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# Differential Hemispheric Specialization and its Relationship to Repression

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# DIFFERENTIAL HEMISPHERIC SPECIALIZATION AND ITS RELATIONSHIP TO REPRESSION

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Alice —

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Thanks.

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This Dissertation submitted by Shirley K. Tyler in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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This Dissertation meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Dean of the Graduate School

## Permission

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## ABSTRACT

In Freud's early formulations regarding a model of the mind, he suggested that repressed material functioned in a separate realm of the mind which was inaccessible to conscious recall or verbal inquiry. Based on studies of split-brain patients and studies of the differential functioning of the cerebral hemispheres, Galin (1977) has suggested that the right cerebral hemisphere may be the locus of unconscious mental contents.

Research with patient populations and normals has shown that each cerebral hemisphere is specialized for a different cognitive style. Right hemisphere cognition is similar in many respects to primary process thinking: global, nonverbal, imaginal, nonlinear association, nonpropositional speech, less concerned with perception of sequence and time. Other data which suggests that the right hemisphere may be implicated in repressed mental contents comes from research on the dissociation of mental contents of the two hemispheres in commissurotomy (split-brain) patients.

Galin (1977) has proposed that in normal intact individuals the mental events of the right hemisphere can become disconnected functionally (repressed) from the left hemisphere by inhibition of neuronal transmission across the cerebral commissures. Recent evidence regarding differential hemispheric functioning during anxiety suggests another mechanism that may result in repression. Tucker, Antes, Stenslie and

Barnhardt (1978) have found that when subjects are anxious the left cerebral hemisphere becomes overactive but dysfunctional. The neuropsychological model proposed in the present paper suggests that "repression" is a function of this restricted perception during anxiety. According to the model, when an unconscious conflict is aroused, the ensuing anxiety serves to overactivate and render dysfunctional the left hemisphere. As a result, perception and processing proceed along right hemisphere lines. Because of their special modes of organization, the knowledge of one hemisphere may not translate readily into the language of the other. Thus, the information stored in the right hemisphere while the left was dysfunctional may not be readily accessible to conscious, verbal left hemisphere thought. As a result, this information may remain "repressed" in the right hemisphere.

The present study attempted a first step in the evaluation of this formulation by evaluating whether left hemisphere perception/processing is hampered more by anxiety than is right hemisphere perception/processing when material is presented simultaneously to both hemispheres. To evaluate the effects of anxiety high and low trait anxious subjects were employed. The effects of state anxiety were studied by experimentally induced arousal. Subjects were asked to perform tasks which require either predominantly left or predominantly right hemisphere functioning and a task that combines both analytic (left hemisphere) and global (right hemisphere) features.

It was hypothesized that under conditions of increased anxiety, performance on left hemisphere tasks would be more negatively affected than would performance on right hemisphere tasks. Contrary to

prediction, right hemisphere task performance actually declined significantly more under conditions of increased anxiety than did left hemisphere task performance. Also contrary to prediction, performance on the analytic (left hemisphere) aspect of the combined task improved significantly with increased anxiety whereas there was a nonsignificant decline in performance on the global (right hemisphere) aspect of the task with increased anxiety. Findings are discussed in terms of reciprocal inhibition of hemispheric function, cognitive style and state dependent memory phenomena.

# CHAPTER I

# INTRODUCTION AND REVIEW OF THE LITERATURE

## Introduction

Repression, the exclusion from conscious awareness of unacceptable thoughts or impulses, has been the cornerstone of psychodynamic theory since its inception. Recently, primarily in the last 20 years, research on the function of the cerebral hemispheres of the brain has suggested that there may be a neuropsychological basis for at least some instances of repression. The present study seeks to provide a model for repression based on differential hemispheric functioning and to evaluate experimentally elements of this model.

First, a brief history of hemispheric specialization as a research field will be provided. Experimental methods employed in this area will then be explored and an overview given of findings in major subdivisions of hemispheric function research. The areas covered will include cognition/perception, emotion, and differences among individuals with characteristic eye movement patterns. Data relating repression to differential hemispheric functioning will then be explored and a neuropsychological model will be offered for this phenomenon.

## Historical Perspective

As the cerebral cortex has evolved and expanded, the mental abilities of mammalian forms have become more complex and sophisticated.

Thus in the creature possessing evolution's most highly developed intellect--man--we find the most massive cortex. In order that this mass may fit into the human cranium, the cortex has become convoluted and folded. These convolutions and folds subdivide the cortex into lobes. The cortex is also divided down the rostral-caudal midline by a deep fissure. The resultant right and left cerebral hemispheres are held together by connective tissues, the principal ones comprising the corpus callosum (Dimond, 1974).

Each of the cerebral hemispheres exerts its primary influence over the opposite or contralateral half of the body and also receives most of its information from the contralateral side. The tactual and motor systems operate almost exclusively in contralateral fashion. Sensations and movement of the left half of the body are mediated by the right hemisphere while those of the right half of the body are mediated by the left hemisphere. Vision to the right of a central fixation point is mediated by the left half of the brain whereas vision to the left of fixation is mediated by the right hemisphere. Each hemisphere receives auditory input from both ears; however, the connections with the contralateral ear appear to be stronger than the ipsilateral connections (Kimura, 1973).

The separation of the cerebrum into two distinct cortices, privy to different funds of information, has led investigators to wonder if man in effect has twin brains, with each cerebral hemisphere duplicating the functions of the other, or if the cerebral hemispheres provide different contributions to mental functioning. According to Searleman (1977), the view that the cerebral hemispheres are specialized in function received support as early as the 1800's with Dax's 1836 paper to the French Medical Society linking right hemiplegia and loss of speech to lesions of the left hemisphere. Then in the 1860's Broca lent further support to the specialization view when he demonstrated that damage to the third frontal convolution of the left hemisphere resulted in a motor speech aphasia whereas damage to the same area of the right hemisphere did not (Searleman, 1977). In their experiments in the 1950's with cats and monkeys, Roger Sperry and R. E. Meyers had shown that doubling (i.e., separation) of mental streams follows cerebral disconnection. Their studies demonstrated that following surgical disconnection of the hemispheres, if one hemisphere learns a discrimination, the other hemisphere does not have access to that knowledge. Despite the early studies suggesting separate streams of mental activity in the hemispheres, research in hemispheric specialization did not truly blossom until the work of Sperry and his colleagues with human patients at the California Institute of Technology (Galin, 1977).

## Patient Populations

Sperry's research involved neurosurgical patients, all advanced epileptics in whom the midline section of the corpus callosum, anterior and hippocampal commissures and, in some cases, the massa intermedia was performed in order to contain severe epileptic seizures which had not responded to medication. Because this surgery prevents the interhemispheric communication which normally occurs by way of the corpus callosum, these human commissurotomy or "split-brain" patients provided an ideal opportunity for studying the functions of each cerebral hemisphere in isolation (Sperry, 1968). While Sperry and his colleagues have published more than 100 studies of their patients, two main findings have emerged, that the two hemispheres in man are specialized for different cognitive functions and that each hemisphere of the "split-brain" appears capable of sustaining an independent autonomous consciousness (Galin, 1977).

Information regarding hemispheric specialization has come from a variety of other sources. Two additional patient populations contributing to knowledge in the area are individuals who have suffered lesions confined to a single hemisphere and patients who receive unilateral carotid sodium amytal injections. Deficits or aberrations of particular cognitive and emotional functions of brain-lesioned patients are generally taken as evidence that these functions were subserved, prior to damage, by the now lesioned hemisphere. A similar interpretation has been given to observations of sodium amytal patients. The sodium amytal or Wada test involves injecting the sedative sodium amytal into the carotid artery of one or the other side of the neck. This results in disruption of the functioning of the cerebral hemisphere on the same side. The Wada test is used prior to neurosurgery to determine which hemisphere has speech representation and to avoid, where possible, surgical destruction of the speech area. Results of the lesion and sodium amytal studies have generally been interpreted as indicating that decreased functioning of the involved hemisphere permits the characteristic functioning of the unaffected hemisphere to come to the fore. Some investigators (e.g., Hall, Hall, & Lavoie, 1968), however, have suggested that the behavior of patients with damage to a single hemisphere is the result of the lesion or sedative exaggerating the characteristic functioning of the affected cerebral hemisphere. This is supported by the findings of Alema, Rosadini and Rossi (1961) that in patients with unilateral brain damage, the specifically lateralized affective response to amytal injection is seen only on the intact side.

While no one would deny the contributions to the area of hemispheric specialization made by studies of neurological patients, findings based on brain damage must be viewed with caution. Dimond (1974) points out that brain damage might feasibly disrupt a function only at particular levels of organization. Furthermore, due to the brain's tremendous capacity to quickly compensate for impairment, changes in behavior following injury may be the result not only of the damage incurred but of compensatory processes. Data from commissurotomy patients is suspect because some effects could be due to preoperative conditions arising from the patient's epilepsy (R. E. Gur & R. C. Gur, 1977).

## Research Techniques with the Neurologically Intact

Because of the limitations of research with patient populations many investigators have turned to the study of normal individuals to elucidate hemispheric functions. Two techniques utilized in research with normal subjects (tachistoscopic and dichotic listening methodologies) have capitalized on the fact that information presented to one-half of the body travels first to the contralateral hemisphere. Thus, visual information to the left of a fixation point is received by the right one-half of each retina; then neural pathways from the right halves of both retinae go to the visual cortex of the right hemisphere.

Similarly, information to the right of fixation is received by the left side of each retina and travels from there to the left hemisphere. Under normal viewing conditions, however, one cannot present an image in only one visual field because the eyes are constantly moving. But using rapid tachistoscopic presentations of stimuli to the left or right of fixation at durations less than the 200 msec required for eye movement effectively results in stimulation of only one side of each retina (and therefore a single hemisphere). Therefore, if responses are more rapid and fewer errors are made in processing particular kinds of information when presented tachistoscopically to one or the other visual field, it can be deduced that the contralateral hemisphere is specialized in dealing with such material. A stimulus presented to the unspecialized hemisphere is considered at a disadvantage because it either must be handled less efficiently by that hemisphere or must travel via the corpus callosum to the specialized hemisphere for processing (Springer, 1977).

Kinsbourne (1970) and White (1971) have given alternative explanations for visual field superiority effects but their arguments have been effectively refuted in an article by Berlucchi (1974). According to Kinsbourne, laterality effects in perception can be attributed to an attentional bias toward the visual field that subserves the specialized hemisphere rather than to more efficient transmission of information by the shorter (contralateral) pathway to that hemisphere. For example, if a subject is involved in a study of visual discrimination of verbal material, Kinsbourne would argue that because of this task set, the left hemisphere becomes activated in "anticipation" of the verbal material. This left hemisphere activation would then trigger selective attention to the right or even a shift in gaze to the right prior to the presentation of task stimuli. Since the subject is already attending to the right, he will be at an advantage when stimuli are presented in the right visual field. Berlucchi, however, presented letter (left hemisphere material) and facial (right hemisphere material) stimuli in random order so that subjects could not anticipate the type of material to be viewed. Right visual half-field (RVHF) superiority for letters and left visual half-field (LVHF) superiority for faces was still found. This argues against the attentional bias hypothesis.

White (1971) has argued that RVHF superiority for letters is explicable on grounds other than left hemispheric specialization for speech and language. He found that right field superiority for identification of the orientation of lines presented at four different angles (0, 45, 90 and 135 degrees) was significantly correlated with right-field superiority for letters in the same subjects. White concluded that right field superiority for identification of both line orientation and letters can be attributed to a selective contouring apparatus which favors these stimuli at a peripheral retinal or central level shown in the right visual hemifield rather than attributing the right field superiority to left cerebral hemispheric specialization for language. Umilta, Rizzolatti, Marzi, Zamboni, Franzini, Camarda, and Berlucchi (1973) also found RVHF superiority when rectangles were presented in the orientations used by White. However, in two additional experiments where line orientation was changed to 30, 45, 120 and 135 degrees from the vertical in one study and 15, 45 and 60 degrees from the vertical in the other, LVHF superiority was demonstrated. Berlucchi (1974) interprets these data in a way that is consistent with the idea that line orientation and letter recognition are facilitated by the left hemisphere language areas. He suggests that the four line orientations used by White are recognized and responded to more rapidly when presented to the RVHF because these orientations are readily analyzed and categorized by the left hemisphere in language terms, i.e., horizontal, vertical, left tilt, right tilt. The rectangles that Umilta and his colleagues used at other orientations would be more difficult to encode singly by way of verbal labels. However, they could be encoded on a comparison basis with the other stimuli. Thus the right hemisphere, adept at analyzing spatial relations, would better handle these discriminations.

The dichotic listening procedure is used with auditory stimulation. The auditory system differs from the visual in that each hemisphere receives information from both ears (Kimura, 1973). As a result, monaural presentation of material does not permit lateralization to only one hemisphere. With the dichotic listening procedure different information is provided simultaneously to each ear via headphones. This procedure does appear to accomplish lateralization of input. Under such conditions of competition it appears that the ipsilateral pathways are suppressed leaving only the contralateral pathways functional (Springer, 1977). Another research tool used with normal as well as patient populations is the electroencephalograph (EEG). Scalp EEG activity is recorded over the two cerebral hemispheres or over particular regions of the cerebral cortex during mental activities that are thought to result in differential activation. When comparing the EEGs of two sites, greater alpha desynchrony is thought to indicate greater activation. Data from several investigators (e.g., Galin & Ornstein, 1972; McKee, Humphrey, & McAdam, 1973) support the use of the EEG as a means for studying hemispheric specialization.

The observation that individuals tend to shift their gaze to the left or right during contemplation or while speaking has been the basis for another measure of hemispheric activation useful with normal populations. These lateral eye movements (LEMs) are controlled by activity in the frontal eye fields and in 1969 Bakan suggested that movements to the left or right are triggered by greater activation of the contralateral cerebral hemisphere. If this were the case, questions thought to elicit left hemisphere processes should produce LEMs to the right while questions triggering right hemisphere processes should result in eye movements to the left (Kinsbourne, 1972). Data have been equivocal in this regard (see review by Ehrlichman & Weinberger, 1978). Greater replicability has been found in studies investigating individual differences in primary direction of lateral eye movements. Subjects have been found to be reasonably consistent in their pattern of eye movements within and between sessions and in different situations so that a large portion of individuals can be classified as left movers (LMs) or right movers (RMs). In addition, LMs and RMs have been found to differ on a number of personality variables and individual characteristics. However, the relationship between these variables and differing functions of the two hemispheres has not always been clear. More importantly LMs and RMs cannot always be distinguished on the basis of functions held to be left or right hemisphere specific. In a recent article G. Tucker and Suib

(1978) suggest that former negative findings regarding LM/RM differences in processing hemisphere specific material may have been due to inadequate experimental controls. They compared WAIS Verbal and Performance IQs of RMs and LMs but only used as subjects those individuals who had been consistently classified as LMs or RMs on two occasions. As would be expected by Bakan's contralateral activation hypothesis, RMs obtained significantly higher Verbal IQs than Performance IQs, and LMs obtained higher Performance IQs.

## Overview of Research

Thus far attention has been directed at the development of interest in hemispheric specialization, patient populations that have provided data regarding the differential functioning of the cerebral hemispheres, and research techniques that have been employed with normal subjects. Now an overview of research findings in this area will be presented. Data presented throughout this paper are limited to right handed subjects. In most right handed subjects language functions, particularly speech production, are controlled by the left hemisphere. The picture is less clear with subjects who are not right handed and for this reason they are treated separately in the literature. About two-thirds of non-right handed subjects also exhibit left hemisphere speech but the remainder have either right hemisphere language or bilateral representation for language skills (Searleman, 1977).

