TABLE 21
Means of Reaction Time Scores for Main Effect of Cognitive Style and Anxiety on the Color-Block Task

<table>
<thead>
<tr>
<th>Color-Block Task</th>
<th>FI (A)</th>
<th>FD (A)</th>
<th>LA (A)</th>
<th>HA (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>440.40</td>
<td>457.0</td>
<td>441.70</td>
<td>455.70</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter under each location and variable, separately, are not significantly different.

FI - Field Independent  
FD - Field Dependent  
LA - Low Anxious  
HA - High Anxious

### TABLE 22
Means and s.d. of Reaction Time Scores for Interaction Effect of Cognitive Style and Level of Anxiety on Color-Block Task

<table>
<thead>
<tr>
<th></th>
<th>FI (A)</th>
<th>FD (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means</td>
<td>437.40</td>
<td>446.00</td>
</tr>
<tr>
<td>s.d.</td>
<td>19.98</td>
<td>37.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>LA (A)</th>
<th>HA (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means</td>
<td>443.40</td>
<td>468.00</td>
</tr>
<tr>
<td>s.d.</td>
<td>53.29</td>
<td>76.05</td>
</tr>
</tbody>
</table>

( ) = Means with the same letter are not significantly different.

FI - Field Independent  
FD - Field Dependent  
LA - Low Anxious  
HA - High Anxious
Hypothesis IV

There will be significant differences in the level of accuracy (number of false positives and number of misses) during the performance of the Stroop task and the Color-Block task as a function of cognitive styles and/or trait anxiety (lower level of accuracy for field dependence and high anxiety as compared with field independence and low anxiety).

For the purpose of testing this hypothesis, data were analyzed using a non-parametric test of significance of a difference between uncorrelated proportions of equal sample size. The statistics involved a pairwise comparison of proportions. The pairwise comparisons of proportions were done by cognitive style and level of anxiety. Separate results were presented for number of false positives and number of misses during the performance on the Stroop task and the Color-Block task.
## Table 23

Pairwise Comparisons of the Proportions of Number of False Positives on the Stroop Task

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Total Number of Button Presses</th>
<th>Number of False Positives</th>
<th>Proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Dependent (FD)</td>
<td>10</td>
<td>427</td>
<td>37</td>
<td>.087</td>
</tr>
<tr>
<td>Field Independent (FI)</td>
<td>10</td>
<td>409</td>
<td>19</td>
<td>.046</td>
</tr>
<tr>
<td>High Anxiety (HA)</td>
<td>10</td>
<td>430</td>
<td>40</td>
<td>.093</td>
</tr>
<tr>
<td>Low Anxiety (LA)</td>
<td>10</td>
<td>406</td>
<td>16</td>
<td>.039</td>
</tr>
</tbody>
</table>

FD-FI = p < .05  
HA-LA = p < .01  
LA-FD = p < .01  
HA-FI = p < .01

Table 23 presents the pairwise comparisons of the proportions of the number of false positives on the Stroop task by the varied cognitive style and level of anxiety. Inspection of this table indicates that the comparison of proportions between low and high anxiety is significant (p < .01). The comparison of proportions between field dependent and field independent is significant (p < .05). The comparison proportions between field dependent and low anxiety is significant (p < .01). The comparison of proportions between field independent and high anxiety is significant (p < .01).
Table 24 presents the pairwise comparisons of proportions of false positives on the Color-Block task by cognitive style and level of anxiety. Inspection of this table indicates that the comparison of proportions between low anxiety and high anxiety is significant ($p<.05$). The comparison of proportions between field dependent and field independent is significant ($p<.05$). The comparisons of proportions between field dependent and low anxiety, between field independent and high anxiety are significant ($p<.05$).
Table 25 presents the pairwise comparisons of proportions of number of misses on the Stroop task by cognitive style and level of anxiety. Inspection of this table indicates that the comparisons of proportions between field dependent and field independent, between low anxiety and high anxiety are significant (p<.01). Same level of significance is noted in the comparison of proportions between field dependent and low anxiety, between field independent and high anxiety.
Table 26 presents the pairwise comparisons of the proportions of the number of misses on the Color-Block task by cognitive style and level of anxiety. Inspection of this table indicates no significant differences in the pairwise comparison of proportions.
SUMMARY OF THE RESULTS

1. Significant differences were obtained in the ANOVA on the P300 amplitude scores at the four brain sites on the Stroop task as follows:

Pz - Main effect of Anxiety
(high anxiety—significantly smaller P300 amplitude mean score as compared with low anxiety)

Cz - Main effect of Anxiety
(high anxiety—significantly smaller P300 amplitude mean score as compared with low anxiety)

LW - Main effect of Cognitive Style
(field dependence—significantly smaller P300 amplitude mean score as compared with field independence)

Main effect of Anxiety
(high anxiety—significantly smaller P300 amplitude mean score as compared with low anxiety)

Interaction effect of Cognitive Style and Anxiety
(field dependence—high anxiety—significantly smaller P300 amplitude mean score as compared with field independence—low anxiety)

(field independence—high anxiety—significantly smaller P300 amplitude mean score as compared with field independence—low anxiety)
RW - Interaction Effect of Cognitive Style and Anxiety (field dependence—high anxiety—significantly smaller P300 amplitude mean score as compared with field independence—low anxiety)

2. There were no significant findings in the ANOVA on the P300 latency scores at the four brain sites on the Stroop task.

3. Significant differences in the ANOVA on the P300 amplitude scores at the four brain sites on the Color-Block task as follows:

Pz - Main effect of Cognitive Style (field dependence—significantly smaller P300 amplitude mean score as compared with field independence)

Cz - Main effect of Cognitive Style (field dependence—significantly smaller P300 amplitude mean score as compared with field independence)

LW - Main effect of Cognitive Style (field dependence—significantly smaller P300 amplitude mean score as compared with field independence)

RW - Main effect of Cognitive Style (field dependence—significantly smaller P300 amplitude mean score as compared with field independence)
4. There were no significant findings in the ANOVA on the P300 latency scores at the four brain sites on the Color-Block task.

5. Significant differences were obtained in the reaction time scores on the Stroop task as follows:

1. Main effect of Cognitive Style
   (field dependence—significantly longer reaction time as compared with field independence)

2. Main effect of Anxiety
   (high anxiety—significantly longer reaction time as compared with low anxiety)

3. Interaction Effect of Cognitive Style and Anxiety
   (field dependence—high anxiety—significantly longer reaction time as compared with field independence—low anxiety, field independence—high anxiety, and field dependence—low anxiety)

6. There were no significant findings in the analysis of reaction time scores on the Color-Block task.

7. There were significant differences in the pairwise comparisons of proportions of number of false positives and number of misses on the Stroop task as follows:

1. High anxiety — significantly larger number of false positives and misses as compared with low anxiety

2. Field dependence — significantly larger number of false positives and misses as compared with field independence

3. High anxiety — significantly larger number of false positives and misses as compared with field dependence

4. Field dependence — significantly larger number of false positives and misses as compared with low anxiety

8. There were significant differences in the pairwise comparisons of proportions of number of false positives on the Color-Block task as follows:
1. High anxiety - significantly larger number of false positives as compared with low anxiety

2. Field dependence - significantly larger number of false positives as compared with field independence

3. High anxiety - significantly larger number of false positives as compared with field independence

4. Field dependence - significantly larger number of false positives as compared with low anxiety
CHAPTER V
DISCUSSION

It is the purpose of this chapter to discuss the findings that were presented in Chapter IV. The present study was designed to examine the differences between the relationship of the neurophysiological measure (P300 waveform) and anxiety on the one hand, and this measure and cognitive style on the other. The design also allowed a determination of whether or not the neurophysiological measure could be regarded as an index of an interaction between cognitive style and anxiety. The differential and interaction effects of cognitive style and anxiety on the accuracy of performance of the tasks in question and on reaction time in making task decisions were also assessed.

