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The Construct of Personality and Hemispheric Usage

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THE CONSTRUCT OF PERSONALITY AND HEMISPHERIC USAGE

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ABSTRACT

Studies on the differential contributions of the cerebral hemispheres to human experience and behavior have demonstrated that the hemispheres are lateralized for cognitive strategies and, possibly, for emotional valance. Recently researchers have demonstrated that the hemispheres may also be lateralized for certain personality disorders and personality traits. Using lateral eye movements as a measure of hemispheric activation, Dawson, Tucker, and Swenson (in preparation) have shown that certain self-description questionnaires may serve to discriminate subjects who characteristically utilize one hemisphere over the other, regardless of the relative adaptiveness of the cognitive strengths of that hemisphere for the task at hand.

This study replicated the findings of the Dawson et al. study, using brain wave activity as an index of lateralized activation. Separating subjects on the basis of their scores on self-description personality measures, it was discovered that subjects who were unrealistically favorable in their self-descriptions (deniers) evidenced greater right hemisphere activation, regardless of the task being performed. Subjects who were overly critical in their self-descriptions (critics) evidenced symmetrical hemispheric activation with a tendency toward greater left

hemispheric activation, particularly evident during the baseline and spatial tasks. These findings were evidenced in both the theta and alpha bands for average power, with comparisons in the theta band demonstrating the clearest personality related effects. Analyses on coherence data were performed and described without interpretation.

The results of this study were used to provide support for a theory of hemispheric personality. A model is built on the research findings on lateralized cognition and then extended to address some of the recent controversies in the lateralization literature. Implications for further research are discussed and suggestions of how such a model might be used in psychological/medical treatment and diagnoses are discussed.

CHAPTER I

INTRODUCTION

Research in neurology and neuropsychology has provided preliminary results suggesting that the two hemispheres of the brain contribute differentially to cognition, emotion, and personality. From early observations of brain damaged patients to more sophisticated present techniques of computerized axial tomography and position emission tomography scanning, researchers have been able to demonstrate that each hemisphere contributes specific perceptual approaches and cognitive processing styles. Although it is not actually correct to speak of either hemisphere as completely controlling specific types of processing, due to the massive interconnections between the hemispheres, it may still be heuristic to describe a "hemispheric style" for an individual.

Essentially, the concept of "hemispheric style" suggests that, even though the hemispheres are intimately linked, through the anterior, posterior, and callosal commissures, a particular hemisphere may come to serve a more prominent role in the processing of a certain type of task. Beyond the relative contributions of each hemisphere to specific types of tasks, some evidence suggests an individual may come to rely more heavily on the processing

mode of a particular hemisphere to approach a variety of situations and tasks.

In order to understand how an individual might come to use a specific "hemispheric style," regardless of whether or not the characteristic processing style of that hemisphere is conducive to the performance of a particular task, it is important to gain a basic understanding of the differential contributions of the hemispheres to cognition, emotion, and personality. This paper presents a brief, general overview of some of the representative research findings in each of these areas and then suggests a model, based mostly on neuropsychological findings of lateralized cognition, which might serve as a heuristic framework with which to understand normal integrative functioning.

CHAPTER II

REVIEW OF THE LITERATURE

Lateralized Cognition

The research on lateralized cognition has provided fairly consistent findings. Overall it appears that the right hemisphere is more responsible for spatial, holistic, and gestalt-like perception and cognition while the left hemisphere is credited with sequential and logical perception and cognition. Evidence for such a model has emerged from research, on both brain-damaged and normal subjects.

Assuming that hemispheric damage is directly related to cognitive deficits that appear after the trauma, researchers have shown that the left hemisphere is particularly important for control of speech (Bogen 1969; Day & Ulatowska 1979; Gazzaniga 1970; Lansdel 1961; Ornstein 1978), and is required for performing verbal tasks (Benton 1962; Bogen 1969; Lansdell 1962; Wexler 1980); auditory tasks (Day & Ulatowska 1979); sequential/analytic processing (Bogen 1969; Galin 1974; Sperry 1968); propositional thinking (Bogen 1969; Galin 1974); musical understanding (Hacaen 1962); tasks requiring extraction of relevant details and symbolic representation of elements (Day & Ulatowska 1970; Nebes 1974); digit tasks (White 1969); writing tasks (Gazzaniga

1970; Ornstein 1978); and tasks of fine motor coordination (Day & Ulatowska 1979).

While the left hemisphere thus appears to be particularly important for verbal, sequential and analytic cognitive processing, the right hemisphere appears to be more important for spatial, non-verbal, and gestalt-like processing. Right hemisphere strengths include: facial recognition (Benton & Van Allen 1968; Wexler 1980); spatial perception (McGlone & Davidson 1973; Nebes 1974; Semmes 1968; White 1969); visual memory (Day & Ulatowska 1979); integrating sensory information (Galin 1974); non-verbal communication (Bogen 1969; Galin 1974; McGlone & Davidson 1973); appositional thinking (Bogen 1969; Galin 1974); recognition of musical sounds (Bogen 1969); visual perception and visual/motor skills (Day & Ulatowska 1979); musical perception (Milner 1962; Ornstein 1978; White 1969); and faster reaction times (Sperry, Zaidel, & Zaidel 1979).

As well as finding functional deficits that seem to correlate with hemispheric damage, other researchers have shown that the hemispheres are anatomically and neurochemically different. Lansdell (1967) has shown that task performance deficits were proportional to the amount of ablated left temporal cerebrum, while damage within the right hemisphere did not appear to significantly correlate with task performance. Lansdell hypothesized that the left hemisphere is more focally organized while the right

hemisphere is more diffusely organized. Recent support for such a hypothesis has been demonstrated by Gur (1980), who found a greater ratio of white to grey matter in the right hemisphere. The author suggests that this finding may indicate a greater hemispheric interconnectedness in the right hemisphere and therefore less regional specificity than may be found in the left hemisphere. This would suggest that both the localizationists and organismic theorists (Goldstein 1948) were correct in their description of functional representation within the hemispheres. It would appear that the left hemisphere is more localized, having specific areas responsible for specific types of processing, while the right hemisphere may be more holistically oriented, with each part of the right hemisphere containing some type of "holographic" representation of function throughout the entire hemisphere.

Semmes (1968) also suggested that the left hemisphere is more focally oriented than the right. She suggested that the left hemisphere is more adapted for manual tasks and speech while the right hemisphere appears more diffusely organized and therefore better suited for associating dissimilar units of information, as in the synthesis of sensory and motor input, and performing spatial tasks. Tucker (1981) reviewed the results of Semmes and Lansdell and suggested that, since the anatomical differences of the hemispheres appear to heuristically parallel the basic

cognitive differences of the hemispheres, the hemispheres' differential ability may be a function of, or facilitated by, their differential neural and anatomical structure.

In another study suggesting anatomical differences between the hemispheres, Galaburda, LeMay, Kemper & Geschwind (1978), using computerized axial tomography, demonstrated that the right frontal lobe is larger than the left frontal lobe, whereas the left posterior region is larger than the right posterior region. The suggestion here is that these differences in anatomical size may be adaptive for performing differential types of functions within the hemispheres. Although it is clear that these differences exist, it is not certain what these differences mean (Tucker, Roth, & Bair 1982).

In a neurochemical study, Oke, Keller, Mefford and Adams (1978) found that the amounts of certain neurotransmitters seem to be lateralized. In a study measuring amounts of neurotransmitters from the hemispheres, Oke et al. found the presence of norephinepherine to be differentially lateralized within the thalamus such that projections to the right hemisphere appear to contain more norephinepherine. Although the specific implications of these findings are not readily apparent, the fact that the hemispheres are structured and neurochemically distributed differentially lends support to the notion that they are functionally differentiated subsystems of the brain.

Research on Normal Subjects

Thus far, research has been reviewed that suggests that each hemisphere has a distinct role in differential organizing and processing of information. Although the evidence presented so far appears to present a rather consistent set of findings suggesting that the hemispheres are both neuroanatomically/neurochemically and functionally different, much of this research was performed on patients with some type of brain abnormality, thereby making generalizations to normals tentative. Unfortunately, research with normals has been hindred by lack of valid, non-intrusive measurement tools.

In order to perform research on normals it has been necessary to restrict stimulus impact to one hemisphere or the other, at least for initial presentation. The right side of the brain receives the majority of its perceptual information from the left side of the body while the left hemisphere receives its stimuli from the right. This lateralization is also true for efferent conduction. Thus, researchers have utilized visual half-field performance (Kimura 1966; Kinsbourne 1970), dichotic auditory listening task performance (Kimura 1967; Safer & Leventhal 1977) and lateral eye movements (Bakan 1969; Crouch 1976; Weiten & Etaugh 1974; Gur, Gur, & Harris 1975). These various methodologies have all demonstrated results consistent with the previous findings on brain damaged and/or brain anomaly patients.

In sum, the evidence from the research on lateralized perceptual and cognitive styles reliably demonstrates a lateralized difference between the hemispheres. The left hemisphere appears to provide relative superiority in logical, sequential, and analytical processing while the right hemisphere appears to be more important to performing spatial, nonverbal, gestalt-like perception and processing.

Although research in lateralized cognitive processing has generally provided consistent results, two recent studies have cast doubt on the reliability of this model. In a recent, highly controlled set of studies, Gevins, Zeitlin, Yingling, Doyle, Dedon, Schaffer, Roumasset, and Yeager (1979) and Gevins, Zeitlin, Doyle, Schaffer, and Callaway (1979) have demonstrated that "no evidence for lateralization of different types of cognitive activity was found in the EEG" (Gevins, Doyle, Schaffer, Callaway & Yeager 1980, p. 1006).

While the findings of the Gevins et al. studies are disconcerting, their results may suggest that some unconsidered confounding variable may exist which can significantly diminish lateralized task effects. Reviewing the Gevins et al. studies, Davidson and Ehrlichman (1980) postulate that the different methods and non-equivalent spatial tasks used across the two experiments of Gevins et al. may have led to the authors' inability to find lateralized cognitive effects. This paper will attempt to explore the effects of yet another possibly confounding variable that could account for the lack of lateralized results in the

Gevins et al. studies. By reviewing some of the literature to date in the areas of cognition, emotion and personality, this paper will attempt to construct a model to account for some of the confounding variance within the research on lateralized cognition and provide a heuristic framework with which to interpret results from the research on lateralized emotion.

Lateralized Emotion

Research striving to uncover the differential contributions of the hemispheres to emotion and personality has often been confusing and contradictory. Essentially, three different views have evolved, each with an explanation of how the hemispheres are important in emotion and personality. The first view suggests that the right hemisphere subserves emotional functioning while the left hemisphere appears to be a relatively non-emotional processor which can provide some inhibitory or modulatory effects on the emotional right hemisphere. Whereas the first view postulates that one hemisphere basically houses emotion, the other two views hypothesize that the hemispheres are differentially lateralized for positive and negative emotion. The second view holds that the left hemisphere is associated with positive emotion, while the right hemisphere is associated with negative emotion. Although the third view also hypothesizes lateralized emotional valances, it asserts that the hemispheric valances are the opposite of those postulated in the second view, that is, the left hemisphere is associated

with negative emotion while the right hemisphere is associated with positive emotion.

In support of the first view, Heilman, Scholes, and Watson (1975) asked patients to judge the emotional tones of a speaker and found that patients with right hemispheric dysfunction were deficient in their ability to comprehend the emotional tone of speech. Tucker, Watson and Heilman (1976) replicated Heilman et al.'s findings (1975) and further demonstrated that right hemisphere damaged patients were also deficient in their ability to express emotion. This latter finding has been recently replicated by Ross and Mesulam (1979) who found that two right hemisphere (frontal) damaged patients had difficulty utilizing emotional inflections in everyday communications. In another experiment, Sackeim, Gur and Saucy (1978) had subjects judge right and left facial composites for emotional expressiveness. The authors found that left facial composites, when compared to right facial composites, were judged as expressing emotion more intensely. Assuming that the right hemisphere has greater control over most left facial muscles, the authors concluded that the right hemisphere exerts greater control over the production of emotional expression than does the left.

Making the same assumption as Sackeim et al. (1978), Schwartz, Ahern and Brown (1979) measured right versus left facial muscle responses and found that left facial muscles were more active than right in negative emotion, while right

facial muscles were more responsive during positive emotion. The implication of this study is that the hemispheres contribute differentially to emotion such that the right hemisphere is more active during negative affect and the left hemisphere is more active during positive affect. This finding is representative of the second view which postulates that each hemisphere is differentially active during emotion, with the left hemisphere being more active during positive emotion and the right hemisphere being more active during negative emotion. In further support of this contention, Dimond, Farrington, and Johnson (1976) have shown that films presented to the right hemisphere were judged to be more unpleasant while evaluations of films presented to the left hemisphere did not differ from evaluations of films presented simultaneously to both hemispheres. The authors concluded that the right hemisphere appears to contribute most heavily to the experience of negative emotion. Lastly, Ahern and Schwartz (1979) found that positive emotionally reflective questions elicited more eye movements to the right (left hemispheric processing) while negative emotional questions elicited more left lateral eye movements (right hemispheric activation).

While the previous researchers postulated that the left hemisphere is important for positive emotion and the right hemisphere is important for negative emotion, other researchers, holding the third view of emotion, have

interpreted their findings to suggest that the right hemisphere is associated with positive emotion while the left hemisphere is associated with negative emotion. Assuming that damage to a hemisphere disinhibits that hemisphere's activation characteristic of its emotional valance, several authors have reported results consistent with the third view. Gainotti (1972a, 1972b) examined 160 patients (80 with left lesions and 80 with right lesions) and found that catastrophic or anxiety depression was more frequent among left hemisphere damaged patients, while spatial neglect, unilateral alterations of body schema and euphoria reactions were more often associated with lesions of the right hemisphere. Black (1975) and Gasparrini, Satz, Heilman and Coolidge (1978) have shown that patients with left hemisphere damage report significantly higher scores on the depression scale of the Minnesota Multiphasic Personality Inventory (MMPI) than do right hemisphere damaged patients. Reporting similar findings, Bear and Fedio (1977) found that left temporal lobe epileptics described themselves in more "catastrophic"/depressive terms than did right temporal lobe epileptics. In fact, right temporal lobe epileptic patients appeared to be unaware of their deficits. Interestingly, Bear and Fedio also employed an observer rating scale and found that, while left temporal lobe epileptics described themselves as more severely disturbed than right temporal lobe epileptics, observers rated right temporal lobe epileptic patients as being more disturbed. In

addition to providing support for a lateralized emotion model, Bear and Fedio's study raises an important question of research design. It would appear that patients' self-report may vary significantly from observer ratings. A replication of the major features of Bear and Fedio's findings has recently been reported (Strauss, personal communication).

