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PATTERNS OF PERCEPTUAL ASYMMETRIES IN THE PERCEPTION OF CHIMERIC FACES: INFLUENCES OF DEPRESSION, ANXIETY, AND APPROACH AND WITHDRAWAL STYLES OF COPING

By

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ABSTRACT

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Heller (1993) has posited a central role for parietotemporal regions of the right hemisphere in the modulation of autonomic and behavioral arousal in emotional states. Her model addresses two dimensions of emotion with special clinical significance — depression and anxiety — by linking depression with a decrease and anxiety with an increase in right hemisphere arousal. Heller et al. (1995) tested the model in undergraduates classified into either high- or low-depression and high- or low-trait-anxiety subgroups. The dependent measure was the Chimeric Faces Task, or CFT (Levy et al., 1983). On this task, most individuals show a left-hemispace bias, seen as reflecting greater right-hemisphere arousal. The results supported the model: depression was related to weaker bias, anxiety to a stronger bias.

The aim of the current study was to test the reliability of Heller et al.'s (1995) results, and to assess contributions to CFT scores of anxiety subtypes — state vs. trait. Along with the CFT, 357 undergraduates completed self-report measures of depression, state anxiety, and trait anxiety. The study also compared Heller's model with a model proposed by Davidson (1992) that shifts the focus from parietotemporal to frontal regions and links approach and avoidance behaviors to left and right frontal regions, respectively. Approach and withdrawal behaviors were measured by a test of coping styles

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The results did not support Heller's model: trait anxiety and depression were unrelated to either strength or direction of hemispace bias, whereas state anxiety was related to a weaker, rather than stronger, left-hemispace bias. Likewise, in subjects high in depression and trait anxiety and in subjects high in state anxiety and trait anxiety, proportionately more, rather than fewer, had right-hemispace biases compared to controls, implying greater left- than right-hemisphere arousal. The only supported prediction was the one derived from Davidson's model, namely, that the tendency to disengage from stressful situations was related to a stronger left hemispace bias. This was true, however, only for subjects high in trait anxiety.

Because state anxiety was inversely, rather than directly, related to CFT scores, the data were re-examined to better understand this relation. First, on the possibility that "state anxiety" contains a mix of subtypes, a principle components analysis was performed on this measure. This analysis revealed four factors. Next, a hierarchical regression was performed to compare the factors' relation to CFT scores. Only two factors were related to bias — those best described as "cognitive worry" and "free-floating anxiety." For both, higher levels were related to weaker left-hemispace bias.

Together, the results suggest that in state-anxious persons, only cognitive worry and free-floating anxiety are associated with decreased right-hemisphere arousal, whereas in trait-anxious persons, disengagement is associated with increased right-hemisphere arousal. The results thus do not support Heller's model but suggest how its with Davidson's might have more explanatory power. Integration, however, will require making meaningful distinctions among anxiety subtypes.

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INTRODUCTION

In human beings, a mass of clinical and experimental evidence has documented that the cerebral hemispheres have different capabilities or organizations, primarily for linguistic and visuo-spatial abilities. Much of this same evidence also shows that the quality and extent of these differences are related to certain subject variables, including sex and handedness. In recent years, there has also been increasing evidence for lateral specialization in the initiation of and control of emotions, and still more recently, research is beginning to suggest that individual differences in hemispheric arousal can account for some of these differences.

A recent neuropsychological model of emotion (Heller, 1993) posits a central role for parietotemporal regions of the right hemisphere in the modulation of autonomic and behavioral arousal in emotional states. The model addresses two dimensions of emotion with special clinical significance — depression and anxiety — by linking depression with a relative decrease and anxiety with a relative increase in right hemisphere arousal. Heller, Marci, Etienne, and Miller (1995) tested the model in right-handed undergraduates classified into either high- or low-depression and high- or low-trait-anxiety subgroups. The dependent measure was the Chimeric Faces Task, or CFT (Levy, Heller, Banich, & Burton, 1983b). On this task, individuals typically show a left-hemispace bias which is seen as reflecting greater right-hemisphere arousal. The results supported the model: depression was related to a weaker left-hemispace bias and anxiety to a stronger left-hemispace bias.

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The major aims of the current study were to examine: 1) whether Heller et al.'s (1995) results are reliable, 2) the relative contributions to CFT scores of anxiety subtypes — state vs. trait, and 3) whether changes in depression and/or anxiety over time are related to changes in CFT scores (in a direction consistent with Heller's model). Another aim of the study was to compare Heller's model with a different model of emotion proposed by Davidson (1992). This model shifts the view from posterior (parietotemporal) regions to anterior (frontal) regions and links approach (engagement) and avoidance (disengagement) behavior to the left and right frontal regions, respectively. Lastly, given the corroboration of evidence for handedness differences in cerebral organization for language and visuo-spatial functions and for individual differences in hemispheric arousal and/or control of emotions, the question thus arises whether these individual differences are related to handedness. There has been little research on this possibility. If such differences exist, then studying them may allow us to better understand how emotion is processed by the brain. In other words, if we can show that right and left-handers also differ in other skills (e.g., the experience and perception of emotion), we then have the means to ask about the functional utility of lateral specialization for those skills.

Before turning to the current study, I shall begin with a review of research on handedness differences in lateralization of speech and language and visuo-spatial functions, then present research on interhemispheric and intrahemispheric specialization for emotion, followed by a presentation of three models for intrahemispheric and interhemispheric interactions in emotional processes, and end with a review of prior studies of emotion and handedness.

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Hemispheric Specialization for Speech and Language in Right- and Left-Handers

Until the 1860s, the two hemispheres of the brain were widely regarded as mirror images of each other, both structurally and functionally. There was only occasional speculation, largely based on clinical observations of individuals with unilateral brain damage, that the hemispheres were not functionally identical. These observations, however, typically lacked essential detail, making it difficult to correlate lesion site to behavioral abnormality with any degree of accuracy (Benton, 1984). It was not until the work of the French physician Paul Broca in the 1860s that the concept of lateralization of function began to emerge and to replace the older view of hemisphere equivalency. Based on clinical studies of patients with unilateral lesions of the neocortex, Broca (1865) concluded that the left hemisphere plays the leading role in language functions.

Since Broca's reports, lateral specialization of function has received a vast amount of attention in new studies of clinical as well as normal populations. The research supports Broca's general proposition that the left hemisphere almost invariably plays the leading role for speech functions — and goes further in regards to language functions generally. It also shows that this is true for right-handers. For left-handers, the picture is more complex as will be discussed later.

Evidence for language laterality comes from studies of clinical as well as normal populations. For example, in the former category are studies of patients who have undergone cortical excisions for the purpose of controlling epileptic symptoms. In one well-known study, of 179 right-handed patients who were operated on the left hemisphere, 124, or 69.8%, showed some form of aphasia following the operation. Of

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254 right-handed patients who were operated on the right hemisphere, only 1, or 0.4%, became aphasic (Penfield & Roberts, 1959). Other localization methods have yielded very similar results. Warrington and Pratt (1973) found that among right-handed depressed patients who had been given ECT, 98% exhibited dysphasia following left-hemisphere ECT, compared with only 2% following right-hemisphere ECT. Rasmussen and Milner (1977) reported similar percentages with the Intracarotid Amobarbital Procedure.[1] In 140 right-handers with late-onset epilepsy[2] (without any history of early brain damage), 96% showed speech-disruption following left hemisphere injection; 4% following right-hemisphere injection. None had bilateral or mixed-speech dominance.[3]

In summary, the literature consistently shows the left hemisphere to be dominant for language in nearly all right-handers. The evidence for left-handers is less clear. It indicates that the majority of left-handers are left-lateralized as well. For example, in the study cited earlier, Penfield and Roberts (1959) also included left-handers and found that of 67 left-handed patients operated on the left hemisphere, 19, or 28.3 %, became aphasic; of 22 left-handed patients operated on the right hemisphere, 2, or 9.1%, became aphasic. Similarly, when Rasmussen and Milner (1977) examined left-handed patients

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[1] This procedure is widely used prior to surgery to excise epileptogenic tissue. First one hemisphere, then the other is anesthetized via a barbiturate, sodium amobarbital, injected into a catheter in the femoral artery to the internal carotid, thereby anesthetizing the ipsilateral hemisphere. When the hemisphere for speech and language is anesthetized, the patient experiences complete aphasia. The symptoms last only for a few minutes.

[2] It is important to note that these individuals had late-onset epilepsy because it suggests that their brains developed normally. Insofar as they did, we can make inferences about speech and language organization in right-handers. Had they had early-onset epilepsy, or a history of brain damage, it is quite likely that reorganization of cerebral functions (e.g., language and speech) also occurred.

[3] Harris (1992) suggests that the term 'bilaterality' may be misleading as it is often misconstrued to mean that both hemispheres are contributing equally to speech functions, which is currently not known. Snyder, Novelly, and Harris (1990) suggest that the term 'mixed speech dominance' replace the term 'bilaterality' as it is less likely to lead to the aforementioned inaccuracies. In the current paper, the term 'mixed dominance' will be used to avoid any misinterpretation.

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with late-onset epilepsy and without any history of early brain damage, 70% of left-handers showed evidence of left-hemisphere speech, 15% showed evidence of right-hemisphere speech, and 15% showed evidence of mixed-speech dominance. Segalowitz and Bryden (1983) found similar percentages from studies of left-handed aphasic patients. They estimated that 61.4% are left-lateralized for speech, 18.8% are right-lateralized, and 19.8% have mixed-speech dominance. Warrington and Pratt (1973) reported similar percentages in their study of dysphasia and ECT. In left-handers, 70% showed dysphasia following left ECT, 23% following right ECT, and 6% following both left and right ECT (suggesting mixed-speech dominance). Taken together, the data indicate that the left hemisphere is the side dominant for speech in nearly all right-handers and in the majority of left-handers. Despite lack of agreement as to the prevalence of mixed speech dominance within the general population, most investigators will agree that mixed-speech and right-hemisphere speech dominance are almost exclusively limited to left-handers and that left-handers, in general, are more neuropsychologically heterogeneous than right-handers.

Hemispheric Specialization for Visuo-Spatial Functions in Right- and Left-Handers

In contrast to the evidence for speech and language, many of the early studies of visuo-spatial functions failed to indicate any remarkable differences between left- and right-handers (see review in De Renzi, 1982). For example, they showed that recognition of faces and drawings was impaired following right-hemisphere lesions in right-handers (Tzavaras, Hécaen & Le Bras, 1970) and left-handers alike (Tzavaras, Hécaen, & Le Bras, 1971). Similar results have been found for spatial disorientation and dressing aprax

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apraxia (Hécaen & Angelergues, 1962), spatial agnosia (Hécaen & Sauguet, 1971), and constructional apraxia (Hécaen, De Agostini, & Monzon-Montes, 1981).

Newer evidence, however, indicates a greater degree of consistency with the language data. That is, the data suggest that left-handers have greater bilaterality in the form of secondary left-hemisphere commitment to visuo-spatial processing. Borod, Carper, Naeser, and Goodglass (1985) examined the relation between handedness in aphasic patients with left-sided lesions on the WAIS Performance Scale (Wechsler, 1958) and the Parietal Lobe Battery (Goodglass & Kaplan, 1972). Relative to right-handers, left-handers were significantly more impaired, especially on tests of visuo-spatial organization and construction. From these findings, the authors suggest that left-handers have more left-hemisphere representation for non-verbal tasks, especially on tasks that involve manipulation and assembly.

Studies of normal adults give a similarly mixed picture. Some studies suggest that right- and left-handers show similar and equally strong organization for visuo-spatial functions. These include divided-visual field studies of recognition of tachistoscopically-projected dot patterns (McGlone & Davidson, 1973) and patterns of steady-state potentials to the temporal and spatial frequencies of stimuli (Mecacci & Spinelli, 1987). Other studies report the same directional effect in right- and left-handers, but with weaker asymmetries in left-handers. These include studies of dot location (Levy & Reid, 1978), tactual discrimination of line orientation (Varney & Benton, 1975), and learning of braille letters by naive, sighted subjects (Harris, 1980).

Taken together, the results from clinical and adult normal populations indicate that for both right- and left-handers, the right hemisphere is dominant for visuo-spatial func

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Left-Handedness Phenotype

From the research reviewed so far, left-handers would seem to be typically less strongly lateralized than right-handers. The problem, as Hellige, Bloch, Cowin, et al. (1994) point out, is that some studies comprise a greater proportion of left-handers with left-hemisphere speech, others with more left-handers with mixed-speech dominance, and still others with more left-handers with right-hemisphere speech. This raises the possibility that the overall weaker lateralization shown by left-handers in all of the neuropsychological measures cited earlier reflects the summing together of these different subgroups.

Many attempts have been made to classify left-handers into meaningful subgroups. One method has relied on studying handedness phenotype because left-handers are more heterogeneous than right-handers in phenotype. In contrast to right-handers, who individually are almost always strongly right-handed, left-handers exhibit greater individual difference in their strength of handedness.

Preference Questionnaires and Performance Tests

To measure handedness, a variety of preference as well as performance measures have been used. On preference tests, subjects are asked to indicate which hand they prefer to use for a variety of unimanual tasks; a Likert-type scale is typically employed to establish strength of preference. Some of these questionnaires are short (10 items or less), some are long (50 questions or more), some ask about preference for typical tasks, and some ask about preference for less typical tasks (Harris, 1992). These questionnaires hav

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have in common the skill level of the task being assessed; all emphasize tasks that require moderate to high skill rather than unskilled acts for the simple reason that tasks requiring a higher level of skill have been shown to be more lateralized (Harris & Carlson, 1993). Harris (1992) estimated that regardless of the inventory used (as long as there were a sufficient number of skilled tasks represented), normative studies of adults yielded a J-shaped distribution with 85-90% reporting an overall right-hand preference, with most of the rest reporting a left-hand preference. These tests have shown hand use for writing to have the highest strength of preference (Kang & Harris, 1992). Left-handers, however, typically show weaker preference than right-handers for other tasks (e.g., Snyder & Harris, 1991). In other words, relative to right-handers, left-handers report using their dominant hand for a smaller proportion of acts on whatever hand preference inventory might be used.

Performance tests assess actual skill, including the rapid movement of pegs in a slotted board (Annett, 1970), rapid tapping of the fingers (Provins & Magliaro, 1989), and inserting a straight pin into holes along a metal grid (Satz & D'Elia, 1989). On these preference tests, left-handers show weaker lateralization than right-handers, that is smaller between-hand differences (e.g., Provins & Magliaro, 1989). Generally, preference and performance tests are significantly correlated (e.g., Peters & During, 1979).

On both preference and performance tests, left-handedness, and to a much lesser extent right-handedness, is shown to be a continuous rather than dichotomous variable. For purposes of categorization, however, researchers divide the continuum into a variety of subgroups. In addition to the two main groups labeled right- and left-handers, rese

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researchers have used a variety of labels for 'both-handed' individuals, or those that lie between the two main groups. Both-handed individuals have been called "inconsistent left-handers," "mixed-handers," "ambidexters," and "ambilaterals" (Harris, 1992). Even more numerous than the names given to weakly-handed individuals have been the methods or criteria used to assign such persons to their respective categories. Some researchers have used stringent criteria. For example, Annett (1972), using a 12-item hand preference questionnaire, classified individuals who reported using the nondominant hand on *any* of the 12 items as mixed-handed. Individuals were classified as right- or left-handed only if they used the same hand for all 12 tasks. Others have labeled all not perfectly consistent right-handers as mixed-handers (e.g., Witelson, 1985). Others have separated right-handers and left-handers with strong and weak preferences in order to obtain four different groups (e.g., Ponton, 1987). Still others have used an 8-item version of the Edinburgh Handedness Inventory (Oldfield, 1971) and a method similar to Annett (1972) but with less stringent criteria (e.g., Peters, 1990; Peters & Servos, 1989; Ponton, 1987). The last method has enjoyed some measure of success in subclassifying left-handers and is the method proposed for use in the current study.

In this method, respondents who reported left-hand preference for seven of eight common unimanual tasks (to write a letter, hammer a nail, throw a ball at a target, unscrew the lid of a jar, use a knife to cut bread, use a toothbrush, hold a match while striking it, and hold a tennis racket), including writing, were classified as consistent left-handers (CLHs). Subjects with inconsistent hand preferences (ILHs) were those who preferred the right hand for two or more of the eight items. When CLHs and ILHs were compared to right-handers on two types of performance tests (tests of fine motor skills and tests of strength), CLHs performed better with the left hand on both types of tests, much like right-handers would, except for the direction of the hand advantage (Peters, 1990; Peters & Servos, 1989). ILHs, on the other hand, performed better with the left hand on tests of fine motor skills, but performed better with the right hand on tests that involved strength and skill together (e.g., throwing a ball at a target). In addition, on fine motor skills tasks, ILH subjects had smaller between-hand differences than either CLHs or the control right-handers.

The evidence reviewed thus far has documented differences in lateral cerebral organization for language and visuo-spatial functions between right- and left-handers. I shall now present evidence for interhemispheric and intrahemispheric specialization for emotion. This review will provide a foundation for a later summary of the literature on handedness differences as they relate to interhemispheric and intrahemispheric specialization for emotion.

Interhemispheric Specialization for Emotion

The literature on the neuropsychology of emotion has focused on three main components of emotion: perception, experience, and expression. The *perception*, or recognition, of emotion has been measured by examining an individual's ability to make judgments of emotionally-laden visual or auditory stimuli as expressed either in human faces or in speech and non-speech sounds (e.g., Harris & Snyder, 1992; Levy, Heller, Banich, & Burton, 1983b). To study lateral specialization for the perception of emotion, researchers selectively present the visual or auditory stimuli in a way designed to give an initial processing advantage to one or the other cerebral hemisphere. Such methods include dichotic listening tasks, divided visual field presentations (e.g., through the use of a tach

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a tachistoscope or special contact lens), and the free-viewing of chimeric faces (e.g., Chimeric Faces Task). If one hemisphere is superior in performance to the other (e.g., in recognizing facial expressions or the emotional tone of a voice), that hemisphere can be said to play the leading role for this function.

The *expression* of emotion has been defined as the production of affective behavior. To study lateral specialization for emotional expression, researchers have also used a variety of methods. One method is to measure differences between the left and right halves of the face during either spontaneous or posed expressions (e.g., Mendolia & Kleck, 1991; Sackeim & Gur, 1978). Another way has been to draw on reports of emotional changes in patients with unilateral brain lesions. To the extent that unilateral lesions have different effects depending on the side of lesion, one can infer functional specialization for behaviors arising or diminishing after hemispheric injury (e.g., Gainotti, 1969, 1972; Goldstein, 1939; Luys, 1890).

Finally, the *experience* of emotion can be defined as an individual's subjective feelings or "felt emotion." It has been measured in a variety of ways including through the use of clinical populations or mood induction techniques in association with those methods mentioned above (e.g., Deglin & Nikolaenko, 1975; Schiff & Lamon, 1989) as well as through the use of more precise measures of regional brain activity including computerized tomography, magnetic resonance imaging, and positron emission tomography (e.g., Davidson, 1993a). Because *experience* lies on a continuum somewhere between perception and expression, it is often difficult to decide the extent to which emotional experience studies are truly studies of experience and not also studies of the perception and/or expression of emotion. That is, using any given task, it is often dif

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difficult to determine the relative contributions of the perception, expression, or experience of emotion to that task. For instance, a task that involves identifying emotional tones (e.g., a dichotic listening task) is typically labeled an interpretive task. However, to the extent that the person also responds to, feels, or reacts to the emotion, then that task also involves the experience of emotion. Given that these two components (i.e., perception and experience) of emotion hold different predictions and that certain tasks (such as dichotic listening) may contain both components, the measure may be inherently confounded.

Clinical and experimental studies of the perception, experience, and expression of emotion have given rise to two main hypotheses about hemispheric specialization for emotion: 1) the right hemisphere hypothesis and 2) the valence hypothesis. These hypotheses are summarized in Figure 1a and 1b.