Both theory and research reviewed in Chapter II suggested the possibility of varied effects in terms of electrophysiological endogenous measures in normal populations with different styles of cognitive processing (field dependence/independence) and with different levels of anxiety (high-low).
during the performance of discrimination tasks (verbal and non-verbal) in an evaluative situation.

**DISCUSSION OF HYPOTHESES**

**Hypothesis 1**

There will be significant differences in the P300 waveform amplitude scores and latency scores at each of the four scalp locations (Pz, Cz, LW and RW) as a function of cognitive styles and/or trait anxiety (smaller P300 amplitude scores and longer latency scores for field dependence and high anxiety as compared with field independence and low anxiety) during the performance of the Stroop task.

The neurophysiological data (P300 amplitude scores) on the Stroop task indicate that the main effect of anxiety was significant (high anxiety—significantly smaller P300 amplitude score in comparison with low anxiety) at the central brain sites of Pz (Parietal Zone) and Cz (Central Zone). At the lateral brain site of LW (Left Wernicke) the significant main effect of cognitive style (field dependence—significantly smaller P300 amplitude score in comparison with field independence) and anxiety (high anxiety—significantly smaller P300 amplitude score in comparison with low anxiety) were noted in addition to the significant interaction effect of these two variables (field independence-low anxiety—significantly larger P300 amplitude score than field dependence-high anxiety, as well as field independence-high anxiety). At the lateral brain site of RW (Right homologue of Wernicke's), only the interaction effect of
cognitive style and anxiety were found to be significant (field independence—low anxiety—significantly larger P300 amplitude score than field dependence—low anxiety).

As was noted in the review of literature, there is some evidence that extremely field dependent individuals may have characteristics which are common to an anxiety-prone group of individuals (Witkin et al., 1962; Goodenough, 1976; Sarris et al., 1976). Some of the electrophysiological studies (Knott et al., 1973) have also suggested the possibility of differential effects in terms of event-related potentials in normal populations with different cognitive style (field dependence/independence) and varied level of anxiety (high-low) during the performance of cognitive tasks. In the present study, the results on the Stroop task provide support for differences between the relationship of P300 amplitude score and anxiety on the one hand, and P300 amplitude score and cognitive style on the other. The results also provide some evidence that P300 amplitude can be regarded as an index of an interaction between cognitive style and anxiety.

As was noted in the review of literature, there is evidence that the interference and distraction caused by task irrelevant information (Stroop task interference), preoccupation with worries, negative self-evaluation of anticipated failure/threats as a function of high anxiety, leads to functional reduction in the range of attention to task relevant materials (Sarason, 1975;
Wine, 1971). The additional loads on short term memory updating and intrusion by less dominant stimuli from external and internal sources of information may cause a decrease in the amount of capacity to process relevant cognitive data and to attain uncertainty resolution of relevant and irrelevant information (Hamilton, 1979). The tendency of field dependent subjects to be affected by distracting stimuli (Bloomberg, 1965) results in their inability to overcome embedded contexts and separate salient from irrelevant cues in perceptual functioning (Witkin & Goodenough, 1977).

The variations in mean size of the P300 amplitude during performance of the Stroop task as a function of field dependence/field independence and high-low anxiety appear to reflect differences in the capacity to process relevant cognitive data and in the decision confidence in the perceptual-discrimination task. The results suggest that the effort to cope with high anxiety and the inability to separate salient and irrelevant, central and peripheral cues, in other words, using a global approach in perception, absorbs the capacity as well as space and time available for performance of verbal/analytic discrimination tasks (Hamilton, 1979).

The differences in the findings at the four scalp locations in terms of main and interaction effects confirm that any particular scalp distribution may derive from different possible generators (Martin & Venables, 1980). It can be considered a
possibility that the variations in the effect of distinct psychological activity (field dependence/independence and high-low anxiety) may have generated a particular scalp distribution. This may account for the differences between findings at central and lateral brain sites while examining the significant main and interaction effects of cognitive style and anxiety on P300 amplitude during the performance of the Stroop task. The significant interaction effect of cognitive style and anxiety on P300 amplitude at the lateral brain sites LW and RW on this verbal task suggests that both the variables were influential in the activation of the two cerebral hemispheres which would appear consistent with the theoretical modes which emphasize the integrative nature of hemispheric functioning (Luria, 1973; Das et al., 1975; Clark & Frisby, 1980; Goldberg & Costa, 1981) and the concept that the whole brain is used for cognition and emotion (Dunn, 1983).

Scrutiny of the amplitude values on the Stroop task reflects smaller intra-group variability than has been noted in other studies (Shockley, 1984; Shibley & Shockley, 1984; Torello, 1984; Simmons, Languis & Drake, 1985) that have used the same dual microcomputer system at the O.S.U. Brain Behavior Laboratory as that used in the present study. For example, in the present study the smallest P300 amplitude SD value on the Stroop task is 1.12 mv whereas the smallest SD value obtained on the control group in the study by Simmons et al. (1985) was 2.9 mv. Reasons
for this might be the separate or combined effects of the use of an extreme groups design, the nature of the task, and factors such as the sample size, the scalp distribution and how conscientiously the subject was engaged in the task situation (Donchin, 1981; Polich, 1986). The present study examined extreme groups in terms of cognitive style and anxiety and, compared to the populations investigated in the studies cited above, these groups might be expected to be marked by greater homogeniety and less variability in relation to decision confidence and contextual updating. Sutton and Ruchkin (1984) in discussing the relationship of the P300 to population variables and state of the organism variables, stated that, "one may find that, under the same experimental conditions, one population has a larger or smaller P300 than another population. Similarly such differences may be found for states of the organism . . ." Perhaps this observation applies to variability as well. Also, a larger sample size might have increased the spread of the scores and the variance.