As evidenced in the foregoing discussion, the research on differential hemispheric contributions to the experience of emotion is confusing and contradictory. While some researchers proposed that only the right hemisphere contributes to emotion, other researchers have proposed that each hemisphere has a propensity toward a certain type of emotion (i.e., positive or negative) although which hemisphere contributes to what emotion is still in hot dispute. Contributing to the controversy is the assumption used to make the interpretation of lateralized emotional balance. While some authors hold that damage to one hemisphere inhibits that hemisphere's contribution to emotional experience, other authors assert that the same damage disinhibits that hemisphere's contribution, thereby arriving at a completely opposite interpretation. For a more comprehensive review of this literature, see Tucker (1981).

A Personality Theory of Hemispheric Activation

Hemispheric Integration

Thus far, the research presented indicates that the hemispheres are functionally differentiated for cognition and emotion. The suggestion of this research is that each hemisphere represents a unique cognitive and emotional style of gathering, processing, and acting on information. Assuming the distinction between the hemispheres to be accurate, the generally smooth, immediate subjective experience of problem solving becomes difficult to reconcile with the functional independence of the hemispheres in information acquisition and processing. Specifically, looking at the evidence on cognitive differences, normal hemispheric functioning implies constant competition between two antithetical problem-solving systems, yet subjective experience of problem solving is paradoxically smooth and conflict-free, even if it may be an illusion (Galin 1978).

In general, three theories describing hemispheric interrelation have addressed this problem. Nebes (1974) suggests that both hemispheres develop individual strategies for the task at hand and final choice of approach is resolved in favor of the hemisphere most adapted for that particular task. In a different vein, Bogen (1969) suggests that the "position of two independent problem-solving organs increases the prospects of a successful solution to a novel situation"

(p. 191). Basically, Bogen suggests that the individual hemispheres interact to gain harmonious/creative solutions, this being the most adaptive approach to problem-solving. In support of this conjecture, Zaidel (1979), in a recent study of patients with corpus callosum commissurotomies, demonstrated that interhemispheric task solution was superior to independent hemispheric solution.

Although sponsoring a theory of mutual cooperation between the hemispheres, Bogen recognizes the possible "hazard of conflict in the event of different solutions" and suggests that the "propositional" mode of the left hemisphere could inhibit the right hemisphere's "appositional" mode. Essentially agreeing with Bogen and using Freud's terms of secondary process and primary process for the processing styles of the left and right hemispheres respectively, Galin (1974) suggests a more dynamic model in which the left hemisphere (secondary process) inhibits the right (primary process). McLaughlin (1978) eloquently expanded Galin's model in describing the parallels between hemispheric processing and the psychoanalytic model. He further suggests that these processes continue throughout life, interactively inhibiting and facilitating each other's growth and development.

Finally, in contrast to the previously presented views of conflict resolution between the differential approaches of the hemispheres, Ornstein (1978) suggests that the

hemispheres do not compete for ascendency in performing a given task, nor is the determination always made in favor of the most appropriate processing style for a given task. Ornstein selected two groups of subjects, lawyers and ceramicists, in order to test this hypothesis, and found that lawyers (considered to use more verbal and analytical skills) used their left hemispheres more (as measured by electroencephalograph recordings) regardless of task demand, than did ceramicists (considered to use more spatial/ holistic skills). Ornstein concludes "apparently the hemispheres are specialized for the kind of thought or information a person chooses to use, not necessarily for the type of material he confronts" and that the hemispheres are "not specialized for different types of <u>material</u> (verbal and spatial), but for different types of <u>thought</u>" (Ornstein 1978, pp. 81, 82).

Ornstein's proposal of hemispheric utilization is radical in that it hypothesizes that the hemispheres are specialized for "thought" and the person "chooses" what material he will use. The concept of "choice," as an organizing principle for utilization of specific hemispheric skills, will be elaborated later in a hypothesis suggesting that "choice," as defined by Ornstein, is a function of the individual's personality, which ultimately directs hemispheric utilization in perceptual information selection and task solution.

<u>Personality Theory of Hemispheric Activation</u>

Thus far, evidence has been presented suggesting that the hemispheres are specialized for different types of cognition and emotional experience. Yet, while the evidence appears to delineate two semi-autonomous organs that provide separate and sometimes antithetical solutions, human subjective experience and behavioral performance suggests a unity of approach, resolution and feeling (Galin 1978). In other words, typical human subjective experience and behavioral performance would seem to suggest that there exists an underlying organization or principle that preselects or instantaneously selects one hemispheric style or the other.

One theorist who speaks to this issue is Ornstein (1978). Ornstein's theory (1978) of hemispheric utilization suggests that the underlying principle that may govern preselection or selection of hemispheric utilization is human choice. Although Ornstein is apparently referring to the cognitive characteristics of the hemispheres, it seems reasonable that this theory might also suggest the mechanism for emotional experience. In fact the distinction between cognition and emotion may be more arbitrary than real. Tucker (1981), in a recent review of the literature, states that "It thus may be necessary to accept the interdependence between cognition and affective arousal as going both ways, with emotion emerging not only from a post hoc cognitive evaluation of an arousal state, but also from the operation

of neurophysiological process which can excite or attenuate cognitive activity" (Tucker 1981, p. 62).

Drawing upon Ornstein's theory of hemispheric utilization and Tucker's suggestion of the interdependence of cognition and affective arousal, it is possible to postulate a theoretical framework within which to view the relationship of cognition and affect, and account for an individual's unique manner of approaching emotional experience. This framework will be referred to as a personality theory.

In essence, a personality theory of hemispheric activation would suggest that the hemispheres are not only differentiated for "types of thought" as Ornstein suggests (i.e., verbal and spatial), but also for types of emotional experience, and that these two elements are interconnected. In other words, this theory suggests that the type of cognition a hemisphere employs dictates the type of affective arousal (and vice versa), and hemispheric selection is the result of an individual's unique background, genetic makeup, and social interactions, that is, his personality.

In order to characterize the interdependence of cognition and emotion within a hemisphere, it is necessary to begin with the evidence on cognitive differences between the hemispheres and consider how these are relevant to lateralized emotional processes. For example, the right hemisphere's propensity for non-verbal and holistic cognition and perception would seem to facilitate immediate,

undifferentiated, and affectively-charged experience and/or expression. These experiences and expressions would be "felt" and less available to verbal description and analytic recall or modifiable by verbal, logical and sequential thinking and discussion than information processed by the left hemisphere. In fact, recall for the right hemisphere might best be facilitated by entering a similar relationship, situation, or emotional experience, because right hemispheric storage of this information occurs in a fusion of experience into a single, syncretic (Tucker 1981), holistic concept. Specific emotions would be experienced and expressed intensely and undifferentially, increasing the possibility of distortion of the factual information or situation.

In contrast to the global, undifferentiated cognitive structure and perceptual approach of the right hemisphere, the left hemisphere provides a more sequential and analytical approach, often involving symbolic representation through words and digits. By accurately defining and separating various components of cognition and affect, the left hemisphere would be able to utilize various components of an experience separately in order to arrive at an expression. Therefore, the left hemisphere would be capable of representing a given event in a purely cognitive form, divorced from its emotional elements.

The preceding model discusses affect in terms of general implications from the lateralized cognitive research.

That is, instead of describing the hemispheres as lateralized for positive or negative emotion this model regards the hemispheres as being lateralized for the cognitive processing style with which a hemisphere characteristically experiences and expresses emotion, both positive and negative. The right hemispheric personality type (i.e., person who relies basically on his right hemisphere processing style) would therefore express both positive and negative affect in an unmodulated fashion. Negative affect would be experienced as devastating, and an individual may have difficulty identifying a precipitating event appropriate to the level of emotional response. Yet, since the right hemispheric processes are less available to verbal description and encoding, this negative affect might fade quickly with little verbal awareness or recollection of the intensity of the negative affective expression. Positive affect would most likely be experienced and expressed in the same manner as negative affect, with the individual demonstrating intensely positive emotion which may be disproportionate to the situation. Once again, memory of the positive affective expression may be inaccurate, with the individual possibly deemphasizing the extent of his emotional expression.

Unlike the right hemispheric personality type, (the deniers), the left hemispheric personality type's (the critic's) characteristics of detail oriented perception, focused awareness, and verbal encoding would most likely

aid him in accurate perceptions of his environment. These characteristics also would aid him in developing detailed, verbal memory stores which are easily retrievable. The critic's propensity toward critical evaluation of his environment could lead to a hypervigilant attentional style. Unlike the critic, the denier might evidence little outward emotional expression yet be intensely focused on whatever affective experience he might have, making him appear to be less affectively stimulated than he may report.

Even though neither style is discussed in terms of having a specific valence, observers of these individual styles may be likely to describe each as having a characteristic valence. Assuming that neither style was observed during an acute emotional event or trauma (e.g., flood, death of a loved one, winning of an award), the deniers' style of passive diffuse awareness and poor accessibility to emotional memory may lead others to perceive that type as generally optimistic, vivacious and positive. Critics, on the other hand, may be perceived in a less favorable light. The critic's propensity toward focused and vigilant awareness, critical evaluation, and emotional regulation may cause others to generally perceive them to be pessimistic, reserved and negative.

Similar to Bear and Fedio's (1977) research with epileptics, the personality theory of hemispheric activation postulates that hemispheric personality types would

describe themselves differently than would their observers. Should the personality model of hemispheric activation prove viable, it would imply that brain damage may serve to exaggerate the normal (intact) characteristic emotional style of the affected hemisphere. Further, the similarity of the model to Bear and Fedio's findings suggests that the psychological defense mechanisms of denial and obsessiveness may respectively describe the characteristic functioning of the right and left hemispheres.

These lateralized styles of emotional and cognitive functioning bear striking resemblance to two neurotic styles described by Shapiro (1965) in his book, Neurotic Styles. In general, Shapiro suggests that, for whatever reason (e.g., genetic, behavioral, psychosexual) an individual develops a characteristic matrix of thinking, experiencing, and feeling. This matrix then regulates the type and amount of perceptual information gathered, the processing performed, and the behavior exhibited. Shapiro further suggests that neurotic manifestations are consistent with this matrix. For example, Shapiro states that no one is surprised to hear that a very logical, exacting person chooses the profession of a bookkeeper and that, when a psychological problem occurs, it manifests itself as an obsessional type of neurosis.

Two basic matrices described by Shapiro are the obsessive-compulsive neurotic style and the hysterical neurotic style. The obsessive-compulsive style is

characterized by analytical cognition with a great attention to detail, deliberate activity and expression. Shapiro states that maintenance of this vigilance to detail and purposeful activity calls for "tense deliberateness" that restricts the abilities of imagination, fantasizing, "whim, playfulness, and spontaneous action in general" (Shapiro 1965, p. 44). Shapiro also characterizes people with this style as dogmatic and worrisome. As can be seen from the preceding description, Shapiro's description of the obsessive-compulsive neurotic style is similar to that proposed for a left hemispheric personality style. A similarity is also evident between Shapiro's description of a hysteric neurotic style and the proposed personality style of the right hemisphere.

Shapiro describes the hysteric neurotic style as being more global, diffuse and impressionistic in cognition and perceptual approach. It is characterized by a relative absence of active, complex cognitive integration, and numerous emotional outbursts that are not truly representative of the hysteric's overall feelings. Shapiro also states that this neurotic style is particularly likely to utilize the psychological defense of repression, that is, "the loss not of affect but of ideational contents to achieve the status of conscious memory or of memories available to consciousness" (Shapiro 1965, p. 109), or "to put it another way, the hysterical affect, like the cognition, does not emerge as a well-developed and articulated mental concept

in a clearly focused well-differentiated awareness, but immediately dominates and captures a diffuse and passive awareness" (Shapiro 1965, p. 131).

Thus far, the hemispheric personality style model postulates that the hemispheres are specialized for certain interrelated types of cognition and emotion. By drawing a parallel to Shapiro's descriptions, it may be hypothesized that the right hemispheric personality style is congruent with an hysteric-like personality style. Evidence supporting such a hypothesis is provided by several studies. Relating a hysteric-like symptom (denial) and right hemisphere activation, Gur and Gur (1975) measured lateral eye movements of normal subjects and found that "left lookers" scored significantly higher than right movers on Reversal, a subtest of the Defense Mechanism Inventory, which is considered to demonstrate defenses, such as repression, denial, negation and reaction formation that "deal with conflict by responding in a positive or neutral fashion to a frustrating object." The authors also found that "left lookers" evidence more psychosomatic symptomatology. Suggesting that hysteria and psychosomatic tendencies are linked, Sommerschield and Reyker (1973) have shown that the degree of repression (a hysteric defense mechanism) is related to the number of psychosomatic complaints and symptoms.