The right hemisphere hypothesis (Figure 1a) holds that the right hemisphere is specialized for the perception, expression, and experience of all emotions regardless of the valence of the emotion, that is, whether the emotion is positive or negative[4] (e.g., Borod, Koff, & White, 1983; Coffey, 1987; Ley & Bryden, 1982; Borod & Caron, 1980; Rubin & Rubin, 1980). The valence hypothesis (Figure 1b) agrees with the right hemisphere hypothesis where perception is concerned but differs for expression and experience. Unlike the right hemisphere hypothesis, the valence hypothesis proposes that the right hemisphere is dominant for the experience and expression of negative emotions,

[4] More recently, Davidson and others (e.g., Davidson, 1992a) have questioned the positive-negative dichotomy as the essential basis for affective asymmetry and believe that the terms 'approach' and 'withdrawal' may be more parsimonious. Throughout this review, both sets of terms will be used to reflect the appropriate researcher's conceptualization of the dichotomy.

the left hemisphere for positive emotions (Davidson, 1992c; Davidson & Fox, 1982; Sackeim, Greenberg, Weiman et al., 1982; Silberman & Weingartner, 1986).

Evidence for the Right Hemisphere Hypothesis

If, following the right hemisphere hypothesis, the right hemisphere is specialized for all components of emotion, irrespective of valence, then right-hemisphere damage should compromise all these components, while leaving cognitive functions (such as speech and language) relatively intact. On the other hand, left-hemisphere damage should compromise cognitive functions (such as speech and language) while leaving emotion relatively intact. This would be an example of a double dissociation (one of the main methods used with clinical populations):[5] Lesions to one hemisphere disturb tasks not disturbed by similar lesions to the other hemisphere, and vice versa. For normal populations, the methods more typically use tachistoscopic, chimeric face, and dichotic listening tests. The following review begins with perception studies and then turns to studies of experience and expression.

Perception. For the perception of emotion, the right hemisphere hypothesis finds abundant support from clinical and experimental populations alike. Among the most frequently used measures are visual-field differences in response to tachistoscopic presentation of facial expressions or to the free viewing of chimeric faces, and ear differences in response to dichotic presentation of affectively toned words or sounds. For instance, Ley and Bryden (1979) asked children and college students to identify the emotions of tachistoscopically projected cartoon faces displaying emotional expressions

[5] This is not to say that this inferential technique cannot be used with normal populations. With the advent of more advanced neuroimaging techniques, double dissociations can be inferred from areas of activation and inactivation in normal persons.

ranging from extremely positive to extremely negative. The result was significant left hemispace (LHBs) biases (indicating a right-hemisphere advantage). Using real photographs, as well as cartoons and line drawings, Strauss and Moscovitch (1981) found a similar LHB advantage for both smiles and frowns. Using the free viewing Chimeric Face Task paradigm,[6] studies consistently show a LHB advantage for the hemiface with the target emotion appearing in the left half of space (e.g., Borod, Vingiano, & Cytryn, 1989; Jaeger, Borod, & Peselow, 1987; Levine & Levy, 1986; Levy, Heller, Banich, & Burton., 1983a). Using schematic facial stimuli, Carlson and Harris (1985) showed that this LHB advantage holds regardless of the valence of the target hemiface (e.g. whether the individual judges a "happier" face or "sadder" face). Not only do normal people show LHB advantages for the perception of emotional faces, but individuals with left-hemisphere lesions do as well. In contrast, subjects with right-hemisphere lesions failed to show a hemispatial bias (Dekosky, Heilman, Bowers, & Valenstein, 1980; Kolb & Milner, 1981; Kolb, Milner, & Taylor, 1983).

A similar right-hemisphere advantage for normal people has been found for dichotically presented words containing both positive and negative emotional content (Bryden, Free, Gangé, & Groff, 1991) and for recognizing emotional expressions (how something is said, not what is said) (Carmon & Nachshon, 1973; Haggard & Parkinson, 1971). Conversely, patients with right-hemisphere disease cannot comprehend affective speech (Heilman, Scholes, & Watson, 1975) because they cannot discriminate cues that

[6] The Chimeric Face Task requires individuals to view two face composites that are mirror images of each other, where one half, for example, is smiling, while the other is frowning. The subject is asked to choose the face composite that is "happier" or "sadder." The rationale for this test is that if subjects consistently choose the face from each pair that has the target emotion in the left or right visual field (hemispace), the hemisphere that lies contralateral to that side of space is considered to be more specialized for the perception of emotion.

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In sum, numerous studies using diverse methodologies and stimuli find a right-hemisphere advantage for the perceptual processing of emotional information, irrespective of its emotional valence. There is only modest evidence to the contrary coming primarily from four studies of right-handed college students. Two are by Reuter-Lorenz and colleagues and use the same tachistoscopic divided-visual field method (Reuter-Lorenz, Givis, & Moscovitch, 1983; Reuter-Lorenz & Davidson, 1981). In both studies, pairs of Ekman faces (one neutral, one sad or happy) were simultaneously projected onto a computer screen so that one face appeared in each visual field. The subjects then were asked to indicate whether the emotional face appeared on the left or the right of the screen by pressing the response key on the corresponding side. The authors found a significant LVF advantage for sad expressions and a significant RVF advantage for both open- and closed-mouth happy expressions suggesting a valence effect for the perception of emotion. A considerable degree of controversy has surrounded these two studies, and questions have been raised about the methodology (see Moretti, Charlton, & Taylor, 1996). One of the most serious questions has to do with the reliability of the findings. Using almost identical procedures to Reuter Lorenz and Davidson (1981), two attempts to replicate the valence-based results failed (Duda and Brown, 1984; McLaren & Byron, 1987). Recognizing that these failed replications could be questioned because of their methodological changes, Moretti, et al. (1996) repeated the study using the same procedures as Reuter-Lorenz and her colleagues. The results were unchanged: no visual field differences for happy expressions and a LVH advant

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advantage for sad expressions. These results do not clearly distinguish between either hypothesis since both predict a right hemisphere advantage for negative expressions, and neither hypothesis predicts a lack of visual-field differences for positive expressions.

More recently, Hugdahl, Iverson, and Johnsen (1993) also found results consistent with a valence for the perception of emotion, a different pattern than either the right hemisphere or valence hypothesis would predict. Although they found a right hemisphere advantage overall, further analysis revealed a significant two-way interaction between emotional expression and visual-field with mean differences in the predicted direction. Measuring cerebral blood flow, Gur, Skolnick, and Gur (1994) found greater left frontal activation for recognition (i.e., perception) of happy expressions and greater right parietal activation for sad expressions.

Expression and Experience. Possibly the earliest evidence implicating the right hemisphere in the control of emotional *expression* comes from an eighteenth century report by Olof Dalin (1745; cited in Benton & Joynt, 1960). Dalin reported the case of a farmer's son who, following an illness, became aphasic and paralyzed on the right side (implying a left-hemisphere lesion). When prompted, however, he was able to "sing certain hymns, which he learned before he became ill, as clearly and distinctly as any healthy person. . .Yet this man is dumb, cannot say a single word except 'yes' and has to communicate by making signs with his hands" (Benton & Joynt, 1960, pp. 114-115). If music is the "language of emotions," then it can be inferred that the right hemisphere is intimately involved in these processes.

Recent clinical studies support Dalin's early report. They show that the loss of musical ability, or amusia, is far more common after right- than left-hemisphere damage.

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In a review of the literature, Zattore (1984) demonstrated that right hemisphere damage was associated with deficits in tasks that demanded the processing of patterns of pitches as well as differences in timbre and that right temporal lobe damage appeared to cause the most consistent deficits. Taken together, the findings that the aphasic can still sing and that amusia is more likely to be acquired after right- than after left-hemisphere injury suggest that the right hemisphere exerts primary control for music and, by implication, for the *expression* and *experience* of emotional/prosodic elements of language.

This interpretation is strengthened by studies of the effects of right hemisphere injury on the emotional content of speech. The earliest studies are probably those by John Hughlings-Jackson. Finding that emotional speech was not disrupted following left hemisphere lesions, Hughlings-Jackson (1879) suggested that emotional speech is represented in the right hemisphere. "The speechless patient may utter 'yes' or 'no,' or both, in different tones, merely according as he is thus excited. It is then not a proposition, but an interjection, a mere vehicle for variations of voice, expressive of feeling" (p. 175).

More recent studies also suggest that right-hemisphere damage impairs the *expression* of emotion. The impairments appear in the affective intonations in speech (Kolb & Taylor, 1981; Ross & Mesulam, 1979; Tucker et al., 1976) and in the impaired expression of emotions through facial gesturing (Buck & Duffy, 1980). Other evidence comes from studies of what Borod, Caron, and Koff (1981) call facedness, which they define as "the relative intensity of expression and the extent of movement on the left and right sides of the face" (p.381). Using facedness as an index for the expression of emot

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emotion, Sackeim, Gur, and Saucy (1978) and Sackeim and Gur (1978) found that left-sided composites of six different posed emotions (happiness, surprise, fear, sadness, anger, and disgust) were judged to express emotions more intensely than right-sided composites. Ekman, Hagar, and Friesen (1981), however, questioned whether this effect holds true for or spontaneous facial expressions or only for 'posed' emotions. A study by Dopson, Beckwith, Tucker, and Bullard-Bates (1984) suggests that it holds for both. Dopson et al. secretly photographed subjects after they had been asked to remember happy or sad experiences. They then compared these photographs with the subjects' posed expressions of happiness or sadness. In both conditions, the faces showed stronger expression on the left side, although the difference was greater in the spontaneous than in the posed condition. Others have reported similar results (Borod et al., 1983; Moscovitch and Olds, 1982; Strauss & Moscovitch, 1981).

Research with normal subjects has also shown the right hemisphere's importance in emotional experience and expression. Measuring emotional responses to films of different emotional valences selectively presented to either the right or left hemisphere, Wittling and Roschmann (1993) found that films of both emotional valences presented to the right hemisphere resulted in stronger subjective responses. Using subjects undergoing unilateral amobarbital injection, Ahern, Schomer, Kleefield, Blume, Cosgrove, and Weintraub (1991) measured subjective emotional reactions to photographs before, during and after left- or right-hemisphere inactivation. Left hemisphere inactivation did not change the felt emotional intensity of the presented stimuli. Conversely, right hemispheric inactivation led to a significant decrease in the patient's rating of the intensity of emotional expressions compared with their ratings after the

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inactivation, regardless of the picture's emotional valence. Although Ahern et al. (1991) interpret these findings to suggest that the right hemisphere is superior for the experience of emotion, one must question the extent to which this study (and others like it) was not also a study of the perception of emotion. That is, persons were asked to make subjective ratings of their emotional state after *perceiving* an emotional photograph. If the right hemisphere is involved in the perception of emotion, then it is not surprising that right hemisphere inactivation would lead to a decrease in the ratings of subjects — the stimuli simply may not have been perceived by the subject.

In summary, clinical and experimental studies of *perception* and *expression* offer strong support for the right-hemisphere hypothesis. For the *experience* of emotion, the evidence is less clear; perhaps because it is questionable whether the methods employed have truly measured "experience" or whether they are more accurately defined as studies of perception, or interpretation, of experience. A study by McFarland and Kennison (1989) illustrates this point. In this study, subjects were monaurally presented four selections music (two of positive and two of negative valence) to individuals. Afterwards, they were asked to "rate the valence of the emotion" they had experienced during the music using a scale anchored by the words "happiness" and "sadness." Significant differences between valences were interpreted to suggest differences in subject's experience of an emotion presumably elicited by the musical selection. But did the subjects actually feel sad or happy (in other words, did they experience sad or happy emotions), or did they simply perceive the *music* as sad or happy? If the latter, then this would be a study of perception; if the former, it was a study of experience. The authors, perhaps sensing these difficulties, use neither term and instead described the results as showing asymme

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Evidence for the Valence Hypothesis

As already noted, the right hemisphere and valence hypotheses are identical with respect to the perception of emotion, so the evidence on perception already reviewed for the right hemisphere hypothesis applies equally for the valence hypothesis. Where the hypotheses differ is in regard to the expression and experience of emotion, where, by the valence hypothesis, the left hemisphere has primary control for positive emotion, the right hemisphere for negative emotion. Support for this hypothesis comes from both clinical and normal populations.

Expression and Experience. Some of the earliest evidence was reported by the physician Jules Luys in the 1880s. At the Salpêtrière in Paris, Luys (1890) noticed certain personality differences between right-hemiplegics and left-hemiplegics. Right-hemiplegics (implying left-sided lesions) were more often dysphoric, showing despair, hopelessness, anger, heightened tendency to self-blame, self-deprecation, and fits of crying. Conversely, left-hemiplegics (implying right-sided lesions) more often appeared indifferent or even euphoric, as marked by minimization of symptoms, denial, emotional plasticity, joking, elation, social disinhibition, and mania.

In 1969, Gainotti reported similar effects in a study of 150 patients with unilateral cerebral lesions. The incidence of dysphoric, or "catastrophic" reactions was significantly higher in patients with left-sided lesions (62% left-sided vs. 10% right-sided), whereas indifferent reactions were significantly higher in patients with right-sided lesions (38% right-sided vs. 11% left-sided). Gainotti (1972) corroborated these results in a more detaile

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in a more detailed study of 160 patients with unilateral lesions (80 left and 80 right). This analysis also disclosed that the depressive-catastrophic reactions associated with left brain-damage occurred primarily in patients with severe aphasia, generally after repeated failures in verbal communication. Similar findings were reported by Sackeim et al. (1982). These investigators examined reports of pathological laughing and crying (involuntary and uncontrollable changes in emotion following a cerebral lesion). Pathological laughing was three times more common after right-sided than left-sided lesions, whereas pathological crying was twice as common after left-sided than right-sided lesions.

The IAP procedure, mentioned earlier, provides further support for the valence hypothesis. For instance, Terzian (1964) noticed that his patients often had intense emotional reactions as the anesthetic was wearing off:

> Amytal on the left side provokes . . . a catastrophic reaction . . . The patient . . . despairs and expresses a sense of guilt, of nothingness, of indignity, of worries about his own future or that of his relatives . . . [amytal on the right side] produces on the contrary a complete opposite emotional reaction, an euphoric reaction . . . The patient appears without apprehension, smiles and laughs and both with mimicry and words expresses considerable liveliness and sense of well-being p. 1232).

These findings were confirmed by Rossi and Rosadini (1967). Of patients showing depression, 62% showed it after left injection, only 16% after right injection. Conversely, of patients who showed euphoria, the figures were 75% after right injection, 38% after left i

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38% after left injection. Finally, only 9% of patients showed a depressed *and* euphoric reactions after right-side injection.

Interpretation of the emotional reaction following anesthetization is difficult because the reaction occurs when the anesthetic is wearing off, not when the patient is at the most anesthetized point in the procedure. This raises the question whether the emotional reaction is due directly to the action of the non-anesthetized side or to the "waking up" of the other side. A further complication is that Milner (cited in Rossi & Rosadini, 1967) was unable to duplicate Rossi and Rosadini's findings. In a study of 104 patients, she found no evidence linking depressive reactions to left-sided injections and euphoric reactions to right-sided injections. Davidson (1983) argues that methodological differences between the studies may account for the discrepancies: 1) Milner used a higher dose of sodium amytal, 2) injections were into the common carotid instead of the internal carotid, and 3) her sample included many individuals with early brain damage.

Gainotti's findings suggest a question similar to one in the amobarbital injection studies; namely, does the person's reaction directly reflect the action of the damaged hemisphere or does it reflect a release of inhibition of the undamaged hemisphere? In other words, is the catastrophic reaction associated with a left hemisphere lesion directly due to the brain damage or is it that the left hemisphere lesion destroyed an area responsible for inhibiting the right hemisphere, thus allowing "catastrophic affect" to flow (or disinhibition of) from the right hemisphere? This is a question that one might have supposed that the IAP procedure could address insofar as it eliminates the possibility of the opposite hemisphere from exerting an influence because it is now anesthetized. However, recall that the IAP data are equivocal because the reactions occur

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when the anesthetic begins wearing off so that the question remains as to whether the reaction is due to the unanesthetized side or the "waking up" of the anesthetized side. Therefore, it might be concluded that lesion studies support the valence hypothesis but are inconclusive about the direction because there is no definitive way to determine whether emotional displays represent the patient's reactions to deficits or to the disinhibition of the non-injured hemisphere. However, by applying Hughlings-Jackson's inhibition theory (1874) to Gainotti's findings, the catastrophic reaction after left hemisphere damage can be seen as the result of the left hemisphere's release of inhibition over the right hemisphere. Furthermore, the euphoric reaction after right hemisphere damage would be the result of the right hemisphere's release of inhibition over the left hemisphere. By this view, it could be argued that the left hemisphere leads for the expression and experience of *positive* emotion, the right hemisphere for *negative* emotion. Further support for this notion comes from studies of emotional outbursts during epileptic seizures (e.g., Sackeim, et al., 1982). Regardless of lateralization, they found few reports of seizure-induced crying. Of the cases of ictal laughing episodes, the epileptic focus was twice as likely to be left sides as right sided. This suggests that activation in the area of the seizure activity is associated with laughing episodes and that the left hemisphere is specialized for positive affect.

In addition to the evidence from clinical populations, support for the valence hypothesis comes from mood induction experiments in normal persons. The methods used to induce mood include having subjects watch television programs with varying emotional content (e.g., Davidson, Schwartz, Saron, Bennett, & Goldman, 1979), asking subjects to self-generate emotional states (e.g., Tucker & Dawson, 1984), and observing emotional display

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emotional displays by others (e.g., Davidson & Fox, 1982). Physiological measures such as EEG recordings are taken or changes in facial expression recorded and hemispheric specialization for emotional experience or expression is inferred. Such methods have supported the valence hypothesis. These studies will be discussed in greater detail when anterior asymmetries in emotion are discussed.

While these findings are congruent with the valence hypothesis, several researchers question their validity (e.g., Schiff and Lamon, 1989). They raise the possibility that the cognitive activities that these subjects engaged in as part of the mood induction might have reflected the lateralization for the processing of emotion as well as for the regulation of emotional experience. In other words, these mood induction experiments might represent the perception of emotion rather than (or in addition to) the experience of emotion. Brokmeier and Ulrich (1993) tried to reduce this possibility by inducing happy or sad moods in subjects while taking measurements of asymmetries of their expressive facial movements. In contrast to most other studies of facial asymmetries, they measured direction, rather than intensity, of movement. Their results indicated greater right-sided lifting of the corners of the mouth during positive mood states and greater left-sided lowering during negative mood states. Schiff and MacDonald (1990) found similar changes when composite photographs were created of persons in positive or negative moods. Subjects who performed difficult verbal tasks reported more unpleasant emotions, tested higher on state anxiety, and showed greater changes in left than right-sided composite photographs compared to a relaxed state. Subject who performed easy versions of the task reported more pleasant emotions, tested lower on state anxiety, and showed greater changes in right than left-sided composite photographs com

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photographs compared to a relaxed state. In addition, physiological measures of persons in naturally occurring mood states (e.g., depressed or anxious states) have also been taken, thereby reducing the possibility that changes are due to extraneous influences (Davidson, 1992a, 1992b, 1992c). Such studies will be discussed in later when anterior asymmetries are discussed. Taken together, these findings suggest a valence effect for the expression and experience of emotion.