For P300 waveform latency scores on the Stroop task, Hypothesis I was not confirmed. Based on the theoretical literature (Duncan-Johnson & Donchin, 1982) the expectation was that stimulus evaluation time would differ significantly as a function of cognitive style and/or level of anxiety, considering the susceptibility of high-anxious and field-dependent individuals to distraction and to preoccupation with irrelevant
internal and external stimuli (Witkin et al., 1962; Goodenough, 1976; Sarris et al., 1976; Knott et al., 1973). However, no significant differences were obtained for latency scores on the Stroop task as a function of cognitive style, level of anxiety or their interaction. This is contradictory to the expectations stated earlier (Duncan-Johnson & Donchin, 1982). The present results appear consonant with the findings of Roth et al. (1980) for the normal subjects in their study. Magliero et al. (1984) demonstrated that the latency of the P300 is responsive to manipulations that affect stimulus evaluation, but this latency is altered to a very small degree by manipulation concerned with response compatibility-incompatibility (for example, button press with same/opposite hand). This lack of significant differences in P300 latency in the normal population may be further reflecting an integrative functioning of the brain rather than an aberrant flow of activity as is noted in aberrant populations (Strandburg et al., 1984).

**HYPOTHESIS II**

There will be significant differences in the P300 waveform amplitude scores and latency scores at each of the four scalp locations (Pz, Cz, LW and RW) as a function of cognitive styles and/or trait anxiety (smaller P300 amplitude scores and longer latency scores for field dependence and high anxiety as compared with field independence and low anxiety) during the performance of the Color-Block task.

The neurophysiological data (P300 amplitude scores) on the non-verbal Color-Block task provide partial support for Hypothesis II in that only the main effect of cognitive style was
found to be significant at all four scalp locations (field dependence—significantly smaller P300 amplitude scores in comparison with field independence). The results do not show any significant main effect of anxiety nor of interaction effect between cognitive style and anxiety. These results suggest that when examining neurophysiological data (P300 amplitude) during the performance of this non-verbal task, the differences in the variable cognitive style were predominantly influential. The possible explanation could be involvement of simpler discrimination requirements in the non-verbal Color-Block task as compared with the Stroop task. Another possibility could be lowered situational anxiety level as indicated by the results of the t-test of pre- and post-performance state anxiety scores, making more room for cognitive appraisal and use of a particular mode of cognitive processing. It is pertinent to mention here that the Color-Block task was administered after the completion of the Stroop task and an inter-task rest period. The gradual situational anxiety dissipation, relatively less preoccupation with negative self-evaluation, the gradual overriding influence of the cognitive factor in the experience, relatively greater control of stress factors (Meichenbaum, 1972; McGrath, 1982) may have allowed for the effect of differences in the relationship between the neurophysiological measure (P300 amplitude) and cognitive style.
The main effect of cognitive style (field dependence—significantly smaller P300 amplitude score in comparison with field independence) on P300 amplitude while the subjects were performing the Color-Block task suggests that the inability of field dependent subjects to separate salient from irrelevant cues may negatively affect the decision making process in a discrimination task. This may tend to lessen the confidence in decision resolution and result in the relatively reduced magnitude of the P300, a waveform whose functional significance is thought to be selective attention, establishing relevance of improbable stimuli, contextual updating, and uncertainty resolution in a discrimination task (Duncan-Johnson & Donchin, 1982). It is inferred that, in a perceptual-discrimination task, perhaps an adoption of an analytic strategy is necessary to generate a larger P300 amplitude which is reflective of ability for greater selective attention and ability for information processing to separate the central and peripheral cues for objective situational analysis. The fact that cognitive style was significantly related to the P300 waveform at all the four locations is consistent with the whole brain concept or the integrative nature of the hemispheric functioning (Luria, 1973; Das et al., 1975; Clark & Frisby, 1980; Goldberg & Costa, 1981; Dunn et al., 1981).

The latency of the P300 during the performance of the Color-Block task does not seem to be affected by the differences
in cognitive style and/or anxiety. The expectation was that the stimulus evaluation time would differ significantly as a function of cognitive style and level of anxiety because of the tendency of high anxious and field dependent individuals to be easily distracted and preoccupied with irrelevant internal and external stimuli (Witkin et al., 1962; Goodenough, 1976; Sarris et al., 1976; Knott et al., 1973). These findings do not provide any support for the expectations based on the theoretical interpretation that there will be differences in P300 latency scores as a function of cognitive style and/or anxiety (Knott et al., 1973; Duncan-Johnson & Donchin, 1982). On the contrary, these results appear to be consistent with the findings by Roth et al. (1980) and Magliero et al. (1984) who explain that little or no significant differences should be found in normal populations for a given task. In other words, in normal populations, the differences in cognitive style and/or anxiety did not affect the duration of stimulus-evaluation processes, as indexed by P300 latency, although the influence of the differences in these variables is noted in the decision making processes, as indexed by P300 amplitude. As stated earlier, this lack of significant differences in P300 latency in the normal population may be further reflecting an integrative functioning of the brain rather than an aberrant flow of activity as is noted in aberrant populations (Strandburg et al., 1984).
However, it is pertinent to mention here that the lack of significant differences in P300 latency scores among groups and across tasks may be due to the use of a relatively small sample size for each group (Polich, 1986). Further scrutiny of separate P300 latency values indicates a wide range in the latency scores, than has been noted in some of the other O.S.U. Brain Behavior Laboratory studies (Shockley, 1984; Shibley & Shockley, 1984; Torello, 1984; Simmons, Languis & Drake, 1985) that have used the same dual microcomputer system as the present study. For example, whereas in the study by Shockley (1984) the latency scores (measured at the brain site Pz) obtained on the Color-Block task, range from 240 msecs to 374 msecs, the range in the present study, looking at the same site and task, is 256 msecs to 432 msecs. The range obtained in the study by Shibley and Shockley on the same task was 228.6 msecs to 443 msecs. Factors such as participant age, memory capacity and variation in stimulus parameters (e.g., the sequence of the two tasks in the present study) may be significant determinants of an individual's P300 latency (Polich, Howard & Starr, 1985) and may be some of the reasons for differential results when measured on the present population through the application of the same equipment. Perhaps these might explain the higher degree of intra-group P300 latency variability range from 18.76 msecs to 79.88 msecs when measured at the brain site Cz on the Stroop task in the present study as compared with SD of 29.1 msecs at the same brain site on an
auditory task in the study by Polich et al. (1985). Reasons for these differences might be the separate or combined effects of the use of an extreme groups design, the nature of the task and the sample size in the present study.

**HYPOTHESIS III**

There will be significant differences in the reaction time scores during the performance of the Stroop task and the Color-Block task as a function of cognitive style and/or trait anxiety (longer reaction time scores for field dependence and high anxiety as compared with field independence and low anxiety).

The findings support the hypothesis on the Stroop task but not on the Color-Block task. The results indicate that for the reaction time scores on the Stroop task there was a significant main effect of cognitive style (field dependence—significantly longer reaction time scores in comparison with field independence) and anxiety (high anxiety—significantly longer reaction time scores in comparison with low anxiety) and an interaction effect of these two variables as well (field dependence-high anxiety—significantly longer reaction time scores than in comparison with field independence-low anxiety; field independence-high anxiety and field dependence-low anxiety). These findings appear to concur with the theoretical interpretation that the interference and distraction caused by task irrelevant information (Stroop task interference) as a function of high anxiety and a global approach to discrimination tasks leads to slower cognitive recognition processes and reaction time as compared with low anxiety and analytic strategy.
(Witkin & Goodenough, 1977; Mathews & MacLeod, 1984). The longer reaction time score on the Stroop task as a function of high anxiety and field dependence as compared with low anxiety and field independence is also consistent with the evidence that extremely field dependent individuals have characteristics which appear common to an anxiety-prone group of individuals (Witkin et al., 1962; Goodenough, 1976; Sarris et al., 1976).