Other researchers have further demonstrated that psychosomatic difficulties are linked to hysteria and the

right hemisphere. Galin, Dimond and Braff (1977) reviewing the cases of female hysterics, found that a significant portion of them exhibited conversion symptoms on their left sides. Kenyon (1964) reviewed records of patients with unilateral psychosomatic symptoms and also found that the symptoms were mostly evidenced on the left side. These findings, plus Gur and Gur's findings on normals, suggest that the right hemisphere may be particularly important to hysterical defense mechanisms and symptomatology. Recently Mesulam (1981) described 12 patients with dissociative symptomotology who were seen over a one year period. A review of 10 of the 12 patients who evidenced abnormal EEGs showed a predilection for the non-dominant temporal lobe. The author hypothesizes that mental processes that originate in the non-dominant (i.e., right) hemisphere are more likely to lead to dissociative states, while processes arising in the dominant hemisphere are more likely to be accepted as part of the self. Dominant hemisphere traits were thought by the author to include aggressiveness, religiosity, and humorlessness.

In reviewing research on cognitive lateralization, it is apparent that the descriptions of left hemispheric functions are congruent with Shapiro's description of the obsessive verbal, analytical style. Although the exact type of emotional expression of the obsessive-compulsive is not stated by Shapiro, it is not unreasonable to infer from

Shapiro's descriptors of "tense deliberateness," worry, and dogma, that the left hemisphere's emotional expression might be one of tension or anxiety that, in times of stress, is characterized by negative self-statements and verbal ruminations (i.e., depressive-like affect). Several studies have demonstrated just such a link between anxiety/depression and the left hemisphere.

Using brain damaged subjects, researchers have shown that patients with left hemisphere damage report more depression (Black 1975; Dikmen & Reitan 1977; Gasparrini, Satz, Heilman, & Coolidge 1978) and anxiety (Dikmen & Reitan 1974) on the Minnesota Multiphasic Inventory. In another study, using the lateral eye movements of normal subjects to indicate hemispheric activation, Day (1967) found that right movers (i.e., left hemisphere) experience more anxiety and experience it as having an external locus.

In another approach researchers interrupted normal left hemisphere functioning by unilaterally injecting sodium amytal in the brains of pre-surgery patients to determine speech lateralization (Rossi & Rosadini 1967; Terzian 1964) or by administering unilateral ECT (Deglin & Nikolaenko 1975) to psychiatric patients. Although the subject populations were different, the results were the same. Assuming that unilateral ECT and amytal injections resulted in the disinhibition of the hemisphere under study, both sets of researchers found that left hemispheric disturbance (i.e.,

injection or ECT) produced behavioral phenomena suggestive of a catastrophic depressive reaction, while induced disruption of the right hemisphere produced patient behavior suggestive of euphoria. Reviewing patients with left hemisphere insults, Robinson and Szetela (1981) found that both patients having head trauma or stroke demonstrated clinically significant depression (60% and 20%, respectively) and that when lesion location was controlled, the severity of the depression was directly correlated with the closeness of the lesion to the left frontal pole.

Specifically looking at anxiety and lateralized cerebral function, Tucker, Antes, Stenslie, and Barnhardt (1978) performed two experiments that indicated left hemispheric involvement in anxiety. In the first experiment they found that higher reported anxiety is associated with greater errors in the right visual half-field. Measuring lateral eye movements and auditory attentional bias, they performed a second experiment which demonstrated that reported trait anxiety is correlated with a decrease in left eye movements and a right ear attentional bias. The authors conclude that anxiety appears to be a left hemisphere phenomenon reducing the left hemisphere's ability to process hemisphere-specific perceptual information due to a hemispheric processing demand overload.

Monakhov, Perris, Botskarov, von Knorring and Nikiforov (1979) have also demonstrated a relationship between

"anxiety-depression" and lateralized hemispheric involvement. The authors analyzed the EEG of 22 depressed patients. Although patients were not differentiated by type of depression (e.g., unipolar, bipolar), distinctions between 12 depressive symptoms were made (e.g., depressed mood, psychic anxiety, motoric restlessness, thoughts of suicide). The 12 symptoms were then grouped into two scores, the first described as an "anxiety-depression" score and the second as an "inhibition-retardation" score. The authors found a pronounced inter-hemispheric correlation with alpha power for the "anxiety-depression" score, demonstrating major activity in the left precentral area.

In summary, each hemisphere appears to have a characteristic form of cognition and emotion and, by exploring the interrelationship of these two characteristics, a general personality style can be attributed to each hemisphere. Through comparing this hemispheric personality style model to the clinically generated neurotic styles described by Shapiro (1965) it is possible to heuristically label the right hemispheric personality style as being hysteric-like and characterized by denial and the left hemisphere's as being obsessive-compulsive-like and characterized by self-criticism. Yet, although it is possible to generate personality style descriptors for the two hemispheres, this model has only characterized the hemispheres as discrete, functioning units. In the following section the hemispheric interaction and overall individual experience will be explored.

Personality

To this point, the personality theory of hemispheric activation (e.g., personality style theory) has been developed in such a way as to suggest that the hemispheres are differently characterized by certain types of interrelated cognition and emotion, yet it has not been postulated how two such diverse and antithetical personality styles exist within one individual. Once again returning to Ornstein's concept of choice as an indicator of hemispheric utilization, it is reasonable to postulate that each hemisphere has its own style of cognitive and emotional functioning and that an individual will "preferentially rely on one hemisphere more than the other, regardless of the type of material that confronts him" (Ornstein 1978, p. 82). It would follow that the more an individual's overall personality tends toward an extreme, the more that individual would rely on a particular hemisphere. Conversely, the less stylized the individual's personality, the more flexible would be his response pattern and, ergo, his hemispheric utilization. In terms of hemisphere utilization the idiom "well-balanced" may literally mean just that.

In an experiment that is relevant to such a model, Smokler and Shevrin (1979) administered selected Rorschach cards and several subtests of the Wechsler Adult Intelligence Scale to a group of subjects. Based on their test performance, subjects who tended toward the hysterical or the obsessive-compulsive extremes were administered a

lateral eye movement questionnaire. The authors found that subjects who tended toward a hysterical extreme produced LEMs suggestive of right hemisphere involvement (i.e., were left lookers) while subjects who tended toward an obsessive-compulsive extreme produced LEMs suggestive of a basically left hemisphere involvement (i.e., were right lookers).

In another study that specifically addresses the relation between the obsessive-compulsive syndrome and the left hemisphere, Flor-Henry, Yeudall, Koles, and Howard (1979) utilized both neuropsychological tests and EEG recordings as indices of hemispheric activation. The authors found that patients with obsessive-compulsive syndrome demonstrated neuropsychological performance suggestive of left frontal dysfunction and EEG data reflective of perturbations (i.e., abnormalities of variability) in the left temporal and parietal regions. They conclude that their results suggest that the syndrome is the product of a dysfunctional left frontal lobe that is no longer able to inhibit the verbal rumination from the posterior areas.

Assuming that certain occupations require individuals to have cognitive styles congruent with the particular demands of that occupation, Galin and Ornstein (1974) and Doktor and Bloom (1977) have demonstrated lateralized EEG activity congruent with a model of hemispheric personality. Galin and Ornstein (1974) compared the eye movements of lawyers to ceramicists and later compared their respective

EEGs (noted in Doktor and Bloom 1977). Essentially, Galin and Ornstein found that, while lawyers and ceramicists did not demonstrate significant group effects across the verbal and spatial tasks, the change in asymmetry was greater for lawyers than ceramicists, and this difference was due largely to the greater change in the left hemisphere leads (central, temporal, parietal) of the lawyers. This finding suggests that lawyers may have more facility in the use of their left hemispheres, the hemisphere whose cognitive approach is logical, verbal, and sequential; skills presumed to be more necessary in the practice of law than ceramics.

In an attempt to replicate Galin and Ornstein's findings of lateralized cognitive styles, Doktor and Bloom (1977) compared the EEGs of eight highly placed executives, thought to be more intuitive thinkers, with the EEGs of six Operation Researchers, who are thought to be more analytical. Consistent with Galin and Ornstein's findings, Doktor and Bloom found that the Operation Researchers demonstrated a significant left hemisphere shift between the verbal-analytic tasks and the spatial-intuitive tasks. This difference was not demonstrated by the executive group. Although no specific explanation is offered for lack of significant inter-task shifts for the executives it is noted that half of the executives shifted in one direction while the other half shifted in an opposite direction.

While the previous two studies of occupation and lateralized hemispheric activation show significant results, Dumas and Morgan's (1975) found no difference. Comparing artists and engineers, the authors found that task effects were significant, whereas "the prediction that individuals may, through the course of experience, learn to rely more on one hemisphere than the other, was not supported." But as Furst (1976) points out in a review of Dumas and Morgan, many other variables may determine occupational choice in addition to cognitive predisposition and further within a given occupation a number of varying cognitive approaches can result in adequate performance. Hypothesizing individual differences, Furst compared the lateralized hemispheric activation of the baseline EEG measure with task performance on a spatial task and found that baseline right hemispheric activation was significantly positively correlated with performance. Furst (1976) concludes that the amount of lateralized activation that an individual brings with him to the experiment is predictive of performance on a spatial task.

Noting the lack of uniformity of EEG data for lateralized task effects expected from clinical and split brain studies, Gur and Reivich (1980) have also postulated that individual differences "may account significantly for variations in cognitive strategy and cognitive performance" (p. 79). Using cerebral blood flow as an index of hemispheric activation the authors performed two experiments. In the

first experiment they found that the left hemisphere demonstrated greater activation during a verbal task but they did not find significantly more right hemisphere activation during the nonverbal task. The authors then correlated the performance measure for the spatial task with the laterality index. This correlation was significant, whereas the same correlation was not significant for the verbal task. The authors interpreted this finding as suggesting that the "verbal task is more 'hardwired' to the left hemisphere, increasing blood flow to the left relative to the right hemisphere . . ." (pp. 86-7). The authors hypothesized further that the spatial task may be solvable by either the right or left hemisphere, although better performance was predicted by greater right hemispheric involvement. The authors concluded that individual differences might therefore account for the lack of lateralized results for the spatial task.

In a second experiment, Gur and Reivich (1980) hypothesized that if the differences in task-related laterality could be accounted for by individual differences, then the lateralized activation during the spatial task should predict an individual style measure such as lateral eye movements. After classifying individuals as right movers or left movers the authors found that left movers demonstrated significantly greater blood flow (i.e., activation) to the right hemisphere, whereas right movers demonstrated a non-significant reversal. The authors conclude

that individual differences may "exert significant influence on cognition and cognitive performance" (p. 89).

By viewing the hemispheres as being lateralized for certain types of thought and recognizing that an individual may choose which he will utilize, it becomes possible to understand the inconsistent realiability of cognitive task effect as well as to explain some of the apparent discrepancies in the literature on emotion and uses of LEMs as an indicator of hemispheric activation. For cognitive tasks, if experimenters were not to control for individual differences, a study might sample left hemispheric thinkers such as students or laboratory workers (Gevins et al. 1979) and therefore not show comparative right hemispheric activation during spatial tasks.

In research on emotion, by comparing a right hemispheric personality style (i.e., hysteric) to a left hemispheric personality style (i.e., obsessive-compulsive), experimenters might incorrectly surmise that the left hemisphere is non-emotional. This misinterpretation might occur due to the left hemisphere's capability to modulate its level of affective expression via its superiority for deliberate activity, that is, its ability to differentiate experience into discrete units (words, digits, concepts, etc.) thereby allowing it to more effectively control and manipulate these units than if the emotion were experienced by a more "diffuse and passive awareness" (i.e., the right

hemispheric personality style). In other words, the left hemisphere's more controlled emotional verbalization and expression may be minimized in comparison to the right hemisphere's diffuse emotional outbursts (Shapiro 1965). Results suggestive of the left hemisphere's control over affect can be found in articles by Shearer and Tucker (1981), Tucker and Newman (1981), and Galin (1974).

As well as suggesting that the right hemisphere is the locus for emotion or has relative superiority in the generation of affective expression, some experimenters might also mistakenly characterize the right hemisphere's emotional style as positive in comparison to a left hemispheric negative emotional style (Harman & Ray 1977, Ehrlichman & Weiner 1978). This misinterpretation might naturally occur as a result of the right hemispheric's hysteric-like personality style which experiences emotion in a transitory fashion. Shapiro (1965), describing the hysteric's affect as immediate and unowned, states "hysterical people do regard their own emotional outbursts very much as they might regard conversion symptoms; that is, they do not quite regard the content of their outbursts as something they have really felt, but rather as something that has been visited on them or, as it were, something that has passed through them" (Shapiro 1965, p. 126). Therefore, negative affect, although immediately felt and intensely presented, may not be "owned" or admitted by the right hemispheric

individual, whereas the left hemispheric individual's tendency toward rumination and worry might easily lend itself to obsessing over negative affect.

This discussion of the hemisphere's differential cognitive process as integral to differential handling of negative and positive affect might be useful in explaining Bear and Fedio's results (1977). Recalling that these authors found significant incongruity between observers' ratings of epileptic patients' displayed personality attributes and emotional expression with the patients' own ratings of this variable, it may be that the patients with right hemisphere epileptic foci subjectively rated themselves as less affectively disturbed (i.e., more elation) since their negative affect was denied, while observers, noting the intensity of expression, would rate them as more affectively disturbed (i.e., more depressed). Similarly, epileptics with left hemisphere damage and exaggerated left hemisphere functioning, due to their more consciously ruminative style, would be more aware of and focused on their deficits and therefore feel more depressed than objective observers might rate the patients, since the observers would be seeing the more modulated affect of the left hemisphere.

In a recent study, Dawson, Tucker, and Swenson (in preparation) have shown results similar to the Bear and Fedio research in a study on normal college students. Using lateral eye movements and neuropsychological task

performance as indices of hemispheric activation, Dawson et al. showed that college students who reported feeling more depressed and anxious produced more right lateral eye movements and performed better on left hemisphere cognitive tests than did college students who reported more denial, were repressive, and endorsed more socially desirable statements. This latter group also appeared to produce more left lateral eye movements and performed better on right hemispheric cognitive tasks.