Other approaches have presented emotional stimuli selectively to each hemisphere and measured emotional reactions. For instance, researchers have presented photographs of emotional faces selectively to one hemisphere (e.g., Davidson, Schaffer, & Saronson, 1985; Natale, Gur, & Gur, 1983), shown films with emotional content to one hemisphere (Dimond & Farrington, 1971; Dimond, Farrington, & Johnson, 1976) and presently painful stimuli to one hand (Schiff & Gagliese, 1994). The results have often been mixed. For instance, Dimond et al. (1976) found that when subjects were asked to evaluate the films for unpleasantness, the right-hemisphere condition yielded more unpleasant judgments than the left, but found no effects for pleasantness. Davidson et al. (1985), on the other hand, found significant differences only for the left hemisphere, namely, that sad pictures were judged as less sad, or more happy, when projected to the left rather than the right hemisphere; there were no significant effects for the happy or neutral pictures. Congruent with the valence hypothesis, Schiff and Gagliese (1994) found that left side pain is tolerated less well than right side pain and results in greater emotional disturbance. In general, these experiments support a valence effect for the experience of emotion, but they often raise the same questions as do the studies mentioned earlier, namely, how well do the stimuli induce mood and do these experiments truly

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In an effort to circumvent these difficulties, Schiff and Lamon (1989) have developed a new method of mood induction whereby each hemisphere can individually be induced. Their method involves the selective contraction of the facial muscles, first on one side, then the other. The assumption is that contracting one side of the face selectively stimulates the contralateral hemisphere and, following the facial feedback hypothesis, can initiate emotions through facial movement (see McIntosh, 1996). In one experiment, subjects simply reported how they felt after each manipulation. After left facial manipulations subjects reported sadness and more positive experiences than after right manipulations. In another experiment, coders blind to condition (left or right facial manipulation) rated the number of emotional propositions (positive, negative, or neutral) used by subjects in telling stories based on TAT cards. Stories told after right facial manipulations were more negative and less positive than those told after left manipulations. Unilateral facial manipulations were also shown to have a similar effect on the expression of ethnic stereotypes as do negative and positive moods induced by other means (Schiff, Esses, & Lamon, 1992). Schiff and colleagues have since shown that such effects are not limited to facial manipulations but also occur using unilateral hand contractions (Schiff & Lamon, 1994; Schiff & Truchon, 1993) and unilateral forced nostril breathing (Schiff & Rump, 1995).

Since publication of Schiff and Lamon's (1989) initial report, only three replications have been reported other than those by Schiff himself (Fogel & Harris, 1998; Kop, Merckelbach, and Muris, 1991; Wissing & Wessels, 1992). Two of these attempts failed, the other f

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failed, the other found only partial support. Wissing and Wessels (1992) were only able to find an effect in men. With female subjects who were asked to evaluate the pleasantness of cartoon faces, Kop, Merckelbach, and Muris (1991) failed to find any effect. However, they did find that increases in reported difficulty of contracting the face and holding it in position was associated with decreases in ratings of the pleasantness of cartoons. Kop et al.'s failed replication led to spirited discourse between the two sets of authors (Kop, Merckelbach, & Muris, 1993; Schiff & Lamon, 1993) with Schiff and Lamon (1993) rightly arguing that the replication was not a true replication and that this may explain the null results. Schiff and Lamon (1993) pointed to numerous inconsistencies in the two methods, including non-alteration of the side of contraction after each manipulation (subjects were assigned to LLLRRR or RRRLLL conditions) and use of different dependent measures (self-report of emotion state after every third contraction and subjective rating of six cartoon figures — one after each contraction — for pleasantness). Following Schiff and Lamon's procedure more precisely, Fogel and Harris (1998) also failed to find an effect for side of contraction in left- and right-handed male undergraduates. Similar to Kop et al. (1993), the self-reported difficulty of performing the contraction was associated with increases in negative mood regardless of side of contraction.

In summary, clinical and experimental studies of *expression* and *experience* offer strong support for the valence-hemisphere hypothesis. The methodologies used to measure possible valences for the expression and experience of emotion encounter similar difficulties in interpretation to those encountered in studies used to support the right hemisphere hypothesis, namely, to what extent do the results reflect pure measures of expression or ex

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expression or experience and to what extent are they contaminated by perceptual processes? However, the fact that valence effects do appear in the face of possible perceptual influences perhaps provides stronger support for the claims made by the valence hypothesis. That is, if the right hemisphere is specialized for the perception of emotion, and if perceptual processes are interfering with valences for experience or expression, then one would expect that such perceptual influences would dampen — not strengthen — possible valence effects. In an attempt to reconcile differences between the right hemisphere and valence hypotheses, Levy (1990), as cited in Borod (1992), has suggested that differential hemispheric specialization as a function of valence may operate when a mood state has been induced, whereas right-hemisphere dominance regardless of valence is more likely to occur when nonverbal processing or social communication is involved. Given the mixed support for both hypotheses, it is safe to conclude that neither hypothesis can adequately explain these conflicting results. More recent evidence has also pointed to the necessity of taking intrahemispheric differences into account, that is, anterior and posterior differences.

Intrahemispheric Specialization for Emotion

With the advent of more precise ways to make inferences about patterns of hemispheric activation, current research is pointing to intrahemispheric differences in emotional processing in addition to interhemispheric differences (see Borod, 1992, for a review). That is, not only are there left-right (interhemispheric) asymmetries in emotional processing, but there are rostral-caudal and cortical-subcortical (intrahemispheric) differences as well. The rostral-caudal distinction contrasts anterior, pre-Rolandic structures (i.e., frontal lobe) with posterior, post-Rolandic structures (i.e., parietal, parietot

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parietal, parietotemporal, or occipital lobe). It is easy to see the many possible interactions that may exist between these regions and the complexity this brings to the study of the neuropsychological study of emotion. The different contributions of rostral and caudal regions to the processing of emotion and the possible communication between these regions are considered in this next section.

Anterior Asymmetries

Evidence for asymmetric contribution of the anterior (i.e., prefrontal) regions of the brain to the processing of emotion comes from both clinical populations and normal subjects. In the first group are patients with unilateral strokes. For example, Robinson, Kubos, Starr, Rao, and Price (1984) studied the relation between lesion location (based on computerized tomography (CT) and magnetic resonance (MR) scan evidence) and the severity of depressive symptomatology. Depression was found in 14 of 22 patients with LH lesions, but in only 2 of 14 patients with RH lesions. Intrahemispheric location also proved to be important. For those 18 patients whose lesions could be classified as either anterior or posterior, 7 of 10 with left-anterior lesions had depression compared to only 3 of 8 with left-posterior lesions, 0 of 6 with anterior lesions, and 1 of 6 with right-posterior lesions. On the other hand, 6 of 14 patients with right hemisphere lesions, but none of the 22 patients with left lesions, showed inappropriate cheerfulness (Starkstein & Robinson, 1988). Frontal lobe lesions have also been found to impair both voluntary and spontaneous expressions (Kolb & Milner, 1981). Furthermore, patients with left-side frontal lesions showed significantly less spontaneous smiling than patients with right-side lesions. In sum, the closer the lesion to the frontal pole (the left in particular), the more severe the depression. These data demonstrate the importance of taking both intrahemispher

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Focusing on specific anterior regions such as the dorsolateral prefrontal cortex, Davidson suggests that asymmetries in these areas also predict depressed versus cheerful emotional states in persons in depressed states without histories of brain damage (e.g., Davidson, 1994, 1993b; Henriques & Davidson, 1990). Using quantitative electroencephalography (EEG) to examine patterns of regional cerebral activation in depression (as defined by high and stable BDI scores), Davidson and colleagues have found that depressed subjects differ from nondepressed subjects in measures of alpha asymmetry in anterior regions (Schaffer, Davidson, & Saron, 1983). Specifically, depressed subjects had less activation than nondepressed subjects in the left frontal region. Using recordings from left and right frontal scalp regions during presentation of happy, sad, and neutral faces to either the left or right visual fields, Davidson, et al. (1985) found similar findings. Davidson (1994) has since hypothesized that the dorsolateral prefrontal cortex may be the area where these anterior asymmetries are most pronounced. Henriques and Davidson (1991) found similar results in clinically depressed subjects.

To examine the degree to which this left frontal hypoactivation in depressives is a marker of the state of depression or a more trait-like characteristic that marks an individual's vulnerability to depression, Henriques and Davidson (1990) compared remitted depressives to healthy controls who were screened for lifetime history of psychopathology. Despite having similar emotional states as controls at the time of testing, previously depressed subjects had less left-sided anterior activation than did never-depresse

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never-depressed subjects. That is, the patterns of anterior activation in previously depressed subjects were similar to patterns found in persons with acute depression and different from persons with no history of psychopathology. This suggests that the decreased left anterior activation that is characteristic of depression remains even when depression is remitted. Davidson and his colleagues interpret these findings as suggesting that "depressogenic" asymmetry patterns may be a state-dependent marker that indexes risk for depression (Davidson, 1992a). That is, following a diathesis-stress paradigm, anterior activation asymmetry (in the direction of lower left frontal activation) may serve as a diathesis that, given the necessary stressors, increases an individual's vulnerability to particular types of emotions and psychopathology. Therefore, although individuals with decreased left prefrontal activation would not be expected to be depressed, they would be expected to show increased levels of sadness in response to specific challenges.

Studies of normal subjects provide additional evidence for the role of the frontal activation asymmetry and its relation to the experience of emotion. For example, in adults, baseline measures of individual differences in frontal activation asymmetry have been shown to be related to how strongly people react to positive and negative emotional challenges, for example, emotional film clips (e.g., Davidson, et al., 1990; Davidson et al., 1979; Tomarken, Davidson, & Henriques, 1990; Wheeler, Davidson, & Tomarken, 1993). Specifically, subjects with greater relative right-sided frontal activation reported more intense negative affect to the negative film clips and subjects with greater left-sided frontal activation at rest reported more positive affect designed to elicit happiness and amusement. These effects were independent of the subject's mood ratings at the time at which

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which baseline EEG were recorded. Using film clips and measures of facial expression, Davidson et al. (1990) report comparable asymmetries in anterior regions.

These patterns are not limited to adults. Similar patterns have been found in infants as young as 10 months when they were divided into groups who cried or did not cry in response to maternal separation (Davidson & Fox, 1989). During the baseline period preceding separation, criers had more right-sided and less left-sided frontal activation than did non-criers. In addition, 10-month-old infants who watched an actress spontaneously generate happy and sad faces showed a higher left to right activity EEG ratio in response to happy than to sad faces (Davidson & Fox, 1982). Still more evidence is found in the relation between individual differences in frontal asymmetry in normal adults and their self-reports of general positive and negative mood (Tomarken, Davidson, Wheeler, & Doss, 1992). Specifically, persons whose EEG data show extreme and stable left frontal activation also report more positive and less negative dispositional affect compared to persons who show the opposite pattern of frontal asymmetry. Taken together these results suggest that baseline anterior asymmetry is a state-dependent measure of affective reactivity, but is itself unrelated to measures of phasic, unprovoked mood.

In sum, evidence from a number of different sources suggests that the anterior regions of the brain are differentially involved in the processing of emotion from other regions and that asymmetries in these areas predict emotional reactivity, psychopathology and temperament. People with brain damage are more likely to show depressed symptomatology after left anterior hemisphere lesions. In addition, depressed persons show left frontal hypoactivation compared to normals. This pattern does not change even when these indiv

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when these individuals no longer exhibit signs of depression, which suggests that such asymmetries may be a state-dependent marker that indexes risk for depression. Further support for this hypothesis come from studies showing that normal adults with greater relative left-sided frontal activation at rest reported more positive affect in response to film clips designed to elicit happiness and amusement. Taken together, it can be concluded that frontal regions are related to the experience of emotion with higher activity in left frontal regions associated with cheerful emotions, and relatively higher activity of the right frontal regions associated with sad or depressed emotions. In addition, according to Davidson's diathesis/stress model, someone with hypoactivation of the left frontal region would be vulnerable to depression given the appropriate environmental conditions. Someone with depression has the biological diathesis (left frontal hypoactivation) and has been exposed to negative environmental stressors. Finally, people with left frontal hypoactivation who are currently nondepressed would be expected to be more vulnerable to depression and to display more intense negative affect in response to situations that elicit negative affect than subjects with the opposite pattern of asymmetry.

Posterior Asymmetries

Having reviewed the evidence for anterior asymmetries, we can now turn to evidence for caudal or posterior regions. The evidence already reviewed on lateralization for the expression and experience of emotion suggests that the direction of the effect depends on the valence of the emotion, with the left and right cerebral hemispheres being specialized for the processing of certain forms of positive and negative affect, respectively. More recent evidence suggests that this lateralized activity is specific to rostral or front

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rostral or frontal regions, possibly the dorsolateral prefrontal cortex, which is specialized for the experience and expression of emotion. Like the evidence for anterior regions, evidence for laterality effects for posterior regions also comes from both clinical and normal populations. First, evidence for the right parietotemporal region's special contribution to the evaluation and perception of emotional information will be summarized. Following this review, the possible relation between frontal and parietal regions will be discussed.

The neuropsychological literature reviewed earlier for the perception of emotion suggests right-hemisphere specialization for the processing of this information. In particular, it appears that the right posterior or parietotemporal region of the brain is associated with the perception, or evaluation, of emotional information (e.g., Luria, 1973). Evidence comes from both clinical and normal populations. Corroborating the right-hemisphere hypothesis, individuals with right-hemisphere lesions have been found to be more deficient than persons with left-hemisphere lesions in recognizing and discriminating emotional tones (Tucker et al., 1977) as well as emotional faces and scenes (Dekosky et al., 1980). However, not all right-hemisphere lesions produced such deficits. Only patients with parietal lesions and/or neglect of the left half of their bodies showed deficits in these two studies. Patients with right-sided nonparietal lesions, who also did not exhibit neglect, were similar to individuals with left-hemisphere lesions in their ability to recognize emotional tone or content in sentences. Perception of faces by patients with right posterior lesions in temporal and parieto-occipital regions failed to show a visual field preference. Normal subjects and persons with left-hemisphere lesions had a left visual field bias (Kolb et al., 1983). Similarly, when patients with right or left tem

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temporoparietal lesions were asked to judge the content of spoken sentences and the emotional mood of the speaker, the two groups performed similarly on content judgments, but the right temporoparietal lesion group was significantly impaired in ability to judge emotional content (Heilman et al., 1975).

Evidence for right posterior involvement in emotion comes from other clinical populations as well, including depressed individuals and persons with organically-based pain syndromes. In a comparison of EEG activity in temporal regions between psychotically-depressed patients and normal controls, Flor-Henry, Koles, Howarth, and Burton (1979) found a bilateral increase in temporal regions in depressed individuals. Furthermore, there was a larger increase in right temporal regions relative to left temporal regions when comparing depressed subjects to controls. Additional evidence comes from two studies by Karlin, Weinapple, Rochford, and Goldstein (1978), as cited in Davidson (1984). The first study involved four right-handed patients suffering from organically based pain syndromes, with the pain being perceived as along the midline of the body, who were exposed to cold pressor pain bilaterally administered. In three of the four cases, temporal activation was significantly greater on the right than the left while patients were resting. When an hypnotic analgesic was administered, a laterality shift toward greater relative left-sided activation emerged. In a second study, the subjects were instructed to recall sad or happy memories while in a hypnotic state. The result was that recollection of sad experiences elicited greater right-temporal activation, as compared with happy experiences. Studies of normal populations provide additional evidence. For instance, using EEG recordings, Davidson and Schwartz (1976) found that the right parietal region was activated in the perception of affective stimuli and that this

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asymmetry in parietal activation did not vary as a function of the valence of the affective stimulus. This finding also supports the right hemisphere hypothesis discussed earlier for the perception of emotion, namely, the right hemisphere is dominant for the perception of emotion regardless of its valence.

Although there is ample evidence to suggest an association between asymmetric activity of the frontal regions and depressed versus happy emotional states, the relation between posterior regions and emotional valence is more controversial. Much of the literature reviewed earlier for the different contributions of the left and right frontal regions to the experience and expression of emotion suggests that these differences are more *specific* to these rostral areas and are largely unrelated to other areas such as parietal regions. Recall Robinson et al.'s (1984) findings that depression far more often was associated with anterior lesions than posterior lesions. In addition, measures of asymmetry from posterior scalp regions obtained in Tomarken et al.'s (1990) and Wheeler et al.'s (1993) studies of emotional reactivity to film clips were unrelated to measures of affective responding. Using similar film clips along with measures of facial expressions, Davidson et al. (1990) also found no asymmetries for parietal regions. Davidson and Fox (1989) reported similar findings in their study of the responses of infants to maternal separation, that is, posterior EEG recordings did not differentiate the responses of criers and non-criers. Davidson and Fox (1982) also found that parietal leads did not discriminate between emotional conditions in their sample of 10-month-old infants exposed to a happy and sad spontaneous facial expressions. Finally, in Tomarken et al.'s (1992) study of the self-report of dispositional positive and negative mood in normal subjects , measures of asymmetry from posterior scalp regions were also unrela

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unrelated to reports of mood. The finding that parietal lead activity in the above-named studies did not show changes between emotional conditions should not be interpreted to mean that parietal areas are uninvolved in the processing of these emotions. A more appropriate interpretation based on the literature reviewed for the right hemisphere hypothesis would be that the right parietal region is involved in the processing of negative as well as positive emotions. Often, significance tests are performed only on relative differences between left- and right-hemisphere activation or on group differences, not on overall changes in a particular area. However, when EEG data are reported for overall parietal activation (e.g., comparisons in parietal leads between pre- and post-mood states), subjects show right-sided activation for both positive and negative conditions (e.g., Davidson et al., 1979; Davidson & Schwartz, 1976).

Taken together, the findings reported above indicate that the valence-related asymmetry in the experience and expression of emotion is specific to anterior brain regions. However, in addition to the typical frontal asymmetries discussed earlier, a number of studies have found asymmetric patterns in posterior regions during depressed versus cheerful emotional states. Furthermore, where posterior asymmetries are found, similar patterns of activation emerge, namely, posterior activity is reciprocal to frontal activity when depression is compared to cheerful emotions. That is, studies that demonstrate higher right than left frontal activity in depressed persons also find a pattern of lower right than left posterior activity.

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Conclusions

From the evidence reviewed thus far, several conclusions can be drawn. First, when examining asymmetries for the perception, expression, and experience of emotion, hemispheric activation cannot be seen as unitary and homogeneous. The reason is that there are not only interhemispheric asymmetries but intrahemispheric distinctions as well. The evidence suggests that activity in the frontal region is related to the experience and expression of emotion. Simultaneous measures of activation asymmetries from posterior cortical regions are not reliably associated with either dispositional mood or phasically aroused emotion. However, asymmetries in certain posterior cortical regions, particularly the parietal region, appear to be related to the perception of emotional information, particularly facial expressions of emotion. The studies of asymmetrical parietal lobe involvement in the perception of emotional information have, for the most part, suggested right hemisphere dominance for the perception of both positive and negative emotion. Thus, whereas the left and right frontal regions appear specialized for the processing of certain positive and negative emotions respectively, the right parietal region has been implicated in the perception of emotional cues regardless of valence. This pattern of results again shows the importance of differentiating among subcomponents of emotion (perception, expression, and experience) and suggests that the perception and experience of emotion may be mediated by different processes. The possible processes involved in the perception and experience of emotion are reviewed below.

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Models for Intrahemispheric and Interhemispheric Interactions in Emotional Processes: Implications for Understanding Psychopathology

The literature reviewed so far suggests interhemispheric as well as intrahemispheric differences in emotional processing. The two main hypotheses regarding hemispheric specialization for emotion — the right hemisphere hypothesis and the valence hypothesis, however, only address the first kind of difference, namely, interhemispheric. Several additional models have been developed to account for the second kind, the intrahemispheric. Three such models are reviewed in this next section: 1) a model to explain mood disturbances after stroke based on noradrenergic pathways and catecholamine; 2) Davidson's (1984) model of differential specialization for frontal regions and their relation to approach and withdrawal behavior and psychopathology, and 3) Heller's (19990, 1993) model, an elaboration of Davidson's model to include interactions between frontal and right parietotemporal regions. Because the current study is based on Heller's elaborated model, both her model and Davidson's will be described in detail.

Model 1: A Possible Role for Noradrenergic Pathways and Catecholamine

In an attempt to explain lateralized emotional responses to stroke and why anterior lesions produce more severe mood disturbances than posterior lesions, Starkstein and Robinson (1988) point to the anatomy of noradrenergic pathways in the brain and propose a role for catecholamine-containing neurons. They present several lines of evidence in support: 1) norepinephrine and serotonin-containing pathways arise from the brainstem, project anteriorly into the frontal cortex, pass anterior to posterior, and then travel deep through the cortical layers with arborizations into more superficial layers;

2) strokes and other focal injuries may cause partial damage to catecholamine-containing neurons and reduce catecholamine concentrations; 3) when catecholaminergic neurons are injured, they may switch from producing neurotransmitter to synthesizing protein for neuron regeneration; and 4) focal cortical lesion can produce widespread depletions of biogenic amine neurotransmitters through injured as well as uninjured regions of the brain. Thus, the widespread depletion of norepinephrine that occurs throughout the brain after stroke may be expressed as major depression or as cheerfulness and apathy. Since the ascending noradrenergic pathways pass through the frontal pole, this might explain why anterior lesions produce more severe mood disorders. That is, since noradrenergic axons branch out as they pass anteriorly to posteriorly through the layers of cortex, an anterior lesion would interrupt these pathways in a more "upstream" position and therefore cause far greater disruption of transmitter concentrations than a posterior lesion which would be more "downstream." Robinson and his colleagues have found evidence for this "graded effect" in animal models. To these observations, Davidson (1984) adds that the frontal lobes have more extensive reciprocity with limbic structures than any other cortical regions. Thus, it should follow that frontal lobe lesions would be associated with deficits in affect.