Cognition/Perception. Springer (1977) has provided an excellent review of findings regarding hemispheric specialization for cognitive and perceptual functions. In terms of these functions, the left hemisphere is specialized for analytic processes such as the perception and production of speech, language and digits. The right hemisphere is adept at holistic processing tasks such as music perception and visuo-spatial performance. The latter includes visual point location, rapid scanning of visual stimuli for enumeration, perception of line orientation, stereoscopic depth perception (Kimura, 1974), identification of many sided regular polygonal forms and face recognition. Most early researches emphasized verbal versus nonverbal input and focused on differential processing of the two hemispheres for different kinds of stimuli. For example, the early finding of better identification of letters flashed to the right visual field was interpreted as indicative of the interaction of the verbal processor of the left hemisphere with verbal stimuli. Stimuli that were more readily processed by the right hemisphere included faces (Springer, 1977), many-sided polygons (Umilta, Bagnara, & Simion, 1978) and melodies (Kimura, 1973). Springer goes on to note that more recent research in hemisphere asymmetries of cognition and perception has focused on task requirements rather than type of stimuli per se. For example, based on characteristics of the stimuli, word matching would be considered a left hemisphere task; however, a right hemisphere advantage for word matching has been shown when subjects could respond solely on the basis of the physical characteristics of the stimuli rather than the meaning. Although visual configurational stimuli are generally considered the province of the right hemisphere, Umilta et al. (1978) found a right visual field (left hemisphere) advantage in recognition of simple geometric forms (e.g., triangles and squares), probably because these stimuli readily lend themselves to verbal labelling. Springer also reports an unpublished study by John Niederbuhl in which opposite hemisphere superiorities were obtained for identification of the same letter stimuli when different task instructions were given. A left hemisphere superiority was found when subjects were to rehearse a set of letters verbally and identify those visually presented stimuli that were set members. Right hemisphere advantage was demonstrated when subjects did not engage in verbal rehearsal and were to identify only those letters composed of straight lines.

Not only task requirements but also response mode is important to consider when evaluating findings regarding hemispheric specialization. In a 1971 study by Geffen, Bradshaw, and Wallace briefer response latencies were found for ambiguous face stimuli presented to the LVHF when manual same/different responses were required. Reaction times were the same for LVHF and RVHF presentations when vocal yes/no responses were required. Each hemisphere should be able to respond equally well manually so that any differences in reaction time with manual responding can be attributed to hemisphere asymmetry for the particular task. Vocal responses must be made by the left hemisphere. Faces presented to the LVHF are processed in the right hemisphere but reaction times increase because the information must then cross over to the left hemisphere for vocal response. With RVHF presentations of faces crossover is not required for verbal response, however, reaction times are slowed since the left hemisphere is not specialized for processing faces. A mutual cancellation occurs with no advantage found for field of presentation. Geffen et al. further found that reaction times were similar with left and right field presentations when a non-identificatory vocal response (saying "bonk" rather than the name of the digit) was required. RVHF superiority was also found when a manual identificatory response was required, e.g., pushing a lever to one side for a number 2 and pushing it to the other side for a number 4. Geffen et al. conclude it is not necessarily the verbal versus manual nature of a response which is critical but rather that it is important to clarify if the response mode is identificatory, presumably the type of response mediated by the left hemisphere.

Emotion. Research findings of hemispheric specialization for cognitive and perceptual functions have stimulated research to determine whether there are differential hemispheric contributions to emotion. According to Gainotti (1972) Goldstein in 1939 was the first investigator to notice the occurrence of catastrophic emotional reaction in left brain damaged patients. Then in 1951 Hecaen, Ajuriaguerra, and Massonet and in 1952 Denny-Brown, Meyer and Hornstein noted the emotional reaction of indifference among patients with damage to the non-dominant (for speech) hemisphere. Gainotti goes on to report that in 1959 Terzian and Ceccotto made similar discoveries regarding patients who received sodium amytal injections: a depressive-catastrophic reaction was noted as the inactivating effects of amytal carotid injection on the side of the dominant hemisphere were wearing off; an euphoric-manic reaction was noted while patients recovered from amytal injection to the carotid on the side of the non-dominant hemisphere. In a study of 150 patients with unilateral cerebral lesions Gainotti (1969) lent further support to this finding when he found a significantly higher incidence of catastrophic reactions in left-lesioned patients and significantly more indifference reactions among the right lesioned. Gainotti (1972) explored this phenomenon further by giving a total of 160 brain damaged patients a battery of neuropsychological tests in order to evaluate their reactions to failures. Among the left lesioned there were significantly more catastrophic reactions or anxious-depressive reactions while the right lesioned were more likely to respond with anosognosia, indifference, or joking. In a study of temporal lobe epileptics Bear and Fedio (1977) found those with right hemisphere involvement exaggerated their positive qualities and those with left hemisphere involvement minimized their positive qualities; the reverse was true for undesirable traits. Although right temporal lobe epileptics tended to minimize or deny sadness, they were actually rated by observers as more sad than the left temporal lobe epileptics who gave self-reports of greater sadness.

Based on data regarding the emotional functioning of patients with brain dysfunction, one would expect left and right damaged individuals to have different MMPI profiles. In a 1977 paper presented to the International Neuropsychological Society, Gasparrini, Satz, and Heilman (Note 1) reviewed studies which compared the MMPI profiles of such patients and found that none of the investigators successfully differentiated left and right damaged groups. However, in a research study of their own replicating methodologically an earlier investigation by Reitan, Gasparrini et al. did find significant differences on Scale 2 (depression). Left damaged subjects scored significantly more often in the pathological range on this scale than did right damaged subjects.

As stated earlier, the usual interpretation given to data resulting from studies of the emotional responses of unilateral brain dysfunction patients is that when one hemisphere is rendered dysfunctional, it is unable to inhibit the function of the unaffected side of the brain. The suggestion is made then that the depressive-catastrophic reaction of the left hemisphere dysfunction patients is indicative of the unhindered right hemisphere's contribution to emotionality. Conversely, the euphoric indifference seen in right dysfunction is considered the reflection of left hemisphere emotionality. However, a study reported by Hall et al. (1968) suggests the opposite may hold true, that depressive-catastrophic responses may be due to exaggeration of the normal mode of function of the left hemisphere, and indifference-euphoric reactions may be due to exaggerated right hemisphere function. These investigators evaluated the Rorschach responses of left and right damaged patients and found the former to be constricted and inhibited and the latter expansive and unconstrained. They argued that these characteristic response styles are exaggerations of the cognitive styles of the intact left and right cerebral hemispheres. This type of exaggeration of the cognitive function characteristic of the damaged hemisphere could feasibly occur for the emotional functioning specific to the damaged side as well. Gainotti (1972) provides the disparate interpretation that the catastrophic depressive reaction is an appropriate emotional response (by the right hemisphere) to the realization that deficits have been incurred by the left hemisphere damage and that the indifference-euphoric response is an abnormal mood reaction that occurs when the emotion-mediating right hemisphere is damaged. Bear and Fedio

(1977) provide a somewhat similar view of the catastrophic reaction. They suggest that the emotional responses accompanying left and right hemisphere dysfunction result from information that is available to the "conscious, verbal" left hemisphere. Deficits in cognitive or in verbal-emotional associations within the dysfunctional left hemisphere will be readily apparent to the conscious verbal inquiry of this hemisphere and then may be exaggerated catastrophically. With right hemisphere lesions, however, they suggest the dysfunctional right hemisphere is unable to provide information regarding its sensory, cognitive or affective deficits. In response, the left hemisphere interprets the lack of information as a sign that there are no problems. Indifference or euphoria is the result.

Lezak (Note 2), in a report on right hemisphere damaged patients, attributed the aberrations of affect they display to defects in the right hemisphere's synthesizing and configurational processing. Several research findings from studies of subjects without brain dysfunction provide support for the role of the right hemisphere in emotion. Schwartz, Davidson, and Maer (1975) devised 40 questions involving emotional and nonemotional stimuli in different combinations. They found significantly more left LEMs on the emotional than the nonemotional questions, indicating greater right hemisphere activation when presented with emotional material. Safer and Leventhal (1977) found that subjects who were presented with taped passages to the left ear used emotional tone of voice rather than content in rating the passages as positive, neutral or negative. They interpreted this finding as indicating a right hemisphere bias for utilization of emotional cues. Sackeim,

R. C. Gur, and Saucy (1978) found that the left side of the face expresses emotion more intensely than the right side, a finding which suggests greater right hemispheric involvement in the production of emotional expression.

Tucker, Stenslie, Roth, and Shearer (in press) reported that investigators (Flor-Henry, 1976; Yozawitz & Bruder, Note 3) have found right hemisphere performance decrements in psychiatric patients with affective disorders, while EEG research (d'Elia & Perris, 1973, 1974) has suggested greater left than right hemisphere activation in depressed patients. Other support for greater left hemisphere activation during depression comes from EEG studies by Harmon and Ray (1977) and Ehrlichman and Wiener (Note 4). Tucker et al. (in press) performed two experiments to evaluate the relative contributions of the left and right hemispheres to emotion. In the first experiment differential hemispheric functioning was demonstrated in normal subjects during hypnotically induced mood states. While left hemisphere performance (on an arithmetic task) was unaffected by mood states, right hemisphere performance decrements (in imagery) were demonstrated during induced depression. Greater right than left auditory attentional bias was also demonstrated during the induced depression condition. However, it was unclear if this difference was a function of the left hemisphere becoming more activated or if it was due to the right hemisphere becoming less activated during depressive mood. To clarify the issue of differential hemispheric activation during emotion, Tucker et al. (in press) performed a second experiment to evaluate the EEGs of subjects taken while they used suggestions offered by the experimenter to arouse a depressed mood state. Rather than simply evaluating left versus right activation, Tucker et al. also looked at differential activation along the rostral-caudal dimension. EEG data were obtained from the left and right frontal, central, parietal and occipital regions of the cortex. In contrast to previous EEG research findings, greater right over left activation was found in the induced depressive states, with this differential activation being specific to the frontal lobes. Subjects were also asked to perform cognitive tasks (imagery and arithmetic) and the typical right/left differences in activation found on these tasks were found to be specific to the occipital lobes. Tucker et al. suggest that it is right frontal lobe activation (rather than left hemisphere activation) which inhibits cognitive performance in the right posterior region during depression. While there was greater right than left frontal lobe activation during depression, relative symmetry of the left and right frontal EEG's was found during the euphoria condition.

Additional studies of hemispheric functioning in emotion have evaluated differential contributions of the left and right cerebral hemispheres to the arousal and inhibition of positive and negative affect, to stress, and to anxiety. In a study of normal college students Shearer and Tucker (in press) presented subjects with sexual and aversive slides under instructions to either facilitate or inhibit emotional arousal. While there was a slight non-significant right ear (left hemisphere) attentional bias across conditions, success in facilitating the experience of aversive arousal and failure to inhibit experienced aversive arousal were accompanied by relatively greater left ear attentional bias (right hemisphere activation). However, this greater right hemisphere activation and greater experienced aversive arousal were accompanied by less physical arousal. Shearer and Tucker also found that subjects tended to use right hemisphere-type cognitive strategies (imagery, nonverbal, global) to facilitate emotional arousal and used left hemisphere-type cognition (internal verbal dialogue, analytic, non-imagery) when trying to inhibit emotion.

In a 1977 experiment designed to study the effects of psychological stress upon the hemisphere activation of normal subjects, Tucker, Roth, Arneson, and Buckingham observed LEMs in response to emotional and nonemotional reflective questions. Subjects were subjected to either a neutral or stress condition; the latter was induced by telling subjects their answers would indicate their intellectual ability and personality stability. As in previous studies there were significantly more left LEMs (implying greater right hemisphere activation) to emotional than to nonemotional questions. Left movers and right movers showed a significant increase in left LEMs during stress whereas this increase was nonsignificant for individuals who showed about equal numbers of left and right LEMs. Both males and females demonstrated increased left LEMs for emotional questions in the stress condition, but this was significant for males only with stress and for females only for emotional questions.

Tucker, Antes, Stenslie, and Barnhardt (1978) report two experiments on the relationship between anxiety and hemispheric functioning. In Experiment I they found that higher state anxiety (induced by conveying to subjects that they were the focal point in a sophisticated, high-pressure research project and measured with the Spielberger State Anxiety Questionnaire) was associated with more errors in the RVHF, especially for verbal stimuli, but did not affect errors in the LVHF. Only extreme scorers were used in the study, i.e., those subjects who scored at least one standard deviation above or below the mean on the state anxiety questionnaire. As a result of this selection process the investigators may have been examining trait anxiety by way of the state measure (Tucker, Note 5). In a second experiment, higher trait anxiety was associated with greater right ear auditory attention bias (left hemisphere activation), a decrease in LLEMs and no change in RLEMs. Tucker et al. interpret their findings as indicating that with anxiety the left hemisphere becomes both overactivated and dysfunctional.

Another area of research in differential hemispheric functioning pertains to both emotional and cognitive functioning. This is research on differential hemispheric functioning in schizophrenia. Beaumont and Dimond (1973) found that schizophrenics had difficulty on matching tasks when the material to be matched was presented in two hemispheres (interhemispheric matching). They also had problems with intrahemispheric matching in the left cerebral hemisphere but only with letter stimuli. These findings are suggestive of left hemisphere dysfunction in schizophrenia. Louks, Calsyn, and Lindsay (1976) found that patients demonstrating left hemisphere deficits on neuropsychological testing tended to score in the psychotic range on the MMPI while patients with right hemisphere deficit tended to score in the neurotic range. Lansdell and Urbach (1965) found higher scores on the F and 8 (schizophrenia) scales of the MMPI with left temporal lobe epileptics when compared to right temporal lobe epileptics. Additional research supporting a connection between left hemisphere dysfunction and schizophrenia includes EEG studies by Rochford, Swartzburg, Chowdhrey, and Goldstein (1976) and by Flor-Henry (1976). Rochford et al. compared left and right hemisphere EEG amplitude variances and found in depression much greater variability in the right hemisphere and with a group of schizophrenics greater variability in the left hemisphere. Their findings were interpreted as indicative of left hemisphere dysfunction in schizophrenics. Flor-Henry found EEG abnormalities in both schizophrenic and psychopathic patients which suggest disorganization in the orbital frontal-temporal regions of the left hemisphere.

Bazhin, Wasserman, and Tonkonogii (1975) have compared subgroupings of schizophrenics: paranoid schizophrenics who were experiencing auditory hallucinations versus non-hallucinating paranoid schizophrenics. They found increased right ear thresholds with the hallucinating group of patients. In a study of 19 schizophrenics, Gruzelier and Hammond (1976) found differences between these patients and a group of normals on four measures of hemispheric functioning. These included an initially higher right ear sensitivity, then gradually increasing right ear auditory thresholds for the schizophrenics. The patients also demonstrated poorer right ear auditory temporal discrimination, increased electrodermal orienting responses to tones on the right side and poorer performances on WAIS verbal subtests as compared with spatial subtests.

R. E. Gur (1978) and Schweitzer, Becker, and Welsh (1978) have used LEMs to measure hemispheric functioning in schizophrenics. R. E. Gur first found that, unlike the controls, the schizophrenics showed right hemisphere superiority on both spatial and verbal tests, suggesting left hemisphere dysfunction with verbal material. In a second study, LEMs were measured in response to reflective questions (verbal neutral, verbal emotional). Schizophrenics made significantly more right LEMs compared to controls regardless of type of question. Results of the two studies are interpreted as indicating both left hemisphere overactivation and left hemisphere dysfunction in schizophrenia. Schweitzer et al. compared LEMs of schizophrenics and normal controls in response to verbal nonemotional, verbal emotional, spatial nonemotional and spatial emotional stimuli and found significantly more right LEMs for schizophrenics overall and on three of the sets of stimuli (verbal nonemotional, verbal emotional and spatial emotional) which is also indicative of left hemisphere overactivation in these patients.

Left Movers Versus Right Movers. A large body of research in the area of hemispheric functioning has involved the comparison of left movers (lookers) and right movers (lookers). These are individuals whose eye movement responses to reflective questions are primarily in one direction. The interpretation is generally given that left movers (LMs) tend to rely more on their right hemisphere in their mental functioning while right movers (RMs) rely on their left hemisphere to a greater extent.

Day in 1964 was the first to make the observation in his work with clinical patients that individuals are rather consistent in direction of eye movements. He described differences in the type of anxiety experienced by LM and RM patients as well as differences in EEG records (1967a) and attentional patterns (1967b). Day (1967b) described RMs as exhibiting an externalized actively responsive distribution of attention emphasizing the visual haptic modes while LMs demonstrated an internalized, subjective, passive distribution of attention in which they were more reactive to auditory and subjective visceral experience. RMs tended to describe their anxiety as having an external locus and their behavior emphasized visual alertness to changes in the environment. The anxiety of LMs was described as having an internal locus with tension felt when internal impulses threatened to emerge. In a 1968 article, Day reported that LMs tend to be more emotional than RMs.