The implication of this study is that there appears to be two general cognitive/affective matrices which describe the personality operations of the hemispheres. Expanding this model, it would be expected that if a person presented some elements from a given matrix, it would be likely that the person would demonstrate other elements of that matrix as well. In other words, if an individual demonstrates a facility with or propensity for, certain types of left hemisphere cognition such as sequential, analytical thinking, it might be expected that they would report matrix-consistent emotion, such as anxiety and depression, as well as left matrix-consistent personality traits, such as a tendency toward vigilance and self-criticism.

Because the research of Dawson et al. with normals parallels Bear and Fedio's (1977) findings with epileptics, it may be possible to consider relations between the disciplines of neurology, medical rehabilitation theory and

psychology. Psychological theory may prove useful in treating brain injured patients, and rehabilitation techniques may be useful in treating psychiatric disorders. Further, it might be expected that certain neuropsychological testing deficits may appear as a function of psychiatric disturbances and not of neurological insult (Kronfol, Hamsher, Digre & Waziri 1978). The neuropsychological deficits would remediate as the psychiatric condition improved.

While the Dawson et al. findings are encouraging in that they provide support for a lateralized personality model and hold implications for both medical and psychological diagnosis/treatment, several methodological errors are evident. First, the factor analysis used had a high subject to variable ratio (circa 1:1), suggesting that the sample was overdescribed and therefore not generalizable. Second, the index of hemispheric preference used in this study (LEMs) has recently been questioned by Ehrlichman and Weinberger (1978). After reviewing the literature on LEMs, Ehrlichman and Weinberger suggest that LEMs may be a result of social training, cultural bias, or some other factor, rather than a measure of hemispheric preference.

A final criticism of the Dawson et al. study has to do with the sample size and variance accounted for by the authors' findings. Dawson et al. correlated the personality factor with a percentage LEM measure on 25 college students. This resulted in a correlation of .35 and a near significant

probability of .08. The small sample and the non-significant correlation, describing only 12% of the sample, further limits the applicability of the findings to other populations. One possible reason for the small variance accounted for may be that the majority of the sample was able to flexibly utilize both hemispheres. As discussed earlier, it is expected that a number of individuals will demonstrate flexible usage of both hemispheres with only a slight tendency toward using one over the other. It may therefore be important to look at extreme groups in order to clearly investigate the validity of a hemispheric personality model.

Summary and Statement of the Problem

While there appears to be reliable evidence to suggest that the hemispheres are lateralized for cognition, emotion and personality traits, the direction of this lateralization is not always clear. Building on the fairly consistent lateralized findings on cognition, it is possible to construct a model of lateralized personality styles. This model can then serve to provide a heuristic framework with which to explain inconsistent and contradictory results appearing in the lateralization literature.

Although other authors have hypothesized the interaction between personality and hemispheric activity, no author to date has specifically hypothesized individual

measures of personality tapping lateralized hemispheric processes or how personality measures will interact with the demands of a task. The purpose of this study is to further investigate the utility of a hemispheric personality model by using the Dawson, Tucker and Swenson personality factor to predict hemispheric activation during cognitive tasks.

Three specific hypotheses are explored in this study. First it is hypothesized that those individuals who have factor scores suggestive of analytical thinking, anxiety, hypervigilance, and self-criticism (critics) will demonstrate overall left hemisphere activation regardless of task, while those individuals who have factor scores suggestive of Gestalt perception, denial, repression and lack of attention to detail (deniers) will demonstrate greater right hemispheric activation.

Second, it is hypothesized that these personality-related differences in hemispheric activation will be less evident during left hemisphere tasks (e.g., Word Fluency and character tasks) which may be "hardwired" (Gur & Reivich 1980) and more evident during a baseline task (e.g., Relaxation) or a right hemisphere task (e.g., Shape task).

Finally, based on the work of Davidson, Schwartz, Saron, Bennett, and Golman (1978) and Tucker, Stenslie, Roth and Shearer (1981), it is hypothesized that critics will demonstrate greater right frontal lobe activity relative to left regardless of task. While Davidson et al.

interpreted this finding as demonstrating a greater involvement of the right hemisphere in negative affect, Tucker et al. have suggested that right frontal lobe activation inhibits right posterior activity. Tucker et al. postulate that depressive affect may be associated with a relatively active left posterior hemisphere, accompanied by an inhibited posterior right hemisphere.

Statistical analyses will proceed in five steps on two separate data sets (i.e., Power and Coherence). The first step will be to replicate the previously generated personality factor of Dawson, Tucker, and Swenson (in preparation). The second step will be to factor analyze the laterality-related personality self-description measures suggested by Dawson et al., for all EEG subjects. Each individual will then be given a factor score which will be used to differentiate subjects for the subsequent analyses.

Thirdly, in order to investigate the relationship between EEG power and personality, the continuous factor score variable will be used in a stepwise regression analysis, across 4 bands (i.e., Delta, Theta, Alpha, Beta) with the exception that lower left hemisphere power and higher right hemisphere power will predict higher factor scores. This relationship will be clearest in the Alpha band and possibly replicated in the Theta band, whereas the effects might be reversed in the Beta 1 band (Schacter 1977). Although significant results may appear in these analyses,

they are not expected to be large since it is assumed that most individuals are "flexible" in their hemispheric utilization and therefore will not demonstrate a large hemispheric preference.

In the fourth set of analyses, standardized factor score limits will be set at ± .75, thereby excluding 55% of the sample. The remaining 45% will be divided into two groups and then compared across all bands on power with the same expectations as the preceding set of analyses. This set of analyses on disparate personality groups are expected to demonstrate the greatest personality effects as well as allow for the clear inspection of the interaction between personality and task demands.

Finally, comparisons between these two personality groups within a task across all bands on coherence data will be performed. Comparisons will be made on multiple, intra- and inter-coherence variables. Because research using coherence measures within tasks are exploratory at this time, no specific hypotheses are made and results will be described without elaborate interpretation.

CHAPTER III

METHOD

Purpose

The purpose of this study was to investigate the replicability of a previously produced hemisphere related personality factor (Dawson, Tucker, Swenson, in preparation) and to relate this factor to another index of cerebral activation, electroencephalographic recordings. It was hypothesized that, if the above personality factor was related to hemispheric activation, it would be possible to predict generalized hemisphere utilization on the basis of cognitive and personality variables. Specifically, it was expected that individuals who demonstrated relatively greater ability to perform spatial and Gestalt-like tasks and endorsed self-description items suggestive of repression, lower trait anxiety and a need to describe oneself in favorable terms, would demonstrate a relatively greater use of their right hemispheres than those individuals, who demonstrated better task performance on verbally or numerically mediated tasks and tasks requiring sequential or logical processing, as well as endorsing self-description items suggestive of self-criticism and less need to appear socially conforming. It was expected that the latter group

would demonstrate relatively greater left hemisphere usage. Hemispheric activation was assumed to occur when power was relatively lower on one side than the other when EEG recordings from the theta and alpha band were analyzed. Although a recent study by Tucker, Dawson, and Roth (in preparation) suggests that both the delta and beta bands may demonstrate task related differences, the literature on the relationship between power in these bands and task effects is minimal. Therefore, investigations were made between personality and task performance measures without specific hypotheses in these bands. Coherence measures across all bands were investigated for personality effects without specific hypotheses.

Subjects

The subjects were 117 right-handed (by self-report) undergraduate students enrolled in an introductory psychology course at the University of North Dakota. Forty of these subjects were solicited from a group of students who had previously volunteered to be practice testing subjects for UND graduate students of psychology. The graduate students had previously administered and scored three personality and one intelligence measures, the Minnesota Multiphasic Personality Inventory (MMPI), Rorschach, Thematic Apperception Test (TAT) and the Wechsler Adult Intelligence Scale (WAIS), respectively. The tests were then reviewed and corrected for scoring accuracy by a graduate teaching

assistant and finally by the professor, a clinical psychologist. Of these forty subjects, 23 were used in the Dawson et al. study and for some of the analyses reported here. The remaining 17 subjects were used for all the analyses in this study.

The forty subjects were contacted by phone and requested to participate in a study investigating the relationship between brain waves and nutrition. They were offered an incentive of ten dollars to participate. The remaining 67 subjects were solicited through a voluntary sign-up procedure and received five dollars and two hours of experimentation credit for their participation.

Materials

For the 17 subjects not previously used in the Dawson, Tucker, and Swenson study, three different tests of personality and an intelligence test had been administered before the subjects arrived for the experimental session. Of these tests only three were retained and of these three, specific subtests were chosen as being sensitive to the dichotomy being studied (i.e., critics versus deniers). Variables selected as being characteristic of critics included the MMPI scales of D, Pk, F, and Sc and the WAIS verbal I.Q. and Arithmetic subtest. Variables thought to be more characteristic of deniers included the MMPI scales of Hy, Hs, K and L, the WAIS performance I.Q., and the WAIS subtests of Block Design and Object Assembly. Selected Rorschach variables included the whole to detail

ratio, egocentricity index, FC/CF + C, total color responses, total achromatic responses, experience base and experience balance. Rorschach scores reflecting affective lability, uninhibitedness, Gestalt perception and impulsivity were thought to describe deniers, while scores reflecting constrained or depressive affect, anxiety, withdrawal, and detail oriented perception were thought to describe critics.

All subjects received three pencil and paper personality questionnaires which had previously proved sensitive to the dichotomy under study (Dawson, Tucker, and Swenson, in preparation). Included were a trait anxiety scale (Spielberger 1968), a social desirability scale (Crowne & Marlow 1960), and the controlled repression-sensitization scale (Orlofsky 1976; Handal 1973). Subjects also received a measure thought to assess an individual's ability to perceive faces in a Gestalt processing fashion. This measure consisted of 24 Mooney faces (Mooney 1957) ranging from easy to difficult to perceive. The responses were scored for accuracy in perceiving the face's sex (male or female), age (child or adult) and direction the face was turned. The number correct was divided by 24 and this percent correct was used in later analyses.

Neuropsychological Tasks

Besides completing the personality questionnaires, subjects were also administered tasks thought to draw upon the processing mode of specific sides of the brain while

subjects' brain wave activity was recorded by an electroencephalograph. The tasks included one eyes-closed task, two eyes-open tasks, and one baseline task. The eyes-closed task was the word fluency task which required subjects to mentally think of four words beginning and ending with two letters given. Once the subject had thought of four words or after twenty seconds the EEG recording was terminated and subjects were queried for their answers.

The two eyes-open tasks included two administrations of the character and the shape tasks. In order to give the subject practice in performing these tasks, both tasks were presented in their complete form, EEG recorded during the second presentation, and used in later analyses. For both these tasks a number of randomly generated characters and numerics were presented on a television screen in front of the subjects. After two presentations, the subjects were required to identify whether or not the two presentations were the same. In the character task the subjects were required to determine whether the two presentations contained the same numerics and characters regardless of the pattern they formed. The shape task, on the other hand, required the subject to ignore the specific characters and numerics in order to determine whether or not the shapes of the two presentations were the same. These tasks were counterbalanced in presentation with the initial task selection randomized by the computer.

The final EEG recording condition required subjects to relax and sit quietly with eyes closed (RELAX). This task was thought to reflect the subjects' general states of awake brain activity without specific task processing demands.

EEG Data Generation

In order to measure the electrical activity of the brain, gold cup electrodes were attached to each subject's scalp, according to the International Ten-Twenty System. The specific sites of attachment were the left and right frontal areas (F3 and F4), temporal areas (T3 and T4), parietal areas (P3 and P4), and occipital areas (O1 and O2). The electrodes were referenced to bilateral inactive sites, linked earlobes (A1 and A2). All electrode impedances were below 10 K ohms.

EEG signals were transmitted by the electrodes to an amplifier. The signals were amplified at a 0.1 second calibrated time constant through a low noise, battery-powered, optically-isolated, A.C.-coupled amplifier. The signals were then filtered with 30 Hz, 3 dB, low pass filters.

Next the signals were digitized. Due to a system changeover that occurred halfway through data collection, part of the data were digitized differently. Data collected in the first part of the study were submitted to an analog-digital conversion system with 10 bit resolution on two second epochs. The sampling rate for this group of

data was 500 samples per channel per second. The samples were then digitally filtered down to 125 per second and finally conditioned with a split cosine bell on the first and last 12-1/2% of the sample to correct for sampling onset and termination.

After the system changeover, the new sampling rate became 256 samples per channel per second and these samples were digitally filtered down to 128 per second and conditioned with a split cosine bell on the first and last 12-1/2% of the sample.

After the samples were tapered, Fast Fourier Transform was performed, and Fourier coefficients corresponding to power at each 1.0 Hz increment were produced. After each segment was transformed, cumulative auto- and cross-spectral densities were computed and scaled by the number of epochs.

Autospectral densities are computed by multiplying each complex Fourier coefficient by its conjugate. This process results in real numbers which are averaged across epochs and across specified spectra. The result is one number per channel per band which represents the average amplitude squared for that band for each channel. This number is referred to as average power.

Cross-spectral densities, on the other hand, are computed by multiplying the complex Fourier coefficients of

one channel with the complex conjugate of another. The result is a complex number which represents the covariance between the two channels. These covariances are also averaged across epochs and spectra. Since there are eight channels, 28 cross-spectra are produced ([N*(N-1) ÷ 2]).

After cumulative cross- and auto-spectral densities were computed, coherences were computed. Coherence is computed by taking the complex absolute value of the cross-spectrum of two channels, squaring the result, and then dividing by the product of the powers of the two channels. The result is a standardized covariance between two channels and is closely analogous to correlation. For a further discussion of the computation and considerations of power, cross-spectral density, and coherence, see Tucker, Roth, and Bair (in preparation). The bandwidths for the spectra used to compute power, cross-spectral densities, and coherence were 0.5 Hz - 3.5 Hz (delta), 4.0 - 7.0 Hz (theta), 7.5 - 12.5 Hz (alpha), and 13.0 - 18.0 Hz (beta). After the average powers and coherences per task per band were computed the indices were copied onto magnetic tape and stored for later analyses.