To explain lateralized differences in emotional response to left-anterior brain injury (i.e., depression) as compared with right-anterior brain injury (i.e., cheerfulness, indifference, and apathy) the authors suggest that type of biochemical response to injury may depend on side of lesion. To support this suggestion, the authors cite evidence from their lab indicating that right middle cerebral artery ligation leads to depletions in ipsilateral and contralateral levels of norepinephrine in both the cortex and locus coeruleus whereas similar left middle cerebral artery ligation does not lead to changes in catecholamine levels. Thus, right hemisphere lesions may lead to a widespread depletion of norepinephrine concentrations leading to inappropriate cheerfulness and apathy while left hemisphere lesions (possibly due to the depletion of another neurotransmitter such a serotonin) may lead to depression.

Model 2: Davidson's Frontal Model: Approach and Withdrawal Systems

Davidson questions the positive-negative dichotomy as the essential basis for affective asymmetry and believes that an alternative explanation is more parsimonious. Based on his EEG studies of frontal asymmetries in the experience and expression of emotion, he has proposed that such asymmetries may be explained instead in terms of two basic circuits, the approach and withdrawal system, each mediating different forms of motivation and emotion (e.g., Davidson, 1992a, 1993b, 1994). Davidson argues that approach and withdrawal are two dimensions along which emotions differ, dimensions which he also argues are basic. They are basic because organisms approach and withdraw at every level of phylogeny where behavior itself is present. Observing that forms of approach and withdrawal occur in very phylogenically primitive organisms with simple nervous systems, Davidson maintains that the decision to approach or withdraw is a fundamental adaptive strategy. Such species do not possess the neural circuitry essential for the production of emotional responses (Davidson, 1992a). Given their simple nervous systems, simple forms of approach and withdrawal behaviors occur in the absence of any emotion. It is important to distinguish between these simple forms of approach and withdrawal behavior and approach and withdrawal behaviors that appear in the context of emotion. Thus, over the course of evolution, approach and withdrawal action emerged prior to the appearance of emotions to solve adaptive problems of primitive species. As environments began to demand more complex adaptive strategies for survival, coordination among perceptual, cognitive and action systems was required. Emotions evolved and became associated with already established approach and withdrawal action systems. A growing body of evidence suggests that approach- and withdrawal-related systems are localized in different hemispheres, with the left frontal region implicated in approach-related behavior and the right frontal region in withdrawal-related emotional behavior. Davidson (1993) believes that there is a logical evolutionary rationale for the separation of the approach and withdrawal systems to the left- and right-hemispheres, respectively, namely, that it minimizes interaction between the two systems.

The approach system facilitates appetitive behavior and produces certain types of positive affect that are approach-related (e.g., enthusiasm, pride). This form of approach-related positive affect is usually generated in the context of moving toward a goal. Davidson (1994) hypothesizes that the dorsolateral prefrontal cortex, particularly the left side, is where the representation of a goal state in working memory is implemented. Unlike the valence hypothesis, the activation of this approach system is not believed to be responsible for all forms of *positive* emotion. Instead, it is hypothesized to be associated with *pre-goal attainment positive affect*, or the form of positive affect that precedes the acquisition of an appetitive goal. According to Davidson (1994), *post-goal attainment positive affect* is a different form of positive emotion that is not associated with activation of the dorsolateral prefrontal cortex. This latter type of positive affect is likely to be experienced as contentment after a desired goal is achieved so that no more demand is being placed on the prefrontal cortex. There are individual differences in the approach

system that are believed to play a role in modulating vulnerability to depression. Based on his studies of individual differences in reactivity to films, vulnerability to depression, and temperament, Davidson (1994) posits that individual differences in the tonic level of activation of the approach system alters a person's propensity to experience approach-related positive affect. These differences will be discussed in detail later when we discuss vulnerability to psychopathology.

The withdrawal system facilitates the retraction of an individual from sources of aversive stimulation and generates certain forms of negative affect associated with the withdrawal from aversive stimuli. Fear and disgust are both examples of emotions that are associated with increasing distance between the organism and a source of aversive stimulation. The emotion, anger, is an example of an emotion that can be associated either with approach movements (e.g., attack) or withdrawal. According to the valence hypothesis, fear, disgust, and anger would all be negatively valenced emotions and, thus, the right hemisphere would be hypothesized to be dominant for its expression and experience. According to Davidson's model, on the other hand, the right frontal region would be activated only during negatively valenced *withdrawal* states (e.g., ; Davidson, et al., 1990; Tomarken et al., 1992). In addition, citing Ledoux's (1987) work, Davidson (1994) believes the amygdala and temporal pole to be critically involved in this withdrawal system as well as the basal ganglia and hypothalamus in the motor and autonomic components.

To further explain possible frontal lobe participation in the processing of emotion, Davidson (1993) proposes that the integration among the various components of emotion (e.g., perceptual, cognitive, and action systems) must occur in some type of convergence zone. He believes the frontal lobes to be a likely candidate because of their functional characteristics and inputs. In particular, Davidson focuses on the orbital prefrontal cortical areas and the input they receive from subcortical sites. Specific amygdaloid nuclei (e.g., the basal nucleus) project to the lateral orbital prefrontal cortex, suggesting that the prefrontal cortex receives already processed input because most sensory input arrives at the lateral nucleus. The prefrontal region also sends inputs to the basal nucleus and other amygdaloid nuclei. In addition, there are connections within the prefrontal area so that orbital and dorsolateral regions are interconnected. The prefrontal cortex, in turn, has anatomical reciprocity with the medial parietal cortex. In sum, the prefrontal cortex communicates with posterior (perceptual processing) regions and with subcortical areas that directly participate in the emotional biasing of sensory input. Projections from the amygdala provide the prefrontal cortex with information about emotional processing, and the prefrontal region can in turn influence the amygdala to bias the emotional processing of sensory input.

Davidson (1994) acknowledges that his account of the prefrontal cortex's role in the processing of emotion remains speculative and that studies using instruments that are more sensitive to subcortical structures must first be conducted in order to ferret out these mechanisms. While the EEG has the advantage of being noninvasive and relatively inexpensive, it has the disadvantage of having poor spatial resolution. That is, while the procedure can be used in broad regional localization, it lacks the precision necessary for more fine-grained functional anatomic studies. Thus, Davidson concedes that it is not entirely clear whether the changes are due to changes in right frontal activation or to r

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volume conducted from other cortical loci. Davidson also recognizes that his use of scalp measures only provides information about cortical activity, not subcortical activity.

The nature of the relationship between Davidson's two hypothesized systems remains to be delineated. However, Davidson has suggested that one function of positive affect (i.e., the activation of the approach system via the left dorsolateral prefrontal cortex) is to inhibit concurrent negative affect (i.e., the withdrawal system). Evidence for this possibility comes from at least two recent studies. For instance, in a study examining individual differences in repressive-defensive coping styles, it was shown that subjects with extreme left frontal activation show a pattern of scores on psychometric measures consistent with repressive defensiveness, a dispositional tendency to inhibit negative affect, and score lower on measures of depression and anxiety (Tomarken & Davidson, 1994). This suggests that increases in left frontal activation may be linked to a "self-enhancing regulatory style" that decreases one's vulnerability to depression. In another study, Davidson, Donzella, and Dottl (1994) found that subjects with greater left-sided frontal activation also showed increases in suppression of a defensive reflex (the startle) following the presentation of a positive affective stimulus compared to subjects who showed more right-sided frontal activation. Based on these findings Davidson and his colleagues suggest that in individuals with left frontal activation, exposure to positive emotional stimulus produces more enduring effects than in subjects with the opposite asymmetry pattern.

Davidson has also extended the examination of relationships between individual differences in anterior asymmetry and emotion to psychopathology. According to his model (e.g., Davidson, 1993), decreased left prefrontal activation reflects an underactivation of an approach-related system and should therefore decrease an individual's likelihood to experience pleasure and to develop positive relations with one's environment, thus increasing the likelihood of developing depressive symptoms. As has been reviewed earlier, data from a variety of populations including the clinically depressed, remitted depressed, and persons with different temperaments have provided support for his model. That is, subjects with increased right-sided anterior activation have been shown to have increased vulnerability to emotions, moods, and psychopathology associated with withdrawal (e.g., Wheeler, et al., 1993; Tomarken, et al. 1990). Such individuals have been shown to be more vulnerable to the emotions of fear and disgust, express more dispositional negative affect, and be more vulnerable to anxiety disorders (anxiety disorders will be discussed later; e.g., Davidson, Henriques, Tomarken, & Marshall, 1994, as cited in Davidson, 1994). In addition, individuals with decreased activation in left anterior regions have been shown to be more vulnerable to those emotional states and traits, such as depression, that are associated with deficits in approach-related activation (Henriques & Davidson, 1990, 1991; Schaffer, et al., 1983). Taken together, Davidson's findings suggest that certain individuals possess certain frontal asymmetries (diatheses) which not only lower their capacity to experience pleasure, but increase their capacity to be affected by life's displeasures (stressors).

Curiously, Davidson does not attempt to include right parietotemporal functioning in his model of emotion and brain organization, perhaps because his EEG studies have not consistently observed asymmetric activity over the parietotemporal regions (e.g., Davidson, 1992). However, recall that data from several studies (including data from Davidson's lab) indicated asymmetries in both frontal and posterior regions. In addition, when these asymmetries were found, they consistently showed an inverse relation between anterior and posterior regions during depressed versus cheerful emotional states (e.g., Davidson, et al., 1985; Schaffer, et al., 1983; Henriques & Davidson, 1990). Despite Davidson's (1984) observation that "reciprocal relations between frontal and parietal asymmetry may be crucial for at least certain affect/cognition interactions" (p. 320) and data from depressed populations which substantiate his claim, posterior regions are still not emphasized in Davidson's model. Davidson does suggest that this pattern of posterior asymmetry is associated with the selective spatial cognitive deficits associated with depression and that certain right-sided posterior activation may directly contribute to certain symptoms of depression, such as poor orienting and deficits in social skills which require the decoding of nonverbal, expressive behavior (Davidson, Chapman, & Chapman, 1987). Additionally he hypothesizes that asymmetries along the anterior/posterior plane "may differ in functional significance and show opposite patterns of activation [and lead us] to consider the possibility of reciprocal interaction between asymmetries in anterior and posterior cortical regions" (Davidson, 1984, pg. 320). However, later revisions of Davidson's model continue to focus on anterior asymmetries without expanding on his initial speculations about "reciprocal interactions" between anterior and posterior regions. Recognizing that few attempts have been made to explain how posteriors regions may be integrated with anterior regions in the processing of emotional information, Heller (1990, 1993) proposes a model to account for how these systems might be integrated. Because it is also the model examined in the current study, it will be described in detail.

Model 3: Heller's Model: An Integration of Frontal and Parietal Functions

Heller (1990, 1993) has recently proposed a model of emotion and brain organization which suggests that parietotemporal regions of the right hemisphere of the brain are not only specialized for the processing of emotional information, but that such regions are also intimately involved with frontal regions and, thus, play a critical role in the experience of emotion. Heller's model attempts to incorporate several aspects of emotional function including the perception and production of emotional information, mood and emotional experience, and autonomic arousal. In this section, the basic tenets of Heller's model are summarized, evidence for the right hemisphere's involvement in arousal is discussed, and the relation between individual differences in arousal and psychopathology is examined.

A Summary of the Model

Heller's model of emotion and brain organization begins with the supposition that valence (pleasant or unpleasant) and arousal (high or low) are two basic dimensions of emotional experience, citing evidence from factor analytic studies which have consistently borne this out (e.g., Lang, 1985; Russell, 1980). Using valence and arousal as two axes, it is possible to locate, or define, all emotions within these four regions. Examples provided by Heller include happiness which would be characterized by pleasant valence and high arousal and its opposite, sadness/depression, which would be characterized by unpleasant valence and low arousal. Heller believes that these two axes, valence and arousal, are also reflective of underlying neural circuits. That is, there are two systems involved in the organization of emotion: 1) the frontal lobes, involved with the modulation of valence (per Davidson's model), and 2) the right parietotemporal region, involved with the modulation of autonomic and behavioral arousal. Rather than any one region of the brain being specialized for a particular class of emotions, emotional states are seen as being associated with the relative activation of these brain regions in reference to each other (see Figure 2). For instance, higher activation of the right parietotemporal region is associated with higher autonomic arousal and activation of the right frontal region with a bias toward a positively valenced emotional state. Based on the interactions of these two systems, this model makes some specific predictions about patterns of regional brain activity and the emotional states that should occur as a result. For example, happiness is an emotion which, according to factor analytic studies, should involve a positive valence and high arousal. According to Heller's model, happiness would also entail relatively higher activation in the left frontal region and relatively higher activation in the right parietotemporal region. Depression, on the other hand, involves a negative valence and low arousal. Thus, it should also involve relatively higher right frontal activation and relatively lower right parietotemporal activity.

Although Heller's model returns to the positive-negative valence dichotomy, she believes that it is not incompatible with Davidson's approach/withdrawal dichotomy. Heller argues that the findings of Davidson and his colleagues can easily be defined along (or translated to) a valence dimension. Furthermore, Heller (1993) believes that her model "expands on that of Davidson and his colleagues by arguing that the right posterior region plays a role in modulating emotional states that is not adequately described by its function specialization for evaluating and interpreting emotional information" (p. 479). Heller's model also avoids correlating specific emotions with specific areas of the brain (see the brain lesion literature reviewed for the valence hypothesis). Rather emotional

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states are viewed as being associated with a particular pattern of regional brain activity. This means that left frontal areas are not viewed as being "specialized" for positive emotion, nor are right frontal areas viewed as "specialized" for negative emotion. Instead, certain emotion states are associated with the relative activation of these areas to each other. As Heller point out, this means that any factor that influences this relative activation will also have an impact on one's emotional state. Heller's model also differs from the right hemisphere hypothesis and its supposition that there is a right hemisphere advantage in processing emotional experiences in general. Heller's model posits that the ability to process emotional information is separate from the experience of emotion and is a more dependent, "hard-wired," specialized processes in the right posterior region. The experience of emotion, on the other hand, is a more dynamic system located in the left and right frontal regions. In sum, Heller's model diverges from other models in three major ways: 1) it includes right parietotemporal regions; 2) it avoids attributing specific emotional qualities to a particular area in the brain; and 3) it diverges from the right hemisphere hypothesis.

Evidence for Heller's Model

As already noted, Davidson and Heller's models are identical with respect to asymmetries in frontal regions, so the evidence for asymmetries in frontal regions already reviewed for Davidson's model applies equally for Heller's model. Where the models differ is in regard to the importance of the right parietotemporal region, where, by Heller's model, it is involved in the modulation of autonomic and behavioral arousal. To demonstrate that the posterior region of the brain plays an important role in the modulation of emotion, we now turn to a review of the relationship of the right hemisphere to autonomic, spatial attention, and behavioral arousal.

Arousal depends on the brainstem reticular formation, nonspecific thalamic nuclei, and certain regions of the neocortex. Furthermore, there is evidence that the right hemisphere plays a dominant role in the modulation of autonomic arousal during both emotional and nonemotional conditions (for reviews, see Cernacek, 1992; Wittling, 1990). For instance, to determine whether individuals with left or right hemisphere lesions had normal arousal, Heilman, Schwartz, and Watson (1978) stimulated the non-effected side with an electrical stimulus while recording galvanic skin responses, a measure of peripheral sympathetic activity that is also a reliable measure of arousal. Patients with right-hemisphere lesions had significantly smaller galvanic skin responses (indicating hypoarousal) than patients with left-hemisphere lesions or controls. Their data also suggested that persons with left-hemisphere lesions might be hyperaroused. Presenting neutral and emotionally laden stimuli to persons with right- or left hemisphere lesions, Morrow, Urtunski, Kim, and Boller (1981) found similar galvanic skin responses. Such arousal asymmetries are not limited to measures of peripheral sympathetic activity. Wittling (1990) observed vegetative associated phenomena of emotions and found that systolic and diastolic blood pressure was higher when films containing a positive emotional content were projected to the left visual field (right hemisphere) than when it was projected to the right visual field. Similar differences have been found when looking at endocrine functions. When a film with negative emotional content was projected to the right hemisphere, the excretion of salivary cortisol was significantly higher than projection of the same film to the left hemisphere. Films with neutral content did not produce such an effect (Wittling & Pflüger, 1990).

A wealth of evidence also suggests that the right hemisphere plays an important role in spatial attention (for review, see Heilman, Chatterjee, & Doty, 1995). Based on this evidence many investigators, such as Heilman, have suggested that the right hemisphere is more intimately involved with subcortical systems that are responsible for arousal and intention. That is, the right hemisphere is dominant not for attention alone but also for mediating responses to excitatory impulses and for preparing for action in both halves of the body (e.g., Heilman & Van den Abell, 1980). This notion is supported by observations that damage to the right parietal region can lead to unilateral neglect, a syndrome in which patients ignore the left half of space (Heilman, Watson, & Valenstein, 1985). Sackeim et al. (1983) observed a more pronounced neglect of the left visual space after administering ECT. ECT administered bilaterally or on the right side alone caused a left side neglect to the same degree. Thus, it is the right hemisphere which, after an electroconvulsion applied to both sides or to the right side alone, is responsible for left side neglect.

While there is a comprehensive literature supporting the role of the right hemisphere in processing emotional and spatial information and spatial attention, the relation between right- and left-hemisphere function and autonomic arousal has not been examined as extensively (Heller, 1993). Based on the evidence reviewed thus far, it could be argued that the right hemisphere is not specialized for the modulation of arousal, but that such differences simply reflect the right hemisphere's superiority for interpreting and evaluating emotional information. However, more recent evidence supports this is not the case, but instead shows that perceptual asymmetries on a free-vision task of face processing, the Chimeric Faces Task are related to self-reported behavioral arousal (Heller, Lindsay, Metz, and Farnum, 1991). This study capitalized on previous research demonstrating that the Chimeric Faces Task can be used as an index of perceptual asymmetries with considerable reliability[7] (Levy et al., 1983a), the observation that there are considerable individual differences in perceptual asymmetries, and that these individual differences can also account for approximate half the variance in asymmetry scores on other measures in both the visual and auditory modality[8] (e.g., Green, Morris, Epstein, West, & Engler, 1992; Kim & Levine, 1991; Levy, Heller et al., 1983b). Indeed, Heller et al. (1991) found that scores on the Chimeric Faces Task were highly correlated with a self-report measure of behavioral arousal (DeWit & Griffiths, 1991) derived from the Profile of Mood States (McNair, Lorr, & Droppleman, 1981). That is, as relative right-hemisphere activity increased (as measured by the Chimeric Faces Task) so did a person's self-reported experience of behavioral arousal. These results suggest that the right hemisphere is specialized for arousal beyond the processing of emotional information because an independent measure of the experience of arousal was also highly correlated with the Chimeric Faces Task.

If right hemisphere activity covaries with autonomic arousal in a linear fashion, and if emotions are associated with particular patterns of autonomic arousal, Heller

[7] An asymmetry score on the CFT is calculated by subtracting left-face-smiling choices from right-face-smiling choices and dividing by the number of stimulus pages presented. Thus, the more negative the score, the greater the left hemispatial bias, and the more positive the score, the greater the right hemispatial bias. The more individuals are biased toward the left side of space, the more inferred right hemisphere relative to left hemisphere activity and vice versa.

[8] For instance, Levey et al. (1983b) found that individuals with left visual field biases on the Chimeric Faces Task performed also performed better on tasks that require more right hemisphere involvement (e.g., face perception). Individuals with right visual field biases, on the other hand, performed better on tasks that require more left hemisphere involvement (e.g., tasks that require language skills).