The reaction time findings on the Color-Block task do not show any significant differences by main effect of cognitive style, anxiety, or the interaction of these two variables. This may have been because the Color-Block task, a non-verbal perceptual discrimination task, is simpler than the Stroop Color-Word task (Strandburg, 1984) and, because of its simplicity, the execution of this task may not be susceptible to the influence of differences in such variables as cognitive style or anxiety level.

HYPOTHESIS IV

There will be significant differences in the level of accuracy (number of false positives and number of misses) during the performance of the Stroop task and the Color-Block task as a function of cognitive styles and as a function of trait anxiety (lower level of accuracy for field dependence and high anxiety as compared with field independence and low anxiety).

Significant differences between high anxiety-high anxiety; field dependence-field independence; high anxiety-field independence; and low anxiety-field dependence, were found in the number of false positives and number of misses during the performance of the Stroop task as a function of cognitive style.
and as a function of anxiety. However, on the Color-Block task significant differences were found only for the number of false positives as a function of cognitive style and as a function of anxiety.

As was noted earlier, the interference and false anticipation caused by task irrelevant information (Hamilton, 1979; Wine, 1971; Sarason, 1975), additional load on working memory (Warburton, 1979), task difficulty (Glanzmann & Laux, 1978), situational complexity (Magnusson, 1985) and experience of unusual laboratory equipment may have resulted in the reduction of the amount of capacity to process and select relevant cognitive data by function of high anxiety as compared with low anxiety. The intrusion by irrelevant stimuli from external and internal sources of information and the inability of the field dependent subjects as compared with field independent subjects to separate the salient from the irrelevant may have led to relatively inaccurate evaluation/encoding of stimuli and identification of targets.

The lower level of accuracy appears to be caused by increased difficulty in detecting the perceptual target on the Stroop task as a function of field dependence and high level of anxiety. This relationship is consistent with the neurophysiological data, which indicates that increases in difficulty of target perception and lower confidence in uncertainty resolution results in decreased P300 amplitude (Ford,
Roth, & Kopell, 1976; Fitzgerald & Picton, 1983; Donchin, 1981). The greater inaccuracy in overt responses and the significantly smaller magnitude of the P300 component of event-related potentials noted as a function of high anxiety and field dependence suggests inhibitory effects in contextual short term memory updating and confidence in decision and uncertainty in resolution. As is stated by Donchin (1982),

Stimulus identification and evaluation process follow encoding. At this stage the stimulus is recognized and relevant information is extracted and the subject's history of memories, expectancies and strategies may influence the speed and/or the accuracy with which stimuli are identified.

CONCLUSIONS

Based on the data obtained in this study the following conclusions can be drawn:

In the performance of perceptual-discrimination tasks, significant differences were noted in the mobilization and focusing of selective attention and the confidence in decision-making as a function of cognitive style (field dependence/independence) and anxiety (high-low). The findings showed that the inhibition in information processing and the reduction in the range of selective attention as a function of high anxiety and field dependence may result in inability to regulate cognitive activity as reflected by the smaller magnitude of the P300 waveform, longer reaction time, and lower level of accuracy in task performance. This leads to the conclusion that field dependence marked by a global approach and inability to ignore
the distracting stimuli as compared with field independence in perceptual-discrimination tasks (Bloomberg, 1965; Witkin et al., 1962; Proulx & Picton, 1984) may be adversely affecting the mechanism of selective attention. High anxiety marked by preoccupation with worries, easy distractibility by task irrelevant information and low retrieval threshold as compared with low anxiety (Wine, 1971; Sarason, 1975; Hamilton, 1979) may be causing a functional reduction in the range of attention. These findings provide important clarification for the discrimination between the relationship of the neurophysiological measure, reaction time, and accuracy of performance of cognitive tasks to cognitive style on the one hand and to anxiety on the other.

As is noted in the review of literature, the interference and distraction from both internal and external sources and the preoccupation with negative self-evaluation as a function of high anxiety and the inability to separate the salient from the irrelevant cues in a perceptual-discrimination task as a function of field dependence tends to reduce the capacity to process relevant cognitive data and interferes with deep and elaborate encoding, retrieval of information, and selection and execution of responses. This reflects a qualitative difference between the two extreme groups of individuals who are characterized by field dependence or field independence (Witkin et al., 1962; Bloomberg, 1965; Witkin & Goodenough, 1977). Qualitative differences are
also reflected as a function of levels of anxiety. In the present study, differences were found in the brain electrical activity data at all brain sites and in overt response measures of reaction time and level of accuracy. Differences were not found, however, in P300 latency. This leads to the conclusion that it is not in the stimulus evaluation time but in the decision confidence and at the response selection/execution stage that the inhibition appears to occur. In other words, the inhibitory effects caused by the lower ability to ignore the distracting stimuli and by the high anxiety, depending upon the brain location, were exhibited in the smaller P300 amplitude and in the delayed overt response execution. The lower confidence in decision making in perceptual processing rather than variations in the stimulus evaluation time seems to be affecting the overt response selection and execution stage. A similar relationship is also noted in terms of accuracy in the performance of a task. These findings were more pronounced for the Stroop task (verbal) than for the Color-Block task (non-verbal).

Based on the theoretical formulations and research findings on the relationship of cognition and affect (Piaget & Inhelder, 1969; Tyler & Tucker, 1982; Begleiter et al., 1983) the present study hypothesized that the P300 waveform across all the four brain sites (Pz, Cz, LW and RW) would index an interaction between cognitive style and anxiety. The findings provide partial support for the statement by Piaget and Inhelder (1969), "The two
aspects, affective and cognitive, are at the same time inseparable and irreducible." The results indicated a significant interaction effect of cognitive style and anxiety on P300 amplitude at the lateral brain sites of LW and RW but not at the central brain sites of Pz and Cz, for the verbal Stroop task. However, such an interaction effect was not noted for the non-verbal Color-Block task. Although hemispheric lateralization is not specifically the focus of this study, nevertheless, these findings indicate that on complex verbal information processing, both cognitive style and anxiety influence the bilateral hemispheric activation. This supports the theoretical formulation that the integrative activity of both cerebral hemispheres is governed by both cognition and affect. This contradicts the viewpoint that only the right hemisphere is specialized for emotion. The lack of hemispheric asymmetry in this population for the P300 is supportive of the integrative nature of hemispheres or perhaps hemispheric dominance has not been strongly established for this pre-adolescent population (Gardner, 1978). This leads to the need for further investigation of the "whole brain concept".