Procedure

Subjects were contacted by telephone by an undergraduate assistant who solicited their participation and scheduled them for two appointments. The first appointment

was for a blood draw of 5 cc which was used in another experiment. The second appointment was scheduled within two days of the first. When subjects arrived for the second appointment, they were met at the door by a registered nurse. The nurse escorted the subjects to an examination room where they filled out the Spielberger (1968) trait anxiety scale, the social-desirability scale, the controlled repression-sensitization scale, and the Mooney Faces form. Gold cup, scalp electrodes were attached to the subjects' heads.

Next, the subjects were escorted by a nurse to a separate room for administration of the neuropsychological tasks and collection of EEG activity. The subjects were placed in a comfortable chair inside an electrically-shielded, acoustically-controlled booth. The subjects faced a television screen which was used for some of the tasks; otherwise the booth was unlit. Once the subjects were comfortable and fully instructed as to strategies to reduce EEG artifact (i.e., don't swallow, try not to move your eyes, relax the muscles of your jaw and scalp, etc.), the nurse shut the door to the booth. When subjects began to demonstrate fairly artifact-free EEG waves, the nurse administered the neuropsychological test battery and recorded the subject's brain waves as they processed or performed the tasks. After all the data were collected the subjects were debriefed and given their recompense.

These data and demographic information were pooled and recorded onto coding sheets by an undergraduate

assistant and the experimenter. The sheets were key-punched onto cards and used in later analyses.

Statistical Analyses

Statistical analyses proceeded in three stages. In the first stage of analyses, an attempt was made to replicate the previously reported hemispherically-related personality factor (Dawson, Tucker, and Swenson, in preparation). In a similar procedure, data from all those subjects for whom the various personality and neuropsychological data had been collected were first subjected to a partial correlation procedure to remove the effects of sex. The resulting partial correlation matrix was then factor-analyzed using ones on the diagonal. A principal axis extraction was performed, the number of factors required to account for about 70% of the variance were retained, and the retained factors were subjected to oblique rotation. The factors were then described.

Next, the three self-description questionnaires suggested by Dawson, Tucker and Swenson as being sensitive to lateralized personality, were factor analyzed for all subjects. Using principal axis extraction and ones on the diagonal, one factor was generated and then used to produce a factor score for all subjects that had power data.

In the second stage of analyses average power was used to predict subjects' personality factor scores. Under the hypothesis that certain personality types tend

to utilize one hemisphere more than the other, regardless of task demands, it was expected that those subjects who tended to be deniers would show larger regression coefficients on right EEG channels (F4, T4, P4 and O2) than critics, while the latter group would grow greater coefficients on the left EEG channels (F3, T3, P3 and O1). Stepwise multiple regressions of EEG average power on personality were done for each of the four bands for each neuropsychological task. In order not to overdescribe the results, only regressions that demonstrated a probability of .1 or less and/or up to a four variable solution were described.

While the above set of analyses might reveal general differences in EEG power fluctuations, it was thought that normals in the middle range (i.e., +/- .75 standard deviation accounting for 55% of the sample) were more likely mixed in their hemispheric utilization and that individuals who produced personality factor scores greater than +/- .75 standard deviation might more clearly demonstrate hemisphereic preferences. In order to address this concern, a third set of analyses were performed, using the Bonferrone t and paired student t tests of coherence on two extreme groups.

Only subjects who had factor scores greater or less than .75 and had EEG data based on at least one second epochs of data for both tasks under consideration, were used for the contrasts. Because the two personality groups

had an unequal number of observations and the design involved repeated measures, the Bonferroni t statistic was selected as the best contrast test (Meyers 1979) for the power data. The Bonferroni t [$t = Y_1 - Y_2 \div MS_{error}(\frac{1}{n_1} + \frac{1}{n_2})$] was appropriate for this particular design because it controls the per experiment error rate (PEER) by setting lower per comparison error rates (PCER) based on the number of selected pairwise mean comparisons that are made (PEER/k = PCER).

The first step in this set of analyses was to code those individuals who had factor scores greater than .75 as deniers and those who had factor scores less than .75 as critics. Next a mean squares error term was generated for each of the three specific hypotheses for each band within sets of tasks. One set of tasks included the eyes-closed verbal task (i.e., Word Fluency) and the eyes-closed baseline task (i.e., Relaxation). The other set of tasks were eyes-open numeric-letter processing task (i.e., Character) and spatial task (i.e., Shape). Tasks were grouped in this fashion to control for power variance directly attributable to whether or not the eyes are open and to allow the comparison of left hemisphere cognitive tasks with a right hemisphere one. These groupings also allowed the direct investigation of whether or not personality lateralization would be more evident during a certain type of cognitive task (i.e., left or right).

To explore the hypothesis that personality types utilize their hemispheres differently regardless of task, four mean comparisons were made; two comparing hemispheric means within a personality type and two comparing congruent hemispheres across personality. Setting the PEER at .05 then required the PCER to be set at .0125. The second hypothesis that personality differences will be more evident in right hemispheric or baseline tasks was examined by making eight pairwise comparisons; four comparing hemispheric means within personality type and task and four comparing congruent hemispheric means across personality types within a task. Setting the PEER at .05 then required the PCER to be .00625.

The third hypothesis that critics would show paradoxical effects by demonstrating right frontal lobe activation, regardless of task, was investigated by making four comparisons; two comparisons of lateralized frontal lobe means within a personality type and two congruent lateralized frontal lobe mean comparisons across personality types. Setting the PEER at .05 required the PCER to be set at .0125.

Thus far, all of the analyses were performed on average power as an index of cortical activation. However, there are current hypotheses suggesting that merely investigating the power at a given site ignores information available through relationships between and/or among sites

(Tucker, Roth, & Bair, in preparation). Tucker et al. have suggested that coherence may provide one measure which reflects the amount of shared variance between two sites. However, while investigating the relationships between sites by coherence may provide valuable information, it is clear that the number of possible combinations to review increases geometrically with the addition of each site.

Since coherence might be considered as statistically comparable to correlation, in order to characterize this multitude of information Tucker et al. have suggested that operations performed on correlations could also be used with coherence. One possible way to reduce coherence information is to compute three multiple coherence measures as suggested by Tucker, Roth and Bair (in preparation). They were a multiple coherence number (between each channel and all others), an intrahemispheric partial multiple coherence number (between each channel and all other ipsilateral channels with the effects of the contralateral channels partialed out) and an interhemispheric partial multiple coherence number (between each channel and all contralateral channels with the effects of ipsilateral channels partialed out).

Multiples, intrahemispheric partial multiples (IAPM) and interhemispheric partial multiples (IRPMs) were computed for all eight leads within a personality type (i.e.,

personality factor score less than or greater than .75). Paired comparison t tests were used to compare congruent channels within a form of coherence within a band across personality types within each of two tasks, Relaxation and Word Fluency. Paired comparison t tests were also used to explore lateralized coherence differences within a personality style. Only within lobe lateralized comparisons were made in this last exploration of the data.

Multiple coherence measures were computed using matrix operations on data from each subject within a frequency band for a personality type. The coherences were then z-transformed and averaged across all subjects to give one mean matrix per band for a personality type. Analyses were performed and all results from coherence data were then described without reference to any specific hypotheses.

RESULTS

Demographic Data

Analysis of the data of 117 subjects revealed that the average age was 19.87, ranging from 17 to 34 (S.D. = 2.95). There were 28 males and 89 females. All subjects were self-reported righthanders. Because data were lost through computer error, editing, or attrition, and because only extreme scores were used in the group comparisons, groups within data sets had unequal numbers of observations. Adjustments were made where appropriate and the number of observations was reported. However, the loss in data was somewhat mitigated by the fact that each subject's power value was averaged across a number of observations, thereby making the power value more stable. A single observation for a subject consisisted of data collected from an average of 33 one second time intervals.

Factor Analysis

In an attempt to replicate Dawson et al.'s lateralized factor pattern, 17 subjects were administered all measures used in that study except for the MMPI scale Pd, the Rorschach index of A%, and the Embedded Figures task. These indices were eliminated from the present factor analyses because they did not prove to load significantly in the factor in the

Dawson et al. study, they are not easily interpretable in terms of the dichotomy presently under study, and their exclusion reduced the variable to subject ratio.

Sex was partialed out of the data and the residual matrix was subjected to principal axis extraction. Six factors accounting for 70% of the total variance were retained and obliquely rotated. The largest factor, the sum of squared factor loadings being equal to 5.0, had 11 variables greater than 3.0. Of the six variables with loadings greater than .40 in the Dawson, Tucker and Swenson study, four were replicated in this study (see Table 1). Other variables with factor loadings greater than .4 in this study were the Rorschach variables of total color responses (-.45663) and zd (-.42742) and the MMPI variables of D (.75831), Pt (.45012) and F (.49748).

Although the majority of the variables in the Dawson et al. personality factor were replicated in this study, it should be noted that two of the six variables of that factor were not replicated at a .4 factor loading or above. One of these variables was the K scale variable of the MMPI. While the K scale variable in this replication demonstrated a factor loading of -.26622, the direction of this loading was consistent with the K scale variable loading of the previous study.

The second variable which did not replicate in the degree or direction of the Dawson et al. personality factor

Table 1

Factor Structure of Variables With Factor Loadings Greater Than .40

	Promox Rotated Factor Pattern (n=17)	
Variables	Dawson et al. Factor	This Study's Factor
SDS	.85141	-.53475
TANX	-.46200	.74454
REPS	-.66445	.86449
ML	.73664	-.79731
MK	.88200	*
WDRATIO	.75088	*

*less than .4

was the Rorschach WD ratio variable. This study's WD ratio = .27956. While this finding is especially disconcerting because of the loading direction reversal, this variable may be sensitive to fluctuations in intellectual abilities rather than an index of stable perceptual style (Exner 1978). The relationship between Whole responses and intellect is particularly evident in the case where the whole response coding is the result of perceiving two or more detail areas in meaningful relationship.

Essentially, the personality factor in this study replicated the personality factor found by Dawson, Tucker and Swenson and described the hypothesized lateralized hemispheric personality style. This factor described a pattern which suggested lack of denial (-ML, REPS), non-endorsement of socially desirable self-statements (-SDS), anxiety/sensitivity (F, Pt, TANX) and depression (D). The only cognitive measure which had a loading near .4 was memory for digits forward and backward (.36065), suggesting that the personality traits described above were associated with numeric memory. Inverted, the factor described a pattern suggestive of denial, repression, endorsing socially desirable self-statements, denial or anxiety and depression, and poor memory for digits.

Stepwise Multiple Regressions on Power

Using the three replicated paper and pencil self-description measures (REPS, TANX and SDS), a second factor

analysis was performed on all subjects who completed all three forms, including the 40 subjects previously reported in the Dawson et al. study (n = 23) and the new subjects of this replication (n = 17), in order to describe an overall factor pattern for these three variables with which to score individuals for analyses to follow. Only the first principal axis extraction factor was retained (n = 95) and this factor replicated the general relationship discussed in Dawson et al. (see Table 2).

After factor scoring all subjects, stepwise multiple regression analyses increasing the R^2 with each variable, were performed. All eight channels of average power were used to predict the factor score of each individual within each task with stepwise multiple regressions (MAX R). In order to best characterize the findings within tasks and bands, the highest significant ($p \leq .1$) regressions using four or less variables were reported. If no regression demonstrated significance, then the regression with a probability closest to .1 and having four or less variables was reported. The R^2, the probability of the R^2, the direction of the coefficient and the probability of each variable were reported (see Tables 3, 4, 5 and 6). The tables report the probability for each channel (frontals: left = F3, right = F4; temporals: left = T3, right = T4; parietals: left = P3, right = P4; and occipitals: left = 01, right = 02) followed by the direction of the b value in parentheses.

Table 2

Principal Axis Extracted Factor of Selected Personality Variables

Variables	Factor Loadings of Combined Dawson et al. and This Study Data (n = 95)
SDS	-.70897
TANX	.84367
REPS	.82819

Table 3

Stepwise Regressions for All Bands of Word Fluency (n = 70)

		Channels									
		F3	F4	T3	T4	P3	P4	01	02	R^2	p =
Delta	prob =	.26(-)	.08(+)	.04(+)			.09(+)			.124	.060
Theta	prob =			.05(-)			.06(+)			.063	.107
Alpha	prob =				.18(+)					.026	.179
Beta 1	prob =		.08(-)	.02(+)			.02(+)		.09(-)	.147	.029

Note. Values reported for each channel are b coefficients followed by the sign of their direction in parentheses.

Table 4

Stepwise Regressions for All Bands of Relaxation (n = 46)

		Channels									
		F3	F4	T3	T4	P3	P4	O1	O2	R^2	p =
Delta	prob =		.26(+)	.05(-)				.15(-)	.01(+)	.225	.024
Theta	prob =	.26(+)	.05(-)	.38(-)			.03(+)			.201	.042
Alpha	prob =	.06(-)			.13(+)					.077	.163
Beta 1	prob =	.46(-)	.23(-)		.01(+)	.48(+)				.164	.096

<u>Note</u>. Values reported for each channel are b coefficients followed by the sign of their direction in parentheses.

Table 5

Stepwise Regressions for All Bands of Character (n = 40)

		Channels									
		F3	F4	T3	T4	P3	P4	O1	O2	R^2	p =
Delta	prob =							.04(-)	.07(+)	.010	.129
Theta	prob =	.32(+)	.18(-)	.29(-)			.21(+)			.196	.082
Alpha	prob =			.12(-)	.21(+)					.063	.282
Beta 1	prob =					.02(-)	.02(+)	.03(+)	.02(-)	.271	.017

Note. Values reported for each channel are b coefficients, followed by the sign of their direction in parentheses.

Table 6

Stepwise Regressions for All Bands of Shape (n = 41)

		Channels									
		F3	F4	T3	T4	P3	P4	O1	O2	R^2	p =
Delta	prob =		.17(+)	.10(-)						.072	.224
Theta	prob =	.31(+)	.41(-)	.01(-)				.09)+)			
Alpha	prob =	.07(+)	.02(-)			.13(+)				.151	.092
Beta 1	prob =	.22(-)			.07(+)			.05(+)	.28(-)	.197	.073

Note. Values reported for each channel are b coefficients, followed by the sign of their direction in parentheses.