(1990) posits that higher right-hemisphere activity should be associated with emotional states accompanied by high autonomic and behavioral arousal (e.g., anxiety) and lower right-hemisphere activity with emotional states accompanied by low autonomic and behavioral arousal (e.g. depression) (see Figure 2). That is, anxiety and depression may be associated with opposite patterns of activity in the right parietotemporal region. Evidence for right hemisphere activity in depression and anxiety is reviewed below.

Depression. Evidence for reduced parietotemporal functioning in depressed patients comes from a number of sources. Recall the earlier discussion of EEG activity in depressed persons collected by Davidson and his colleagues suggesting reduced right parietotemporal activation (Davidson, et al., 1987; Davidson, et al., 1985; Schaffer et al., 1983; Henriques & Davidson, 1990). In addition to those studies already reviewed, clinically depressed patients and persons in depressed moods have also been shown to be impaired on tasks that are sensitive to right hemisphere functions generally (e.g., Otto, Yeo, & Dougher, 1987), and right parietotemporal function specifically (e.g., Heller, 1993). Right hemisphere dysfunction in depressed individuals can be inferred on the basis a number of findings. Greater improvement in mood following right hemisphere ECT relative to left hemisphere or bilateral ECT suggests lateralization of depressive affect (Deglin & Nikolaenko, 1975). In addition, Kronfol, Hamsher, Digire, and Waziri (1978) found increased performance on neuropsychological tests sensitive to right hemisphere dysfunction following ECT that successfully decreased depression. Further evidence for right hemisphere dysfunction comes from mood induction studies. Method actors, asked to generate emotions of depression, exhibit greater alpha suppression over the left hemisphere than the right. Furthermore, during sad mood states, diminished performance of the right but not the left hemisphere is observed (Tucker and Dawson, 1984). After induction into a depressed mood, but not after induction into a euphoric mood, normal individuals exhibit a deficit in visual imagery and a right-ear attentional bias on a tone judgment task (Tucker et al., 1981). Subjects induced into a sad mood before performing a light detection task manifested significantly greater increases in reaction time to left visual field than right visual field trials relative to the baseline condition of just detecting the spot of light alone (Ladavas, Nicoletti, Umilta, & Rizzolatti, 1984). On a digit-matching task, subjects induced into a depressed mood exhibited poorer performance than subjects induced into a neutral mood on right- but not left-hemisphere trials (Banich, Stolar, Heller, & Goldman, 1992).

Depressed persons have also shown specific deficits in right parietotemporal functioning. For instance, depressed patients when engaged in a repetitive learning task, exhibit a selective decrease of blood flow to right temporal and parietal regions (Wood & Flowers, 1988). Further evidence for right temporal region dysfunction in depressed persons comes from studies which have found that depressed persons showed left-ear deficits on a number of different dichotic listening tasks (Berger-Gross, Bruder, Quitkin, & Goetz, 1985; Bruder, Sutton, Berger-Gross, Quitkin, & Davies, 1981; Johnson & Crocket, 1982). In addition, Sackeim, Decina, Epstein, Bruder, and Malitz (1983) report the case of a bipolar patient who when presented with a dichotic listening task, showed low right parietotemporal activity during a depressive episode, and relatively high right temporoparietal activity during a hypomanic episode. Evidence also comes from studies involving facial perception tasks — tasks that involve right parietotemporal regions (e.g., DeKosky et al., 1980; Kolb et al., 1983). For instance, in a comparison of depressed and nondepressed

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nondepressed individuals on the perception of chimeric faces, Jaeger et al. (1987) found that depressed persons were significantly less lateralized than controls. Also using a chimeric faces task, Heller, Etienne, and Miller (1995) reported similar findings in a sample of over one thousand college students. Most recently, Bruder, Fong, Tenke, et al. (1997) found that EEG measures of parietotemporal activity in nonanxious depressed patients showed less activation over right than left posterior sites. There is also preliminary evidence suggesting that differences in perceptual asymmetries in depression depend on its diagnostic subtype (Bruder, Quitkin, Stewart, Martin, Volmaier, & Harrison, 1989). Persons who met DSM-III criteria for melancholia also showed abnormal perceptual asymmetries on dichotic listening tasks with an abnormally large right-ear advantage for a verbal task and a right-ear advantage for complex tone task. In contrast, persons with atypical depression (marked by reactivity of mood with preserved pleasure capacity) did not differ from normal controls. Taken together, these findings suggest a suppression of right-hemisphere function in depression and the possibility for different patterns of perceptual asymmetries depending on the type of depression.

Anxiety. While anxiety is often a common clinical feature of depressive disorders, evidence is pointing to very different abnormalities of hemispheric asymmetry in anxiety and depression (e.g., Bruder et al., 1997; Heller et al., 1995). Not only do patterns of hemispheric activity vary as a function of depression, but as a function of anxiety as well. The data for anxiety, however, are less consistent. Evidence for the hypothesis that anxiety is associated with reduced left- and increased right-hemisphere activity does, however, come from a number of sources. Several studies, using a variety of imagining techniques, have found increases in right parietotemporal regions in anxious states (e.g., B

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states (e.g., Bruder et al., 1997; Naveteur, Roy, Ovelac, & Steinling, 1992). Clinical populations also provide evidence. For instance, Davidson, et al. (1994), as cited in Davidson 1994, compared the brain activity of persons meeting diagnostic criteria for social phobia and control subjects while they anticipated making a public speech. The phobics showed a large increase in activation from baseline in the right anterior temporal region during the anticipation period compared to control subjects.

The evidence for brain activity in anxious individuals does not always point to right hemisphere hyperactivity. For instance, patients diagnosed with obsessive-compulsive disorder (an anxiety disorder) were found to show abnormalities on a dichotic listening task, suggestive of left hemisphere dysfunction (Wexler & Goodman, 1991). Similarly, patients diagnosed with dysthymic disorder showed a left visual field deficit, while patients diagnosed with generalized anxiety disorder tended to have the opposite visual field asymmetry (Liotti, Sava, Rizzolatti, & Caffarra, 1991). Carter, Johnson, and Brokervec (1986) also reported greater left hemisphere activity in brain activity in persons who were currently in states of worry. These results are indicative of increases in left hemisphere activity. Still other studies find no evidence of asymmetries in anxious states. For instance, in an experiment of experimentally induced phobias, Fredrikson, Gustav, Greitz, et al. (1993) report no evidence of asymmetries. Similarly, when comparing the frequency of anxiety during an attack of temporal lobe epilepsy, Altshuler, Devinsky, Post, and Theodore (1990) found the rates to be equal in patients with right-side and left-side foci. It should be noted, however, that this sample included both persons who exhibited depression and those that did not in their analyses. As can be seen from a revie

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Heller raises the possibility (Heller 1990, 1993) that anxiety and depression may be associated with opposite patterns of activity in specific regions of the cerebral hemispheres, one area being the right parietotemporal lobe. To the extent that persons with symptoms of depression also have symptoms of anxiety or vice versa, this then raises the possibility that any differences between depressed and anxious persons in perceptual asymmetries may be washed out depending on the ratio of one to another (Heller et al., 1995). Recent research is beginning to support this proposition. When anxious and/or depressed persons are considered separately (Heller et al., 1995), differences in perceptual asymmetries between the two groups appeared in the direction predicted by Heller's (1990) model. However, Heller et al. (1995) did not find support for her model's prediction that high anxiety in the absence of depression would be associated with relatively larger left hemispatial biases compared to controls. She speculates that these null findings may have been due, in part, to the type of anxiety that was examined. The measure of anxiety Heller used was the State-Trait Anxiety Inventory Trait-Anxiety Scale. Heller and her colleagues argue that this type of anxiety might be more reflective of a ruminative anxiety (e.g., verbal rumination or cognitive worry), a type of anxiety which they believe may not be related to right-hemisphere activity, but rather left-hemisphere activity. As Heller et al. (1995) observe, researchers who have found higher right-hemisphere activity in anxious states have focused on states of panic (e.g., Reiman, Raichle, Butler, Herscovitch, & Robins, 1984), while researchers who have not have tended to focus on anxious states of worry (e.g., Reiman, Fusselman, Fox, & Riac

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Fox, & Riachle, 1989). The importance of distinguishing among subtypes of anxiety fits in well with Davidson's proposed approach-withdrawal dichotomy. While it is difficult to conceptualize ruminative anxiety as either approach or withdrawal (it instead appears to be related to inactivity or being "stuck"), it is quite possible to hypothesize that panic and fear (and its relation to withdrawal) are associated with posterior right-hemisphere functions.

So far, such differences have been demonstrated using a chimeric faces task with college students classified as either low or high anxious and/or depressed (Heller et al., 1995) and through EEG measures of brain activity in major depressives with or without an anxiety disorder (Bruder et al., 1997). Neither study, however, examined possible handedness differences, a focus of the current study.

Hemispheric Specialization for Emotion in Right- and Left-Handers

So far we have reviewed the evidence for several models pertaining to the organization of emotion. Let us turn now to studies that compare right- and left-handers on tasks similar to those already cited. These studies are divided into two groups: 1) studies that compare right- and left-handers on presumptive tests of emotion, and 2) laterality studies, like those reviewed earlier, that compare right- and left-handers on tests of the perception and expression of emotion.

Studies of Handedness and Psychological Tests of Emotion

The literature on emotional/psychological differences between right- and left-handers includes tests of emotional stability, anxiety, and temperament. One of the earliest such comparisons was reported by Ingram and Reid in 1956 (cited in Orme, 1970). They found a high incidence of left-handedness and emotional disturbances in children with

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children with developmental aphasia but with normal intelligence (ages not given in Orme's report). Later, Orme (1970) made a similar investigation in 300 non-aphasic British school girls, ages 14-17. Of these adolescents, 23 were left-handed, 277 were right-handed, as measured by the hand used for writing. Emotional stability was measured by a 13-item questionnaire created by Orme (1965). Using a chi-square test, Orme concluded that the left-handers were significantly more emotionally unstable than the right-handers. Indeed, only one left-hander (4.3%) scored in the emotionally stable range compared to 89 (32.1%) of the 277 right-handers. Hicks and Pellegrini (1978) questioned Orme's data analysis, however, on the grounds that he violated the rule pertaining to the minimum number of cases per cell in a contingency table and that because the emotional stability scale score Orme computed was a parametric statistic, a more powerful statistic should have been used to measure the strength of effect.

Only a few studies have focused on possible links between handedness and anxiety. Hicks and Pellegrini (1978) compared 23 left-handed, 12 mixed-handed, and 35 right-handed college students on the Taylor Manifest Anxiety Scale (1953). Right-handers were significantly less anxious than either left- or mixed-handers, who were not different from each other. The relation between anxiety and handedness was also examined by Mueller, Grove, and Thompson (1993), who drew on archival data from four studies. In each study, handedness was based on self-report of hand-writing preference, and anxiety was measured by the Test Anxiety Inventory (TAI; Spielberger, 1980). The total number of subjects across the four samples was 166 left-handers and 1,388 right-handers. No significant differences were found between the two groups in base levels o

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Harburg, Roeper, Ozgoren, and Feldstein (1981) approached the question somewhat differently by focusing on temperament. Their subjects were 1,153 persons ages 18 to 70 who were subjects in the Tecumseh Community Health Study. This was a longitudinal study begun in 1959, and most of the data were medical. The protocol included a measure of handedness (showing two different hand-writing postures, inverted and normal, for both hands) and two measures of temperament. The only differences were between the younger (18-39 year old) subjects. In this subgroup, left-handers (N=86) compared to right-handers (N=565) showed significantly more emotionality (fear and anger), less sociability, less sensation seeking, and less extroversion.

In summary, the relation between handedness and these measures of emotionality is weak; sometimes it is there, sometimes not. However, when a difference occurs, it is always in the direction of left-handers exhibiting more "negative" emotion, or anxiety. This, in itself, offers some justification for including left-handers in the current study.

Handedness and Lateralization of Emotion

In most of the studies on lateralization of emotion reviewed earlier, subjects were either right-handers or handedness was not mentioned. The literature on handedness and lateralization of emotion thus is slim. Nevertheless, there are a sufficient number of studies to permit comparison of right- and left-handers on all three components of emotion: perception, expression, and experience.

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Perception. Beginning with perception studies, most research suggests that both right- and left-handers show right-hemisphere dominance. Most of the evidence comes from chimeric face and dichotic listening studies. For example, Luh, Reid, and Levy (1994) compared 72 right-handers with 72 left-handers on four free-vision chimeric face tasks that required judgments of emotion. The chimeric faces were smiling on one side and neutral in expression on the other. They also differed in sex, one side male, the other female. The latter difference allowed them to be rated for what the investigators called "femininity." Each condition included photographs of real and cartoon faces. For the emotion task, subjects were asked to judge which face looked happier. For the femininity task, they were asked which face looked more feminine. For both tasks, right- and left-handers showed left-hemispace biases. However, the task-specific reliable variance was decreased, and the variance common to all tasks was increased for left- compared to right-handers. More specifically, in left-handers the left visuo-spatial bias was higher for judgments of femininity than for emotion, whereas in right-handers, the emotional content of the face was more important. Confirming previous research (e.g., Gilbert & Bakan, 1973; Hoptman & Levy, 1988; Levy et al., 1983a), Luh et al.'s findings suggest that those processes that underlie the perception of emotion are less lateralized in left-handers than in right-handers.

Bulman-Fleming and Bryden (1994) found similar results with a dichotic listening task. They presented 64 left-handers and 64 right-handers with a target word spoken in a happy, sad, or angry voice. They then asked them to report each time they heard a particular word or a particular emotion. All three emotions — happy, sad, and angry — showed a left ear advantage of similar magnitude. These results are largely congruent with those of

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with those of Bryden et al.'s (1991), except that Bulman-Fleming and Bryden (1994) found a much larger left-ear advantage for angry words than for happy, sad, or neutral words. The left-ear advantage was reduced in left-handers, but the difference failed to reach significance. As in the study by Luh et al. (1994), left-handers also showed higher variance.

Other studies report mixed findings. Some report no overall advantage for either hemispace in left-handers. For instance, although Heller and Levy (1981) found that for both right- and left-handers posing happy expressions, the expression was judged to be stronger on the left side of their faces, only right-handed subjects judged faces as happier when the smiling half-face was in the left visual field. Others report a reversed valence effect in left-handers. Recall that Reuter-Lorenz and Davidson (1981) and Reuter-Lorenz et al. (1983) found a valence effect for the perception of emotion in right-handers. They also found evidence for a reversed valence for certain left-handers, namely those who wrote in the non-inverted posture. The authors therefore suggested that: 1) non-inverted and inverted left-handers differ in their neural organization for the perception of emotion and 2) the two hemispheres are differentially specialized for positive and negative affect. Recall, however, the suggestion raised earlier that these findings might reflect some methodological artifact. Still others report finding differences in perceptual patterns between right- and left-handers only for emotions of a particular valence. Everhart, Harrison, and Crews (1996) found evidence suggesting differential lateralization for the perception of neutral stimuli in left- and right-handed subjects. Using tachistoscopically presented emotional faces and a forced-choice reaction-time paradigm, they found that left-handers i

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left-handers identified neutral stimuli as more positive when presented to the LVF and as more negative when presented to the RVF.

Given the mixed findings of these studies it is difficult to reach any definite conclusions about differences in perceptual asymmetries. Although a majority of the studies suggest that left-handers are like right-handers in showing a left-visual field advantage for the perception of emotion, they also indicate that left-handers show greater variance across different emotional tasks and smaller perceptual biases for face chimeras when left visual biases are found. Some left-handers show very large perceptual asymmetries, either in the same or opposite direction of right-handers, and some show no or small perceptual asymmetries.

The question is, how can we interpret these individual variations in perceptual asymmetries? In the case of right-handers, Levy et al. (1983) argue propose at least two possibilities: 1) the perceptual variations reflect variations underlying hemispheric specialization for the perception of emotion itself, or 2) variations in hemispheric arousal patterns. Levy et al. (1983) favor the latter possibility, citing its ability to account for the observation that right-handers with right-hemispace biases have smaller asymmetries than right-handers with left-hemispace biases. For left-handers, Levy et al. (1983) also suggest that the much weaker association between the magnitude and direction of perceptual asymmetries would reflect the fact that left-handers are more diverse in hemispheric specialization for the perception of emotion itself.

Expression. Like the research on the perception of emotion, most of the evidence on expression of emotion suggests that right- and left-handers alike show right-hemisphere dominance. Recall that the usual method of demonstrating this effect is through the s

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through the study of facedness, that is, by comparing changes in expression (e.g., degree of change) on the two sides of the face. For instance, Borod and Caron (1980) had 31 right-handers and 20 left-handers perform nine different emotional expressions including greeting, disapproval, clowning, flirting, grief, toughness, and horror. Except for "toughness" where left-handers were significantly right-faced, right- and left-handers were both significantly left-faced for all emotions. Borod et al. (1981) found similar results, and, once again, toughness was reversed in left-handers. It may be significant that toughness was the one expression requiring unilateral facial movement. To study unilateral facial movements in greater detail, Chaurasia and Goswami (1975) examined deliberate manipulation of the face in 300 right- and 30 left-handers. The result was an inverse relation between handedness and facedness. Of the right-handers, 59% showed a left-sided smile and found it easier to perform a variety of facial manipulations with the left side of the face, whereas 73% of left-handers showed the reverse effect. Campbell (1979), on the other hand, observed 24 left-handers while they expressed a posed smile and found them to be significantly left-faced.[9] In support of Campbell's (1979) results and in contrast to Chaurasia and Goswami's (1975), Heller and Levy (1981) found that for right- and left-handers alike, left-side facial composites created after they performed a posed smile were judged to be happier than right-side composites.

The discrepancies in these studies are hard to explain in terms of neuropsychological theory. However, the pattern of results across experiments supports the view that both right-and left-handers are left-faced, but significantly so only for right-handers.

[9] However, a reversal in the asymmetry was observed when the subjects' facial expressions were relaxed (based on a photograph taken after the subject performed the posed smile).

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Experience. In contrast to the extensive literature relating handedness to the perception and expression of emotion, the laterality literature on handedness and experience of emotion is sparse. One reason may be related to the difficulty in defining "experience." Recall earlier, the study by McFarland and Kennison (1989) which illustrates this point.

McFarland and Kennison (1989) presented four selections of music to 80 right-handers and 80 left-handers. Two selections were independently judged to have a negative valence (evoking images of agitated grief, sadness, and despair), and two were judged to be positive (evoking images of jollity, celebration, happiness, and contentment). The musical selections were presented monaurally to the right or left ear for 3 minutes and 40 seconds. After that, the subjects were asked to "rate the valence of the emotion" they had experienced during the music using a scale anchored by the words "happiness" and "sadness." Right-handers reported more positive and less negative affect for music played to the right ear, whereas left-handers showed the reverse effect, reporting more positive and less negative affect for music played to the left ear. These results, therefore, suggest reverse valences for the experience of emotion between right- and left-handers. But did the subjects actually feel sad or happy (in other words, did they experience sad or happy emotions), or did they simply perceive the *music* as sad or happy? If the latter, then was a study of perception; if the former, it was a study of experience. The authors, perhaps sensing these difficulties, use neither term and instead described the results as showing asymmetry in the "processing" of emotions, which could mean perception, expression, or experience of emotion, individually or in combination.

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In an attempt to better understand the relation between handedness and the experience of emotion, Smith, Kline, and Meyers (1990) made parietal EEG recordings from right- and left-handed adults while they listened to a variety of emotional sounds. The sounds included a woman screaming, a woman laughing, a woman crying, and a baby cooing. The subjects were instructed to process the sounds in three different ways. In the "affective" condition, they were asked to "concentrate on feelings and actively attempt to experience the emotions elicited by each stimulus" (p. 63). In the "cognitive condition," they were instructed to avoid making an affective response. In the neutral condition, they were asked to focus full attention on the stimuli and to maintain a neutral (i.e., nonaffective, noncognitive) set. Left-handers showed a greater overall level of activation (arousal), especially for the emotional conditions, relative to right-handers. Across the three conditions, however, right-handers showed greater overall lateralization, whereas left-handers showed nearly identical activity in the two hemispheres across all three conditions. This last finding corroborates the reports of increased variability for left-handers in the perception and expression studies cited earlier, which raises the possibility that the cerebral organization of emotional experience in left-handers, at a group level, is more diffuse than in right-handers.