Both independent variables cognitive style and anxiety, either separately or by interaction, were related to the dependent variables of P300 amplitude, reaction time and level of accuracy. The degree of effectiveness of each of the independent variables varied with brain location, the nature (verbal/non-
verbal) and demands of the task, and situational complexity. The indication was that both affective and cognitive processes influence reactions and responses whether covert (event-related potentials, amplitude) or overt (reaction time and accuracy level). The degree of relationship depended to some extent on the level of anxiety and on the cognitive style. Perhaps the function of high anxiety and field dependence as compared with low anxiety and field independence in terms of discrimination tasks resulted in some inherent difficulty in perceiving extrinsic stimulus organizations and difficulty of assimilating external stimulus requirements into the behavioral strategies. This would be consistent with the findings of Witkin and his associates (1962) that field dependent children prove more sensitive than field independent children to feedback from the environment, for instance, in an evaluative situation featuring an unfavorable emotional climate.

**IMPLICATIONS FOR PSYCHOLOGY AND EDUCATION**

Event-related potential research allows one to look at the integrity of the internal processing system and note the inhibition effects in the mobilization and focusing of attention whether related to cognitive or affective factors. Considering the results of this and related studies (Chattopadhyay et al., 1980; Sayer & Torres, 1966; Federico, 1984; Lewis, 1982), event-related potential research, in combination with behavioral research, may be used as an aid in diagnosis and development of
programs that adapt instructional techniques to individual differences. It is suggested that remedial instructional training, such as biofeedback for specific stages or processes, may help improve responses and performances and it may be possible to monitor any changes in brain electrical activity at the different stages of information processing. This technique could provide the instructor with a measurable record of the progress and criterion for strategies which will improve performance; in other words, this type of analysis could provide a useful additional index of performance at specific stages of information processing.

It may be argued that event-related potential measures are less invasive and more objective than overt response measures. Some of the problems encountered in psychometric testing, such as those related to the interpersonal interaction of the test-giver and the test-taker, may not be operative when such measures are used (Horst & Thatcher, 1984). Once reliable event-related potential differences are established between normal and aberrant populations of children, then any aberrant brain electrical activity might be used as one factor to alert parents and educators that a child is at risk of learning disability before the manifestation of an actual change in school performance.

Event-related potentials related to cognitive and/or affective factors could help identify a need for differential cognitive/affective rehabilitation programs. Biofeedback training
may improve performance in different stages of information processing (Lubar, 1985). Application of metacognitive strategies and/or cognitive appraisal of emotions through insights gained from event-related potential approaches may help the learner to modify the processing of his/her own efficiency in task performance (Languis, Letteri, Pennell & McQueen, 1984). The subsequent insights gained from event-related potential studies may help to set up remedial techniques designed to meet the differential needs of different learners.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. Event-related potential studies examining affective and cognitive developmental stages (infancy through adulthood), sex differences, and different modalities will enable us to better understand the relationships among developmental, neuropsychological, and behavioral levels of investigation.

2. The present study used only analytic tasks. Use of both analytic and holistic tasks may elicit different event-related potential patterns and behavioral data and may provide a more varied picture of differences.

3. It would be informative to study other cognitive style dimensions, such as reflectivity-impulsivity, to further determine the interaction between cognition and affect in relationship with neurophysiological measures and overt responses.
4. The present study did not discriminate between speed and accuracy. Hence, the possible speed/accuracy trade-off could not be assessed. This trade-off should be studied in terms of both affect and cognition while looking at the event-related potential components.

5. As noted earlier,

The evaluation of these event-related potentials at multiple scalp locations becomes a very powerful tool in the dissection of distinct psychophysiological events. Scalp-recorded events with different voltage distributions must derive, at least in part, from different sources (Martin & Venables, 1980).

The present study explored only the P300 component of the event-related potential waveform. Perhaps examining other components would provide a better understanding of processes underlying each component in different populations and of the scalp distribution of these potentials.
LIST OF REFERENCES


APPENDIX A

STATE-TRAIT INVENTORY FOR CHILDREN
PLEASE NOTE:

Copyrighted materials in this document have not been filmed at the request of the author. They are available for consultation, however, in the author's university library.

These consist of pages:

Appendix A State-Trait Inventory For Children Pages 142-143

Appendix B Group Embedded Figures Test Page 145

University Microfilms International
300 N Zeeb Rd., Ann Arbor, MI 48106 (313) 761-4700
APPENDIX C
EDINBURGH HANDEDNESS TEST
(MODIFIED VERSION)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>(back side) write your name</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>(back side) draw a happy face</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>open this box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>show me how you would throw this ball</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>show me how you would use these scissors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>show me how you would use this toothbrush</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>show me how you would cut cheese with this knife</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>show me how you would use this spoon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>show me how you would strike this match</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>show me how you would open this jar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>show me how you would use this tube if it were a telescope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>show me how you would look through the hole at this &quot;X&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>I'm going to whisper something to you softly; close your eyes, you may turn your head to hear better if you like, repeat what I whisper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>use this broom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>kick a football (simulate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>step on a bug (simulate)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D

LETTER TO PARENTS FOR PHASE I

OF THE STUDY
Dear Parent(s):

There is currently a growing trend towards applying neurophysiological techniques to understand how children take in information and what strategies they use to learn from materials presented to them. We are also extremely interested in finding out how the brain functions when children are thinking as they are doing different types of tasks. Since your child is at present in the age group (11-12 year olds) that we are interested in studying, we request your permission for your child's participation in this study.

This research project is entitled "Interaction effects of anxiety (high/low), cognitive styles (field-dependent/independent) on P300 waveform at central and lateral brain sites during the performance of cognitive tasks under stress/nonstress conditions." This project will be conducted in two stages. Stage I will involve the administration of some paper and pencil tasks:

(i) Edinburgh Handedness Scale
(ii) Trait Anxiety Scale for Children
(iii) Group Embedded Figures Test

All these instruments will be administered by Nina Gibson, M.A., and Ranju Kapahi, M.A. From this initial group of children who have completed Stage I some children will be selected for further participation in Stage II of this study. This investigator will contact you and provide you with the details for the procedures to be used in the next stage of this project if your child is included in the group to be tested in Stage II.

We think that this study will make a valuable contribution to the understanding of thinking, emotional processes, and brain functions. We want to assure you that the results of this project are confidential. That is, individual participants will not be identified or identifiable in any report of results of the study. If you have any questions, please feel free to contact us at 422-6412 or 422-1712. We will be happy to talk with you about our study. You may withdraw this permission for your child's participation in this study at any time by writing to us. Also, you child may withdraw at any time. Thank you so very much for your attention and support.

Sincerely,

Philip M. Clark, Ph.D.

Ranju Kapahi, M.A.
APPENDIX E

LETTER TO PARENTS FOR PHASE II

OF THE STUDY
Dear Parent(s):

This is to inform you that your child has been selected for the second stage of the research project entitled "Interaction effects of anxiety (high/low), cognitive styles (field-dependent/independent) on P300 waveform at central and lateral brain sites during the performance of cognitive tasks under stress/nonstress conditions."