The most consistent results within a band across tasks were found in the alpha band and suggested the deniers were associated with right temporal lobe activation and the critics were associated with deactivation of the right temporal lobe (see Table 7). Results in the theta band suggested that critics were associated with right frontal lobe and left temporal lobe activation, and left frontal lobe deactivation, while deniers were associated with just the opposite. Although not as clearly interpretable, the delta band demonstrated that increasing right frontal and decreasing left temporal powers were associated with higher critics' scores, while only decreasing right occipital lobe power was consistently associated with critics' scores in the beta band (see Table 7).

Bonferroni t Tests on Power

While the regressions generally suggested that critics were associated with greater left hemispheric activation and deniers with right hemispheric activation, paradoxical effects were noted in the frontal leads in the theta band. Although these findings were consistent across all tasks, the variance for reported regressions ranged from 3% to 21% and not all of the leads were individually significant contributors. Assuming that individuals with more extreme factor scores would demonstrate clearer results than comparisons made against a continuous variable, those individuals demonstrating factor scores greater than .75 were labeled

Table 7

Summary of Stepwise Multiple Regression Across Tasks and Within Bands

Band	Channel (Frequency)	Frequency 3 or Greater
Delta	-F3(1), +F4(3), -T3(3), +P3(1), -O1(2), +O2(2)	+F4, -T3
Theta	+F3(3), -F4(3), -T3(4), +P3(3), +O1(1)	+F3, -F4, -T3, +P4
Alpha	+F3(1), -F3(1), -F4(1), -T3(1), +T4(3), +P3(1)	+T4
Beta 1	-F3(2), -F4(2), +T4(2), +P3(1), -P3(1), +P4(2), +O1(2), -O2(3)	-O2

Note. The sign (+ or -) represents the direction of the b coefficient.

critics and those with scores below -.75 were labeled deniers.

Using personality as a classification variable, specific hypotheses were investigated in the average power data set. In order to investigate the three specific hypotheses of this study, tasks were combined into two sets based on whether or not the subjects' eyes were open during the task. The same comparisons were performed on each band for each set of tasks. The results of these comparisons were reported for each set of tasks per hypothesis across all bands with particular emphases on the more easily interpretable theta and alpha bands. A summary across sets of tasks was then made.

Eyes Closed Tasks

For all of the following analyses on the eyes closed tasks there were 23 subjects. Nine were critics and all were right handed females with a mean age of 20.78 (S.D. = 5.4). Of the remaining 14 deniers, 3 were male and 11 were female. All deniers were right handed and had a mean age of 20.79 (S.D. = 3.0).

Hypothesis I. In order to investigate the hypothesis that each personality type utilized their hemispheres differentially, regardless of task, the PEER was set at .05 for four contrasts and $df_{error} = 21$, thereby requiring that a comparison demonstrate an absolute t of 2.831 or better

to be significant. Comparisons across personality types (i.e., hemisphere congruent comparison: critics' left hemispheres with the deniers' left hemispheres and critics' rights with deniers' rights), revealed significant results for only the alpha band.

Comparisons within the alpha band demonstrated two significant contrasts. The first significant contrast revealed that the deniers had more active right hemispheres than did the critics (t = 2.963), while the left hemispheres of deniers were not significantly different from critics'. Significantly greater right than left hemispheric activation was also noted with deniers (t = 4.133), whereas critics did not show any lateralization within a personality type (see Table 8). These results suggested that deniers used their right hemispheres more than critics, regardless of task. Further, although not significant, the critics demonstrated a reversal of lateralized activity, compared to deniers (see Table 8).

Hypothesis II. The second hypothesis was that both personality types would demonstrate greater lateralization effects during a spatial task or baseline period than during a left hemisphere task. Eight comparisons were made, four lateralized comparisons (within each task within each personality type) and four hemisphere congruent comparisons (comparing congruent hemispheres within each task across each personality type). Since the t table did not list an

Table 8

Personality by Hemispheric Comparison
in Alpha for Average Power

For Word Fluency and Relaxation*			
Critics		Deniers	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
3.96	4.00	4.38	3.20

*These means and all that follow were $\log_{10}$ transformed for the analysis and were transformed into average power for these tables ($10^{\log_{10}\text{mean}}$).

exact t value for a PEER of .00625, the next highest t for df_{error} = 21 was used, making the test more conservative. The next highest t resulted in a PEER of .008.

For this personality by hemisphere by task investigation, significant differences were discovered in both the theta and alpha bands. In the alpha band, the results essentially replicated the findings of the hemisphere by personality comparisons, but only for the Relaxation task (see Table 9). Within the Relaxation task deniers used their right hemispheres significantly more than the left (t = 13.260) and used the right hemisphere significantly more than did critics (t = 12.490).

Comparisons within the theta bands duplicated those of the alpha band for both lateralized comparisons (t = 4.597) and hemisphere congruent comparisons (t = 8.015) during the Relaxation task. Beyond these results, the theta band comparisons also demonstrated differences during the Word Fluency Task. During this task, deniers demonstrated lower right hemisphere average power (t = 3.964) while critics demonstrated relative symmetry (see Table 10). Hemisphere congruent comparisons within Word Fluency and across personality types revealed lower average power in the left hemisphere of critics relative to deniers (t = 5.214).

The results from the alpha and theta bands suggested that personality did interact with the type of task.

Table 9

Personality by Hemisphere and Task Comparisons in Alpha for Average Power

For Word Fluency and Relaxation			
Critics		Deniers	
Word Fluency		Word Fluency	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
2.72	2.67	3.07	3.13
Relaxation		Relaxation	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
5.78	6.01	6.24	3.19

Table 10

Personality by Hemisphere and Task Comparisons in Theta for Average Power

For Word Fluency and Relaxation

Critics		Deniers	
Word Fluency		Word Fluency	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
2.58	2.56	3.01	2.68
Relaxation		Relaxation	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
3.15	4.00	3.07	2.69

Deniers demonstrated greater right hemisphere activation in both tasks for theta and in Relaxation for alpha. Comparisons in both bands demonstrated that deniers have lower average power (i.e., higher activation) in the right hemisphere during Relaxation than critics. In theta critics demonstrated greater activation in the left hemisphere relative to deniers during Word Fluency. These results suggest that personality interacted with task and that personality effects may be more distinguishable in the theta band than in the alpha band. Further it appeared that right/left hemispheric asymmetry effects were more apparent during Relaxation. Although this difference was not significant for critics ($t = 2.603$ in theta, $t = .815$ in alpha), the direction of their asymmetry was consistent with a hemispheric personality model.

Hypothesis III. The third hypothesis was that a paradoxical effect would occur in the frontal lobes of critics. Specifically, it was expected that critics would demonstrate greater activation in the right frontal lobe relative to the left, regardless of task. Further, it was predicted that critics would have lower average power in the right frontal lobe than would deniers.

Because four comparisons were made and the PEER was set at .05, a comparison needed to produce a probability equal to or less than .0125. With df error = 63 the t needed to be greater than or equal to 2.660 to be considered

significant. Comparisons within and between personality types in the frontal lobes revealed significant results in both the theta and alpha bands (see Table 11). In the alpha band significant comparisons demonstrated that both the left and right frontal lobes of critics had significantly less average power than deniers (t = 3.211 for left frontal lobes and t = 4.568 for right). No within personality type differences were noted.

The only significant comparison (see Table 12) within the theta band revealed that the left frontal lobe of critics evidenced less average power than that of deniers (t = 3.799). This finding and those in the alpha band suggested that critics had less average power in their frontal lobes than did deniers and that this difference was only exhibited in the left frontal lobe for the theta data. These findings were in contradiction to the third hypothesis.

Assuming that the frontal lobes might have been overly sensitive to task demands, a post hoc set of comparisons were performed on the eyes closed baseline task, Relaxation. The findings of this set of contrasts duplicated the previously reported findings, with one additional finding in theta. This finding suggested that, during the Relaxation task, deniers' right frontal lobes demonstrated significantly (t = 3.971) less average power than their left frontal lobes. This latter finding was in direct opposition to Hypothesis III (see Table 13).

Table 11

Personality by Lateral Frontal Lobe Mean Comparisons in Alpha for Average Power

Across Word Fluency and Relaxation			
Critics		Deniers	
Left Frontal	Right Frontal	Left Frontal	Right Frontal
2.88	2.76	3.87	3.65

Table 12

Personality by Lateral Frontal Lobe Mean Comparisons in Theta for Average Power

Across Word Fluency and Relaxation			
Critics		Deniers	
Left Frontal	Right Frontal	Left Frontal	Right Frontal
3.56	3.63	4.61	3.97

Table 13

Personality by Lateral Frontal Lobe Mean Comparisons in Theta for Average Power

For Relaxation			
Critics		Deniers	
Left Frontal	Right Frontal	Left Frontal	Right Frontal
3.81	3.91	4.20	3.64

Summary. The selected pairwise mean comparisons performed on Word Fluency and Relaxation for each of the four frequency bands (i.e., delta, theta, alpha, beta) revealed several significant findings. One of the most interesting findings was that only the theta and alpha bands demonstrated personality effects, and these effects appeared to be more apparent in the theta band. In terms of the hypotheses, it was found that the personality types demonstrated characteristic laterality effects, suggesting that deniers utilize their right hemispheres more than their lefts and more than critics used their right hemispheres. Further, it was found that these differences were more evident in the Relaxation task than the Word Fluency task, although some task and personality interactions were seen during the Word Fluency task in the theta band. Most of these reported differences were basically due to significantly lower average power in the right hemisphere of deniers, although a non-significant, hypothesis-consistent, reversal was noted for critics. There were no findings to support a notion of paradoxical frontal lobe activation. Instead the findings paralleled hemispheric comparisons, that is, greater right frontal lobe activity was noted for deniers.

Eyes Open Tasks

For all of the following analyses on the eyes open tasks there were 30 subjects. Nine were critics, and all were

right handed females with a mean age of 21 (S.D. = 5.36). Eight had been included in the previously reported eyes closed analyses. Of the 21 deniers, 4 were males and 17 were females, and all were right handed. Thirteen of the 22 deniers were included in the eyes closed analyses and of these 13, 3 were male.

Hypothesis I. The first hypothesis, that each personality type would utilize their hemispheres differentially, was investigated. With the PEER set at .05, df error = 28, and four comparisons, significant results (t = 2.763) were found in only the theta and alpha bands. In the alpha band only the hemisphere consistent comparisons across personality type demonstrated significant results (see Table 14). The results showed that critics had less average power in both hemispheres than did deniers (t = 3.375 for the left hemispheres and a t = 2.945 for the right ones). No asymmetrical differences within each personality type were noted, although deniers demonstrated a slight trend toward lower average power in the right hemisphere (t = .464).

In the theta band the only significant (t = 4.958) comparison demonstrated that critics had lower average power in their left hemispheres than deniers (see Table 15). Although non-significant, two other comparisons were worthy of note. First, right hemisphere comparisons showed a strong tendency (t = 2.667) toward lower average power for critics compared to deniers. While this essentially

Table 14

Personality by Hemisphere Comparisons
in Alpha for Average Power

For Character and Shape

Critics		Deniers	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
1.55	1.55	1.86	1.82

Table 15

Personality by Hemisphere Comparisons
in Theta for Average Power

For Character and Shape			
Critics		Deniers	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
2.22	2.19	2.77	2.47

replicated the findings in alpha, the slight tendency toward lower average power in the right hemisphere for deniers was more strongly demonstrated (t = 2.523). Overall, the theta band replicated the findings of the alpha band with the further indication that deniers have lower average power in the right hemisphere.

Hypothesis II. The second hypothesis, that both personality types would demonstrate greater lateralization during a spatial task, was investigated. Since no precise t for a PCER of .00625 and df error = 28 was available the next smallest tabled t probability ($p \leq .001$) was used, thereby resulting in a PEER of a more conservative .008. To be significant a t value would have had to have been equal to or greater than 3.674. Investigations revealed significant contrasts for all bands. Results within the delta and beta 1 bands were noted without assumptions regarding activation.

Significant comparisons within the alpha band for Hypothesis II duplicated those findings in the alpha band under Hypothesis I. That is, in both the Character and Shape tasks critics evidenced less average power than deniers (Character; left t = 4.549, right t = 4.785; Shape; left t = 7.126, right t=5.536). No asymmetrical differences within personality types were noted (see Table 16).

Unlike the alpha band, comparisons within the theta not only replicated the findings under Hypothesis I

Table 16

Personality by Hemisphere and Task Mean Comparisons in Alpha for Average Power

For Character and Shape

Critics: Character, Left Hemisphere	Critics: Character, Right Hemisphere	Deniers: Character, Left Hemisphere	Deniers: Character, Right Hemisphere
1.62	1.56	1.86	1.81

Critics: Shape, Left Hemisphere	Critics: Shape, Right Hemisphere	Deniers: Shape, Left Hemisphere	Deniers: Shape, Right Hemisphere
1.49	1.54	1.86	1.83

(Character: left t = 12.810, right t = 9.022; Shape: left t = 14.382, right t = 5.725), but also demonstrated less average power in the right hemisphere for deniers (see Table 17) for both the Character (t = 7.142) and Shape (t = 6.567) tasks. Results in both theta and alpha indicated that the Character task was associated with less average power in both hemispheres and, at least in theta, that deniers evidenced lower average power in their right hemispheres relative to their lefts.

Comparisons within the delta band revealed that critics had lower average power than deniers for the Shape task (left t = 5.771, right t = 4.642). Critics also had lower power in the right hemisphere during the Shape task than deniers (t = 4.187). Unlike any other band, significant contrasts in the beta 1 band demonstrated less average power in the right hemisphere than the left within both personality types for the Shape task (critics' t = 4.281, deniers' t = 3.798) and for critics in the Character task (t = 5.287). This last difference was nearly significant (t = 3.008) for deniers during the Character task with greater left hemisphere average power (see Table 18).