Evidence from clinical populations, however, points to similarities between left- and right handers for the experience of emotion. In an examination of rates of mood disorders for thirty left-handed stroke patients, patients with left hemisphere lesions had significantly higher depression scores and more depressive diagnoses than patients with right hemisphere lesions (Robinson, Lipsey, Bolla-Wilson, et al., 1985). Moreover, major depression was strongly associated with left anterior brain injury. These results are remarkably s

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remarkably similar to those found in right-handers (see Anterior Asymmetries section for a review of these results).

For right-handers, then, some tentative conclusions can be drawn about neuropsychological organization of emotion, namely, that they show a right-hemisphere effect for the perception of emotion and a valence effect for the expression and experience of emotion — negative for the right hemisphere, positive for the left hemisphere. Left-handers appear to differ from right-handers, but it is hard to say how they differ with any certainty. Given the aforementioned findings and the ample evidence of the heterogeneity of left-handers, it is plausible to hypothesize that, at the group level, left-handers show increased diffusion of cerebral organization for emotion. It is far more difficult to accept McFarland and Kennison's (1989) conclusion that the valence is reversed in left-handers. It is also likely that some of the increased bilaterality in left-handers occurs at a group level when phenotypic subgroups of left-handedness are grouped together. Perhaps only when these subgroups are examined separately will we be able to determine whether left-handers, in general, show greater bilaterality for the lateralization for the experience of emotion, or whether it is only certain subgroups of left-handers who show increased diffusion of cerebral organization for emotion.

As one can see from this review, there is a hole in the literature where intrahemispheric differences in emotion and handedness are concerned. To date, no study has examined such differences.

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Rationale and Predictions

The current study was designed to examine the relation between differences in levels of depression and anxiety and patterns of perceptual asymmetry as well as possible differences that may exist between left- and right-handers along these dimensions. The specific aims were: 1) to determine whether Heller et al.'s (1995) findings could be replicated and whether the addition of a measure of approach and withdrawal coping styles would also explain a portion of the variance, 2) to determine whether the addition of a measure of state-anxiety would explain an additional portion of the variance, 3) to examine whether changes in levels of depression and state-anxiety over time would be related to changes in perceptual biases (and, by implication, right parietotemperal functioning) within the same individual, and 4) to determine whether right-handers would differ from left-handers in cerebral organization for perceptual asymmetries.

Replication of Heller et al.'s (1995) Study: Contributions of Depression and Trait Anxiety

To date, there have been no replications of Heller et al.'s (1995) study. To avoid any difficulties in making comparisons between their findings and the current findings, I adhered to their procedure as closely as possible. This included the use of a similar method to design the Chimeric Faces Task packet and the use of at least one of their dependent measures, namely, the STAI Trait-anxiety form.

Patterns of Perceptual Asymmetries: Contributions of State Anxiety and Trait Anxiety

Where the current study purposefully deviated, however, was in the selection of certain additional dependent measures to assess the subject's current mood state. Recall that Heller et al. (1995) used the Trait-Anxiety Scale of the STAI and the General

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Behavior Inventory, or GBI (Depue, Krauss, Spoont, & Arbisi, 1989). Although the Trait-Anxiety Scale of the STAI is an excellent measure of general level of trait anxiety, there are questions as to whether it should be used to make inferences between current anxiety levels and patterns of perceptual asymmetry. That is, if level of experience of anxiety is hypothesized to be related dynamically to patterns of perceptual asymmetry, it would seem more appropriate to assess *current* level of anxiety rather than *general* level of anxiety. If Davidson's data are correct, then according to his diathesis-stress model, persons with higher trait anxiety who are currently in an anxious state should be much more likely to show changes in perceptual asymmetries than persons with high trait anxiety but who are not currently in an anxious state. State anxiety has been shown to modulate the association between trait anxiety and attentional biases, such that anxious individuals often do not show a bias toward threatening stimuli unless anxious arousal has been elicited (e.g., Broadbent & Broadbent, 1988; MacLeod, & Mathews, 1988). Furthermore, attentional biases have been found to disappear in patients with generalized anxiety disorder, in social phobics, in spider phobics, and in rape victims with post-traumatic stress disorder upon remission, which suggests that such biases are state-dependent (McNally, in press). To assess this possibility, the State-Anxiety Scale of the STAI was used in addition to the Trait-Anxiety Scale. Also, instead of using the GBI, the current study used the Center for Epidemiologic Studies Depression Scale (CES-D). The CES-D is much more widely used and allows for much more rapid assessment of depressed symptomatology than the GBI.

Patterns of Perceptual Asymmetries: Contributions of Approach and Withdrawal

The current study also attempted to include an assessment of panic levels. Recall from Heller et al.'s (1995) study that high anxiety in the absence of depression was not associated with relatively higher left-hemispatial biases compared to controls. The authors posited that one candidate for these null findings might be the type of anxiety measured. That is, it may be that posterior right-hemisphere functions are associated with fear or panic responses, whereas certain left-hemisphere functions may be involved in worry (e.g. verbal rumination or cognitive worry). In order to distinguish between these two types of anxiety I also planned to include a measurement of panic, namely, the Panic and Agoraphobia Scale, or P & A (Bandelow, 1995; Bandelow et al. 1995). The P & A, however, proved to be too expensive[10] and was replaced by the COPE test, a measure of approach and withdrawal and other coping behaviors in response to stressful situations (COPE; Carver, Scheier, Weintraub, 1989).

In combination, Davidson's approach/withdrawal dichotomy for the experience of emotion and Heller's proposed division for subtypes of anxiety (i.e., the association between panic and right hemisphere activity and the association between anxious rumination and left hemisphere activity), lead to the following prediction: there should be a positive relation between withdrawal coping styles and left-hemispace biases in subjects with high levels of anxiety.

[10] One U.S. dollar was requested for each administration.

Changes in Patterns of Perceptual Asymmetries: Contributions of Changes in Levels of Anxiety and Depression

To date, the effects of changes in levels of anxiety and/or depression over time within the same individual on biases in the perception of emotion have yet to be investigated. The literature suggests that different levels of depression and anxiety *between* individuals are associated with changes in perceptual biases. If perceptual asymmetries are related to emotional states as well as trait, or predispositions, then changes in levels of depression and/or anxiety *within* the same individual should be related to changes in the perceptual biases as well. Using a repeated measures design allowed changes in mood to be measured over time and, in turn, allowed for more powerful analyses and conclusions to be drawn about the effects of current levels of mood on perceptual biases.

Test of Handedness Differences in Perceptual Asymmetries

Lastly, the current study sought to contribute to research on handedness and the perception of emotion, a slim literature where handedness is concerned. To the extent that right- and left-handers can be shown to differ in other psychological processes (e.g., the perception of emotion), then a comparison between right- and left-handers could reveal clues to understanding the functional utility of lateralization for those processes. That is, because left-handers are reported to differ from right-handers on selected psychological tasks and to be more common in certain clinical and other special populations, the study of left-handedness and emotion may hold a key to understanding a fundamental question in neuropsychology — the relationship of laterality to cognitive, perceptual and emotional processes (Harris, 1992).

Based on the review of emotionality and handedness, six major predictions were made.

Prediction #1: Contributions of Depression and Trait Anxiety to Perceptual Asymmetries

In accordance with evidence for associations between changes in arousal, changes in right hemisphere activation, and changes in perceptual asymmetries, it was predicted that increased depressed symptomatology between groups would be related to a weaker left-hemispace bias, whereas increased levels of trait anxiety would be related to a stronger left-hemispace bias. On the CES-D, it was predicted that increases would be related to a weaker left-hemispace bias on the CFT. On the STAI Trait-Anxiety Scale, it was predicted that increases (in the absence of depression) would be related to a stronger left-hemispace bias on the CFT.

Prediction #2: Contributions of State Anxiety and Trait Anxiety to Perceptual Asymmetries

In accordance with Davidson's diathesis-stress model of the experience of emotion, persons who are currently in a state of anxiety should show a stronger left-hemispace bias than persons not currently in a state of anxiety. That is, not only must one have the diathesis (trait) for heightened levels of anxiety, but one must also currently be in a stressful state for that anxiety to be expressed. Therefore, it was predicted that subjects with both high levels of trait- and state-anxiety should have stronger left hemispace biases on the CFT than subjects with high trait anxiety, who are not currently experiencing high state anxiety. Specifically, on the STAI, it was predicted that changes in hemispace biases would be significantly more related to changes in the State-Anxiety Scale than in the Trait-Anxiety Scale. In addition, it was predicted that subjects with elevated Trait- and State-Anxiety scores would show stronger left hemispace biases than subjects with elevated Trait- but not State-Anxiety scores.

Prediction #3: Trait Anxiety, Approach/Withdrawal, and Patterns of Perceptual Asymmetries

Again based on the integration of Davidson's approach-withdrawal distinction and Heller's proposed rumination-panic distinction for anxiety, there should be a positive relation between withdrawal styles of coping behaviors and left-hemispace biases. It was hypothesized, therefore, that greater levels of withdrawal behaviors in trait-anxious subjects would be related with to stronger left-hemispace biases. Thus, it was predicted that increases in denial and behavioral disengagement (i.e., withdrawal-related coping behaviors) in subjects with high trait-anxiety would be related to stronger left-hemispace biases as measured by the CFT, whereas active coping and planning (i.e., approach-related coping behaviors) would be unrelated to hemispace biases.

Prediction #4: Changes in Levels of Depression, Trait Anxiety, and Perceptual Asymmetries From Time 1 to Time 2

If patterns of perceptual asymmetries are related to anxiety and/or depression, then changes in these states over time, *within* the same individual ought to be related to changes in the perceptual biases in the direction suggested by prediction #1. That is, increases in levels of depression over time should be related to decreases in left-hemispace biases. On the other hand, increases in levels of anxiety should be related to increases in left-hemispace biases. The reverse predictions would be made for decreases in levels of anxiety and decreases in depression. For depression, therefore, increases in CES-D scores would be related to decreases in left-hemispace biases, whereas decreases in CES-D scores would be related to increases in left-hemispace biases. For anxiety, increases in STAI State-Anxiety Scale scores would be related to increases in left hemispace bases, whereas decreases in State-Anxiety Scale scores would be related to decreases in left-hemispace biases as measured by the CFT.

Prediction #5: Handedness and Mood

Based on the literature reviewed earlier on the relation between handedness and emotionality (e.g., emotional stability and temperament), it was predicted that any differences that are found would be in the direction of higher rates for left-handers than for right-handers on measures of negative emotional states (e.g., depression and anxiety). On both the CES-D and STAI, this would correspond to higher scores in left-handers relative to right-handers.

Prediction #6: Handedness, Mood, and Perceptual Asymmetries

Irrespective of results pertaining to prediction #5, based on the literature on handedness and lateralization for perception of emotion, it was predicted that right-handers would be more clearly lateralized than left-handers on the CFT (Prediction #6a). That is, at the group level, right-handers would show stronger left-hemispace biases. At the individual level, fewer right-handers would show right-hemispace biases than left-handers. An additional prediction is that at comparable levels of depression, right-handers' perceptual asymmetries would show a greater reduction in magnitude of left-hemispace biases. Likewise, at comparable levels of anxiety, their perceptual asymmetries would show a greater increase in magnitude of left-hemispace biases (Prediction #6b). Finally, based on evidence for relations between 1) variations in perceptual asymmetries and individual differences in hemispheric arousal (e.g., Levy et al., 1983), 2) hemispheric arousal and depression and anxiety (e.g., Heller et al., 1995), and 3) left-handers who fail to show a left-hemispace bias and higher left-hemisphere than right-hemisphere arousal (e.g., Levy et al., 1983), then it should follow that left-handers with right-hemispace biases will show changes in strength of right-hemispace biases in accordance with Heller's (1993) model (Prediction #6c). That is, left-handers with right-hemispace biases should show weaker right-hemispace biases in relation to higher levels of depression and stronger right-hemispace biases in relation to higher levels of anxiety.

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Subjects

Subjects were 118 male (82 right-handed, 36 left-handed) and 317 female (275 right-handed, 42 left-handed) undergraduate students from the Psychology Department Human Subjects Pool at Michigan State University.[11] Subjects were tested in groups of approximately 10 (range from 1 to 22). Subjects were enrolled in one of several large introductory psychology classes and received course credit for participation. The age of the subjects ranged from 18 to 58 with a mean age of 20.0 years (SD = 3.6). Subsets of subjects were selected for certain analyses as described below. Subjects were treated in strict accordance with the ethical standards of the American Psychological Association (American Psychological Association, 1992).

Of the entire sample, 82.3% of the subjects were Caucasian, 6.2% were African-American, 1.4% were Native-American, 3.4% were Asian-American, and 4.4% were Hispanic. The remaining 2.3% indicated that they were biracial. Subjects ranged from freshman to graduate students. Of the entire sample, 40.3% were freshman, 26.5% were sophomores, 17.3% were juniors, 15.4% were seniors, and 0.4% were graduate students. Subject demographic information is broken down by handedness and sex in Table 1.

[11] To achieve this sample size and to recruit as many left-handed subjects as possible, I tested subjects over two successive semesters (Fall 1997 and Spring 1998). In addition, permission was sought by professors participating in the Subjects Pool to make announcements in their classes and to post sign-up sheets for left-handers. This announcement was made in all eight classes participating in the pool.

Materials

Materials included an informed consent form, subject background and demographic survey, 8-item handedness questionnaire, Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), State-Trait Anxiety Inventory (STAI; Spielberger, 1968), the COPE (Carver, Scheier, & Weintraub, 1989), and the Chimeric Faces Task (CFT; Levy, et al., 1983a, Levy et al., 1983b).

Informed Consent Form

The Informed Consent Form (Appendix A) included the following information: 1) that the study involved examining the effects of mood on the perception of emotion in a normal, healthy population, 2) that subjects would be asked to complete a background and demographic survey, an eight-item handedness questionnaire, and several questionnaires pertaining to their mood, 3) that subjects would have the opportunity to complete these measures again at a later date (approximately four weeks later), and 4) that the main investigator of the study would have permission to call subjects to remind them of the second testing date and time.

Personal Information and Background Questionnaire

The Personal Information and Background Questionnaire (Appendix B) asked for the subject's full name, age, sex, years of education, academic major, ethnicity/race, and handedness. The handedness question asked the subject to define his or her general handedness: 1) strongly left-handed, 2) moderately left-handed, 3) ambidextrous (either-handed), 4) moderately right-handed, or 5) strongly right-handed. This question was included in the Personal Information and Background Questionnaire rather than the

Laterality Questionnaire in order to get a general sense for how subjects defined their handedness independently of the more detailed assessment that followed.

The Handedness Questionnaire

The Handedness Questionnaire (Appendix C) asked subjects to indicate their hand preference for eight common tasks: 1) write a letter, 2) hammer a nail, 3) throw a ball at a target, 4) unscrew lid of a jar, 5) use a knife to cut bread, 6) use a tooth brush, 7) hold a match while striking it, and 8) hold a tennis racket. These eight items were taken from the 10-item Edinburgh Handedness Inventory (Oldfield, 1971) and are commonly used to assess degree of hand preference (e.g., Peters, 1990; Peters & Servos, 1989; Ponton, 1987). Strength of hand preference was rated on a 5-point Likert Scale, from 1 (always left) to 5 (always right). A laterality index score was created by adding the strength of preference scores for each of the eight tasks. Therefore, scores could range from 8 (exclusive left-hand use for all items, i.e., 8×1) to 40 (exclusive right hand use for all items, i.e., 8×5).

State-Trait Anxiety Inventory (STAI)

The STAI is printed on a single page and provides a measure of self-reported current (state) and general (trait) levels of anxiety (Appendix D). The State-Anxiety Scale appears on one side and the Trait-Anxiety Scale on the reverse. The 20 State-Anxiety items are each rated on a four-point intensity scale, labeled "Not At All," "Somewhat," "Moderately So," and "Very Much So." Respondents are instructed to indicate how they feel "right now" by filling in the circle around the appropriate response number. The 20 Trait-Anxiety Scale items are rated on a four-point frequency scale labeled "Almost Never," "Sometimes," "Often," and "Almost Always." Here respondents are instructed to indicate how they "generally feel." In both sets of instructions, subjects are assured that there is no right answer and they are discouraged from spending too much time on any one item. Although there is no time limit, most respondents complete both scales in less than 10 minutes (Chaplin, 1984). When the full 40-item STAI is administered, two scores are obtained. One score reflects the person's current level of state anxiety and can range between 20 to 80, with higher scores reflecting more anxiety. The other score indicates the person's general level of trait anxiety and also can range from 20 to 80, with higher scores indicating more anxiety. A subject's score on each scale is simply the sum of the responses to the 20 items on that scale. Beforehand, however, the responses to the 10 "anxiety-absent" items on the State-Anxiety scale and the nine anxiety-absent items on the Trait-Anxiety are reversed (e.g., 1 = 4, etc.) before they are summed. The manual provides both percentile and standard (T) scores for men and women in three age groups (19-39, 40-49, 50-69). The internal consistency of the Trait-Anxiety Scale, as indexed by coefficient alpha, ranges from .89 to .91 across male and female samples of working adults and college and high school students. For the State-Anxiety Scale this range is from .86 to .95 (Spielberger, 1968). Test-retest reliability was also assessed for periods varying between one hour and 104 days (using male and female high school and college students). Reliability intervals decreased as a function of interval length. For the Trait-Anxiety Scale the coefficients ranged from .65 to .86, whereas the range for State-Anxiety was .16 to .62. A lower level of reliability for the State-Anxiety Scale is expected since this measure samples transient situational factors of anxiety present at the time of testing. Had the test-retest reliability of the State-Anxiety Scale not been lower than the reliability of the Trait-Anxiety Scale, there would be reason to question the validity of these scales. The STAI has been found to be a reliable and valid measure of the construct of anxiety (Finney, 1985) and also has been used in studies of hemispheric asymmetry (e.g., Hagstadius & Reisberg, 1989; Heller et al., 1995; Rodriguez, Cogorno, Gris et al., 1989; Tucker et al., 1978).

Center for Epidemiologic Studies Depression Scale (CES-D)

The CES-D (Radloff, 1977) is a 20-item self-administered "state" measure of depressive symptomatology (Appendix E). The CES-D provides a state measure of depression to the extent that it indicates *current* levels of functioning. To accomplish this, the CES-D asks the respondent to assess the frequency and duration of symptoms associated with depression that occurred within a one-week interval preceding its administration. Sixteen of the items measure cognitive, affective, and behavioral features of depression. An additional four items measure positive affect in an effort to monitor possible response sets. For each item, respondents circle a number between 0 and 3 to indicate the frequency or duration with which they have experienced certain symptoms during the preceding week. The possible range of scores is between 0 and 60, with higher scores indicating greater depressive symptomatology. There is considerable evidence that the CES-D is a reliable and valid measure of depressed symptomatology that can be used with nonclinical populations (for a review, see Devins & Orme, 1985). Test-retest reliabilities for periods of two, four, six, and eight weeks were .51, .67, .59, and .59, respectively (Radloff, 1977). Using three different samples, tests of internal consistency yielded coefficient alphas of .84, .85, and .90. The CES-D takes approximately five minutes to complete.

The COPE

As noted earlier, the COPE (Carver et al., 1989) was included to replace the Panic and Agoraphobia Scale, or P & A (Bandelow, 1995; Bandelow et al. 1995), which could not be included due to its financial cost. See Appendix F for a summary of the P & A.

The COPE (see Appendix G) is a 60-item multidimensional coping inventory that assesses 14 different dispositional styles of coping in response to stressful situations. Five scales measure aspects of problem-focused coping (i.e., active coping, planning, suppression of competing activities, restraint coping, and seeking of instrumental social support). Five scales measure aspects of emotion-focused coping (i.e., seeking of emotional social support, positive reinterpretation, acceptance, denial, and turning to religion). The remaining four scales are believed to measure less useful ways of coping (i.e., focus on venting of emotions, behavioral disengagement, mental disengagement, and alcohol-drug disengagement). For each of the 60 items, respondents are asked to mark a number from 1 to 4 to indicate the frequency with which they generally exhibit certain coping behaviors in response to stressful events. The possible range of scores for each subscale is between 4 and 16, with higher scores indicating greater frequency of such coping behaviors.