Some of Day's observations have been corroborated by more recent research. Miskin and Singer (1974) found that high inner attentive subjects were more likely to be LMs. It has been found that LMs are more susceptible to hypnosis (Bakan, 1969; R. C. Gur & R. E. Gur, 1974) and to persuasion (Ehrlichman & Weinberger, 1978). However, in a study of hypnotic susceptibility, R. E. Gur and Reyher (1973) found that active induction methods reduced the susceptibility of the LMs. They interpreted this as indicating that these individuals are more internally oriented, an interpretation that is congruent with Day's early observations. In her doctoral dissertation, R. E. Gur (1973) found that LMs reported more psychosomatic symptoms than did RMs which is in line with Day's observation that LMs internalize anxiety. R. E. Gur also found that LMs used reversal as a defensive strategy more than did RMs while RMs used turning against object and projection to a greater extent. Again commensurate with Day's observations and corroborating R. E. Gur's dissertation findings, R. E. Gur and R. C. Gur (1975) found LMs to score higher on a defense mechanism cluster that included repression and denial whereas RMs scored higher on defenses of projection and turning against others. Gerdes and Kinsbourne (1974) used pulse rate to measure anxiety and found that LMs underestimated their level of anxiety. This is congruent with the use of repression and denial as defensive strategies. RMs were found to overestimate their anxiety level.

Smokler and Shevrin (1979) reasoned that qualities marking a hysterical personality style (repression of disturbing ideas, emotional lability, a concrete, stimulus-bound cognitive approach) are consistent with research findings regarding right hemisphere functioning and that obsessive compulsive personality traits (repression of disturbing affect, almost exclusive use of an ideational approach, logico-deductive cognitive approach) are consistent with research data regarding left hemisphere functioning. Their hypotheses that hysterical style would be correlated with left looking and obsessive compulsive style with right looking were borne out.

In a two part study of eye movement tendencies and psychopathology, R. E. Gur, R. C. Gur, and Marshalek (1975) first observed classroom seating preferences and found that LMs tended to sit on the right side of the classroom and RMs on the left side. In a followup investigation they found that male students who sit on the left side of the room (presumably RMs) when compared with students with a right side of the room seating preference give self-reports of more psychopathology. Female students who sit on the left side of the classroom (presumably RMs) report less psychopathology than females who sit on the right side of the room.

In evaluations of LM/RM differences in achievement and in intellectual vocational orientation, Bakan (1969) found that RM college students scored higher on the quantitative than the verbal section of the

Scholastic Aptitude Test and that LMs preferred "soft" over "hard" academic majors. LMs also have been found to endorse more humanistic items on the Tomkins Polarity Scale (Ehrlichman & Weinberger, 1978). R. E. Gur (1973) did not find differences between LMs and RMs on the Strong Vocational Interest Blank and, contrary to expectation, found that RMs rather than LMs performed better on the Minnesota Spatial Relations Test.

Ehrlichman and Weinberger (1978) in a review of the LM/RM research, report that despite general consistency in findings in this area, studies that have used standard personality measures such as the MMPI, 16PF Questionnaire, Rorschach and field dependence-independence measures have failed to find consistent differences between the two groups. Ehrlichman and Weinberger further report that several studies have failed to differentiate LMs and RMs using a variety of verbal, spatial and imagery ability tests. They also note that there have been equivocal findings in research comparing the two groups on creativity. Because of studies that have failed to differentiate LMs and RMs on tasks that would appear most likely to characterize the abilities of the left and right hemispheres (e.g., verbal and imagery) Ehrlichman and Weinberger have been critical of the interpretation that LMs rely more on right hemisphere mental processes and RMs on left hemisphere functioning. They allow that there are some quite consistent differences between LMs and RMs but deny the relevance of the differences to left versus right hemisphere processing. They give hypnotic susceptibility as an example of a consistent but non-relevant difference. It could be argued, however, that features of right hemispheric cognitions, e.g., holistic, non-analytic, global, non-logical, are features of the mental attitude and processing important to attaining a hypnotic state.

The Relationship of Differential Hemispheric Functioning to Repression. As indicated earlier in this paper, Galin (1977) distills the findings of Sperry and his colleagues into two fundamental observations: (a) lateral specialization of cognitive function and (b) the capability of the two cerebral hemispheres, when surgically separated, to sustain independent, autonomous consciousness. The latter provides for a duality or dissociation of consciousness. Up to this point, this paper has addressed research in lateral specialization. The focus now changes to the duality and dissociation of consciousness and to their relationship to repression. It should be pointed out that much of the research in lateral specialization that has been reviewed also is relevant to a study of hemispheric duality.

In general, neuropsychological research has focused on lateralization of function, leaving the study of dissociations and internal conflicts to clinical psychology and psychiatry. Galin (1974, 1977) has attempted a rapproachement between the research evidence in neuropsychology and psychodynamic theory, by pointing out parallels between the behavior of split-brain patients and individuals employing the defense mechanism of repression. Here again Galin refers to the work of Sperry and his colleagues. In describing the dissociated visual experiences of commissurotomy patients, Sperry (1968) notes that visual material projected to the right half of the field (left hemisphere) can be described in speech and writing in an essentially normal manner. But when the visual material is projected to the left half of the field (right hemisphere) the patient insists he saw either nothing or a flash of light. If, instead of asking the patient to verbally report what he saw, he is instructed to use his left hand to point out a matching picture or object from a group of pictures or objects, he has no trouble in pointing out the very item he had just insisted he did not see. Sperry also found that the right hemisphere of commissurotomy patients can comprehend both written and spoken words to some extent, although this comprehension cannot be expressed verbally. For example, if the name of an object, e.g., the word "eraser", is flashed to the left visual field, the patient can select correctly an eraser from a group of objects, using only touch with the left hand. The conclusion is that the right hemisphere must have read and understood the test word. Of course, if asked to name the object, the patient is unable, since the "talking" left hemisphere has no access to the information in the right hemisphere. The behavior of these patients is analogous to that explained by the psychodynamic notion that unconscious processes have a direct influence on behavior while remaining outside of awareness. Levy, Trevarthen, and Sperry (1972) demonstrate that there can exist concurrent diverse perceptual events in each of the disconnected hemispheres. In their experiments different stimuli, such as photographs of faces, were exposed briefly and simultaneously to the right and left visual half-fields. If the subject was asked to select from an array of photos, by pointing to the one he had just seen, he would tend to select the photo that had been exposed to the left half-fields (right hemisphere). If asked to describe the face he had seen, he would describe the face exposed to the right visual half-field (left hemisphere). Sperry (1968) provides a startling example of behavior in split-brain patients which mimics repression. In this experiment a series of neutral geometric figures are flashed tachistoscopically to the right and left visual half-fields at random. A pinup shot of a nude is interjected, by surprise, to the left field. When asked to report what he saw, the patient will invariably state either nothing or just a flash of light. Despite the verbal report, the patient will respond emotionally with a grin, a giggle or a blush. When asked why he is giggling, the patient is unable to say. What is noteworthy here is the ability of a single hemisphere to trigger emotional reactions appropriate to the information entering it, yet of which the other hemisphere is totally unaware (Lishman, 1971). If the physical fact of the commissurotomy were not known to the observer, one might conclude the patient was repressing the perception of conflictual material.

In commenting on the results of the split brain research, Sperry (1966) notes that such patients are left with two separate minds, or two separate spheres of consciousness. The mental activities of one hemisphere lie entirely outside the realm of awareness of the other hemisphere. Bogen (1969b) suggests that duality is also present in the intact, normal brain so that commissurotomy only serves to make the already present duality evident.

The psychodynamic approach to duality began with Freud's early topographic model of the mind (Galin, 1977). In this early formulation, repressed mental contents functioned in a separate realm that was inaccessible to conscious recall or verbal interrogation. This realm functioned according to its own rules and pursued its own goals. Based on commissurotomy research, the analogous structures for the "unconscious" would be the right cerebral hemisphere with its contents inaccessible to conscious (i.e., verbal) recall.

Later psychodynamic models based the division of the mind on differences in the formal organization of thought and the control of emotional energy, with the focus on primary versus secondary thought processes (Galin, 1977). Horowitz (1972) provides a model for the defenses based on the interactions between different modes of thought representation. There are two different forms of thought (image and lexical or verbal) and two different ways in which thought is organized (primary process and secondary process). The two different forms of thought conform to the cerebral lateralization of cognitive mode (right hemisphere for images, left hemisphere for verbal). Horowitz notes that images are suited to express the immediate quality and intensity of complicated affective states which are hard to articulate and that censorship operates less well over images than over lexical thought. Freud and others actually used images to skirt defensive procedures and gain access to repressed mental contents by asking patients to think in images rather than in words. If the right hemisphere is the locus of repressed mental contents it would follow that entry to this material could best be gained through right hemisphere cognitive forms.

The two types of thought organization (primary and secondary process) distinguish the organization of thought in the two hemispheres (primary for the right hemisphere, secondary for the left hemisphere). The characteristics of secondary process--analytical, propositional, sequential--are attributed to left hemisphere cognition (Bogen, 1969b). Certain aspects of right hemisphere functioning are congruent with primary process thinking (Galin, 1977): (a) The right hemisphere primarily uses a nonverbal mode of representation, including visual, tactile, auditory and kinesthetic images (Morgan, McDonald, & McDonald, 1971; Moscovitch, 1976). (b) The right hemisphere reasons by nonlinear mode of association rather than syllogistic logic. It is superior to the left hemisphere in part/whole relations, grasping the concept of the whole or gestalt from a part (Nebes, 1974; Zangwill, 1974). (c) The right hemisphere is less involved with the perception of time and sequence than is the left (Zangwill, 1974). (d) While the right hemisphere possesses words, these are not used in propositional speech. Right hemisphere speech reflects complexes taken as a whole rather than serially considered parts. Examples would be puns, double-entendres, metaphors, rebus (word pictures), the sort of language that appears in dreams and slips of the tongue (Bogen, 1969b). The right hemisphere has the advantage for emotional tone (Schwartz et al., 1975) and contextual inference (Dwyer, 1976) while the left hemisphere has the advantage for the content of messages. (e) The right hemisphere produces more archaic (unconscious, affective, intuitive) associations to words than does the left hemisphere (Adair, 1976).

Galin (1977) proposes that in normal, intact individuals the neural events of the right hemisphere can become disconnected functionally from the left hemisphere and can continue a life of their own. To the extent that unconscious processes are subserved by the right hemisphere, it can be expected that expression of unconscious material will be through output channels not preempted by the left hemisphere. While the left hemisphere has preemptive control over the mainstream of body activity and propositional speech, two vehicles for expression left open to the right hemisphere are dreams and somatosensory representations. The mode of cognition in dreaming is primary process, that is, it is nonverbal, uses image representations and nonsyllogistic logic, and violates normal temporal sequencing. Galin (1974) reviews reports regarding the dreams of brain-injured patients. Some patients with posterior brain injuries that resulted in left homonymous hemianopsia (indicating injury to the right visual pathways) have spontaneously reported cessation of dreaming. These patients also have impaired visual imagery in the waking state. Several split-brain patients also reported they no longer had dreams. One interpretation of the latter finding is that the right hemisphere may still have been experiencing dreams, but the reporting left hemisphere no longer had access to the right hemisphere's experiences. To illustrate how unconscious right hemisphere processes may be expressed somatically, Galin (1977) notes a greater incidence of conversion symptoms on the left side of the body. Ferenczi (1926) was first to observe that unilateral hysterical conversion symptoms (in this case hemianesthesia) are more common on the left side. Engel (1970) also observed conversion hemisensory disturbance to be more frequent on the left side. To substantiate the observations of Ferenczi and Engel, Galin, Diamond and Braff (1977) undertook an examination of the hospital records of patients with lateralized conversion symptoms at the University of California, San Francisco Hospitals from 1963 through 1974. Of the 52 patients meeting criteria for inclusion in the study, a significantly greater percentage (63%) had unilateral symptoms on the left. When only females were included in the analysis, 71% showed left-sided symptoms. Kenyon (1964) studied a hospital patient population with hypochondriacal symptoms. Of those patients with hypochondriasis as the primary diagnosis and who had unilateral symptoms, 65% were referred to the left side of the body. Where hypochondriasis was a secondary diagnosis, 80.7% of patients with unilateral complaints had them on the left side.

In an early study Halliday (1937) looked at unilateral symptoms in psychosomatic disorders. He found that 13 of 14 rheumatoid patients with neck and arm pain experienced these symptoms on the left. R. E. Gur (1973) found that individuals who make more left lateral eye movements (presumably activating the right hemisphere) are more likely to report psychosomatic symptoms than are right movers. The relationship between repressed mental contents of the right hemisphere and psychosomatic symptoms is complicated by findings reported by Reyher and his associates (Perkins & Reyher, 1971; Reyher & Basch, 1970; Sommerschild & Reyher, 1973) who report a negative correlation between frequency of physical symptoms and the degree of repression.

Paradoxes in the literature on the relationship between psychosomatic symptoms and repression may stem from two sources. The Repression-Sensitization Scale (Byrne, 1963), which is used widely to operationalize the concept of repression, correlates highly with standard measures of anxiety (Weinberger, Schwartz, & Davidson, 1979). As a result a low score on this measure of repression may either be a function of excessive denial and repression of conflict or may be due to lack of anxiety without significant defensiveness (Orlofsky, 1976). Since an additional measure of defensiveness, such as the Social

Desirability Scale (Crowne & Marlowe, 1960) was not used in the investigations of the relationship between psychosomatic symptoms and repression, these studies may have contaminated their repressor group with low anxious, non-repressing individuals. In addition, Weinberger et al. (1979) point out that repressors are not cognizant of their own physiological symptoms of anxiety. Similarly they may ignore or repress the recognition of the symptoms of physical illness. Thus, self-report measures of physical illness may not reflect a repressor's actual physical status. The use of self-report without independent verification of illness in some of the studies cited would be another source of error.

Research in hemispheric differences in affective reactions and coping strategies suggests a more direct relationship between right hemisphere functioning and repression. As indicated earlier in this paper, anosognosia (the condition in which a patient with gross neurological deficit, such as hemiphegia or hemianopsia, is unaware of his disability, shows an attitude of indifference or denies it) is much more common following right hemisphere lesions (Gainotti, 1969, 1972, 1976; Heilman, Scholes, & Watson, 1975). This denial of dysfunction is analogous to the denial of unpleasant thoughts seen in the hysteric.

Bear and Fedio (1977), in a study of temporal lobe epileptics, found that right temporal lobe epileptics rated themselves more highly on socially desirable traits than observers rated them. The euphoria experienced with right carotid amytal injection (Gainotti, 1972) implies a denial of the significance of the patient's circumstances (impending neurosurgery). Both findings can be interpreted as a denial or minimization of the negative and parallel the defensive strategy of the hysterical patient. If the emotional responses of individuals with right hemisphere dysfunction can be taken to reflect an exaggeration of the normal emotional functioning specific to the right hemisphere (an extrapolation from the 1968 study of Hall et al.), the extreme denial observed in patients with right hemisphere dysfunction may suggest that denial and repression as defensive strategies may be mediated by the right cerebral hemisphere. Support for this interpretation comes from an investigation of normal subjects by Gerdes and Kinsbourne (1974). In this study left movers (individuals showing greater activation of the right hemisphere) were found to underestimate their level of anxiety.

Other investigators have looked directly at the relationship of hemispheric lateralization to defense preference. R. E. Gur and R. C. Gur (1975) found that left movers scored higher on a defense mechanism cluster that included repression and denial, whereas right movers scored higher on the defense cluster of projection and turning against others. Woods (1977) compared left and right lookers on the Repression-Sensitization Scale and found they did not differ significantly. However, there was a non-significant tendency for female left lookers to score in the repressive direction on the scale. There was a non-significant tendency for left looking males to score in the sensitizing direction, which was the opposite of expectation. Sterne (1977) predicted that individuals with a greater degree of lateralization (left hemisphere performance superiority on a visual discrimination task) would use more discreet defenses, that is, defenses that would require a more detailed perceptual style such as projection and isolation. Persons with a lesser degree of lateralization (those not showing a left hemisphere performance superiority) were expected to use defenses which require perception that is capable of assimilating parts into a gestalt such as denial or repression. These hypotheses regarding the relationship between lateralization and defense mechanism utilization were not supported. Another study that does provide support for the relationship between right hemisphere function and repression is Smokler and Shevrin's (1979) evaluation of eye movement prediliction for different personality styles. They found there was significantly more left-looking among hysterical subjects, who use repression and denial as primary defenses.

Neuropsychological research suggests the possibility of mental duality and the possibility that the right hemisphere is the locus for repressed mental contents. Galin (1977) offers a theory as to how this duality may develop and a possible mechanism for repression. Developmental neuroanatomy provides a clue as to how duality might develop. The cerebral commissures are not myelinated at birth. Myelinization does not begin until age four months and is not completed for at least four years. If the function of the commissures is reduced in at least the first two years of life this would provide the condition for the two cerebral hemispheres to organize themselves as separate, autonomous (dual) entities. As the commissures mature, communication between the hemispheres becomes possible. However, the hemispheres may still retain their ability to function autonomously.