Hypothesis III. The third hypothesis, that a paradoxical lateralization would occur in the frontal lobes, was investigated. There was no precise t value for a PCER of .01 and df_{error} = 84 therefore a more conservative t value (i.e., using a df_{error} of 60) was selected, that is,

Table 17

Personality by Hemisphere and Task Mean Comparisons in Theta for Average Power

For Character and Shape			
Critics		Deniers	
Character		Character	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
2.23	2.11	2.75	2.45
Shape		Shape	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
2.20	2.28	2.79	2.51

Table 18

Personality by Hemisphere and Task Mean Comparisons, Average Power for the Character and Shape Tasks

Delta Band

Critics		Deniers	
Character		Character	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
5.34	5.00	5.74	5.61
Shape		Shape	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
5.64	5.56	6.60	6.31

Beta 1 Band

Critics		Deniers	
Character		Character	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
.863	.763	.826	.770
Shape		Shape	
Left Hemisphere	Right Hemisphere	Left Hemisphere	Right Hemisphere
.879	.795	.839	.768

a t of 2.660 or greater was needed to be significant. Significant contrasts comparing the frontal lobe activities of critics and deniers were evidenced in only the alpha and theta bands. In alpha (see Table 19) critics demonstrated significantly greater left frontal lobe activation than deniers (t = 3.042). This finding was also evidenced (t = 3.330) in the theta band (see Table 20).

Summary. The selected pairwise comparisons performed on the Character and Shape tasks for each of the four frequency bands (i.e., delta, theta, alpha and beta 1) revealed several significant results. Once again most of the significant effects for personality types were evidenced in the alpha and theta bands, and only in the theta band was a within personality type asymmetrical difference significant.

In terms of the hypotheses, it was demonstrated that the Character task involved overall greater activation of both hemispheres of critics than deniers. This finding is similar to the findings of Tucker, Dawson, and Roth (in preparation) that verbal (left hemisphere) tasks involve more overall activation of both hemispheres and suggests that critics use their hemispheres in a way consistent with the demands of verbal tasks. Further, critics appear to utilize their left hemispheres more than deniers and deniers utilize their right hemispheres more than their lefts, regardless of task, whereas critics were symmetrical

Table 19

Personality by Hemisphere Mean Comparisons in Alpha for Average Power

Across Chracter and Shape			
Critics		Deniers	
Left Frontal	Right Frontal	Left Frontal	Right Frontal
1.47	1.42	1.88	1.74

Table 20

Personality by Hemisphere Mean Comparisons
in Theta for Average Power

Across Character and Shape

Critics		Deniers	
Left Frontal	Right Frontal	Left Frontal	Right Frontal
2.93	2.97	3.69	3.47

in their hemispheric activation. No paradoxical frontal lobe effects were noticed.

Summary of Paired Comparisons on Power

In summary, the analyses on average power for both the eyes open and eyes closed tasks presented several consistent findings. First, personality effects were seen in both task sets primarily in the theta and alpha bands, with the most interpretable results in the former. Overall, it appeared that laterality effects occurred within and between personality types. Deniers used their right hemispheres more than critics and critics used their left hemispheres more than deniers. Although critics demonstrated only a tendency for their left hemispheres to show greater activation than their rights, a significant laterality effect was demonstrated for deniers with their right hemispheres showing relatively greater activation than their lefts.

Further, it should be noted that lateralized personality effects were demonstrated more clearly for the eyes closed tasks than for the eyes open tasks. One reason for such a difference may have been the physiological implications of having the eyes open or closed. Goodman, Beatty, and Mulholland (1980) have shown that open eyed tasks have less power to begin with and may therefore make finding significantly personality effects more difficult. Another possible explanation may involve the different subject makeup of the two sets of tasks.

Within the eyes open tasks comparisons there was an interesting, non-lateralized personality by task interaction. Critics demonstrated less overall average power compared to deniers in the alpha band, suggesting that critics utilize both hemispheres more than do deniers for both a verbal and a spatial task. The similarity of critics' hemispheric usage and Tucker, Dawson and Roth's (in preparation) finding that a verbal task was associated with less overall power compared to a spatial task, suggests that the cognition required to perform a left hemisphere task may be similar to a critic's characteristic processing style.

Finally, left hemisphere tasks showed lateralized personality effects and tendencies less clearly than did the spatial task or the baseline task. This may have been because left hemisphere tasks are "hardwired" (Gur & Reivich 1980) or because left hemisphere tasks may exert more processing demand (Tucker, Dawson, & Roth, in preparation) and thereby occlude the visability of the personality effects due to lowered power.

<u>t Tests on Coherence Data</u>

In the next set of analyses t tests were performed on multiple coherences, intrahemispheric partial multiples (IAPM's) and interhemispheric partial multiples (IRPM's) within each task and band between extreme personality types (i.e., $\pm$ .75 personality factor score).

Paired-comparisons t tests were also performed in order to investigate asymmetrical differences within each band and task for a personality type.

Results from asymmetrical comparisons performed on multiple coherences demonstrated only two significant ($p \leq .05$) asymmetrics across all bands and tasks. Critics evidenced greater right (compared to left) occipital multiple coherence during the Relaxation task in the theta band (mean difference = -.053, t = -2.68, p = .03), whereas deniers demonstrated greater right (compared to left) temporal coherence during the same task (mean difference = -.075, t = -2.81, p = .01) in the alpha band. No asymmetrical comparisons were significant for either personality type during the Word Fluency task.

Asymmetrical comparisons using IAPMs revealed three significant differences ($p \leq .05$) for the personality types. Critics demonstrated greater right frontal lobe coherence (mean difference = -.110, t = -2.96, p = .02) and right occipital lobe coherence (mean difference = -.080, t = -2.34, p = .05) in the theta band during the Relaxation task. Within the same task deniers evidenced greater right frontal lobe coherence (mean difference = -.100, t = -2.95, p = .01) in the alpha band.

Unlike the other two coherence computations, comparisons using IRPMs evidenced significant asymmetrical comparisons for deniers in both the Relaxation and Word Fluency

tasks. Deniers demonstrated greater left frontal coherence (mean difference = -.023, t = 2.18, p = .05) in the delta band and greater left temporal coherence (mean difference = -.065, t = -2.75, p = .02) in the alpha band during the Word Fluency task. During the Relaxation task deniers evidenced greater right occipital coherence (mean difference = -.095, t = -2.18, p = .05) in the delta band and greater right frontal coherence (mean difference = -.029, t = -2.30, p = .04) in the theta band. Critics demonstrated significant asymmetrical IRPM comparisons for only the Relaxation task. Critics evidenced greater left occipital coherence in the delta (mean difference = .136, t = 3.69, p = .03), theta (mean difference = .104, t = 2.69, p = .03) and alpha (mean difference = .183, t = 5.16, p = .001) bands; and greater left parietal coherence (mean difference = .050, t = 3.88, p = .005) in the alpha band.

Although the findings were not completely consistent or easily interpretable there was one finding worthy of note. Critics demonstrated higher left than right occipital lobe interhemispheric coherence across several bands. No other finding demonstrated such a consistent asymmetrical difference. Further, no other finding demonstrated probability low enough to indicate with acceptable certainty that the finding was real and not the result of chance factors. Since 64 mean comparisons were made per coherence data type (i.e., multiple, IAPM, IRPM), it was expected

that at least three comparisons would be significant by chance. Across all three coherence data types it would be expected that at least nine comparisons would be significant by chance. The PEER at .05 resulted in a PCER of .003. No single comparison was significant.

Next t tests were performed comparing congruent lobes between personality types for each task in each band within each coherence data type (see Tables 21 through 24). Three significant ($p \leq .05$) findings were revealed for the multiple coherence data of the Relaxation task. In the theta band deniers demonstrated significantly greater left occipital coherence than did critics ($t = -2.30$, $p < .03$). This finding was replicated in the alpha band ($t = -2.837$, $p < .01$). In the beta band, deniers demonstrated greater right temporal coherence ($t = -2.039$, $p < .05$) compared to critics. No significant comparisons were found within the Word Fluency task.

Congruent lobe comparisons made on IAPM coherence data revealed no significant findings, and only four significant findings within IRPM coherence data. The significant congruent lobe comparisons for IRPM coherence data occurred in the Relaxation task and revealed that deniers had greater intrahemispheric coherence in both occipital lobes in the alpha band and both the right parital and right occipital lobes in the beta 1 band, compared to critics.

Table 21

Multiple and Partial Multiple Coherences for the Relaxation Task for Deniers

	x1	x2	x3	x4	x5	x6	x7	x8
			Multiple Coherence Means					
Delta	.859	.866	.736	.762	.901	.918	.903	.891
Theta	.791	.798	.647	.692	.878	.888	.848*	.833
Alpha	.852	.862	.705	.78	.896	.929	.903**	.903
Beta 1	.618	.628	.492	.546*	.787	.825	.778	.787
			Intra-Hemispheric Partial Multiple Coherence Means					
Delta	.499	.594	.616	.554	.524	.613	.638	.530
Theta	.382	.479	.634	.538	.406	.533	.667	.554
Alpha	.329	.513	.720	.660	.429	.583	.759	.665
Beta 1	.241	.370	.608	.556	.301	.408	.664	.585
			Inter-Hemispheric Partial Multiple Coherence Means					
Delta	.656	.652	.397	.376	.462	.504	.569	.557
Theta	.573	.603	.303	.329	.456	.495	.455	.468
Alpha	.613	.583	.327	.339	.517	.544	.488*	.471**
Beta 1	.401	.376	.226	.217	.359	.394*	.383**	.381

* $p < .05$; differs significantly from Word Fluency
** $p < .01$

Table 22

Multiple and Partial Multiple Coherences for the Word Fluency Task for Deniers

	x1	x2	x3	x4	x5	x6	x7	x8
				Multiple Coherence Means				
Delta	.861	.871	.741	.794	.919	.930	.920	.913
Theta	.803	.819	.691	.721	.878	.903	.847	.846
Alpha	.769	.770	.686	.648	.862	.893	.829	.848
Beta 1	.585	.557	.417	.374	.771	.776	.746	.756
				Intra-Hemispheric Partial Multiple Coherence Means				
Delta	.535	.599	.609	.507	.582	.673	.626	.483
Theta	.428	.538	.612	.510	.468	.575	.643	.510
Alpha	.337	.715	.671	.596	.344	.467	.697	.607
Beta 1	.261	.321	.611	.555	.260	.264	.610	.552
				Inter-Hemispheric Partial Multiple Coherence Means				
Delta	.700	.678	.436	.337	.524	.542	.616	.606
Theta	.635	.625	.394	.388	.498	.514	.486	.496
Alpha	.566	.546	.359	.294	.512	.529	.448	.483
Beta 1	.403	.362	.161	.159	.356	.374	.368	.393

Table 23

Multiple and Partial Multiple Coherences
for the Relaxation Task
for Critics

	x1	x2	x3	x4	x5	x6	x7	x8
				Multiple Coherence Means				
Delta	.852	.865	.722	.753	.910	.914	.823	.828
Theta	.812	.839	.684	.705	.900	.907	.766*	.833
Alpha	.868	.875	.647	.696	.901	.899	.852**	.860
Beta 1	.678	.670	.359	.411	.793	.790	.724	.736
				Intra-Hemispheric Partial Multiple Coherence Means				
Delta	.451	.580	.629	.489	.493	.610	.651	.512
Theta	.326	.493	.645	.482	.436	.545	.680	.562
Alpha	.322	.478	.737	.653	.346	.519	.743	.662
Beta 1	.211	.234	.606	.536	.242	.274	.602	.535
				Inter-Hemispheric Partial Multiple Coherence Means				
Delta	.664	.664	.401	.385	.581	.583	.437	.445
Theta	.573	.584	.299	.289	.520	.503	.378	.416
Alpha	.705	.694	.329	.334	.504	.454	.370*	.321*
Beta 1	.496	.454	.159	.192	.328	.132	.253**	.283

* $p < .05$; differs significantly from Relaxation
** $p < .01$

Table 24

Multiple and Partial Multiple Coherences for the Word Fluency Task for Critics

	x1	x2	x3	x4	x5	x6	x7	x8
Multiple Coherence Means								
Delta	.898	.906	.765	.812	.936	.930	.900	.880
Theta	.788	.812	.673	.723	.909	.912	.847	.848
Alpha	.754	.769	.562	.674	.853	.865	.804	.802
Beta 1	.535	.555	.331	.380	.765	.772	.722	.725
Intra-Hemispheric Partial Multiple Coherence Means								
Delta	.603	.664	.679	.574	.624	.676	.655	.534
Theta	.400	.523	.673	.554	.493	.594	.684	.557
Alpha	.281	.430	.680	.604	.354	.518	.702	.600
Beta 1	.205	.250	.587	.511	.222	.299	.610	.540
Inter-Hemispheric Partial Multiple Coherence Means								
Delta	.774	.736	.502	.482	.592	.646	.559	.567
Theta	.570	.589	.394	.391	.552	.553	.469	.475
Alpha	.556	.555	.283	.309	.490	.479	.472	.428
Beta 1	.383	.379	.171	.195	.311	.330	.318	.339

Like the findings of asymmetrical comparisons, the congruent lobe comparison findings were not easily interpretable or consistent. Further, no single comparison demonstrated a probability low enough ($p \leq .0003$) to firmly establish it as a non-chance finding.

Although analyses performed on coherence data for lobe congruent and asymmetrical lobe comparisons were not particularly revealing in terms of the hypotheses of this paper, two general observations were made which are of interest. First, of the twenty comparisons which proved to be significant ($p \leq .05$), only two were within the Word Fluency task. This suggests that the Word Fluency task may engage both hemispheres similarly and may be less influenced by personality variables than other tasks. Secondly, the finding that critics demonstrated greater left than right occipital interhemispheric coherence was interesting because it replicated the findings of Tucker, Roth and Bair (in preparation).