To assess approach and withdrawal behaviors in the present study, four of the 14 subscales were selected, namely, active coping, planning (both construed as approach coping styles), denial, and behavioral disengagement (both construed as withdrawal coping styles). Appendix H contains the four subscales and the items contained within each. Carver et al. (1989) report that the internal consistencies (coefficient alphas) for active coping, planning, denial, and behavioral disengagement in a sample of 978 college students were .62, .80, 71, and .63, respectively. Test-retest reliabilities across an 8-week period for these same subscales were .56, .63, .54, and .66, respectively.

Chimeric Faces Task (CFT)

There are a number of variations of the Chimeric Faces Task, or CFT, including the use of fewer stimulus pages, color versus black and white photographs, schematic versus real faces, and targets of different emotional valences. Given that the current study sought to further investigate Heller et al.'s (1995) work, stimulus pages were constructed to mirror their original stimulus packet as closely as possible. Heller et al.'s (1995) CFT stimulus booklet contains 36 pages, each depicting two black and white (Chimeric) faces of real persons, with half the face smiling, and the other half neutral or unsmiling. The two halves of each image are of the same person, and the two faces on each page are exact mirror images (see Appendix I for an example). Subjects are asked to choose the face composite that is "happier." The CFT takes advantage of the hypothesized tendency for task-specific hemispheric specialization also to produce biases in attention toward one side of space relative to the other for information that is not initially restricted to one hemisphere (for a review, see Heller, 1991). The rationale for this test is that if subjects consistently choose the face from each pair that has the target emotion in the left or right visual hemispace, the hemisphere that lies contralateral to that side of space is considered to be more specialized for the perception of emotion.

The CFT created for the current study contained 34 pages, each depicting two black and white faces of real persons, with half of the face smiling, and the other half neutral or unsmiling. Each contained a different person. Two stimulus booklets were created, A and B, to counterbalance the position of the two images (top or bottom).

Subjects indicated their choices on a separate answer sheet that also contained the instructions for completing the task (see Appendix J).

Procedure

The prospective subjects entered the room and were given a packet of information to complete. Determination of who received booklet A or B was based on the subject identification number. Subjects with odd numbers received booklet A, subjects with even number, booklet B. Subjects were told that the packet contained instructions with sufficient detail so that the entire test packet could be completed without interruption.

Next, subjects completed the questionnaires followed by the CFT. At the conclusion of the experiment, subjects returned the materials to the investigator and were given credit for participation. On average, the whole procedure took approximately 25 minutes to complete. Subjects were thanked for participating and were told that a short summary of the experiment would be sent via email.

Subjects then were queried about their possible interest in participating in the second phase of the experiment that would occur four weeks later. They also were told that the second phase would involve completing a similar set of questionnaires for which they would receive an additional research credit. If interested, subjects were directed to a table on which was placed a calendar highlighting the dates, times, and locations of the second testing session and a notebook of sign-up sheets that was organized by date and time. If there was a suitable date and time, subjects were instructed to turn to the correct sign-up sheet and complete the information.

To increase the likelihood that subjects would return for the second testing session, two methods were employed. First, after completing the sign-up sheet, subjects were given a reminder sheet with their scheduled date, time, and location on it. This sheet also included the main investigator's telephone number for use to reschedule if necessary. Second, subjects received a reminder via telephone the evening before their scheduled testing day. This method resulted in a 95% return rate (that is, of persons who scheduled a second testing session).

A spread sheet file was created prior to the second testing session with subjects' names, identification numbers, and scheduled appointments. This file was then organized by the second testing date and time. Upon the subject's return, a match was made between they name and identification number so that they would complete the same version of the CFT (booklet A or B) as was completed for the first testing session.

Data Reduction

Using Heller et al.'s (1995) study as a model, asymmetry scores were calculated on the CFT for each subject by subtracting the total number of left-face emotion (smiling) choices from the total number of right-face emotion (smiling) choices and dividing by the total number of face pairs [Total Right-Face Choices - Total Left-Face Choices/Total Number of Face Pairs]. Thus, scores that are increasingly negative are also indicative of a stronger left hemispatial bias. On the other hand, scores that are increasingly positive are indicative of a stronger right hemispatial bias. These scores were used to infer side of greater hemispheric activity in the perception of emotion.

Analyses completed on the STAI Trait-Anxiety Scale, STAI State-Anxiety Scale, and CES-D used both raw and percentile scores. Percentile scores for the STAI were obtained from the manual (Spielberger, 1968). CES-D percentile scores were gathered form a series of samples taken from normal populations (Radloff, 1977). Scores corresponding to the 50th and 80th percentiles were 34 and 43 for the STAI Trait-Anxiety Scale, 34 and 45 for the STAI State-Anxiety Scale, and 9 and 16 for the CES-D. It should be noted that the cutoffs for the 50th and 80th percentiles reported by Spielberger (1968) for the STAI Trait-Anxiety Scale were slightly different from those reported by Heller et al. (1995) — their reported values for low- and high-trait anxiety were 41 and 48, respectively. Unfortunately, Heller and her colleagues did not explain how they derived these cutoffs nor provide any citations. Compared to Spielberger's (1968) cutoffs, those used by Heller et al. (1995) had somewhat more conservative "high trait-anxiety" cutoffs and somewhat more liberal "low trait-anxiety" cutoffs.

RESULTS

The results are divided into two parts. Part 1 contains descriptive statistics for the various subgroups and for the independent and dependent measures. Part 2 presents the results of tests of the predictions for Time 1 and Time 2, separately, then for the contributions of approach and withdrawal, next for changes from Time 1 and Time 2, and lastly for handedness, but only for Time 1. In this part, results are first reported for comparisons between trait anxiety and depression and then for comparisons between state- and trait-anxiety. Each comparison is made first using the same statistical tests used by Heller et al. (1995; i.e., ANOVAs, T-tests of subgroup mean CFT scores, and subgroup phi-coefficient analyses), and then using additional statistical tests, namely, correlational analyses and hierarchical regressions. Lastly, post hoc analyses are reported.

Descriptive Statistics

The Laterality Index Score

Across both right- and left-handed men and women, the internal consistency of the 8-item handedness scale at Time 1 and Time 2, as indexed by coefficient alphas, was .95 and 94, respectively (see Table 2). Test-retest reliability over a four-week interval was .95 (see Table 3). Of the right-handers, all reported using their right hand for writing. Their mean laterality score was 36.94 (SD = 3.06). Of the left-handers, 77 of the 78 (98.7%) reported using their left hand for writing. Their mean laterality index score was 15.17 (SD = 6.0). Consistent with past studies, left-handers, as a group, were more heterogeneous than right-handers as indexed by Levene's (1960) test for equality of variances, F (1, 433) = 88.0, $p < .0001$. Across seven of the eight tasks, left-handers were more heterogeneous than right-handers, the only exception being the question about hand preference for writing a letter.

Consistency of Handedness

Consistency of handedness was determined using Peters' decision rule (Peters, 1990; Peters & Servos, 1989; Ponton, 1987). Subjects who reported left-hand preference for writing and for six of seven other common unimanual tasks (hammer a nail, throw a ball at a target, unscrew the lid of a jar, use a knife to cut bread, use a toothbrush, hold a match while striking it, and hold a tennis racket) were classified as consistent left-handers (CLHs). Subjects who reported right-hand preference for two or more of the eight items were classified as inconsistent left-handers (ILHs). Of the left-handed sample, 36 (46.2%)were CLHs and 42 (53.8%) were ILHs. Applying the same decision rule for right-hand preference in right-handers, 284 (79.6%) were CRHs and 73 (20.4%) were IRHs. A significantly greater proportion of left-handers met criteria for "inconsistent handedness" than did right-handers, χ^2 (1, N = 435) = $p < .0001$. This classification yielded results consistent with those found in other studies using similar criteria (e.g., Peters, 1990; Peters & Servos, 1989; Ponton, 1987).

State-Trait Anxiety Inventory (STAI)

The internal consistency of the 20-item State-Anxiety Scale for Time 1 and Time 2, as indexed by coefficient alphas, was .91 and .93 ,respectively. The internal consistency of the 20-item Trait-anxiety inventory for both Time 1 and Time 2 was .92. These figures are consistent with those reported by Spielberger (1968). Test-retest reliability over a four week interval was .52 for the State-Anxiety Scale and .85 for the

Trait-Anxiety Scale. These figures are consistent with those reported by Spielberger (1968), including the lower test-retest reliability of the State-anxiety scale relative to the Trait-Anxiety Scale. Recall that a lower level of reliability for the State-Anxiety Scale is expected since this measure samples transient situational factors of anxiety present at the time of testing.

Center for Epidemiologic Studies Depression Scale (CES-D)

The internal consistency of the CES-D (20 items) for Time 1 and Time 2, as indexed by coefficient alphas, was .88 and .91, respectively. Test-retest reliability over a four-week interval was .55. These figures are consistent with those reported by Radloff (1977). The test-retest reliability of the CES-D found in the present study is lower than the test-retest reliability of the STAI Trait-Anxiety Scale but parallels that of the State-Anxiety Scale. This is to be expected given that both the State-Anxiety Scale and CES-D are state measures, that is, indications of current levels of functioning.

Chimeric Faces Task (CFT)

The internal consistency of the 34 chimeric face pairs, as indexed by a coefficient alpha, was .95, for both Time 1 and Time 2. Test-retest reliability over a four-week interval was .75. These results are consistent with those reported by Levy et al. (1983). The overall group mean and standard deviation obtained in the current study ($\underline{M}$ = -.366, $\underline{SD}$ = .54) were similar to those reported by Heller et al. (1995; $\underline{M}$ = -.377, $\underline{SD}$ = .5) and Levy et al. (1983; $\underline{M}$ = -.303, $\underline{SD}$ = .440). Recall that more negative scores correspond to stronger left hemispace biases.

Delay

The mean delay between Time 1 and Time 2 was 32.3 days (SD = 3.9). Of the 435 subjects tested at Time 1, 272 (62.5%) were scheduled to return for Time 2. Interest in returning for the second testing session was lower than might otherwise be expected because I began late in the Fall semester after subjects had completed most of their research credits. In the Spring semester testing began early, resulting in approximately 85% of subjects reporting interest in returning for Time 2. Of the 272 subjects scheduled for Time 2, 258 (95%) returned.

Group Membership

The following terms will be used to label subjects according to group membership. Subjects who are low depressed and low trait-anxious will be called "controls." Subjects who are high-depressed, low-trait-anxious will be called "depressed-only." Subjects who are low-depressed, high-trait-anxious will be called "trait-anxious-only." Lastly, subjects who are high-depressed, high trait-anxious will be called "depressed/trait-anxious." A similar classification scheme is employed for state- and trait-anxiety group membership (i.e., state-anxious-only and state-anxious/trait-anxious).

The number of subjects meeting criteria for group membership into high- and low-depression and high- and low-trait-anxiety is reported in Table 4 for Heller et al.'s (1995) study and the present study for both Time 1 and 2. Group membership was similar to that reported by Heller et al. (1995) with the exception of the trait-anxious-only group. Only one subject (0.3% of the total sample) met criteria for trait-anxious-only membership, in contrast to Heller et al. (1995), who found 2.0% of their total sample meeting criteria for this condition. Similarly, group membership for high-and low-state anxiety and high-and low-trait-anxiety for the current study for both Time 1 and Time 2 is reported in Table 5. Left-handers were excluded from these analyses and their data are reported separately (see Table 26).

Tests of Predictions: An Overview of the Analyses

Before turning to the results of the tests of predictions, it will be helpful to briefly explain some of the tests used to measure group differences in the magnitude and frequency of hemispace biases.

In order to compare the subgroups on magnitude of CFT scores (i.e., strength of hemispace biases), the results of two tests are reported: an ANOVA and a t-test comparing group means to zero. The latter test was performed to examine the extent to which the data from subjects who met group membership criteria (e.g., depressed-only) replicated those of Heller et al. (1995). In this test, the mean CFT score for each group is examined to determine whether it differs significantly from chance. If it does, then the group shows a reliable perceptual bias, either to the left or right. If it does not differ significantly from chance, then the group does not show a reliable perceptual bias in any direction.

To compare the frequency of left- versus right-hemispace-biased subjects according to group membership, the current study used a method similar to the one used by Levy et al. (1983), Jaeger et al. (1987), and Heller et al. (1995). Subjects in each group were divided into left-biased (negative CFT score) or right-biased (positive CFT score) categories, and a four-fold point correlation, or phi coefficient analysis, was performed. Subjects with no bias (CFT score of zero) were not included. It should be noted that Heller et al. (1995) appeared to use a liberal decision rule, or cutoff, for inclusion into left- or right-biased categories. In their study, which used 36 chimeric pairs, a score of 18 meant that a subject made exactly 18 left choices and 18 right choices. These subjects were the only ones not to be considered as left- or right-biased. If, however, subjects' scores were greater or less than 1 above or below 18, they were categorized as left- or right-biased, respectively. Using the same cutoffs, Table 6 compares the number of subjects with left- and right-perceptual biases for Heller et al.'s (1995) study and for the current study. Table 8 shows the same comparison using a more conservative decision rule based on the binomial distribution and a p-value of .05. According to this decision rule, to be considered left- or right biased required making a CFT score of 21 or 13, respectively. To be considered "no bias" required a score between 14 and 20. In the current study, all phi coefficient analyses performed on frequency of hemispace biases used cutoffs based on the binomial distribution and a p-value of .05.

To analyze the contributions of depression, trait anxiety, and state anxiety to CFT scores, hierarchical regressions were performed. For each regression, the variables entered at Step 1 were those that may influence on CFT scores, but without being central to the prediction being tested. Step 2 variables are the variables of interest for prediction. For instance, in a test of the influence of depression and trait anxiety on the prediction of CFT scores, the "sex," "handedness," and "state anxiety" variables would be entered at Step 1, "depression" and "trait anxiety" variables and their interaction at Step 2.

Time 1 Analyses

The following analyses were conducted on the measures at Time 1 to examine the effects of depression, state anxiety, and trait anxiety, on hemispace biases (CFT scores). Left-handers were excluded from these analyses and their data are reported separately.

Depression and Trait Anxiety

Magnitude Analyses. A three-way analysis of variance with sex (male, female), depression (high, low), and trait anxiety (high, low) as between-subjects variables was performed on the CFT scores. There were no significant main effects or interactions (see Table 8).

Using t-tests, the mean CFT scores four each of the four groups were compared to zero (which would indicate no asymmetry). Given that only one subject met criteria for trait-anxious-only, analyses were performed on the remaining three groups. All three groups showed significant left-hemispace biases: controls: $t(123) = -7.93$, $p < .0001$; depressed-only: $t(36) = -2.64$, $p = .012$; depressed/trait-anxious: $t(60) = -3.16$, $p < .01$. These results are comparable to those reported by Heller et al. (1995), except for the depressed-only subjects, whose mean left-hemispace bias, unlike the current results, did not differ significantly from zero in their study [$t(19) = -1.18$].

Frequency Analyses. The four-fold point correlations (Phi Coefficients) between left- versus right-bias and comparisons of all combinations of group membership (control vs. depressed-only; trait-anxious only vs. depressed/trait-anxious; control vs. trait-anxious-only; depressed-only vs. depressed/trait-anxious; control vs. depressed/trait-anxious; depressed-only vs. trait-anxious-only) were nonsignificant (see Table 7). That is, none of the groups differed significantly in their proportion of left- to right-asymmetry scores. This is in contrast to Heller et al. (1995), who found that depressed-only subjects vs. trait-anxious-only subjects and depressed-only subjects vs. control subjects differed in the frequency distribution of their asymmetry scores.

Hierarchical Regression. An examination of the bivariate correlation coefficients failed to show any correlations between CFT scores and either depression or trait anxiety (see Table 9). As expected, however, a significant correlation was found between depression and trait anxiety, $r = .745$, $p < .01$, two-tailed. Likewise, a hierarchical regression analysis performed on variables predicting CFT scores (sex, handedness, and state anxiety entered at Step 1; depression and trait anxiety entered at Step 2) revealed no significant relationships between CFT scores and depression or trait anxiety (see Table 10).

State Anxiety and Trait Anxiety

Magnitude Analyses. A three-way analysis of variance with sex (male, female), state anxiety (high, low), and trait anxiety (high, low) as between-subjects variables was performed on the CFT scores. There were no significant main effects or interactions (see Table 11).

Using t-tests, the mean CFT scores four each of the four groups were compared to zero (which would indicate no asymmetry). The state-anxious/trait-anxious subjects did not differ significantly from zero, $t(34) = -1.34$, $p = .19$. For the other three groups the differences were highly significant: controls: $t(164) = -9.08$, $p < .001$; state-anxious-only: $t(13) = -2.69$, $p < .05$; trait-anxious-only, $t(9) = -4.12$, $p < .001$. This suggests that the state-anxious/trait-anxious group did not show an overall left-hemispace bias.

Frequency Analyses. The four-fold point correlations (Phi Coefficients) between left- versus right-bias and comparisons of all combinations of group membership (control vs. state-anxious-only; trait-anxiety-only vs. state anxious/trait-anxious; control vs. trait-anxious-only; state-anxious-only vs. state-anxious/trait-Anxious; state-anxious-only vs.

trait-anxious-only) were nonsignificant except for control vs. state-anxious/trait-anxious, $r = .152$, $p < .05$ (see Table 12). These results indicate that state-anxious/trait-anxious subjects differed from controls in the frequency distribution of their asymmetry scores with proportionately more state-anxious/trait-anxious subjects showing right-asymmetry scores.

Hierarchical Regression. An examination of the bivariate correlation coefficients (see Table 9) showed a significant correlation between CFT scores and state anxiety, $r = -.106$, $p < .05$, two-tailed. That is, higher levels of state anxiety were correlated with decreases in CFT scores (left-hemispace biases). As would be expected, there also was a significant correlation between state anxiety and both trait anxiety, $r = .664$, $p < .01$, two-tailed, and depression, $r = .576$, $p < .01$, two-tailed. Likewise, a hierarchical regression analysis performed on variables predicting CFT scores (sex, handedness, and depression entered at Step 1; trait anxiety and state anxiety entered at Step 2) revealed no significant relationships between CFT scores and trait anxiety but did show an inverse relation between state anxiety and CFT scores (see Table 13).

Time 2 Analyses

The following analyses were conducted on the measures at Time 2 to examine the effects of depression, state-anxiety, and trait-anxiety, on hemispace biases (CFT scores). Left-handers were excluded from these analyses.

Depression and Trait Anxiety

Magnitude Analyses. A three-way analysis of variance with sex (male, female), depression (high, low), and trait anxiety (high, low) as between-subjects variables was performed on the CFT scores. Like the results reported for Time 1, there were no significant main effects or interactions for Time 2 (see Table 14).

Using t-tests, the mean CFT scores four each of the four groups were compared to zero (which would indicate no asymmetry). Given that only one subject met criteria for trait-anxious only, analyses were performed on the remaining three groups. All three groups showed significant left-hemispace biases: controls: $t(79) = -6.47$, $p < .0001$; depressed-only: $t(35) = -4.49$, $p < .0001$; depressed/trait-anxious: $t(31) = -2.46$, $p < .02$. These results are comparable to those reported by Heller et al. (1995), except for the depressed-only subjects, whose mean left-hemispace bias, unlike the current results, did not differ significantly from zero in their study [$t(19) = -1.18$].

Frequency Analyses. The four-fold point correlations (Phi Coefficients) between left- versus right-bias and comparisons of all combinations of group membership (control vs. depressed-only; trait-anxious-only vs. depressed/trait-anxious; control vs. trait-anxious-only; depressed-only vs. depressed/trait-anxious; depressed-only vs. trait-anxious-only) were nonsignificant except for control vs. depressed/trait-anxious, $r = .227$, $p < .05$ (see Table 15). These results indicate that depressed/trait-anxious subjects differed from controls in the frequency distribution of their asymmetry scores with proportionately more state-anxious/trait-anxious subjects showing right-asymmetry scores.