According to Galin (1977), there are two different ways in which the hemispheres could function as though disconnected in normals, i.e., two possible mechanisms for repression. Because the two hemispheres have specialized areas of competence, different forms for thought representation and different ways in which thought is organized, the knowledge that one hemisphere possesses may not translate well into the language of the other. Galin provides two illustrative examples: (a) aspects of the experience of attending a symphony concert are not readily expressed in words and (b) the concept that "democracy requires informed participation" is hard to convey in images. What may be translated is only the conclusion and not the details on which the evaluation was based. Bogen (1969a) provides an example of how this difficulty in translation can be seen in a patient population. Following cerebral commissurotomy, the right hander has a period of apraxia in the left hand and is unable to follow a verbal instruction with the left hand, such as, "stick out your left little finger". Bogen suggests that this apraxia may be based on the inability of the right hemisphere to translate verbal comprehension into action. Gazzaniga (1972) suggests that early childhood experiences may be inaccessible because they occur before the development of a language system and, therefore, are incapable of translation into or retrieval by that system. Galin (1977) hypothesizes another mechanism for disconnection--the active inhibition of neuronal transmission across the corpus callosum and other cerebral commissures. J. E. Bogen and G. M. Bogen (1969) also hypothesize inhibitory activity in the callosal fibers that may prevent access to the left hemisphere of the products of right hemisphere activity. Research on the neuroanatomy and neuropsychological functioning of schizophrenics is relevant here. Rosenthal and Bigelow (1972) report that the corpus callosum of schizophrenics has been found to be abnormally thick on autopsy. This finding, in isolation, would not support the notion of difficulty in transmission across the corpus collosum. However, Beaumont and Dimond (1973) have found that schizophrenics have particular difficulty in inter- as opposed to intrahemisphere cognitive transfer when compared to normals. Other investigators (Dimond, Scammel, Pryce, Huws, & Gray, 1979) have found that schizophrenics exhibit left hand anomia (i.e., difficulty in correctly naming objects placed in the left hand out of vision). This would support the idea that, at least in some individuals, the left hemisphere has difficulty gaining access to right hemisphere data.

Based on the problems in translation between hemispheres and on certain other features of right hemisphere and left hemisphere processing, a neuropsychological model for at least some instances of repression can be proposed that does not require the condition of active inhibition at the commissures. According to the model proposed in this paper, the right hemisphere has a lower threshold for the perception of visual stimuli, contextual cues, inferences, emotional tone, etc. If these aspects of a stimulus (when perceived subliminally by the right hemisphere) arouse internal conflict, anxiety ensues. This anxiety renders the left hemisphere dysfunctional so that perception and processing proceed along right hemisphere lines. The material is organized through right hemisphere modes and stored in right hemisphere forms which are not readily translatable into left hemisphere terms. As a result, the material remains "repressed" unless accessed through right hemisphere modes and forms (dreams, free associations, etc.). Another implication is that since the material is not available to the scrutiny of left hemisphere logic and analysis, reality testing would be impaired. This provides an explanation for how irrational beliefs develop and why they are so resistant to change by rational analysis.

Before proceeding with a testable hypothesis based on this model, additional research evidence may be reviewed which is relevant to this formulation. Goodglass, in a personal communication to Dimond and Beaumont (1974), reported a lower threshold for visual stimuli presented to the right hemisphere. One would also expect a lower threshold by the right hemisphere for verbal tone, inferences, contextual cues, innuendo, etc. A number of researchers have provided evidence that subliminal perception is more likely to occur with individuals who show a greater reliance on right hemisphere over left hemisphere functioning or those who adopt a right hemisphere cognitive style. Murch (1969) found that subjects who used intuitive cognitive strategies showed greater subliminal effects than subjects who used an analytic, premeditated approach. Allison (1963) found subliminal effects when subjects were instructed to think "globally, intuitively and freely" but not when subjects were instructed to think in analytic, logical and organized modes. Gordon (1967) found significant subliminal effects for students in the arts and humanities (who may be more likely to have a right hemisphere cognitive style) but not for science and engineering students. Sackeim, Packer and Gur (1977) found an interactive effect between hemisphericity and cognitive set on subliminal perception. Left movers (right hemisphericity subjects) showed subliminal effects when encouraged to report their perceptions in a holistic fashion. An unpredicted finding was that right movers (left hemisphericity subjects) also showed subliminal effects if encouraged to report their impressions in an organized and logical manner. The latter finding conflicts with previous research in subliminal perception which points to generally greater subliminal effects when a right hemisphere approach is utilized.

If the right hemisphere more readily perceives subliminal effects, this would mean that stimuli could be perceived by the right hemisphere before conscious awareness (by the left hemisphere). If the material perceived subliminally by the right hemisphere is conflictual, anxiety would then be aroused before left hemisphere perception could occur. Some research studies have addressed the effects of anxiety on hemisphere function. Budzynski (1977) has hypothesized that the left hemisphere functions effectively over a narrow mid-range of cortical arousal. He gives the example that when frightened, one "doesn't think straight". He suggests that at arousal levels above and below this narrow mid-range, the right hemisphere takes over. Studies by Tucker and colleagues (Tucker at al., 1978) support this hypothesis. In an initial experiment, Tucker and his associates found that higher state anxiety was associated with greater errors in the right visual half-field (left hemisphere); left visual half-field errors (right hemisphere functioning) were not affected by anxiety. In a second experiment, Tucker at al. found that higher trait anxiety was associated with greater right ear (left hemisphere) attentional bias. Taken together these studies indicate that when significant anxiety is present, the left hemisphere becomes overactive but dysfunctional, whereas right hemisphere function is relatively unimpaired. This would set the stage for repression as outlined in the model. Once conflicts were stimulated and anxiety aroused, left hemisphere processing would be impaired and perception and processing could proceed along right hemisphere lines. Cognition would be organized in terms of primary process and would assume right hemisphere forms (e.g., images).

The difficulty in translating from right hemisphere to left hemisphere forms provides the final, necessary condition for "repression" of mental contents in the unconscious (the right hemisphere). Lishman (1971) in discussing the emotional responses of commissurotomy patients notes that the right hemisphere, working in isolation, can trigger emotional responses to information that is presented only to that hemisphere and of which the left hemisphere is unaware. The existence of a separate, autonomous emotional "life" in the right hemisphere may also occur in normal individuals where the connections between hemispheres are intact but where translation from the language of one hemisphere to that of the other is difficult. Two dichotic listening studies are relevant here (Gordon, 1973; Milner, Taylor, & Sperry, 1968). In both studies different commands were presented to the left and right ears. The left hand carried out the command presented to the left ear (right hemisphere). However, when subjects were questioned immediately after a trial, they were often unable to name or misnamed the actions carried out by the left hand. It would appear that the left hemisphere was occupied with its own task and, as a result, did not attend to the task being carried out by the right hemisphere. Since it was the right hemisphere that was involved in decoding the message presented to the left ear and in formulating the action for the left hand, it can be surmised that the entire process took place in right hemisphere modes and forms, not readily available to left hemisphere translation. The finding by Dimond et al. (1979) of left hand anomia in schizophrenics also suggests that information processed and encoded by the right hemisphere is difficult for the left hemisphere to access. A study by Risse and Gazzaniga (1976) also supports the notion of difficulty in translation between hemispheres. Patients were given left carotid injections of sodium amytal, effectively anesthetizing the left cerebral hemisphere. While the left hemisphere was anesthetized, the patient was presented with a familiar object in the left hand out of view and allowed to palpate it for several seconds. After the drug effects subsided, the patients were unable to name the object but recognized it immediately when presented visually along with other items. These patients readily named objects which had been presented prior to amytal injection so this finding does not indicate a general disturbance in recall. Instead, the results may suggest that the left hemisphere does not have access to right hemisphere memories encoded while the left hemisphere is dysfunctional. If the right hemisphere memories were not available to verbal consciousness, they might remain effectively repressed in the right hemisphere unless accessed through right hemisphere modes.

Of relevance to this model is the body of research on state dependent learning and memory. Several studies which have used drugs to manipulate state have found that free-recall is higher under conditions where input state is congruent with test state. In one study (Bustamente, Jordan, Vila, Gonzalez, & Insua, 1970) learning and test trials were conducted under similar conditions for controls (i.e., subjects participated in both learning and testing trials under a drugged, amphetamine or amobarbital, or non-drugged, placebo, state). Learning and test trials were conducted under different conditions for experimental subjects (e.g., learning trial after amphetamine, test trial after placebo ingestion). The same forgetting curve was found for both drug controls and for placebo controls. However, there was impaired retrieval in the experimental groups. Similar results have been found in studies manipulating state through the use of alcohol (Eich, Weingartner, Stillman, & Gillin, 1975) and marijuana (Goodwin, Powell, Bremer, Hoine, & Stern, 1969). Bartlett and Santrock (1979) suggest that the state dependent memory phenomenon may occur when state is varied by affective condition rather than drugs. To test this hypothesis, they presented five-year-old children with target words in contexts designed to induce happy or sad affect. Memory for the words was later tested under happy or sad conditions and, as expected, free recall was better under conditions where affective learning and affective test states were congruent. It is feasible that state dependent memory effects may be mediated by differential hemisphere functioning occurring under different states. If a drug (or affectively) induced state would either facilitate or impair cerebral hemisphere function differentially, then processing and encoding of information might proceed essentially in the language of a single hemisphere. During retrieval the same state that resulted in one hemisphere's prepotence would have to again be invoked so that the same hemisphere could access the information stored in its language.

The Present Study

According to the neuropsychological model for repression suggested in this paper, the right hemisphere has an advantage for the perception of certain stimuli (visual images, contextual cues, inferences, emotional tone, etc.). If the perception of these aspects of a stimulus arouses anxiety, the left hemisphere becomes dysfunctional and perception and encoding of information proceed along right hemisphere lines. Retrieval is best accomplished through right hemisphere modes because of the difficulty in translating from right to left hemisphere terms.

The issues involved in the various aspects of this model are extremely complex. One of these is the basic assumption that anxiety results in greater left than right hemisphere performance impairment. Previous research (Tucker et al., 1978) would suggest that this is the case. However, Tucker et al. employed specialized techniques to restrict input to a single hemisphere. This has also been the case in studies of hemisphere dissociation or duality in commissurotomy patients (Sperry, 1968). However, in nature when repression occurs information is presented simultaneously to both hemispheres. In the present study, then, information input was provided simultaneously to both cerebral hemispheres. Under these conditions if anxiety could be shown to impair left hemisphere performance significantly more than right hemisphere performance, a basis for repression would be suggested.

In order to assess left versus right performance impairment, subjects were asked to perform tasks that require relatively greater involvement by one or the other hemisphere. They were also asked to perform a task that combined components specific to the functioning of each cerebral hemisphere.

In order to evaluate the effects of anxiety on differential hemispheric functioning, arousal state was manipulated. Ethical considerations mitigated against manipulating state anxiety related to repressed sexual or other conflictual material. As an alternative, state anxiety was varied by way of arousal induced experimentally through task instructions and the use of white noise. Based on the model, this manipulation could be reasonably expected to reveal differences in left versus right hemisphere performance among experimental groups. However, individual differences might interact with level of arousal to affect task performance. Based on the model, individuals who are characteristically anxious could be expected to evidence a cognitive style marked by overactivation but impairment of left hemisphere functioning. For this reason a factorial design was employed, using both trait and state anxiety as independent variables. Other individual difference variables might affect the interaction of trait and state anxiety on performance. Important variables to consider would be differences in sex, direction of eye movements, and tendency to repress. Woods (1977), in a comparison of left and right lookers on the repression-sensitization scale found tendencies for female and male left lookers to differ. Female left lookers scored in the repressive direction and males in the sensitizing direction on the scale. Because of findings such as these it would be important to take sex of subject into account in the present study. The findings of Woods as well as other investigators (R. E. Gur & R. C. Gur, 1975; Smokler & Shevrin, 1979) regarding differences in tendency to repress for left versus right lookers would argue for a consideration of individual differences in eye movement directionality. Individual differences in characteristic defensive style should also be taken into account by way of a measure of repressive tendencies. These factors were not controlled in the experimental design. However, measures were taken of these individual difference variables so that the uncontrolled variance contributed by them to the independent variables could be removed by way of covariate analysis.

In the present study, performance on left hemisphere tasks would be expected to be more adversely affected by anxiety than would performance on right hemisphere tasks. It would be expected that the right hemisphere (global) features of the combined task would prove more salient under conditions of anxiety than would the left hemisphere (analytic) features. The present study was expected to lend further understanding to the relationship between differential hemispheric functioning and repression. If the hypotheses were supported, this would suggest the basic ingredient for neuropsychologically based repression--a suspension of the logic and analysis of the verbal left hemisphere so that cognition might proceed in right hemisphere primary process terms.

# CHAPTER II

# METHOD

## Subjects

subjects were university undergraduates recruited from introductory psychology classes and given course research credits for their participation. Subjects were screened using a trait anxiety questionnaire (Spielberger, 1968). Assignment to high and low trait anxiety groups was based on criteria used in a study by Tucker et al. (1978) in which these groups were distinguished by differential hemispheric activation with the high anxious subjects demonstrating an increased left hemisphere activation. The score cut-offs were 49 for the high trait anxiety group and 40 for the low group (Tucker, Note 6). Of the 60 subjects selected for participation, 22 received high scores on the trait anxiety measure, 33 obtained low scores and 5 scored in the mid-range. Twenty-three subjects were male; 37 were female. All subjects also participated in a separate experiment involving a visual perception task, immediately preceding this study. All experimental subjects were right handed and reported normal vision or normal vision with correction. Audiometric screening was conducted with each subject to assure functional hearing. Using a Beltone audiometer set at 25 decibels, hearing was assessed at frequencies of 250, 500, 1000, 2000, 4000 and 8000 Hz. All subjects demonstrated auditory acuity adequate for the experimental tasks.

## Experimental Tasks

Experimental tasks were chosen to indicate differential hemispheric function. There are certain limits on inferring exclusive use of one hemisphere on a task. While this would represent the ideal situation, in reality there are more likely contributions by both hemispheres to any one endeavor. However, by selecting tasks for which research data is strongly supportive of differential hemispheric functioning, one can hope to look at the relative contributions of one hemisphere over the other. A visual and an auditory task dependent on relatively greater left hemisphere functioning were employed as well as a visual and an auditory task that rely on relatively greater right cerebral hemisphere functioning. The two left hemisphere tasks were the verb count and digits forward tasks. Tonal memory and Mooney Closure Faces were the right hemisphere tasks that were used. The design discrimination task combined left hemisphere and right hemisphere task features.

Evidence regarding the hemisphere specificity of the verb count task comes from EEG studies of differential hemispheric activation with tasks varying in linguistic difficulty (McKee, Humphrey & McAdam, 1973). The greatest left hemisphere activation was demonstrated on a task requiring subjects to glean, from a reading, all instances of the usage of a particular verb. Left hemisphere specificity for auditory perception of digits has been demonstrated through use of the dichotic listening procedure (Kimura, 1967). Other evidence for the role of the left hemisphere in recall of digits is derived from the study of patients who have undergone left temporal lobectomy (Shankweiler, 1966). Evaluation of these patients has revealed significant reduction in accuracy of reporting digits. Differential hemisphere function in the ability to recall tones has also been demonstrated in the study of lobectomy patients. Milner (1967) found that following right temporal lobectomy there is impairment in the discrimination of tonal patterns, as measured by the Seashore Tonal Memory Test. Performance of the Mooney Closure Faces Test has been demonstrated, through EEG studies (Tucker, 1974, 1976), to rely on right hemisphere functioning. Tucker found greater alpha desynchrony, i.e., greater activation, of the right hemisphere during performance of the Mooney task. The finding was significant for individuals classified on personality measures as more differentiated and for males. The design discrimination task combines distinct analytic and global features. Although hemisphere specificity for the different aspects of this task has not been previously evaluated, research in differential cognitive and perceptual functioning of the hemispheres has demonstrated the left hemisphere adept at tasks requiring analytic analysis, whereas the right hemisphere is superior on tasks dependent on global processing (Springer, 1977).

The verb count task (left hemisphere task) consisted of a practice trial and two experimental trials, each utilizing a paragraph of reading material projected on a screen (see Appendix A). Task instruction included a definition and examples of verbs. Subjects were instructed to count the verbs contained in each paragraph and to give the total when the slide left the screen. Following a practice trial, the correct responses for the practice paragraph were pointed out by the experimenter. Each paragraph was presented for 35 seconds. The error score for each of the two experimental trials was equal to the absolute difference between the subjects' answer and the correct number of verbs contained in a paragraph. Error scores for the two experimental trials were summed to give a single verb count error score for each subject.