As indicated in our previous letter to you, currently innumerable studies are being done by applying neurophysiological techniques to understand how children take in information and what type of strategies they use to learn from material presented to them. Neurophysiological studies are those which measure the activity in specific parts of the brain while the person is working on a certain type of task. These recordings give us an opportunity to better understand how the brain functions.

With your written permission, your child will be tested in the Brain Behavior Laboratory in the Nisonger Center at The Ohio State University, Columbus, Ohio by Nina Gibson, M.A., and Ranju Kapahi, M.A. This is a comfortable office with our T.V. monitors, and computers. Your child will sit in a chair and will view and respond to colored pictures while sounds from a pair of headphones will prevent him from being distracted by outside sounds. We will then place four to seven sensors on his head depending upon the number of sites from which we are recording the brain activity. Sensors will be placed on the scalp with a water soluble gel to measure brain activity while he is participating in several tasks. There will be no discomfort of any sort with this procedure. In fact, most children find it enjoyable. Some verbal and nonverbal tasks will be presented to your child while we are recording the brain activity and he will be encouraged to perform well. In between tasks there will be intervals when the instructions for the next task will be given. A State Anxiety Scale for Children will be administered just prior to collection of brain activity information and again just after.

Once again, let us assure you that there are no discomforting components to this procedure. We will monitor your child carefully and make adjustments to meet his needs.

We think that our findings will make a valuable contribution to the understanding of thinking and emotional factors involved in information processing. These investigators are willing to discuss any aspect of this project and answer any questions. Please feel free to contact us at 422-6412 or 422-1712. We will be happy to talk with you about our study. You may withdraw this permission for your child's participation in this study at any time by writing to us. Also, your child may withdraw from the study at any time. Thank you so much for your attention and support.

Sincerely,

Philip W. Clark, Ph.D. Ranju Kapahi, M.A.

College of Social and Behavioral Sciences
APPENDIX F

PARENT AND SUBJECT CONSENT FORMS
Parent Consent Form

I give permission for my child to participate in this project:


Date:__________________________

Address:__________________________________________

Phone Number:__________________________
Subject's Consent Form

I understand the explanations given to me about this research study. I understand what I am expected to do.

I am willing to participate in this study.
Name______________________________

I am not willing to participate in this study.
Name______________________________
APPENDIX G

CONSENT TO INVESTIGATIONAL
TREATMENT OR PROCEDURE
CONSENT TO INVESTIGATIONAL TREATMENT OR PROCEDURE

1. I, ______________________________________, hereby authorize or direct Philip M. Clark, Ph.D., or his associates or assistants of his or her choosing, to perform the following treatment or procedure (describe in general terms).

Recording of brain electrical activity to simple cognitive tasks.

The experimental (research) portion of the treatment or procedure is:

Determination of neurophysiologic correlates of learning and performance via attachment of electrodes to the head.

This is done as part of an investigation entitled: Interaction effects of anxiety, cognitive styles on P300 ERP waveform at central and lateral brain sites during the performance of cognitive tasks under stress/non-stress conditions.

1. Purpose of the procedure or treatment: Assessment of neurophysiologic patterns demonstrated while performing simple cognitive tasks. The information is to be used to determine individual and group variability in the P300 component of brain activity.

2. Possible appropriate alternative methods of treatment: None

3. Discomforts and risks reasonably to be expected: Infrequently, mild tenderness may occur to the scalp from placement of the electrodes.

4. Possible benefits for subjects/society: The development of diagnostic assessment methodology which will enhance more completely the understanding of individual variability in learning characteristics or cognitive dysfunction.

5. Anticipated duration of subject's participation: Approximately one (1) hour.
I hereby acknowledge that __________________________________________ has provided information about the procedure described above, about my rights as a subject, and he/she answered all questions to my satisfaction. I understand that I may contact him/her should I have additional questions. He/She has explained the risks described above and I understand them; he/she has also offered to explain all possible risks or complications.

I understand that, where appropriate, the U.S. Food and Drug Administration may inspect records pertaining to this study. I understand further that records obtained during my participation in this study may be made available to the sponsor of this study and that the records will not contain my name or other personal identifiers. Beyond this, I understand that my participation will remain confidential.

I understand that I am free to withdraw my consent and participation in this project at any time after notifying the project director without prejudicing future care. No guarantee has been given to me concerning this treatment or procedure.

In the unlikely event of injury resulting from participation in this study, I understand that immediate medical treatment is available at University Hospital of The Ohio State University. I also understand that the costs of such treatment will be at my expense and that financial compensation is not available. Questions about this should be directed to the Human Subject Review Office at 422-9046.

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: _____________________ Time _______ Signed __________________ ”

(Subject)

Witness(es) ____________________

Signed: ___________________

(Figure Authorised to Consent for Subject - If Required)

I certify that I have personally completed all blanks in this form and explained them to the subject or his/her representative before requesting the subject or his/her representative to sign it.

Signed: ___________________

(Signature of Project Director or his/her Authorised Representative)

Form HS-028R (Rev. 12/83)
APPENDIX H

ANOVA TABLES FOR P300 LATENCY SCORES ON STROOP TASK AND COLOR-BLOCK TASK AT SCALP LOCATIONS

Pz, Cz, Lw, and Rw
Results for Latency on Stroop Task at
Scalp Locations Pz, Cz, LW and RW

TABLE 27
ANOVA of P300 Latency Scores at Scalp Location Pz on the
Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>51.200</td>
<td>51.200</td>
<td>0.02</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>540.800</td>
<td>540.800</td>
<td>0.18</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>12.800</td>
<td>12.800</td>
<td>0.00</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>48963.400</td>
<td>3022.400</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>48963.200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 27 shows that of the principal effects (cognitive style, anxiety, and cognitive style x anxiety) no significant differences were obtained for the mean values of latency scores at the scalp location Pz on the Stroop task by cognitive style and level of anxiety. This indicates similarity of the contrasted mean values by cognitive style and level of anxiety.
Table 28 summarizes the results of the two factor ANOVA of P300 latency scores at the scalp location Cz on the Stroop task by cognitive style and level of anxiety.

TABLE 28

ANOVA of P300 Latency Scores at Scalp Location Cz on the Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>352.800</td>
<td>352.800</td>
<td>0.11</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>0.800</td>
<td>0.80</td>
<td>0.00</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>980.000</td>
<td>980.00</td>
<td>0.30</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>52083.200</td>
<td>3255.200</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>53416.800</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 28 indicates that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) no significant differences were obtained for the mean values of latency scores at the scalp location Cz on the Stroop task by cognitive style and level of anxiety. This indicates similarity of the contrasted mean values by cognitive style and level of anxiety.
Table 29 summarizes the results of the two factor ANOVA of P300 latency scores at the scalp location LW on the Stroop task by cognitive style and level of anxiety.

TABLE 29

ANOVA of P300 Latency Scores at Scalp Location LW on the Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>3.200</td>
<td>3.200</td>
<td>0.00</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>2691.200</td>
<td>2691.200</td>
<td>1.59</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>720.000</td>
<td>720.000</td>
<td>0.43</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>27084.800</td>
<td>1692.800</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>30499.200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 29 indicates that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) no significant differences were obtained for the mean values of P300 latency scores at the scalp location LW on the Stroop task by cognitive style and level of anxiety.