CHAPTER V

DISCUSSION

Analysis of personality self-report measures suggested that individuals can be characterized along a self-description continuum. Individuals at one extreme describe themselves in an unrealistically favorable light (deniers) while individuals at the other extreme are overly critical in their self-descriptions (critics). Further, comparing individuals' self-description biases to brain wave activity showed that deniers characteristically utilized the right hemisphere more than the left, while critics were less consistent in demonstrating lateralized effects. Yet, when significant or near significant asymmetries were observed for critics, the asymmetries demonstrated greater left hemispheric activation.

Analyses relating electroencephalographic measures to the personality factor were performed on two data sets, power and coherence. Analyses were performed on power data using a self-description factor score as both a continuous and a dichotic variable. Multiple regressions, using the factor score as a continuous variable, revealed significant relationships between the personality types (i.e., critics

and deniers) and power in all bands. Although the alpha band demonstrated only one significant regression ($p \leq .1$), the results of regressions within the alpha band tended (in three of the four tasks) to suggest that the right temporal lobe was most sensitive to personality variation, such that deniers demonstrated greater right temporal lobe activation compared to that of critics.

As in the alpha band, temporal lobe activation was consistently related to personality style such that critics demonstrated greater use of their left temporal lobes while deniers demonstrated less use of their left temporal lobes. Deniers also demonstrated greater right parietal lobe activation compared to the activation of right parietal lobe of critics. Although deniers generally demonstrated right hemispheric activation and critics demonstrated greater left activation, paradoxical effects in the regression analyses were found in the frontal lobes. For critics the right frontal lobe demonstrated more activation. These effects were reversed for deniers. These frontal lobe effects are consistent with the findings of Tucker et al. (1981) and Davidson et al. (1978) and have been interpreted by Tucker et al. (1981) as indicating "shutdown" of the hemisphere with frontal lobe activity and activation of the hemisphere with posterior activity. Specifically, Tucker et al. found that depressive affect was associated with right frontal lobe activity and, presumably, right posterior hemispheric "shutdown."

Since the implications for activation are not clearly delineated in the literature for the delta and beta 1 bands, interpretations of the findings are not offered here. It was noted, however, that within the delta band higher right frontal and lower left temporal average power were associated with critic's factor scores relative to deniers. Findings within the beta 1 band demonstrated that only the right occipital lobe differentiated the personality types, with lower average power predictive of critics and higher average powers predictive of deniers.

In the second set of analyses, only the extreme personality types were selected, those with factor scores falling $\pm$ .75 standard deviations above and below the mean. The rationale was that in so doing the effects due to personality type would be demonstrated more emphatically than if the more flexible personality types with factor scores close to the mean were included. Paired comparisons of means were performed between the extreme groups.

This set of analyses on power replicated the general trends found with the multiple regressions. In general, it was found that greater right hemispheric activation was associated with deniers; critics demonstrated a relative symmetry, with some tendency toward greater left hemispheric activity. Surprisingly, the paradoxical frontal effect demonstrated in the theta band of the regressions were not replicated in analyses on extreme groups, possibly suggesting

that the paradoxical frontal lobe effect may be the result of self-generated or transient emotional experience rather than a basic personality trait. This distinction between trait and transient emotion is discussed below.

Interestingly, the personality-consistent, asymmetrical hemispheric activity was produced only in the baseline and spatial tasks. This finding is consistent with Gur and Reivich's (1980) findings and suggests that left hemisphere cognitive tasks may be more "hardwired" into the brain and therefore less amenable to the influence of "choice" or personality. Further, eyes closed tasks demonstrated these effects more clearly than eyes open tasks. Different results may be obtained by comparing a left hemisphere task to a right hemisphere task, as opposed to comparing it to a baseline measure. These differences may also be the direct result of lower variability of power due to having the eyes open.

Although critics did not show significant lateralized encephalographic effects, they did show a non-significant tendency in both the baseline and spatial tasks to have greater left hemispheric activation. It is interesting to note that this tendency was repeated across tasks and bands, and that this tendency was a clear reversal from the lateralization trend demonstrated in the left hemispheric cognitive tasks. One possible explanation for the lack of a significant lateralization for critics may be due to the make-up of this group. When the critic subjects were selected

in order to maximize lateralized hemispheric activation due to personality traits, all members of the critic group were females. It has been shown consistently that females are less likely than males to demonstrate lateralized brain activity (Tucker 1976).

It is also interesting to note that, like the results of the multiple regressions, the most frequent personality type effects across sites were seen within the theta band. Although some personality effects were also noted within alpha, it would appear that these effects were confounded with and, at times, masked by the demands of the type of task. The theta band therefore appears to be most sensitive to personality types (Heinze & Kunkel 1979) and the least affected by task demands. It was also noted that the direction of the effects in theta was the same as in alpha, suggesting that activation in the theta band is equivalent to activation in alpha, that is, lower average power indicating higher activation.

Comparing critics to deniers revealed differences consistent with the right/left hemisphere comparisons. Deniers appeared to use their right hemispheres more than did critics during the baseline tasks, whereas critics tended to show symmetrical hemispheric activity which generally was not significantly different from the level of power evidenced in the deniers' less active left hemispheres. In the other tasks, which required some type of processing

(i.e., verbal or spatial), comparisons between deniers and critics were not as consistent as those within the baseline task. Critics demonstrated lower average power in both hemispheres compared to deniers. This finding may suggest that critics characteristically rely more heavily on both hemispheres to process a task, or that those tasks we have characterized as verbal (i.e., left hemisphere priming) tasks may actually require concurrent right hemispheric activity, or the brain activation of the critics was non-specific, diffusely activating the entire cortex.

The preceding findings on the power data seem generally consistent with the Dawson et al. (in preparation) results and suggest that self-description personality traits are associated with asymmetrical hemispheric activity as well as hemisphere-consistent cognitive abilities. Critics demonstrate symmetrical or greater left hemispheric activity and greater use of verbal and analytical strategies, while deniers demonstrate greater right hemispheric activation and greater use of non-verbal and spatial strategies. The fact that the relationship between personality and asymmetrical activation was clearly demonstrated in the theta band and somewhat in the alpha band implies that hemispheric activation may be more closely associated with the personality of the subject than the demands of the task. Overall, the results of the analyses on the power data confirm the relationship between personality and

lateralized cortical activity and therefore support the utility of a theory which postulates the existence of hemispheric personality types.

While the results of analyses on power were straightforward and clearly address the relationship between personality and activation, results on coherence were not so consistent or clearly interpretable. Although significant findings within the coherence data were not particularly revealing, two observations are noteworthy. First, like the findings within the power data, more significant comparisons were found during the Relaxation task than the Word Fluency task, suggesting that the Relaxation task may place less symmetrical processing demand on the hemispheres and thereby allow another variable, such as personality, to reveal itself. Secondly, the finding that critics had greater left occipital interhemispheric coherence is interesting because it replicates a research finding of Tucker, Roth and Bair (in preparation). Although the findings of the analyses on coherence data are not presently interpretable, these findings may prove valuable as further explorations of coherence data are performed.

In summary, the results of this study appear to confirm the utility of a hemispheric personality type model. The personality type most descriptive of an individual's self-description bias (i.e., denier or critic) appears to be predictive of his lateralized hemispheric activation,

although this predetermined laterality may be less evident for left hemispheric cognitive tasks than for right hemispheric cognitive tasks and baseline tasks. Further, it would appear that the effects of personality on brain wave activity will be more evident for the theta band than the alpha band, and more evident for eyes closed tasks than eyes open tasks.

The implications of a hemispheric personality model are paramount both for research and for practical applications of psychological and neuropsychological theory. In terms of research, the administration of the self-description questionnaires and subsequent factor scoring, using the loadings from this study, could provide a covariate which, when properly controlled, could lead to clearly delineated task effects, particularly for the alpha band. It is evident that without such controls, a sample might become loaded with a specific personality type and as a result, produce confounding interations leading to spurious or conflicting results as was demonstrated in the results of Gevins et al. (1979), who used a selected group of individuals (laboratory researchers) whose occupation may have been partially determined by their hemispheric preference.

This model could also serve to provide a heuristic paradigm with which to understand the conflicting results in the areas of emotion, and lateral eye movements. Differentiating the use of lateral eye movements in terms of

type of looker and question-specific response, it is likely that the subject's overall LEM response pattern may be synonymous with personality type, whereas question-specific LEMs may refer to lateralized hemispheric activity only for those individuals who are more "flexible" in their cognitive approaches to tasks.

As for emotion, if individuals are able to choose (Ornstein 1978) their style of cognitive approach to a task rather than responding reflexively as suggested by Galin (1974), emotional traits such as anxiety, depression, euphoria and denial of unpleasant affects may be predictive of hemispheric utilization within a given task. This assertion assumes that one's chronic life-long emotional style, rather than immediate affective experience, predicts predominant hemispheric usage. This approach to emotion differs from that of Davidson et al. (1978) and Tucker et al. (1981) who looked at acutely experienced emotion, in that acute emotional experience may be associated more generally with arousal mechanisms and therefore more of a right hemispheric phenomena (Tucker 1981), whereas emotional style may be more of a conscious "choice" and therefore less tied to the right hemisphere.

By viewing emotional style as a result of consicous cognitive "choice," possibly influenced by genetics, early childhood experiences or continuing schedules of reinforcement, it may be expected that the type of emotion selected

and its style of presentation will be generally consistent with the cognitive personality style of the individual. However, this does not preclude the experience of overwhelming affect which at times may override an individual's ability to exercise his characteristic cognitive style. For example, one may be a very emotionally controlled, verbal individual for the most part, but when faced with a disaster or emergency might become hysterical, and verbally nonsensical. The distinction here may be the difference between descending, cerebral control (hemispheric personality type) versus ascending brain stem and subsequent cortical arousal (e.g., catastrophe, immediate fright, remembering or viewing unpleasant or frightening scenes, etc.) with the implication that the personality type will modulate lateralized activation until that point that ascending afferent information overwhelms normal descending cerebral regulation.

In terms of practical applications, this model suggests that extreme personality types may be associated with certain mental health problems, such as character disorders and anxiety disorders. This model would imply that therapies providing practice for the client with an opposing personality type set of cognitive and/or emotive therapies may prove useful. For example, it might be expected that individuals who have histrionic personalities will benefit from an approach that will increase activation within the left hemisphere. Such an approach would probably take the

form of helping the client to practice affective constraint and logical, rational cognition. Tucker, Shearer and Murray (1977) explored this proposition by dividing speech anxious college students into two groups on the basis of their LEMs (i.e., right-lookers versus left-lookers). Assuming that a coping strategy opposite in cognitive approach to their preferred style would have the greatest therapeutic effects, the authors had right-lookers (i.e., critics) use an imagining technique while left-lookers were given a verbal strategy to cope with their anxiety. Although not significant, the results indicated a tendency for students to benefit most from a treatment strategy opposite of that which might be expected by knowing their characteristic hemispheric utilization.

Nevertheless, the hemispheric personality model cannot provide a simple framework for selecting an appropriate treatment modality because it cannot approach the complexities of human problems and ways of coping. Rather, the hemispheric personality model might be most facilitative when viewed in conjunction with traditional theories of psychopathology. For example, instead of subjecting an obsessive-compulsive patient to a regimen of body cathartic, emotional, or non-verbal therapies, a therapist may choose to utilize a cognitive, verbal approach to help the client gain greater logical control over his anxiety as well as teaching him other step-by-step techniques to mentally

control painful affect, such as meditation and relaxation. In this case one strengthens hemisphere-congruent coping strategies to help the client gain control.

In another approach, the therapist might select a verbal, analytical approach for an obsessive patient, yet might emphasize the associative or metaphorical aspects of their interactions as opposed to focusing on concrete or purely logical progressions in thought. Conversely, a therapist might select a more non-verbal, cathartic and emotive therapeutic approach for a histrionic patient yet focus on providing logical, sequential antecedents for the patient's therapeutic experiences.

This study, in conjunction with that of Bear and Fedio (1977) with an epileptic population, suggests that techniques developed to improve diminished cerebral activity may also prove useful in therapy with psychiatric patients. For example, having an obsessive client draw pictures upside down or mentally rotate objects may increase relative right hemispheric activation and improve the client's psychiatric symptomology. Conversely a neurological patient might also benefit from psychotherapy geared to facilitate one personality type or the other.

Beyond providing treatment implications, this theory might also provide some diagnostic benefits for patients with neurological damage. In neurological cases in which obvious signs of neurological damage (e.g., hemiplegia, unilateral spatial neglect, etc.) are not present, a brief

questionnaire screening might provide some indications of possible hemispheric over-utilization and therefore emphasize the need for lateral hemispheric investigations by more expensive or intrusive techniques. Conversely, it might be expected that certain types of psychiatric patients will demonstrate psychoneurological difficulties which will improve concurrent with a reduction in psychopathology.

Finally, this model provides implications for psychological and educational development. The emphases in the United States for children to use their right hands and to develop their analytic-logical minds may cause many untapped resources and abilities to be overlooked. It is possible that teaching children to effectively utilize both hemispheres could increase their learning potential, reduce the incidence of learning disabilities and create more "well-balanced" personalities. By being sensitive to the personality type dichotomy, teachers might be able to detect children early, at a more malleable point, who may begin to evidence an over-utilized personality type and by manipulation of learning materials, help the student to modify their learning skills, as well as their personalities in such a way as to bring them into less conflict with their environment. In this case a personality change might be effected with minimal personal intrusiveness.

Overall, it would appear that the hemispheric personality model is a viable framework with which to view

hemispheric activation. This model can serve to provide a way of controlling for confounding variance in the study of cognition and emotion, as well as serve as a design for further research into personality. Further, this model may prove useful in diagnosing and treating various psychological and neurological maladies. Finally, this model may serve to stimulate educational specialists to consider the need for restructuring educational programs to provide for the stimulation of both halves of the brain and therefore help children to better realize their potentials both intellectually and emotionally.

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