The digits forward task (left hemisphere) was modeled after the WISC-R digit span subtest. Subjects were presented with digit sequences of increasing length, beginning with two digits. The subject was asked to repeat each sequence. Two trials were administered for each sequence length, and the task continued until the subject missed both trials of a given series. A score of two was assigned if the subject correctly repeated both trials of a given sequence length; a score of one was assigned if only one of the two trials was repeated correctly, a score of zero if both trials were missed. Scores were summed to provide a single digits forward score for each subject.

The Mooney Closure Faces Test (Mooney, 1956) is a right hemisphere task that uses as task stimuli irregular shapes which at first appear meaningless. When synthesized into an integrated gestalt, each shape becomes a face. The task of the subject is to signal when his perception of the stimulus changes from an amorphous shape to a face. In the present study subjects were given a maximum of 30 seconds for identification. After signaling recognition, subjects were asked to trace the outline of the face, pointing out the features as they did so. One practice trial and eight experimental trials were administered. A score of one was assigned for each correct response; these were summed for the eight experimental trials. A latency to response score, in seconds, was also obtained for each trial with a latency of 30 seconds ascribed to incorrect responses. Latency scores were also summed across the eight trials.

The tonal memory task (right hemisphere) was derived from the Seashore Tonal Memory Test (Saetveit, Lewis, & Seashore, 1940). It was similar to the digits forward task but employed tones rather than numbers. The task consisted of tones combined in sequences of increasing length. For each trial, two sequences of equal length were presented, and subjects were asked to state whether the sequences were the same or different. In order to be classified as the same, the two sequences had to be identical both in tone content and order. Two trials of two sequences each were administered for each length, beginning with two tones and proceeding to six tones. A total of ten trials was given to each subject. Total number of correct responses was tabulated for each subject, each correct response receiving a score of one.

The design discrimination task (combined right and left hemisphere task) was taken from an experiment by Navon (1975, 1977) which sought to test whether global perceptual processing precedes analytic processing of visual stimuli. The task was designed so that accurate perception of a stimulus required that the subject place equal importance on both levels. It also required a critical duration of stimulus exposure that would be too short for good perception at both levels but not so short that all perception would be disrupted. The design discrimination task required subjects to make same/different judgments on pairs of simple geometric patterns presented sequentially. (See Figure 1 for the designs that were used.) A pair of designs could differ either on the analytic or global level.

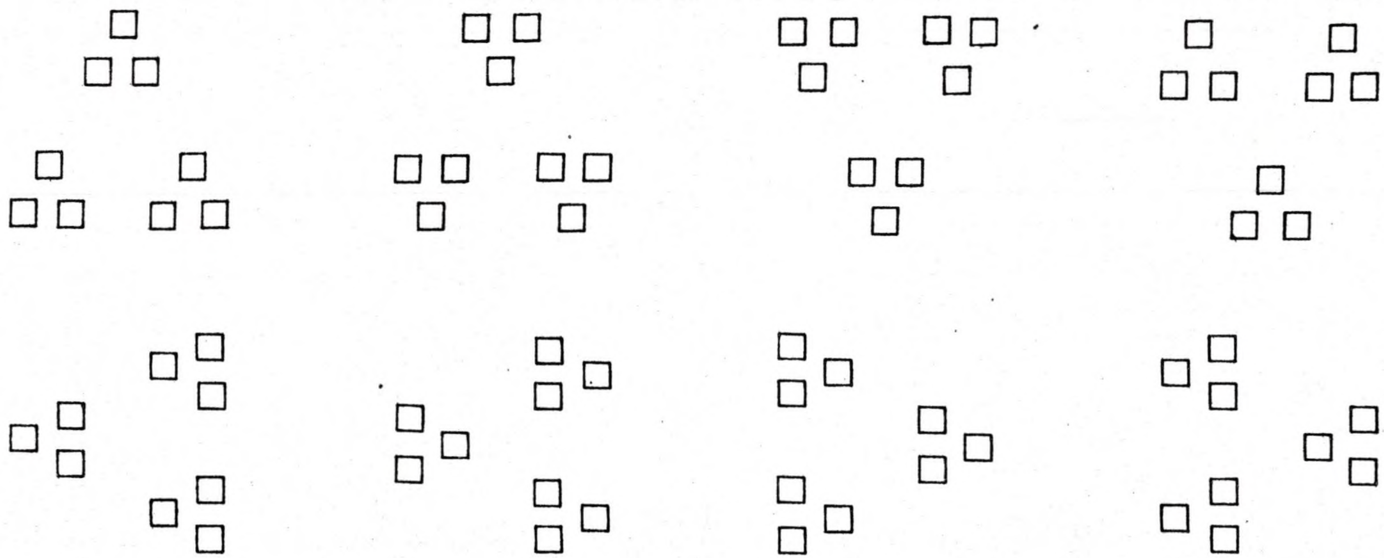

Figure 1. Designs used as test stimuli for the design discrimination task.

Each pattern consisted of nine squares grouped in three clusters of three squares each. Each cluster of three squares was arranged in the form of a triangle with the centers of the squares falling on the vertices of an imaginary isoceles triangle. The triangle could point up, down, or to the right or left. The spatial arrangement of the three clusters with respect to one another followed the same pattern, i.e., the three clusters taken together conformed to the shape of a larger triangle. The imaginary squares circumscribing each of the three clusters were arranged in such a way that their centers fell on the vertices of an imaginary isoceles triangle, three times larger than the triangles formed by the three clusters. Within a given design the arrangement of squares within the clusters was identical across the three clusters. This was called the local or analytic configuration of a design. The larger configuration formed by the three clusters comprised the global configuration.

In essence, then, each pattern resembled a large triangle with each point of the triangle composed of a smaller triangle. Each point of the smaller triangles was composed of a small square. When comparing two designs, the large triangles might differ in their orientation (up, down, right, or left) and the small triangles might also differ in their orientation from design to design. Within a single design, however, all three small triangles were oriented in the same direction. The different combinations of orientation of large triangle and orientation of smaller component triangles yielded a total of 16 possible designs. Eight of these were used in the present study and are depicted in Figure 1.

In order to disrupt retinal after-image, a mask stimulus preceded and followed the target stimulus for approximately 200 msec. The mask consisted of a profusion of squares identical to those in the designs but arranged randomly over the slide. The target stimulus was presented for a predetermined exposure duration. Method for deriving the exposure duration is explained below. The probe stimulus remained on the screen until the subject gave his response.

Subjects were instructed to report if the two designs presented sequentially were the same or different. For the designs to be considered the same, they had to be completely identical, that is, the large triangles had to be oriented in the same direction and the smaller component triangles of one design had to be oriented in the same direction as the smaller component triangles of the second design. There were four blocks of 16 experimental trials each. The two designs presented on a trial were the same 50 percent of the time. When they differed, it was either on the global dimension (25 percent of the time) or the analytic dimension (25 percent of the time) but never on both levels. Figure 2 illustrates sample design comparisons. A score of one was assigned to each correct response given when designs differed on the analytic dimension. These were summed to provide an analytic score for each subject. Similarly, a score of one was assigned to each correct response given when designs differed on the global dimension and were tallied to produce a global score for each subject.

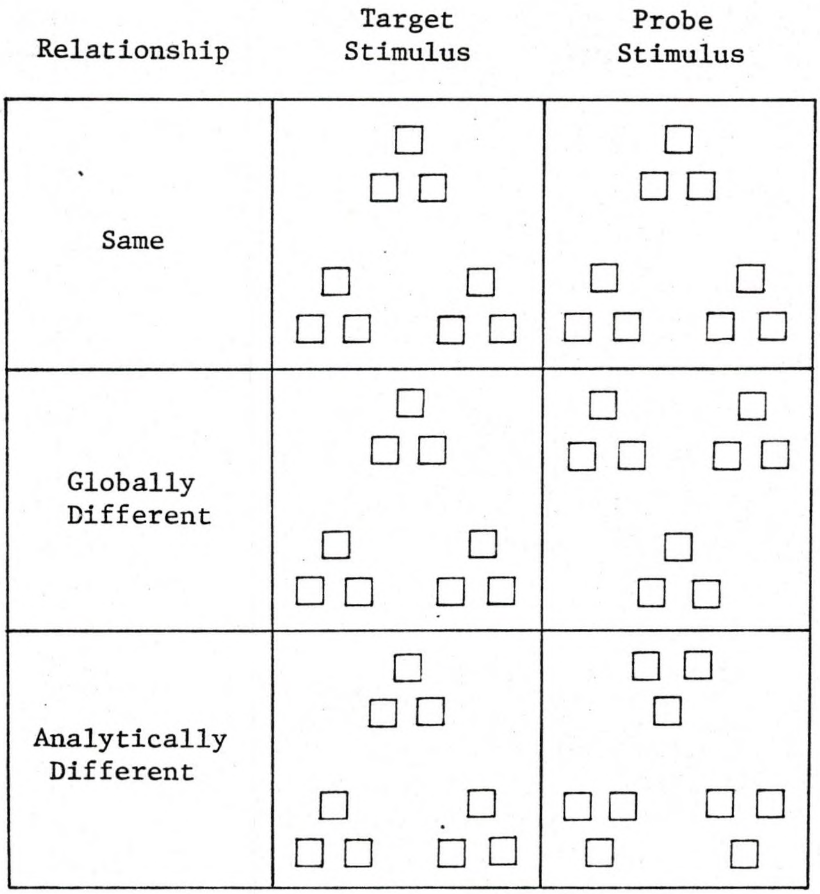


Figure 2. Sample design comparisons.

## Apparatus

Throughout the experimental tasks, the subjects were seated facing a screen, 45 cm. from the face and with central fixation point on the screen approximately at eye level. Visual tasks were back projected on the screen using a carousel slide projector. Tachistoscopic lenses were employed in conjunction with slide projectors for the mask and target stimuli of the design discrimination task. A portable Centrex cassette tape recorder was centered behind the subject for use with the two auditory tasks. A Panasonic cassette recorder, also centered behind the subject, was used for a white noise tape. A white noise generator produced the noise tape. Intensity was monitored using a B and K sound level meter, Type 1613. Intensity level of the white noise tape averaged 75 dBSPL. Intensity of the auditory task stimuli tapes (digits and tones) averaged 85 dBSPL. The ten decibel difference between white noise level and auditory task stimuli was maintained to assure that the white noise did not hamper auditory perception of the task stimuli.

## Design and Procedure

The experimental design was a 2 x 2 factorial with arousal condition and trait anxiety as the two independent variables and performance on the various experimental tasks as the dependent variable. To determine if anxiety and arousal were more disruptive to performance of the left hemisphere tasks taken as a whole than to performance of the right hemisphere tasks, a 2 x 2 x 2 repeated measures design was employed with the within subjects comparison as the third factor. For this analysis, scores on the two left hemisphere tasks were combined, as were scores on the two right hemisphere tasks. The repeated measures design was also used in evaluating differential performance on the analytic versus global aspects of the design discrimination task. An arousal manipulation (see below) was performed to assess group differences in hemispheric functioning under high and low arousal conditions. Trait anxiety, tendency to repress and eye movement directionality were measured to investigate the influence of individual difference variables on differential hemispheric function under varying states of arousal.

Experimental subjects were run individually. Following a brief explanation regarding the nature of the study, preliminary testing was accomplished. This included the audiometric screen, eye movement evaluation, Marlowe-Crowne Social Desirability Scale, Byrne Repression-Sensitization Scale, and the stimulus exposure duration determination for the design discrimination task.

Eye movement directionality was determined using questions from Schwartz, Davidson, and Maer (1975). Experimenter and subject sat facing one another while questions were read to the subject. Deviation to the left, right, up or down from central fixation was recorded for the first shift in gaze following a question. Non-deviations, i.e., stares, were also recorded.

The Controlled Repression-Sensitization Scale (Handal, 1973) is a 30 item version of the Revised Repression-Sensitization Scale (Byrne, 1963) that controls, to some degree, for social desirability and acquiescence bias. The repression end of the scale (low scores) probably identifies not only true repressors but also healthy, non-repressing individuals who do not experience much anxiety. Orlofsky (1976) has suggested that these two types of low scorers may be distinguished on the basis of their social desirability scores. True repressors would be expected to score high and non-defensive, non-anxious subjects to score low in social desirability. Orlofsky suggests an additional correction to the Repression-Sensitization Scale to weed out the non-defensive non-anxious from low scorers. This correction was used in the present study and consists of subtracting from the repression score the social desirability score when the repression-sensitization score is below the mean. The social desirability score is added to the repression-sensitization score when the latter is above the mean.

Critical stimulus exposure duration for the design discrimination task was determined individually for each subject during the pretesting. The procedure was identical to the experimental task except that each block of 16 pretesting trials was presented using a different exposure time. The critical exposure duration used for the experimental trials was that exposure duration at which the subject correctly responded 70 to 80 percent of the time during pretesting. This critical exposure duration ranged from 40 to 240 msec. Directions for the design discrimination task given at the time of the exposure duration determination included explicit instructions regarding the nature of the task and the experimental stimuli. Illustrations depicting sample pair comparisons were included. Subjects were questioned regarding these examples and additional explanations were provided as needed to assure complete understanding of the task. The subjects were instructed to focus on the fixation point at center screen at all times except when a blank slide was projected. The blanks provided the opportunity for brief breaks in which the subject could gaze away from the screen, thereby minimizing fatigue. Later, for the experimental task proper, the essential features of the task instructions were repeated.

Following preliminary testing, the arousal manipulation was introduced. Instructions to subjects under the two arousal conditions were as follows:

> Low Arousal Condition. Now we will do some additional visual and auditory perception tasks. The main goal is for you to enjoy the tasks, so relax and take it easy. I do want you to pay attention and do the tasks, but don't be so concerned about how you do.
> High Arousal Condition. Now we will do some additional visual and auditory perception tasks. You have been chosen to be in the high stress condition. You will be anxious throughout these tasks, and you will be quite uptight. However, you should work hard to do your very best because this is extremely important.

Following these instructions, subjects in the high arousal condition were given the option of foregoing participation in the remainder of the experiment. For high arousal subjects a white noise tape was played at 75 decibels throughout the five experimental tasks and during completion of state anxiety questionnaires. The tape was not played during task instructions. The white noise tape was omitted in the low arousal condition. Support for the relationship between white noise and increased arousal is derived from the following research findings (Berlyne, Borsa, Hamacher & Koenig, 1966): (a) continuous white noise causes skin resistance to drop significantly over a period of 15-20 minutes in conditions that would otherwise leave skin resistance unchanged; (b) auditory sounds increase muscle tension; (c) there is neurophysiological evidence that all exteroceptive stimulation (which would include white noise) activates the reticular arousal system.

Following the arousal manipulation, subjects completed the five experimental tasks, presented in the same order for all subjects: verb count, Mooney Closure Faces, digits forward, tonal memory and design discrimination task. State anxiety questionnaires (Spielberger, 1968) were completed following the Mooney Closure Faces and the design discrimination task to evaluate the success of the arousal manipulation. Feedback was given regarding the purpose of the experiment, and subjects were afforded the opportunity to ask questions.

## RESULTS

### Effectiveness of Experimental Manipulation

The arousal manipulation was successful. Arousal condition significantly affected scores on the first state anxiety measure taken, $F(1, 58) = 12.17$, $p = 0.0009$; the second state anxiety measure, $F(1, 58) = 5.27$, $p = 0.03$; and the mean of the two state anxiety measures, $F(1, 58) = 10.12$, $p = 0.002$. Mean state anxiety scores under conditions of low and high arousal were as follows: first state anxiety measure 38.24 ($n = 29$), 47.10 ($n = 31$), respectively; second state anxiety measure 40.28 ($n = 29$), 46.55 ($n = 31$); mean of two measures 39.26 ($n = 29$), 46.82 ($n = 31$). In each case increased state anxiety occurred under the high arousal condition.