Table 30 summarizes the results of the two factor ANOVA of P300 latency scores at the scalp location RW on the Stroop task by cognitive style and level of anxiety.
TABLE 30

ANOVA of P300 Latency Scores at Scalp Location RW on the Stroop Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>793.800</td>
<td>793.800</td>
<td>0.50</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>1065.800</td>
<td>1065.800</td>
<td>0.68</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>105.800</td>
<td>105.800</td>
<td>0.07</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>25193.600</td>
<td>1574.600</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>27159.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 30 shows that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) no significant differences were obtained for the mean values of P300 latency scores at the scalp location RW on the Stroop task by cognitive style and level of anxiety.
Results for Latency on Color-Block Task at Scalp Locations Pz, Cz, IW, and RW

Table 31 summarizes the results of the two factor ANOVA of latency scores at the scalp location Pz on the Color-Block task by cognitive style and level of anxiety.

TABLE 31

ANOVA of P300 Latency Scores at Scalp Location Pz on the Color-Block Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>1411.200</td>
<td>1411.200</td>
<td>0.47</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>8323.200</td>
<td>8323.200</td>
<td>2.79</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>259.200</td>
<td>259.200</td>
<td>0.09</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>47718.400</td>
<td>2982.400</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>57712.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 31 indicates that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) no significant differences were obtained for the mean values of latency scores at the scalp location Pz on the Color-Block task by cognitive style and level of anxiety.
Table 32 summarizes the results of the two factor ANOVA of P300 latency scores at the scalp location Cz on the Color-Block task by cognitive style and level of anxiety.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>2247.200</td>
<td>2247.200</td>
<td>0.52</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>10580.000</td>
<td>10580.000</td>
<td>2.44</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>500.000</td>
<td>500.000</td>
<td>0.12</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>69337.600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>82664.800</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 32 indicates that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) no significant differences were obtained for the mean values of latency scores at the scalp location Cz on the Color-Block task by cognitive style and level of anxiety.

Table 33 summarizes the results of the two factor ANOVA of P300 latency scores at the scalp location LW on the Color-Block task by cognitive style and level of anxiety.
TABLE 33

ANOVA of P300 Latency Scores at Scalp Location LW on the Color-Block Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>12.800</td>
<td>12.800</td>
<td>0.00</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>8000.000</td>
<td>8000.000</td>
<td>2.22</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>12.800</td>
<td>12.800</td>
<td>0.00</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>57651.200</td>
<td>3603.200</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>65676.800</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 33 shows that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) no significant differences were obtained for the mean values of latency scores at the scalp location LW on the Color-Block task by cognitive style and level of anxiety.

Table 34 summarizes the results of the two factor ANOVA of P300 latency scores at the scalp location RW on the Color-Block task by cognitive style and level of anxiety.
### TABLE 34

ANOVA of P300 Latency Scores at Scalp Location RW on the Color-Block Task by Cognitive Style and Level of Anxiety

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td>1</td>
<td>500.000</td>
<td>500.000</td>
<td>0.18</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1</td>
<td>1479.200</td>
<td>1479.200</td>
<td>0.52</td>
</tr>
<tr>
<td>Cognitive Style x Anxiety</td>
<td>1</td>
<td>1344.800</td>
<td>1344.800</td>
<td>0.47</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>45331.200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>48655.200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F - nonsignificant

Inspection of Table 34 indicates that of the three principal effects (cognitive style, anxiety, and cognitive style x anxiety) no significant differences were obtained for the mean values of latency scores at the scalp location RW on the Color-Block task by cognitive style and level of anxiety.
APPENDIX I
THE PAIRED t-TEST BETWEEN PRE-PERFORMANCE AND POST-PERFORMANCE OF STATE ANXIETY OF SUBJECTS
The Paired t-Test for Determining Differences Between Pre-Performance and Post-Performance State Anxiety of Subjects

\[ T_{\text{paired}} = \frac{\bar{D} - 0}{\frac{SD}{\sqrt{n}}} = \frac{1.8 - 0}{2.91 \sqrt{20}} = 2.77 \]

Where \( \bar{D} \) and SD are the sample mean and standard deviation respectively of Di's difference.

Rejection region for level test = .05

\[ T_{\text{paired}} > t_{\alpha'}, n - 1 \]
\[ 2.77 > t_{19, .05} = 1.729^* \]

State anxiety decreases between pre- to post-performance period and therefore, reject Ho which is \( UD = 0 \).

\[ ^*p < .01 \]

Inspection of Table 35 indicates that the level of state anxiety of subjects decreased from pre- to post-task performance.
APPENDIX J

DEFINITION OF TERMS
DEFINITION OF TERMS

1. Electroencephalogram (EEG)

Activity of the countless cells which constitute the human body is manifested by physical, chemical and electrical phenomena which are measurable, such as temperature, secretions, and electrical potential. The electrical potentials of the brain cells (neurons or grey matter) vary constantly. Each neuron is affected by the activity of neighboring neurons. However, the discharge of the electrical activity is not haphazard. There is enough synchrony with significant groups of neurons to produce differences of potential measurable on the scalp. The measurement of these differences of potentials and their temporal variations constitute the electroencephalogram (EEG). There are some potential variations which are slower and others which are faster. For example, alpha wave is a rhythmic wave that occurs at a rate of 8 to 13 times a second (cycles per second—cps—or hertz—Hz) at magnitude of about 20 to 60 μV (microvolts—millionths of a volt), and beta wave is an irregular wave that occurs at a frequency of 14 to 30 cps at a magnitude of approximately 2 to 20 μV. There are other types of brain waves identified, namely delta, theta, kappa, lambda and mu waves, which reflect differences in frequencies and magnitude of brain waveform on an encephalographic record.
2. **Event-Related Potentials (ERPs)**

According to Vaughan (1969) who proposed the term "event-related potentials", these are a variety of brain responses that show stable time relationships to actual or anticipated stimuli that may be visual, auditory, somato-sensory, etc. These are embedded within the EEG waveform and are usually smaller in voltage than background EEG activity including alpha, beta, theta and delta waves. Therefore, these potentials which are precisely time-locked to the presentation of a target stimulus may be extracted from the EEG by using a signal averaging technique in which samples of on-going EEG are taken at the instant each successive target stimulus is presented. These samples are fed into a digital computer over a preset period of time, e.g., 700 milliseconds (msecs), and are averaged out. These components are defined in terms of their polarity (positive or negative voltage-microvolts, mv), latency range (temporal relationship to the event, milliseconds), and scalp distribution (variation in voltage with electrode location on the scalp).