### Survey of Mean Performance Scores

Table 1 presents the means and standard deviations for the dependent measures under conditions of high and low trait anxiety and high and low state anxiety. For state anxiety, the anxiety measure closest temporally to the arousal manipulation was used. A perusal of the means for each dependent measure under conditions of low trait anxiety/ low state anxiety versus high trait anxiety/high state anxiety demonstrates that for three of the four hemisphere-specific tasks (digits forward, Mooney Closure Faces, and tonal memory) there was a decline in

Table 1

Means for Dependent Variables at Different Levels of Trait and State Anxiety (First Measure)

| Dependent Measure | Trait Anxiety | State Anxiety Low n | Low M | Low SD | High n | High M | High SD | Total n | Total M | Total SD |
|---|---|---|---|---|---|---|---|---|---|---|
| Verb Count- Errors | Low | 22 | 6.95 | 2.50 | 12 | 6.67 | 2.87 | 34 | 6.85 | 2.60 |
| | High | 12 | 7.42 | 3.60 | 14 | 6.36 | 3.48 | 26 | 6.85 | 3.51 |
| | Total | 34 | 7.12 | 2.89 | 26 | 6.50 | 3.15 | 60 | 6.85 | 3.00 |
| Digits Forward | Low | 22 | 10.68 | 1.52 | 12 | 10.17 | 1.64 | 34 | 10.50 | 1.56 |
| | High | 12 | 10.33 | 1.72 | 14 | 10.07 | 1.73 | 26 | 10.19 | 1.70 |
| | Total | 34 | 10.56 | 1.58 | 26 | 10.12 | 1.66 | 60 | 10.37 | 1.62 |
| Mooney Faces- Correct | Low | 22 | 4.14 | 1.49 | 12 | 4.42 | 0.67 | 34 | 4.24 | 1.26 |
| | High | 12 | 4.08 | 1.16 | 14 | 3.29 | 1.82 | 26 | 3.65 | 1.57 |
| | Total | 34 | 4.12 | 1.37 | 26 | 3.81 | 1.50 | 60 | 3.98 | 1.42 |
| Mooney Faces- Latency | Low | 22 | 129.82 | 36.82 | 12 | 115.42 | 17.66 | 34 | 124.74 | 31.87 |
| | High | 12 | 131.75 | 30.70 | 14 | 153.21 | 47.02 | 26 | 143.31 | 41.03 |
| | Total | 34 | 130.50 | 34.32 | 26 | 135.77 | 40.70 | 60 | 132.78 | 36.98 |
| Tonal Memory | Low | 22 | 7.91 | 1.44 | 12 | 8.17 | 1.03 | 34 | 8.00 | 1.30 |
| | High | 12 | 8.00 | 1.13 | 14 | 7.14 | 1.61 | 26 | 7.54 | 1.45 |
| | Total | 34 | 7.94 | 1.32 | 26 | 7.62 | 1.44 | 60 | 7.80 | 1.38 |
| Left Hemisphere Tasks Averaged For Each Subject | Low | 22 | 0.08 | 0.59 | 12 | - 0.03 | 0.58 | 34 | 0.04 | 0.58 |
| | High | 12 | - 0.10 | 0.76 | 14 | - 0.01 | 0.72 | 26 | - 0.05 | 0.73 |
| | Total | 34 | 0.01 | 0.65 | 26 | - 0.02 | 0.65 | 60 | 0.00 | 0.64 |

Table 1--Continued

| Dependent Measure | Trait Anxiety | State Anxiety Low n | M | SD | High n | M | SD | Total n | M | SD |
|---|---|---|---|---|---|---|---|---|---|---|
| Right Hemisphere | Low | 22 | 0.09 | 0.81 | 12 | 0.35 | 0.35 | 34 | 0.18 | 0.69 |
| Tasks Averaged | High | 12 | 0.08 | 0.74 | 14 | - 0.51 | 0.86 | 26 | - 0.24 | 0.85 |
| For Each Subject | Total | 34 | 0.09 | 0.77 | 26 | - 0.11 | 0.79 | 60 | 0.00 | 0.78 |
| Design Discrim- | Low | 22 | 10.55 | 2.60 | 12 | 11.67 | 2.71 | 34 | 10.94 | 2.65 |
| ination Task- | High | 12 | 11.83 | 4.45 | 14 | 11.57 | 2.56 | 26 | 11.69 | 3.48 |
| Analytic Aspect | Total | 34 | 11.00 | 3.36 | 26 | 11.62 | 2.58 | 60 | 11.27 | 3.04 |
| Design Discrim- | Low | 22 | 12.32 | 2.01 | 12 | 12.83 | 2.33 | 34 | 12.50 | 2.11 |
| ination Task- | High | 12 | 12.33 | 2.46 | 14 | 11.93 | 3.38 | 26 | 12.12 | 2.94 |
| Global Aspect | Total | 34 | 12.32 | 2.14 | 26 | 12.35 | 2.92 | 60 | 12.33 | 2.49 |

performance with increased anxiety. On the fourth hemisphere specific task, verb count, performance improved with increased anxiety (i.e., error scores were reduced).

The sixth dependent measure presented in Table 1 is the average score on left hemisphere tasks (verb count and digits forward) for each subject. To arrive at the measure of left hemisphere performance, for each subject scores for the individual tasks were converted to *Z* scores. A negative transformation was then performed on the verb count error *Z* scores in order that the direction of scores would be the same for this task as for digits forward. This transformed verb count *Z* score and the digits forward *Z* score were then averaged to provide a single combined score for each subject. Right hemisphere task scores (Mooney Closure Faces score for number correct, Mooney Closure Faces latency score, and tonal memory score) were also averaged in similar fashion to provide a single right hemisphere task score for each subject. After the three scores were converted to *Z* scores, a negative transformation was performed on the latency score; then the three scores were averaged to create a single composite score for each subject. All analyses that refer to averaged left hemisphere and/or averaged right hemisphere tasks used these score averages.

Inspection of Table 1 indicates that for the averaged left hemisphere tasks score there was also a decline with increased anxiety. The same held true for the averaged right hemisphere tasks score.

A study of the means for design discrimination, the task that contains both left hemisphere and right hemisphere features, reveals for the global aspect of the task a decrease in performance scores with increased anxiety and for the analytic aspect an increase in performance scores with increased anxiety.

Overview of Statistical Analyses

In general, comparisons of the effects of trait and state anxiety on performance measures showed anxiety to significantly impair performance on right rather than left hemisphere tasks. Anxiety was found to significantly enhance performance on the analytic (left hemisphere) component of the design discrimination task.

Before looking at specific results, an overview of the sequence followed in conducting statistical analyses will be provided. Separate analyses of variance were performed for each dependent measure as well as for the averaged left hemisphere tasks and for the averaged right hemisphere tasks (see Table 2). Trait anxiety and state anxiety were the two between subjects factors in these analyses. Next, a repeated measures analysis of variance was performed with each subject's average score on left hemisphere tasks versus his average score for right hemisphere tasks as the within subjects variable (see Table 3). A repeated measure analysis of variance was also performed for the design discrimination task with analytic versus global aspect of the task as the within subjects variable (see Table 4).

All of the analyses described thus far were performed using trait anxiety and the first state anxiety measure as the two continuous independent variables. It was reasoned that the first state anxiety measure (closest temporally to the arousal manipulation) should be most reflective of the arousal manipulation. Each subject had three state

Table 2

Summary of Analyses of Variance for Dependent Measures

| Dependent Variable | Source | df | MS | F | p = |
|---|---|---|---|---|---|
| Verb Count-Errors | Trait Anxiety (T) | 1 | 5.14 | 0.55 | n.s. |
| | State Anxiety-First Measure (S1) | 1 | 3.02 | 0.32 | n.s. |
| | T X S1 | 1 | 5.12 | 0.55 | n.s. |
| | Error | 56 | 9.31 | | |
| Digits Forward | T | 1 | 0.28 | 0.11 | n.s. |
| | S1 | 1 | 0.33 | 0.12 | n.s. |
| | T X S1 | 1 | 0.03 | 0.01 | n.s. |
| | Error | 56 | 2.63 | | |
| Mooney Faces-Correct | T | 1 | 6.32 | 3.49 | n.s. |
| | S1 | 1 | 7.78 | 4.30 | 0.04 |
| | T X S1 | 1 | 9.92 | 5.48 | 0.02 |
| | Error | 56 | 1.81 | | |
| Mooney Faces-Correct | T | 1 | 10.16 | 5.27 | 0.03 |
| | Arousal Condition (A) | 1 | 4.03 | 2.09 | n.s. |
| | T X A | 1 | 4.15 | 2.15 | n.s. |
| | Error | 56 | 1.93 | | |
| Mooney Faces-Latency | T | 1 | 6084.94 | 5.15 | 0.03 |
| | S1 | 1 | 8331.33 | 7.06 | 0.01 |
| | T X S1 | 1 | 9424.69 | 7.98 | 0.01 |
| | Error | 56 | 1180.47 | | |
| Tonal Memory | T | 1 | 6.10 | 3.32 | n.s. |
| | S1 | 1 | 4.80 | 2.61 | n.s. |
| | T X S1 | 1 | 6.79 | 3.70 | n.s. |
| | Error | 56 | 1.84 | | |

Table 2--Continued

| Dependent Variable | Source | *df* | *MS* | *F* | *p* = |
|---|---|---|---|---|---|
| Left Hemisphere Tasks | T | 1 | 0.29 | 0.69 | n.s. |
| | S1 | 1 | 0.22 | 0.51 | n.s. |
| | T X S1 | 1 | 0.19 | 0.44 | n.s. |
| | Error | 56 | 0.43 | | |
| Right Hemisphere Tasks Averaged for Each Subject | T | 1 | 3.58 | 7.03 | 0.001 |
| | S1 | 1 | 4.03 | 7.93 | 0.01 |
| | T X S1 | 1 | 5.04 | 9.91 | 0.003 |
| | Error | 56 | 0.51 | | |
| Design Discrimination Task-Analytic Aspect | T | 1 | 35.78 | 4.05 | n.s. |
| | S1 | 1 | 29.96 | 3.28 | n.s. |
| | T X S1 | 1 | 27.02 | 3.06 | n.s. |
| | Error | 56 | 8.83 | | |
| Design Discrimination Task-Analytic Aspect | T | 1 | 37.43 | 4.23 | 0.04 |
| | State Anxiety-Mean of 2 Measures (MS) | 1 | 24.17 | 2.73 | n.s. |
| | T X MS | 1 | 27.66 | 3.13 | n.s. |
| | Error | 56 | 8.84 | | |
| Design Discrimination Task-Global Aspect | T | 1 | 1.90 | 0.31 | n.s. |
| | S1 | 1 | 0.16 | 0.03 | n.s. |
| | T X S1 | 1 | 0.24 | 0.04 | n.s. |
| | Error | 56 | 6.19 | | |

Table 3

Summary of Repeated Measures Analyses of Variance for Averaged Left Hemisphere Versus Averaged Right Hemisphere Tasks

| Source | df | MS | F | p = |
|---|---|---|---|---|
| A. ANOVA Using State Anxiety as Factor | | | | |
| Between Subjects | | | | |
| Trait Anxiety (T) | 1 | 0.91 | 1.87 | n.s. |
| State Anxiety-First Measure (S1) | 1 | 1.19 | 2.44 | n.s. |
| T X S1 | 1 | 1.64 | 3.37 | n.s. |
| Error | 116 | 0.49 | | |
| Within Subjects | | | | |
| Hemisphericity of Averaged Tasks Within Subject (LR) | 1 | 2.58 | 5.01 | 0.03 |
| T X LR | 1 | 2.96 | 5.76 | 0.02 |
| S1 X LR | 1 | 3.06 | 5.95 | 0.02 |
| T X S1 X LR | 1 | 3.59 | 6.98 | 0.01 |
| Error | 56 | 0.51 | | |
| B. ANOVA Using Arousal Condition as Factor | | | | |
| Between Subjects | | | | |
| T | 1 | 2.34 | 4.70 | 0.03 |
| Arousal Condition (A) | 1 | 0.37 | 0.75 | n.s. |
| T X A | 1 | 0.26 | 0.52 | n.s. |
| Error | 116 | 0.50 | | |
| Within Subjects | | | | |
| LR | 1 | 0.91 | 1.66 | n.s. |
| T X LR | 1 | 0.92 | 1.67 | n.s. |
| A X LR | 1 | 1.09 | 1.98 | n.s. |
| T X A X LR | 1 | 1.42 | 2.58 | n.s. |
| Error | 56 | 0.55 | | |

Table 4

Summary of Repeated Measures Analyses of Variance for Analytic Versus Global Aspect of the Design Discrimination

| Source | df | MS | F | p = |
|---|---|---|---|---|
| A. ANOVA Using State Anxiety as Factor | | | | |
| Between Subjects | | | | |
| Trait Anxiety (T) | 1 | 8.30 | 1.03 | n.s. |
| State Anxiety-Mean of Two Measures (MS) | 1 | 8.86 | 1.10 | n.s. |
| T X MS | 1 | 7.66 | 0.95 | n.s. |
| Error | 116 | 8.04 | | |
| Within Subjects | | | | |
| Task Component Within Subject (AG) | 1 | 30.41 | 4.57 | 0.04 |
| T X AG | 1 | 33.30 | 5.01 | 0.03 |
| MS X AG | 1 | 15.80 | 2.38 | n.s. |
| T X MS X AG | 1 | 21.81 | 3.28 | n.s. |
| Error | 56 | 6.65 | | |
| B. ANOVA Using Arousal Condition as Factor | | | | |
| Between Subjects | | | | |
| T | 1 | 0.79 | 0.10 | n.s. |
| Arousal Condition (A) | 1 | 29.73 | 3.79 | n.s. |
| T X A | 1 | 24.81 | 3.17 | n.s. |
| Error | 116 | 7.84 | | |
| Within Subjects | | | | |
| AG | 1 | 30.33 | 4.35 | 0.04 |
| T X AG | 1 | 18.98 | 2.72 | n.s. |
| A X AG | 1 | 0.70 | 0.10 | n.s. |
| T X A X AG | 1 | 0.04 | 0.01 | n.s. |
| Error | 56 | 6.98 | | |

anxiety scores as well as a designation for arousal condition. The state anxiety scores were derived from the first measure, taken after the Mooney Closure Faces and closest to the arousal manipulation, the second measure, taken immediately following the final performance task, and the mean of the two measures. Each of the anxiety scores and the arousal condition could feasibly be relevant to changes in task performance. Therefore, although the primary analysis used the first state anxiety measure as a factor, analyses using the second measure, mean of two measures or arousal condition were also taken into account if they added to an understanding of the relationship to task performance. If the combination of one of these factors and trait anxiety resulted in significant effects not demonstrated with trait anxiety and the first state anxiety measure, these additional findings are also presented. For example, for the design discrimination task, an analysis employing trait anxiety and the average of the two state anxiety measures is also presented since it provided significant effects not demonstrated in the analysis using trait anxiety and the first state anxiety measure as independent variables. The second anxiety measure was taken immediately following the design discrimination task and for this reason, may have contributed to significant effects on this dependent measure when averaged with the first state anxiety measure. For a few dependent measures, the use of trait anxiety with arousal condition as independent variables provided additional significant effects. In these cases, these analyses are presented in addition to those employing trait anxiety and the first state anxiety measure. Arousal condition was a dichotomous variable.

Two additional analyses of variance were performed using extreme anxiety groups only. Both trait anxiety and arousal condition were dichotomized for these analyses. One group was characterized by high trait anxiety/high arousal, the other by low trait anxiety/low arousal. One of these extreme group analyses involved a repeated measures comparison with each subject's average score on left hemisphere tasks versus his average score for right hemisphere tasks as the within subjects variable (see Table 5). The other extreme group analysis was a repeated measures comparison with analytic versus global component of the design discrimination task as the within subjects variable (see Table 6). In addition to the analyses of variance that have been described, covariant analyses were conducted to remove the effects on the independent variables of uncontrolled factors, such as sex, repression-sensitization, social desirability, and eye movements. The covariant analyses were performed for each of the dependent measures as well as the averaged left hemisphere tasks score and the averaged right hemisphere tasks score. Where covariant analysis resulted in additional significant effects, these results are presented in the text.

The preceding has been a description of the various analyses that were performed. Next, the covariates will be discussed in relationship to other variables. Then, those statistical analyses resulting in significant effects will be discussed for dependent measures individually.

Table 5

Summary of Repeated Measures Analyses of Variance with Extreme Groups for Averaged Left Hemisphere Versus Averaged Right Hemisphere Tasks

| Source | df | MS | F | p = |
|---|---|---|---|---|
| Between Subjects | | | | |
| Trait Anxiety/Arousal Group- High/High Versus Low/Low (T/A) | 1 | 0.03 | 0.07 | n.s. |
| Error | 26 | 0.41 | | |
| Within Subjects | | | | |
| Hemisphericity of Tasks Within Subject (LR) | 1 | 0.53 | 0.83 | n.s. |
| T/A X LR | 1 | 0.84 | 1.32 | n.s. |
| Error | 26 | 0.63 | | |

Table 6

Summary of Repeated Measures Analyses of Variance with Extreme Groups for Analytic Versus Global Aspect of the Design Discrimination Task

| Source | df | MS | F | p = |
|---|---|---|---|---|
| Between Subjects | | | | |
| Trait Anxiety/Arousal Group High/High Versus Low/Low (T/A) | 1 | 2.26 | 0.35 | n.s. |
| Error | 26 | 6.47 | | |
| Within Subjects | | | | |
| Task Component Within Subject (AG) | 1 | 11.30 | 1.60 | n.s. |
| T/A X AG | 1 | 25.23 | 3.56 | n.s. |
| Error | 26 | | | |

Covariates

The individual difference variables sex, repression-sensitization, social desirability, modified repression-sensitization/social desirability, and eye movements were used as covariates. Correlations between the covariates are presented in Table 7. For all analyses, males were scored as 1, females as 2. The correlations between the covariates and trait anxiety were: sex 0.12, repression-sensitization 0.58 ($p$ = 0.0001), social desirability -0.18, modified repression-sensitization 0.55 ($p$ = 0.0001), left eye movements -0.25, right movements 0.21, upward movements 0.15, downward movements 0.21, stares -0.05. Correlations between the first state anxiety measure and the covariates were: sex 0.04, repression-sensitization 0.16, social desirability 0.007, modified repression-sensitization 0.18, left movements -0.06, right movements 0.04, upward movements 0.22, downward movements 0.001, stares -0.02. Correlations of covariates with the second state anxiety measure were: sex -0.10, repression-sensitization 0.30 ($p$ = 0.02), social desirability 0.03, modified repression-sensitization 0.35 ($p$ = 0.007), left movements -0.28 ($p$ = 0.03), right movements 0.21, upward movements 0.04, downward movements 0.05, stares 0.17. Correlations of covariates with the mean of the two state anxiety measures were: sex -0.03, repression-sensitization 0.25, social desirability 0.02, modified repression-sensitization 0.29 ($p$ = 0.02), left movements -0.19, right movements 0.14, upward movements 0.14, downward movements 0.03, stares 0.08. Correlations of covariates with arousal condition were: sex -0.08, repression-sensitization 0.06, social desirability -0.25,

Table 7

Correlations Between Individual Difference Variables

| | Sex | Repression-Sensitization | Social Desirability | Modified Repression-Sensitization | Left Eye Movements | Right Eye Movements | Upward Eye Movements | Downward Eye Movements | Stares |
|---|---|---|---|---|---|---|---|---|---|
| Sex | | -0.15 | 0.15 | -0.13 | -0.05 | 0.07 | -0.03 | -0.35* | 0.17 |
| Repression-Sensitization | -0.15 | | -0.11 | 0.86* | -0.36* | 0.23 | 0.23 | 0.16 | 0.20 |
| Social Desirability | 0.15 | -0.12 | | -0.05 | 0.08 | -0.03 | -0.01 | 0.05 | -0.13 |
| Modified Repression-Sensitization | -0.13 | 0.86* | -0.05 | | -0.17 | 0.11 | 0.20 | 0.10 | 0.09 |
| Left Eye Movements | -0.05 | -0.36* | 0.08 | -0.17 | | -0.89* | -0.12 | -0.12 | -0.25 |
| Right Eye Movements | 0.07 | 0.23 | -0.03 | 0.11 | -0.89* | | -0.12 | -0.07 | -0.16 |
| Upward Eye Movements | -0.03 | 0.23 | -0.02 | 0.20 | -0.12 | -0.12 | | 0.05 | 0.34* |
| Downward Eye Movements | -0.35* | 0.16 | 0.05 | 0.10 | -0.12 | -0.07 | 0.05 | | -0.05 |
| Stares | 0.17 | 0.20 | -0.13 | 0.09 | -0.25 | -0.16 | 0.34* | -0.05 | |

*$p < .05$

modified repression-sensitization 0.05, left movements -0.12, right movements -0.05, upward movements 0.11, downward movements -0.003, stares 0.14.

Mooney Closure Faces--Number Correct

A review of Table 2 reveals a significant main effect of state anxiety on the number of correct responses to the Mooney Closure Faces. There was also a significant interactive effect of trait anxiety and state anxiety on the number of correct responses on this task. The main effect of trait anxiety approached significance in the analyses using trait anxiety and first state anxiety measure as independent variables and reached significance when arousal condition was used as an independent variable in lieu of state anxiety. With the effect of sex removed, the effect of arousal condition was significant, $F(1, 55) = 4.49$, $p = 0.04$. With the effect of sex removed, the interaction of arousal condition and trait anxiety was also significant, $F(1, 55) = 4.82$, $p = 0.03$, on the number of correct Mooney Closure Faces. Males gave more correct responses ($M = 4.52$, $n = 23$) than did females ($M = 3.65$, $n = 37$) on the Mooney task. Males were scored as 1, females as 2; the correlation between sex and number correct on the Mooney Closure Faces was -0.30, $p = 0.02$. A review of the group means for correct responses on the Mooney task in Table 1 shows a decrease in number of correct responses with increased anxiety. Table 8 gives the mean number of correct responses on the Mooney task at different levels of trait anxiety and under different arousal conditions. These means are in the direction of fewer correct responses with increased anxiety and arousal.

Table 8

Mean Number of Correct Responses on the Mooney Closure Faces at Different Levels of Trait Anxiety and Under Different Arousal Conditions

| | | Arousal Condition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | | | High | | | Total | | |
| Dependent Measure | Trait Anxiety | *n* | *M* | *SD* | *n* | *M* | *SD* | *n* | *M* | *SD* |
| Mooney Faces-Correct | Low | 18 | 4.06 | 1.47 | 16 | 4.44 | 0.96 | 34 | 4.24 | 1.26 |
| | High | 11 | 3.91 | 1.45 | 15 | 3.47 | 1.68 | 26 | 3.65 | 1.57 |
| | Total | 29 | 4.00 | 1.44 | 31 | 3.97 | 1.43 | 60 | 3.98 | 1.42 |

Mooney Closure Faces--Latencies

Analysis of variance of latency scores for the Mooney Closure Faces yielded significant main effects for trait anxiety and for state anxiety, and a significant interaction of trait anxiety and state anxiety (see Table 2). Table 1 mean latencies for Mooney task performance demonstrate an increase in latency (i.e., impaired performance) with increased anxiety.

Averaged Right Hemisphere Tasks

When scores for the two right hemisphere tasks were averaged for each subject, analysis of variance (Table 2) demonstrated significant effects for trait anxiety, state anxiety and the interaction of trait and state anxiety. As indicated in Table 1, mean performance on averaged right hemisphere tasks was negatively affected by anxiety.

Design Discrimination Task--Analytic Aspect

A significant main effect of trait anxiety was demonstrated for the analytic aspect of the design discrimination task when trait anxiety and the mean of the two state anxiety measures were used as independent variables (see Table 2). Table 9 gives the mean number of correct responses on the analytic aspect of the design discrimination task at different levels of trait anxiety and at different levels of the mean of the two state anxiety measures. These means show enhanced performance with increased anxiety. With the effect of repression-sensitization removed, the main effect of state anxiety on the analytic aspect of the

Table 9

Mean Number of Correct Responses on the Analytic Aspect of the Design Discrimination Task at Different Levels of Trait and State Anxiety (Mean of Two Measures)

| | | State Anxiety | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | | | High | | | Total | | |
| Dependent Measure | Trait Anxiety | *n* | *M* | *SD* | *n* | *M* | *SD* | *n* | *M* | *SD* |
| Design Discrimination Task-Analytic Aspect | Low | 22 | 10.59 | 2.86 | 12 | 11.58 | 2.19 | 34 | 10.94 | 2.65 |
| | High | 10 | 12.10 | 4.82 | 16 | 11.44 | 2.48 | 26 | 11.69 | 3.48 |
| | Total | 32 | 11.06 | 3.57 | 28 | 11.50 | 2.32 | 60 | 11.27 | 3.04 |

design discrimination task was significant, $F(1, 55) = 4.26$, $p = 0.04$. Mean responses on the analytic aspect of the design discrimination task were fewer for higher repression-sensitization scores ($M = 10.89$, $n = 27$) than for lower repression-sensitization scores ($M = 11.58$, $n = 33$). The nonsignificant correlation between repression-sensitization scores and performance on the analytic component of the design discrimination task was 0.01.

Tonal Memory

No significant main or interactive effects were obtained for anxiety measures and tonal memory. However, with the effects of repression-sensitization, eye movements to the left, and eye movements to the right removed in separate covariate analyses, the effect of trait anxiety on tonal memory attained the following significance levels respectively: $F(1, 55) = 4.23$, $p = 0.04$, $F(1, 55) = 4.56$, $p = 0.04$, and $F(1, 55) = 4.72$, $p = 0.03$. With the effects of the same covariates removed, the effect on tonal memory performance of the trait anxiety by state anxiety interaction was also found to be significant at these levels: $F(1, 55) = 4.32$, $p = 0.04$ (with effect of repression-sensitization removed), $F(1, 55) = 4.74$, $p = 0.03$ (with effect of eye movements to the left removed), $F(1, 55) = 4.84$, $p = 0.03$ (with effect of eye movements to the right removed). Correlations between these covariates and dependent measures were nonsignificant. Subjects who had higher repression-sensitization scores scored lower on tonal memory ($M = 7.67$, $n = 27$) than did subjects who scored lower in repression-sensitization ($M = 7.91$, $n = 33$). The correlation between repression-sensitization scores and tonal memory performance was -0.10. Subjects who exhibited greater numbers of left eye movements scored higher (*M* = 8.00, *n* = 28) on tonal memory than did subjects who exhibited fewer left eye movements (*M* = 7.63, *n* = 32). The correlation between left eye movements and tonal memory was 0.15. The opposite was true for right eye movements. For subjects who exhibited greater numbers of right eye movements mean tonal memory score was 7.48 (*n* = 33) and was 8.19 (*n* = 27) for subjects who exhibited fewer right eye movements. The correlation between right eye movements and tonal memory was -0.21.

Means relevant to the analysis of variance for tonal memory are presented in Table 1. With increased anxiety there was a decline in task performance.

## Repeated Measures Analyses of Variance--Averaged Left Hemisphere Tasks Versus Averaged Right Hemisphere Tasks

A repeated measures analysis of variance (Table 3, Part A) was performed with each subject's average score on left hemisphere tasks versus his average score on right hemisphere tasks as the within subjects variable. This resulted in significant effects on task performance for the within subjects comparison. Significant effects were also found for the interaction of trait anxiety with the within subjects variable, the interaction of state anxiety with the within subjects variable, and for the interaction of trait anxiety, state anxiety, and the within subjects variable. When arousal condition was used in the between subjects analysis in lieu of state anxiety (Table 3, Part B), a significant main effect was found for trait anxiety.

Means and standard deviations relevant to these repeated measure analyses are presented in Tables 10 and 11. For left hemisphere tasks, performance declined with increased anxiety. Similarly performance declined on right hemisphere tasks under conditions of increased anxiety. This was the case whether arousal condition or state anxiety was used as the independent variable.

In Figure 3 the effects of trait and state anxiety on performance scores are graphed for the averaged left hemisphere tasks and for the averaged right hemisphere tasks. The graph demonstrates that performance on both left hemisphere tasks and right hemisphere tasks was impaired by increased anxiety. However, performance on averaged right hemisphere tasks was more negatively affected by increased anxiety than was performance on averaged left hemisphere tasks.

### Repeated Measures Analyses of Variance--Analytic Versus Global Aspect of the Design Discrimination Task

A repeated measures analysis was also performed for the design discrimination task with analytic versus global aspect of the task as the within subjects variable (see Table 4, Part A). Here, significant effects on task performance were found for the within subjects comparison and for the interaction of trait anxiety with the within subjects variable. Means and standard deviations relevant to this repeated measure analysis are provided in Table 12. For the analytic aspect of the design discrimination task, performance was enhanced under conditions of increased anxiety. For the global aspect of the task, performance declined with an increase in anxiety. A significant main effect for

Table 10

Means for Averaged Left Hemisphere Tasks Versus Averaged Right Hemisphere Tasks at Different Levels of Trait Anxiety and State Anxiety (First Measure)

| | | State Anxiety | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | | | High | | | Total | | |
| Hemisphericity of Tasks | Trait Anxiety | n | M | SD | n | M | SD | n | M | SD |
| Left | Low | 22 | 0.08 | 0.59 | 12 | -0.03 | 0.58 | 34 | 0.04 | 0.58 |
| | High | 12 | -0.10 | 0.76 | 14 | -0.01 | 0.72 | 26 | -0.05 | 0.73 |
| | Total | 34 | 0.01 | 0.65 | 26 | -0.02 | 0.65 | 60 | 0.00 | 0.64 |
| Right | Low | 22 | 0.09 | 0.81 | 12 | 0.35 | 0.35 | 34 | 0.18 | 0.69 |
| | High | 12 | 0.08 | 0.74 | 14 | 0.51 | 0.86 | 26 | -0.24 | 0.85 |
| | Total | 34 | 0.09 | 0.77 | 26 | 0.11 | 0.79 | 60 | 0.00 | 0.78 |
| Left and Right Combined | Low | 44 | 0.08 | 0.70 | 24 | 0.16 | 0.50 | 68 | 0.11 | 0.63 |
| | High | 24 | -0.01 | 0.74 | 28 | -0.26 | 0.82 | 52 | -0.14 | 0.79 |
| | Total | 68 | 0.05 | 0.71 | 52 | -0.07 | 0.72 | 120 | 0.00 | 0.71 |

Table 11

Means for Averaged Left Hemisphere Tasks Versus Averaged Right Hemisphere Tasks at Different Levels of Trait Anxiety and Arousal

| | | Arousal Condition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Hemisphericity of Tasks | Trait Anxiety | Low | | | High | | | Total | | |
| | | n | M | SD | n | M | SD | n | M | SD |
| Left | Low | 18 | -0.01 | 0.61 | 16 | 0.10 | 0.55 | 34 | 0.04 | 0.58 |
| | High | 11 | -0.24 | 0.76 | 15 | 0.08 | 0.70 | 26 | -0.05 | 0.73 |
| | Total | 29 | -0.10 | 0.67 | 31 | 0.09 | 0.62 | 60 | 0.00 | 0.64 |
| Right | Low | 18 | 0.07 | 0.78 | 16 | 0.30 | 0.55 | 34 | 0.18 | 0.69 |
| | High | 11 | -0.07 | 0.78 | 15 | -0.35 | 0.90 | 26 | -0.24 | 0.85 |
| | Total | 29 | 0.02 | 0.77 | 31 | -0.02 | 0.80 | 60 | 0.00 | 0.78 |
| Left and Right Combined | Low | 36 | 0.03 | 0.70 | 32 | 0.20 | 0.55 | 68 | 0.11 | 0.63 |
| | High | 22 | -0.15 | 0.76 | 30 | -0.14 | 0.82 | 52 | -0.14 | 0.79 |
| | Total | 58 | -0.04 | 0.72 | 62 | 0.04 | 0.71 | 120 | 0.00 | 0.71 |

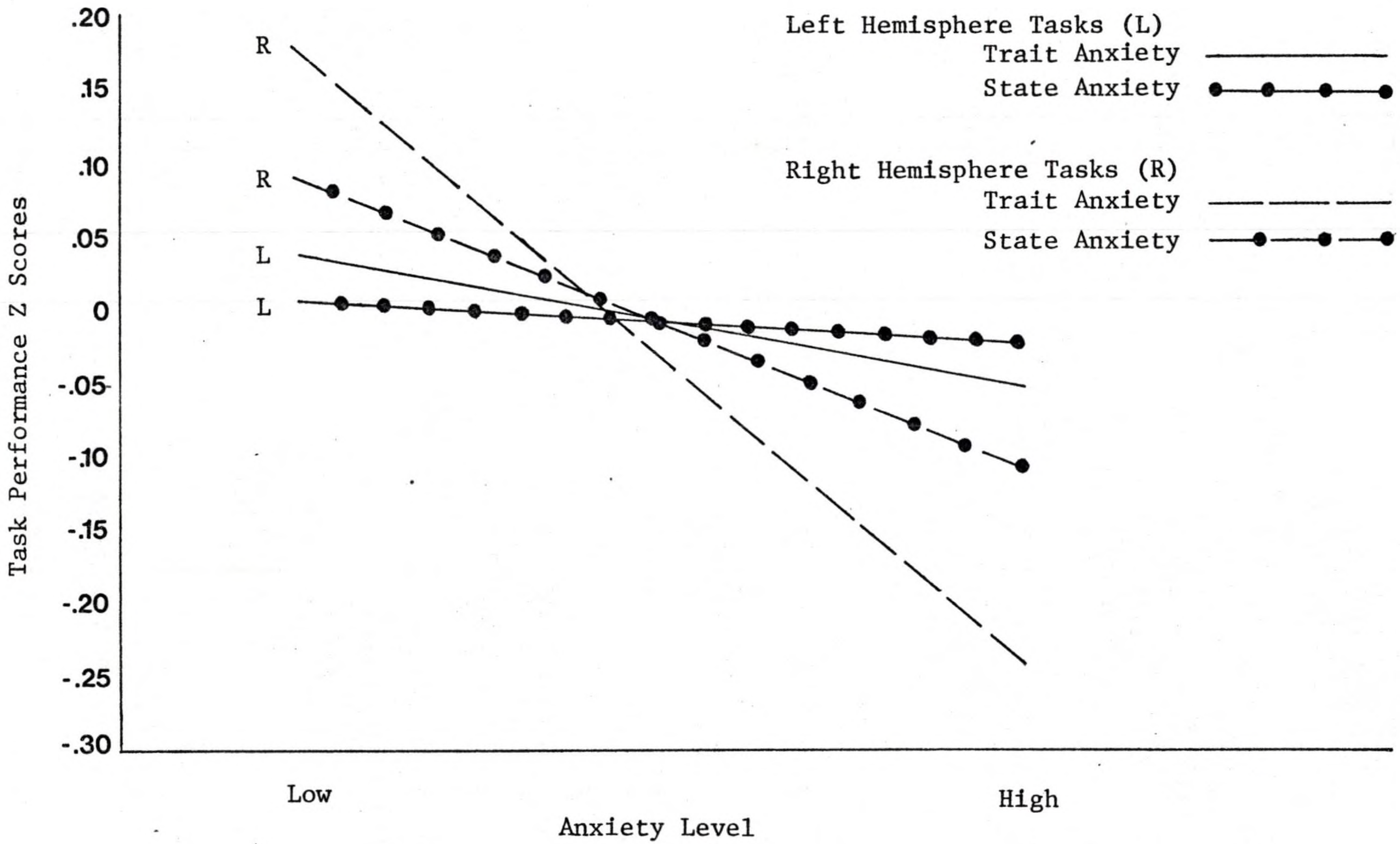


Figure 3. The effects of trait and state anxiety on averaged left hemisphere tasks and averaged right hemisphere tasks.