There are two major types of event-related potentials (John, 1963), "Exogenous" and "Endogenous". Exogenous event-related potentials are determined by an external stimulus and its variance is controlled by the physical parameters of a stimulus (modality, intensity, etc.). These potentials may be detected within approximately the first forty milliseconds after the onset
of the stimulus. They are apparently invariant to psychological manipulations and can be recorded without the subject's cognitive responses. Endogenous event-related potentials are sensitive to the variation in the psychological state of the subjects and are invoked by the processing demands of a task. These occur approximately 100-600 milliseconds after the stimulus presentation.

3. **P300 Event-Related Potential Waveform**

The P300 waveform is the focus of the present study and is the most widely researched component of event-related potentials. This is elicited by task relevant rare stimuli with a latency from 275 ms to 600 ms. The amplitude of this component is the greatest at the midline over the parietal regions of the scalp. The size of the amplitude is related to the probability and predictability of the target stimulus. If the probability, certainty and expectancy of a target stimulus is low and if the individual is confident about his decision in discriminating the target stimulus, the amplitude of the P300 will be the largest (Squires, Squires & Hillyard, 1975). The subject is required to selectively attend to an "oddball" event that occurs every "now and then" and this paradigm is referred to as "oddball paradigm" (Duncan-Johnson & Donchin, 1977). The amplitude may be associated with the amount of prior uncertainty resolved by selectively attending and detecting the rare stimulus (Andreassi, 1980). The
amplitude of the P300 indexes the degree of confidence in the
detection and decision making of the rare stimulus, information
delivery, and task relevance. Both the amplitude and latency of
the P300 are influenced by task demands and subjective
psychological manipulations.

4. **Brain Locations - Pz, Cz, LW and RW**

   Pz - Parietal midline
   
   Cz - Central midline
   
   LW - Left Wernicke's (Temporoparietal)
   
   RW - Wernicke's homologue on Right (Temporoparietal)

   Pz and Cz brain sites are central locations based on a
portion of the International 10-20 system (Jasper, 1958). This
system is so-named because the various locations are either 10% or
20% of the distance between standard points (nasion to inion and
right pre-auricular point to left pre-auricular point). For
measurement see Figure 1.

   Approximations of LW and RW (lateral locations - either
side of midline) were used since the International 10-20 system
does not have a placement over Wernicke's area and its homologue
on the right side. See Figure 2.
Figure 1. Reproduction of diagram in Jasper (1958)
Figure 2. Reproduction of figure depicting brain site measuring system followed in the Brain Behavior Laboratory, The Ohio State University, Columbus, Ohio.
5. **Cognitive Styles**

This term refers to relatively stable and reliable individual differences in mode or pattern of processing information. In this study the subject's cognitive style was labeled as either field independent (dealing with the environment in a verbal, analytic manner) or field dependent (dealing with the environment in a spatial, holistic manner).

6. **Anxiety—State and Trait Anxiety**

Anxiety has been defined as a "state of diffuse arousal following the perception of threat or alternatively, as unresolved fear" (Epstein, 1975). Spielberger (1972) conceived of anxiety "as a specific emotional state which consists of unpleasant, consciously perceived feelings of nervousness, tension, and apprehension, with associated action on arousal of the autonomic nervous system." "The term anxiety is currently used to refer to at least two related yet logically quite different constructs. Empirically, anxiety is perhaps most often used to describe emotional state or condition." It is also used to describe relatively stable individual differences in anxiety-proneness as a personality trait.

The distinction between anxiety as an emotional state and as a characteristic received its first meaningful attention in the work of Cattell and Scheier (1963) who coined the term "state" (temporary) anxiety and "trait" (proneness) anxiety.
These terms received further attention and were elaborated by Lazarus (1966) and Spielberger (1966, 1972, 1976, 1979, 1983). According to the latter, state anxiety exists at a given moment in time and is transitory in nature. On the other hand, trait anxiety refers to relatively stable individual differences among people in the tendency to perceive stressful situations as dangerous or threatening and to respond to such situations with elevations in the intensity of state anxiety reactions. Persons with high trait anxiety exhibit state anxiety elevations more frequently and with greater intensity than low trait anxiety individuals because they perceive a wider range of situations as threatening.

7. **Evaluative Situation**

This term refers to an achievement-demanding situation where one is evaluated along with peers, and thus runs the risk of failure and hence becomes an ego-threatening situation (Magnusson, 1985).
APPENDIX K

RAW DATA
Table 36

Raw Data
Group I - Low Anxious/Field Independent

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Anxiety Score</th>
<th>PDI Score</th>
<th>P300 Amplitude Task - Stroop</th>
<th>P300 Latency Task - Stroop</th>
<th>No. False Positives</th>
<th>No. Misses</th>
<th>Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33</td>
<td>17</td>
<td>18.6 6.50 16.25 11.60</td>
<td>276 292 336 384</td>
<td>2</td>
<td>1</td>
<td>503</td>
</tr>
<tr>
<td>2</td>
<td>34</td>
<td>13</td>
<td>21.45 13.95 14.10 17.10</td>
<td>288 296 296 368</td>
<td>1</td>
<td>0</td>
<td>493</td>
</tr>
<tr>
<td>3</td>
<td>33</td>
<td>16</td>
<td>23.0 8.10 19.15 13.15</td>
<td>368 384 288 278</td>
<td>0</td>
<td>0</td>
<td>481</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>12</td>
<td>20.7 12.45 16.65 17.05</td>
<td>368 408 392 392</td>
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<td>0</td>
<td>454</td>
</tr>
<tr>
<td>5</td>
<td>31</td>
<td>15</td>
<td>15.9 12.75 18.35 14.10</td>
<td>328 416 352 392</td>
<td>1</td>
<td>0</td>
<td>425</td>
</tr>
</tbody>
</table>
Table 37

Raw Data
Group I - Low Anxious/Field Independent

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Anxiety Score</th>
<th>FDI Score</th>
<th>P300 Amplitude</th>
<th>P300 Latency</th>
<th>No. False Color Block</th>
<th>No. Misses Color Block</th>
<th>Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33</td>
<td>17</td>
<td>14.65 18.70 12.80 14.85</td>
<td>312 304 320 292</td>
<td>0</td>
<td>1</td>
<td>452</td>
</tr>
<tr>
<td>2</td>
<td>34</td>
<td>13</td>
<td>27.45 16.40 11.65 20.95</td>
<td>256 328 320 296</td>
<td>0</td>
<td>0</td>
<td>459</td>
</tr>
<tr>
<td>3</td>
<td>33</td>
<td>16</td>
<td>16.2 8.35 11.85 13.55</td>
<td>264 276 280 292</td>
<td>0</td>
<td>0</td>
<td>425</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>12</td>
<td>26.35 11.35 17.7 17.2</td>
<td>280 400 328 352</td>
<td>0</td>
<td>0</td>
<td>441</td>
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Table 38

Raw Data
Group II - High Anxious/Field Independent

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<th>P300 Latency Task - Stroop</th>
<th>No. False Positives</th>
<th>No. Misses</th>
<th>Reaction Time</th>
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Raw Data
Group II - High Anxious/Field Independent

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<th>P300 Latency (Pz, Cz, LW, RW)</th>
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Raw Data
Group III - Low Anxious/Field Dependent

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Group IV - High Anxious/Field Dependent

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