Table 12

Means for Analytic Versus Global Aspect of the Design Discrimination Task at Different Levels of Trait Anxiety and Different Levels of State Anxiety (Mean of Two Measures)

| | | State Anxiety | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Task Component | Trait Anxiety | Low | | | High | | | Total | | |
| | | n | M | SD | n | M | SD | n | M | SD |
| Analytic | Low | 22 | 10.59 | 2.86 | 12 | 11.58 | 2.19 | 34 | 10.94 | 2.65 |
| | High | 10 | 12.10 | 4.82 | 16 | 11.44 | 2.48 | 26 | 11.69 | 3.48 |
| | Total | 32 | 11.06 | 3.57 | 28 | 11.50 | 2.32 | 60 | 11.27 | 3.04 |
| Global | Low | 22 | 12.64 | 2.17 | 12 | 12.25 | 2.05 | 34 | 12.50 | 2.11 |
| | High | 10 | 12.70 | 2.71 | 16 | 11.75 | 3.11 | 26 | 12.12 | 2.94 |
| | Total | 32 | 12.66 | 2.31 | 28 | 11.96 | 2.67 | 60 | 12.33 | 2.49 |
| Analytic and Global Combined | Low | 44 | 11.61 | 2.71 | 24 | 11.92 | 2.10 | 68 | 11.72 | 2.50 |
| | High | 20 | 12.40 | 3.82 | 32 | 11.59 | 2.77 | 52 | 11.90 | 3.20 |
| | Total | 64 | 11.86 | 3.09 | 56 | 11.73 | 2.49 | 120 | 11.80 | 2.82 |

arousal was found in the between subjects analysis when arousal condition was used in lieu of state anxiety (Table 4, Part B). Means and standard deviations relevant to this repeated measures analysis are provided in Table 13. For the analytic aspect of the task, performance was increased with increased anxiety and arousal. For the global aspect of the task, increase in the independent variables resulted in a decline in performance.

Additional analyses were then conducted to test the effects of independent variables on design discrimination task performance with individual difference variables covaried out. By removing the effects of sex, left eye movements, right eye movements, repression-sensitization, and modified repression-sensitization/social desirability in separate covariate analyses, a main effect for arousal was obtained at the following significance levels respectively: $F(1, 115) = 4.13$, $p = 0.04$; $F(1, 115) = 4.13$, $p = 0.04$; $F(1, 115) = 4.12$, $p = 0.04$; $F(1, 115) = 4.47$, $p = 0.04$; $F(1, 115) = 4.72$, $p = 0.03$. All correlations between these covariates and dependent measures were nonsignificant. Males performed better than females on the analytic aspect of the design discrimination task ($M = 11.43$, $n = 23$; $M = 11.16$, $n = 37$ respectively). Numerical designation for males was 1 and for females was 2. The correlation between sex and performance on the analytic component of the task was -0.04. Males also performed better than females on the global aspect of the task ($M = 12.43$, $n = 23$ for males; $M = 12.27$, $n = 37$ for females). On the global task component the correlation between sex and performance was -0.03. On the analytic aspect of the task subjects who exhibited greater numbers of left eye movements had higher task scores

Table 13

Means for Analytic Versus Global Aspect of the Design Discrimination Task at Different Levels of Trait Anxiety and Under Different Arousal Conditions

| | | Arousal Condition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | | | High | | | Total | | |
| Task Component | Trait Anxiety | n | M | SD | n | M | SD | n | M | SD |
| Analytic | Low | 18 | 10.00 | 2.89 | 16 | 12.00 | 1.93 | 34 | 10.94 | 2.65 |
| | High | 11 | 11.82 | 4.71 | 15 | 11.60 | 2.41 | 26 | 11.69 | 3.48 |
| | Total | 29 | 10.69 | 3.71 | 31 | 11.81 | 2.15 | 60 | 11.27 | 3.04 |
| Global | Low | 18 | 12.44 | 2.12 | 16 | 12.56 | 2.16 | 34 | 12.50 | 2.11 |
| | High | 11 | 12.27 | 2.65 | 15 | 12.00 | 3.23 | 26 | 12.11 | 2.94 |
| | Total | 29 | 12.38 | 2.29 | 31 | 12.29 | 2.70 | 60 | 12.33 | 2.49 |
| Analytic and Global Combined | Low | 36 | 11.22 | 2.79 | 32 | 12.28 | 2.04 | 68 | 11.72 | 2.50 |
| | High | 22 | 12.05 | 3.73 | 30 | 11.80 | 2.81 | 52 | 11.90 | 3.20 |
| | Total | 58 | 11.53 | 3.17 | 62 | 12.05 | 2.43 | 120 | 11.80 | 2.81 |

(*M* = 11.46, *n* = 28) than did subjects who exhibited fewer left eye movements (*M* = 11.09, *n* = 32). The correlation between left eye movements and performance on analytic task component was -0.05. The same held true for the global aspect of the task; subjects who exhibited greater numbers of left eye movements obtained higher scores (*M* = 12.46, *n* = 28) than did subjects who exhibited fewer left eye movements (*M* = 12.22, *n* = 32). A correlation of -0.05 was present between performance on global aspect of the design discrimination task and left eye movements. The relationship between right eye movements and analytic response scores was in the opposite direction. Those subjects who exhibited more right eye movements made fewer (*M* = 11.18, *n* = 33) correct responses on this task component than did subjects who exhibited fewer numbers of right eye movements (*M* = 11.37, *n* = 27). Correlation between right eye movements and performance on the analytic component of the task was 0.06. However, for the global task component subjects demonstrating greater numbers of right eye movements had a higher rate of correct responding (*M* = 12.39, *n* = 33) than did subjects who made fewer right eye movements (*M* = 12.26, *n* = 27). The correlation between right eye movements and scores on the global component was 0.05. For the analytic task component subjects scoring higher on repression-sensitization, that is, at the sensitization end of the scale, had lower task scores (*M* = 10.89, *n* = 27) than did subjects who scored at the lower, repression end of the scale (*M* = 11.56, *n* = 33). The correlation between repression-sensitization scores and analytic task performance was 0.03. For global task component, subjects with higher repression-sensitization scores had lower task scores (*M* = 11.89, *n* = 27) than did subjects with lower repression-sensitization scores (*M* = 12.70, *n* = 33). The correlation between repression-sensitization scores and global component scores was -0.01. Subjects with higher scores on modified repression-sensitization/social desirability had lower analytic task component scores (*M* = 10.89, *n* = 27) than did subjects with lower scores on the modified scale (*M* = 11.58, *n* = 33). The correlation between this modified individual difference measure and analytic performance was -0.10. On global task component the mean number of correct responses for subjects with higher modified scores was 11.89 (*n* = 27) while mean number of correct responses for subjects with lower scores was 12.70 (*n* = 33). The correlation between the modified repression-sensitization/social desirability measure and global component performance was -0.12.

## CHAPTER IV

## DISCUSSION

The following experimental hypotheses were derived from the neuropsychological model of repression proposed in the first chapter: (a) that performance on left hemisphere tasks would be more adversely affected by anxiety than would performance on right hemisphere tasks; (b) that performance on the analytic aspect of the combined task would be hampered more by anxiety than would performance on the global aspect. These hypotheses were not supported by research findings. To the contrary, findings were opposite to those predicted and, as such, do not lend support to the proposed neuropsychological model for repression.

For two of the dependent measures, Mooney Closure Faces and tonal memory, performance decreased with higher levels of anxiety. Both of these were right hemisphere tasks. The repeated measures analysis of averaged left hemisphere tasks versus averaged right hemisphere tasks revealed that under conditions of increased anxiety, decline in performance was significantly greater for right hemisphere tasks than for left hemisphere tasks.

Also opposite to prediction, performance on the global aspect of the design discrimination task showed a nonsignificant decline with increased anxiety while performance on the analytic aspect of the task significantly increased with higher levels of anxiety. The repeated measures analysis using analytic versus global component of the task as the within subjects variable demonstrated that the difference in direction of findings for the analytic and global task components was significant.

The individual difference variables studied, including sex, repression-sensitization, social desirability, modified repression-sensitization/social desirability, and eye movements had very little direct relationship to task performance. However, a few important inter-relationships between individual difference variables were noted and will be commented on later in the discussion.

Findings of the present research suggest improved left hemisphere and impaired right hemisphere function with increased anxiety. This would indicate that higher levels of anxiety result in a shift in cognitive approach from right hemisphere perception and processing to left hemisphere cognition.

While findings do not support the proposed model for repression, they are relevant to the body of data regarding the relative contributions of the two hemispheres to emotion and the neuropsychological interrelationship of cognition and emotion. Tucker et al. (1978) found that higher trait anxiety was associated with a right ear auditory attentional bias and a decrease in left eye movements. The results can be taken to indicate the presence in trait anxious subjects of an overactivated left hemisphere which inhibits right hemisphere function. The model of reciprocal inhibition of function, suggested here and espoused by Kinsbourne (1970), can be offered as one explanation for the findings of the present study. Increased anxiety may have served to activate and prime the left hemisphere, resulting in improved analytic task performance. The activated left hemisphere may have concurrently inhibited right hemisphere function resulting in the decreased performance on right hemisphere tasks. Tucker et al. (1978), in another experiment, found higher state anxiety to be associated with more errors in the right visual half-field, particularly for verbal material. The present study found improved rather than impaired left hemisphere performance. The discrepancy may be due to the fact that Tucker et al. used only those individuals as research subjects who scored extremely high or low (one standard deviation above or below the mean) on state anxiety. If more extreme state anxiety scores had been employed in the present study, perhaps a drop in performance would have occurred at higher anxiety levels.

An alternative explanation for the present findings may be couched in terms of induced cognitive set. Shearer (1978) found that subjects who were asked to attempt to inhibit emotional arousal, reported using verbal, analytical thinking as an inhibitory strategy. Tucker and Newman (in press) assessed the efficacy of analytic, verbal thinking versus global, imaginal thinking as arousal mediating strategies and found the former to be a more successful strategy in inhibiting arousal. In the present study, under the high arousal condition, subjects were told that they would become quite anxious. This warning may have triggered coping strategies which, according to the research just cited, would be more likely to involve the adoption of an analytic, verbal cognitive demeanor. If this were the case, these subjects, already thinking analytically, would be more apt to perform well on analytic left hemisphere tasks and poorly on right hemisphere tasks.

The foregoing is relevant to a discussion of possible differences in influence associated with trait and state anxiety. A main effect of trait anxiety was found for the Mooney Closure Faces task, tonal memory, the averaged right hemisphere tasks, and the analytic component of the design discrimination task. It is possible that trait anxiety does not have a direct influence on task performance but rather typifies a personality type that tends to exhibit a left hemisphere cognitive style. Trait anxiety correlates .58 with repression-sensitization in the present study and indicates a tendency toward emotional arousal in trait anxious subjects. These individuals may developmentally adopt a cognitive strategy of verbal analysis to cope with the tendency toward over-arousal, so that it is the cognitive style of trait anxious subjects, rather than trait anxiety per se, that influences task performance. Significant main effects were also shown for state anxiety for the Mooney task, averaged right hemisphere tasks and analytic component of the design discrimination task and may represent a more direct influence on task performance.

In evaluating the present study, attention should be directed to the state dependent memory literature (e.g., Bartlett & Santrock, 1979). Studies in this area have shown that memory is impaired if encoding and retrieval occur under different states. In the present study, retrieval immediately followed encoding in the tasks that contained memory as a task element. As a result, both proceeded under the same state. In future experiments in the area of repression, investigators might wish to vary state for encoding and retrieval in order to determine if this would interact with differential hemispheric function to produce repression.

An evaluation of the interrelationships of cognitive style and emotion has provided the most viable approach to the study of repression to date. Smokler and Shevrin (1979) noted that qualities typifying a hysterical personality style (repression of disturbing ideas, emotional lability, a concrete cognitive approach) are consistent with data regarding right hemisphere functioning whereas obsessive compulsive traits (inhibition of affect, use of an ideational, analytic cognitive approach) are consistent with data regarding left hemisphere functioning. Consistent with this they found individuals exhibiting a hysterical style to demonstrate more left looking and obsessives to demonstrate more right looking. Congruent with their findings, the present study found a correlation of -0.36 between left eye movements and repression-sensitization, indicating that left movers tend to score at the repression end of the scale.

It should be emphasized that the approach of Smokler and Shevrin was aimed at repressive style rather than repression in the sense that the present study had endeavored to neuropsychologically explicate. The present study had sought to clarify the nature of the repression of unconscious instinctual conflictual wishes which, according to psychodynamic theory, is an integral part of the psychological functioning of all individuals, not simply those individuals who adopt a repressive style. The neuropsychological dimensions of this more common repression may be quite different from those of repressive style and warrant further investigations. On the other hand, repression as a means to keep unconscious conflicts from awareness may be an outmoded construct so that repression as a function of cognitive style may prove to be the only viable instance of this phenomenon.

In order to better evaluate repression in terms of neuropsychological function, it may be necessary to abandon an analogue approach. One reason for doing so, is the fact that in repression the anxiety that triggers the defense is not consciously experienced if the repression is successful. The effects of this type of anxiety could be categorically different in a neuropsychological sense from the anxiety induced experimentally that is consciously felt. The transition from analogue to clinical research would be complex but might prove more valuable in understanding the nature of repression as it relates to differential hemisphere functioning.

# APPENDIX A

Practice Trial*

On the first day of September, Ninnis and Mertz took a team to the ridge to deposit bags of food for the next journey. They allowed the huskies to run loose and then tried to coax them to run back to the hut with the sledge. The case, however, was some sort of inexplicable magnet to the dogs.

Experimental Trial 1*

I was playing in a joint on the town square in Tuscaloosa, and right outside there was this little boy about 12 or 13 who was selling watermelons, only every time you turned around, this little fella had deserted the watermelon stand and was sneaking in the poolroom, but the owner, a Mr. McHenry, who . . .

Experimental Trial 2*

The increased field of subject matter presented in the intermediate grades, far from a burden, should provide an opportunity for exploration into many facets of human experience and an awareness of the interaction of all areas of study with each other, with life itself, and with one's own personality. Obviously, the pupil will at this stage come into contact with subject matter about which he has never expressed interest and with which he has had no previous experience. The factor of readiness to read therefore becomes of paramount importance and receives a degree of emphasis at least equal to that which it requires at the preparational stages in laying the ground work for the initial schoolwork.

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*Note: Verbs are underlined above but were not underlined when stimulus materials were presented during the experiment.

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