Hierarchical Regression. An examination of the bivariate correlation coefficients failed to show any significant correlations between CFT scores and either depression or trait-anxiety (see Table 9). As would be expected, however, a significant correlation was found between depression and trait-anxiety, $r = .673$, $p < .01$, two-tailed. Similarly, a hierarchical regression analysis performed on variables predicting CFT scores (sex, handedness, and state anxiety entered at Step 1; depression and trait anxiety entered at Step 2) revealed no significant relationship between CFT scores and either state anxiety or trait anxiety. (see Table 16).

State Anxiety and Trait Anxiety

Magnitude Analyses. A three-way analysis of variance with sex (male, female), state anxiety (high, low), and trait anxiety (high, low) as between-subjects variables was performed on CFT scores (see Table 17). There were no significant main effects or interactions except for trait anxiety, $F(1, 131) = 4.26$, $p = .05$. That is, high trait anxious subjects showed significantly weaker left hemispace biases than low trait anxious subjects.

Using t-tests, the mean CFT scores four each of the four groups were compared to zero (which would indicate no asymmetry). Two groups did not differ significantly from zero: high trait-anxious-only, $t(3) = -1.12$, $p = .35$; state-anxious/trait-anxious, $t(20) = -1.79$, $p = .09$. For the other two groups the difference was highly significant: controls: $t(92) = -7.23$, $p < .0001$; state-anxious-only: $t(92) = -7.23$, $p < .0001$; trait-anxious-only, $t(20) = -2.37$, $p < .028$. This suggests that the both the trait-anxious-only group and the state-anxious/trait-anxious group did not show overall left-hemispace biases.

Frequency Analyses. The four-fold point correlations (Phi Coefficients) between left- versus right-bias and comparisons of all combinations of group membership (control vs. state-anxious-only; trait-anxious-only vs. state-anxious/trait-anxious; control vs. trait-anxious-only; state-anxious-only vs. state-anxious/trait-anxious; state-anxious-only vs. trait-anxious-only) were nonsignificant except for control vs. state-anxious and trait-anxious, $r = .200$, $p < .05$ (see Table 18). These results indicate that state-anxious/trait-anxious subjects differed from controls in the frequency distribution of their asymmetry scores with proportionately more state-anxious/trait-anxious subjects showing right-asymmetry scores.

Hierarchical Regression. Unlike Time 1, an examination of the bivariate correlation for Time 2 failed to show any significant correlations between CFT scores and state anxiety. As expected, however, there was a significant correlation between state anxiety and both trait-anxiety, $r = .549$, $p < .01$, two-tailed, and depression, $r = .612$, $p < .01$, two-tailed. Similarly, a hierarchical regression analysis performed on variables predicting CFT scores (sex, handedness, and trait anxiety entered at Step 1; trait anxiety, and state anxiety entered at Step 2) revealed no significant relationships between CFT scores and both state anxiety and trait anxiety (see Table 19).

Characteristics of Approach vs. Withdrawal

High Trait-Anxious Subjects

As Table 20 illustrates, behavioral disengagement was the only scale correlated with CFT scores in right-handed trait-anxious-only subjects, $r = .235$, $p < .05$, two-tailed. That is, increases in self-reported tendencies to withdraw from stressful situations in right-handed subjects with high trait-anxiety were related to stronger left-hemispace biases. Additionally a hierarchical regression analysis on the prediction of CFT scores from the four COPE scales (with sex entered at Step 1 and Active Coping, Planning, Behavioral Disengagement, and Denial entered at Step 2) revealed a significant association between CFT scores and both Denial and Behavioral Disengagement (see Table 21).

Low Trait Anxiety Subjects

In right-handed subjects with low trait anxiety, there were no significant correlations between their CFT scores and any of the four COPE approach/withdrawal scales (see Table 22). However, a hierarchical regression analysis on the prediction of CFT scores from the four COPE scales (with sex entered at Step 1 and Active Coping, Planning, Behavioral Disengagement, and Denial entered at Step 2) revealed significant partial correlations between the two approach scales (active coping and planning) and CFT scores; active coping, $r = 1.32$, $p < .05$, two-tailed, and planning, $r = -.136$, $p < .05$ (see Table 23). That is, increases in self-reported tendencies to approach stressful situations in right-handed subjects with low trait-anxiety was related with weaker left-hemispace biases.

Time 1 - Time 2 Analyses: Change Scores

The correlations between handedness, sex, the independent variables, and the dependent variables for Time 1 and Time 2 are shown in Table 9.

To examine the relationship between changes in the independent measures (depression, state-anxiety, and trait-anxiety) and the dependent measure (CFT scores), a preliminary analysis was conducted on change scores. Change scores were created for each subject by subtracting Time 2 scores from Time 1 scores on these measures.

Change score correlations between the CFT change scores and all dependent measures were nonsignificant (see Table 24). The only significant correlations were between the three independent measures. Similarly, a hierarchical regression analysis (handedness, sex, and Time 1 scores for the CFT, depression, state- and trait-anxiety entered at Step 1; Time 2 depression, state- and trait-anxiety entered at Step 2) revealed no significant association between changes in depression, state-anxiety, or trait-anxiety and prediction of Time 2 CFT scores (see Table 25).

Handedness Analyses

Handedness analyses were performed only on Time 1 measures because of the low rate of return of left-handers for testing at Time 2. Table 26 shows the number of left-handers who met criteria for inclusion into the high- and low-depression, trait-anxiety, and state-anxiety groups at Time 1.

Comparisons Between Right- and Left-Handers

Separate t-tests revealed no significant differences between left- and right-handers on depression, state-anxiety, and trait-anxiety (see Table 27). Table 28 and Table 29 show the means for each of the independent and dependent measures for handedness and sex. These results suggest that the right- and left-handers reported similar levels of depression, state-anxiety, and trait-anxiety.

To examine possible differences between handedness and hemispace biases, an independent samples t-test was performed between left- and right-handers' CFT scores (M = -.235 and -.366, respectively). The difference failed to reach significance, $t(430) = 1.74$, $p = .061$. However, a hierarchical regressions revealed that handedness was a significant predictor of CFT scores when other variables such as sex, depression, and trait anxiety were removed (see Tables 10 & 13). The data were then examined with regard to frequency of left- versus right-biased subjects according to handedness by dividing subjects into left-biased (a negative score) or right-biased (a positive score) categories (see Table 30). The four-fold point correlation (Phi Coefficients) between left- versus right-bias and handedness was significant, $r = -.118$, $p < .05$. These results indicate that left-handed subjects differed from right-handed subjects in the frequency distribution of their asymmetry scores, with proportionately more left-handers showing right-hemispace biases. Lastly, to examine possible differences between left- and right-handers with right- or left-hemispace biases in the magnitude of their perceptual asymmetries, a two-way analysis of variance with handedness (left, right), and direction of perceptual asymmetry (left-bias, right-bias) as between-subjects variables was performed on CFT scores (see Table 31). There was a significant main effect for direction of perceptual asymmetry indicating that, regardless of handedness, subjects with left-hemispace biases have stronger perceptual asymmetries than subjects with right-hemispace biases. The other main effect and the interaction failed to reach significance. This suggests that left-handers and right-handers do not differ in the magnitude of their perceptual asymmetries when the directions of the perceptual asymmetries are the same.

Depression and Trait-Anxiety. A four-way analysis of variance with handedness (left, right), sex (male, female), depression (high, low), and trait-anxiety (high, low) as between-subjects variables was carried out on the CFT scores and revealed no significant main effects or interactions (see Table 32). Given the absence of sex differences between handedness groups, the right- and left-handers were compared again, this time with the men's and women's scores combined. Again, there were no significant main effects or interactions (see Table 33).

State- and Trait-Anxiety. A four-way analysis of variance with handedness (left, right) sex (male, female), depression (high, low), and trait-anxiety (high, low) as between-subjects variables was carried out on the CFT scores and revealed no significant main effects or interactions (see Table 34). Given the absence of sex differences between handedness groups, the right- and left-handers were compared again, this time with the men's and women's scores combined. Again, there were no significant main effects or interactions (see Table 35).

Comparisons Between Subgroups of Left-Handers

Depression and Trait-Anxiety. A two-way analysis of variance with depression (high, low), and trait anxiety (high, low) as between-subjects variables was performed on the CFT scores. There were no significant main effects or interactions (see Table 36).

Using t-tests, the mean of the four groups was compared to zero (which would indicate no asymmetry). Given that no subjects met criteria for trait-anxious-only, analyses were performed on the remaining three groups. All three groups did not differ significantly from zero: controls: $t(23) = -.374$, $p = .712$; depressed-only: $t(7) = -1.44$, $p = .193$; depressed/trait-anxious, $t(11) = -1.819$, $p = .096$.

The four-fold point correlations (Phi Coefficients) between left- versus right-bias and comparisons of all combinations of group membership (control vs. depressed-only; trait-anxious only vs. depressed/trait-anxious; control vs. trait-anxious-only; depressed-only vs. depressed/trait-anxious; control vs. depressed/trait-anxious; depressed-only vs.

trait-anxious-only) were nonsignificant (see Table 37). That is, none of the groups differed significantly in their proportion of left- to right-asymmetry scores.

A hierarchical regression analysis performed on variables predicting CFT Scores (sex entered at Step 1; depression, trait-anxiety, and state-anxiety entered at Step 2) revealed a significant relationship between CFT scores and depression such that higher levels of depression were correlated with stronger left-hemispace biases (see Table 38). A similar hierarchical regression analysis conducted separately for consistent and inconsistent left-handers revealed that that the association between CFT scores and depression was present in inconsistent but not consistent left-handers (see Table 39).

State- and Trait-Anxiety. A two-way analysis of variance with state anxiety (high, low), and trait anxiety (high, low) as between-subjects variables was performed on the CFT scores. There were no significant main effects or interactions (see Table 40). Using t-tests, the mean of the four groups was compared to zero (which would indicate no asymmetry). Given that only one subject met criteria for state-anxious-only, analyses were performed on the remaining three groups. The control group was the only one to differ significantly from zero, $t(34) = -3.14$, $p < .01$. The other two groups did not differ significantly from zero: trait-anxious-only, $t(2) = .060$, $p = .958$; state-anxious/trait-anxious, $t(8) = -1.891$, $p = .10$.

The four-fold point correlations (Phi Coefficients) between left- versus right-bias and comparisons of all combinations of group membership (control vs. state-anxious-only; trait-anxious only vs. state-anxious/trait-anxious; control vs. trait-anxious-only; state-anxious-only vs. state-anxious/trait-anxious; control vs. state-anxious/trait-anxious; state-anxious-only vs. trait-anxious-only) were nonsignificant (see Table 41). That is, none of the groups differed significantly in their proportion of left- to right-asymmetry scores.

A hierarchical regression analysis performed on variables predicting CFT Scores (sex entered at Step 1; depression, trait-anxiety, and state-anxiety entered at Step 2) revealed no significant relationship between CFT scores and either state anxiety or trait anxiety (see Table 38). Performing a similar hierarchical regression analysis on consistent and inconsistent left-handers separately revealed similar results (see Table 39).

Post Hoc Analyses

Stable Group Membership

On the possibility that the null findings for trait-anxiety and depression were related to the "state" nature of the depression inventory (in contrary to the GBI, a trait measure of depression, used by Heller et al., 1995), a subset of stable group members was selected and an ANOVA was performed on their CFT scores. Stable group members were subjects whose group membership (low or high trait-anxiety, low or high depression) did not change over the course of the two testing sessions. Two kinds of analyses were performed: 1) an ANOVA on CFT scores using stable depression and trait-anxiety group membership, and 2) an ANOVA on CFT scores using stable state-anxiety and trait-anxiety group membership.

First, a two-way ANOVA with stable depression (high, low), and stable trait anxiety (high, low) as between-subjects variables was carried out on the CFT scores at Time 1 and Time 2 separately. There were no significant main effects or interactions for either time (see Tables 42 & 43).

Second, a two-way ANOVA with stable state anxiety (high, low) and stable trait anxiety (high, low) as between-subjects variables was carried out on the CFT scores at Time 1 and Time 2 separately. This analysis revealed no significant main effects for either time. There was, however, a significant interaction between state anxiety and trait anxiety at Time 2 such that subjects with stable levels of both high state anxiety and high trait anxiety showed weaker left-hemispace biases (see Tables 44 & 45).

STAI State-Anxiety Scale Principle Components Analysis

On the possibility that the inverse relation between state-anxiety and CFT scores might be due to the influence of ruminative anxiety as measured by the STAI State-Anxiety Scale, the STAI State-Anxiety Scale items were analyzed using a oblique principle components analysis. This analysis revealed a four-factor solution (see Table 46). An analysis of the items in each factor suggested that factors 1-4 were conceptually related to serenity (or lack of anxiety), free-floating anxiety, autonomic anxiety, and cognitive worry.

A hierarchical regression analysis (see Table 47) performed on these four factors and their prediction of CFT Scores (handedness, sex, depression, and trait anxiety entered at Step 1; serenity, free-floating anxiety, autonomic anxiety, and cognitive worry entered at Step 2) revealed that anxious ambiguity was significantly correlated with CFT scores. Examination of the separate partial correlation coefficients for each of the four factors revealed that both anxious ambiguity (r = .-147, p = .002) and cognitive worry (r = .113, $p < .02$) were inversely related to CFT scores. That is, increases in anxious ambiguity and cognitive worry were related to weaker left-hemispace biases.

Self-Reported Intensity of Affect

Given 1) that psychological dimensions of valence and arousal have been shown to covary with particular physiological events, including attention and the startle reflex (e.g., Lang, 1995; Lang, Bradley, & Cuthbert, 1990), and 2) that arousal has been associated with right hemisphere function, including skin conductance (e.g., Heilman, Schwartz, & Watson, 1978) and abnormal skin conductance responses in persons with right-hemisphere brain-damage (e.g., Zoccolotti, Scabini, & Violani, 1982), a measure of affect intensity was included to assess its effects on hemispace biases (see Discussion section for a discussion of the rationale for including this measure). The Affect Intensity Measure, or AIM, (Larsen, 1984) was chosen to measure affect intensity (see Appendix K).

The AIM is a 40-item questionnaire designed to assess the characteristic strength with which a person experiences both positive and negative affect. Although Larsen (1984) suggested that the AIM can be used as a unidemensional index of affect intensity, Weinfurt, Bryant, and Yarnold (1994), on the basis of a sample of over 600 college subjects, effectively argue for a four-factor interpretation of the AIM: Positive Affectivity, Negative Intensity, Serenity, and Negative Reactivity. The first factor, positive affectivity, assesses both the degree to which one typically reacts to pleasurable events with positive affect and positive intensity, or the characteristic strength of the positive affect one generally experiences. The second factor, negative intensity, assesses a wide range of negative affective responses, including the intensity (frequency and duration) of negative emotions in general. The third factor, serenity, assesses the degree to which one experiences positive affect as energetic arousal versus calmness. Lastly, negative reactivity assesses negative affective reactions to environmental stimuli or events. In the present study, the AIM (and its four factors) had both high internal consistency and test-retest reliability (see Tables 2 & 3).

It was hypothesized that affect intensity (along all four dimensions) would be correlated with hemispace biases. Thus, it was predicted that increases in the four factors would be correlated with increases in left-hemispace biases as measured by the CFT. As Table 48 illustrates, negative reactivity was the only factor correlated with CFT scores ($r = -.105$, $p < .05$, two-tailed. That is, increased levels of intensity of negative reactivity were related to decreases in left-hemispace biases. This correlation appeared only at Time 1 (see Table 49 for Time 2 correlations). Furthermore, it was not correlated with state-anxiety as measured by the STAI-S — the only other measure related to CFT scores at Time 1.

DISCUSSION

The discussion begins with a restatement of the major predictions followed by a summary of the results. It then presents some general conclusions, limitations of the study, and, finally, directions for further research.

Contributions of Depression and Trait Anxiety to Perceptual Asymmetries

Recall Heller et al.'s (1995) finding that depressed subjects showed no reliable asymmetries on the CFT, whereas high-anxious subjects had stronger left-biases (as indexed by frequency, or direction, as well as magnitude of effects). Prediction #1 followed from Heller et al.'s (1995) findings, namely, that increased depressed symptomatology between groups would be related to a weaker left-hemispace bias, whereas increased levels of trait anxiety would be related to a stronger left-hemispace bias. Although the current study followed Heller et al.'s (1995) method for determining group membership, it failed to reveal any significant relation between depression, trait anxiety, and hemispace bias as indexed by the CFT for either magnitude or frequency. Thus, prediction #1 was not supported. That is, the current study did not find that subjects with high depression would have weaker left hemispace biases than subjects with low depression, or that subjects with high trait anxiety would have stronger left hemispace biases than subjects with low trait anxiety. Instead, all subgroups had left-hemispace biases.

The results, however, are consistent with Jaeger et al. (1987) for depression, the only measure used in their study. Heller et al. (1995) argued that Jaeger et al.'s (1987) data were confounded because the investigators failed to screen for levels of anxiety in their depressed subjects. Their subjects therefore may have had levels of high anxiety concomitant with their high depression. The current study, however, controlled for levels of trait anxiety and still found the same pattern for depressed-only subjects as that reported by Jaeger et al. (1987).

Although no support was found for Prediction #1, the results did reveal certain relations between the interaction of depression, trait anxiety, and CFT scores. Specifically, the results suggest that subjects with high trait anxiety and high depression differ from subjects who are low on both dimensions in the frequency distribution of their asymmetry scores, such that proportionately more of the high-anxious, high-depressed subjects show right-hemispace biases compared to controls. Although this effect was of uncertain reliability (occurring only at Time 2), it is in the opposite direction from what would be predicted by Heller et al. (1995). According to Heller et al. (1995), subjects who are high on both dimensions should not differ from controls in either the frequency or magnitude of hemispace biases. The competing patterns of arousal for anxiety and depression should cancel each other out.

In summary, for depression and trait anxiety, the current found no support for Heller's (1993) model and no support for Heller et al's. (1995) findings. Instead, when compared to controls, the number of subjects with right-hemispace biases was proportionately greater among subjects high on depression as well as trait anxiety.

Contributions of State Anxiety and Trait Anxiety to Perceptual Asymmetries

Prediction #2 was that high state anxiety in combination with high trait anxiety would be associated with stronger left-hemispace biases than either condition alone. This prediction likewise was not supported. Although anxiety was related to hemispace biases, it was in the opposite direction, such that the state-anxious/trait-anxious group not only had weaker left-hemispace biases than controls but also a greater proportion of right-hemispace membership.

The effects just described were stable across both Time 1 and Time 2. They also are the effects that constitute the most direct tests of the prediction. There were certain other effects, however, less directly tied to the prediction, that were unstable, that is, either present in Time 1 but not Time 2, or present in Time 2 but not Time 1. At Time 1, trait anxiety did not appear to be related to hemispace biases as indicated by any of the following analyses: ANOVA, hierarchical regression, t-test comparing trait anxiety CFT means to zero, and phi coefficient analyses between the frequency of left- or right hemispace biases in the trait-anxious-only group compared to the other three groups. By contrast, several of the same analyses for state anxiety revealed that state anxiety was related to changes in magnitude of hemispace biases (except in the opposite direction of the prediction). At Time 2, these results changed. Now, trait anxiety was related to weaker left-hemispace biases (as indicated by ANOVA and t-test), whereas state anxiety was no longer correlated with hemispace biases.

In summary, the results suggest an inverse relation between concomitant levels of high state- and trait-anxiety and hemispace biases, such that combinations of high state- and trait-anxiety are related to weaker left-hemispace biases and a greater frequency of right-hemispace bias group membership.

Trait Anxiety, Approach/Withdrawal, and Patterns of Perceptual Asymmetries

Derived from the interaction of Heller's (1993) model and Davidson's (1992) approach-withdrawal model, Prediction # 3 was that greater levels of withdrawal behaviors in trait-anxious subjects would be related to stronger left-hemispace biases. Prediction #3 was supported. That is, in a group of trait-anxious subjects, the tendency to behaviorally disengage (to withdraw) from stressful situations was correlated with stronger *left* hemispace biases. Likewise, in non-anxious subjects, the increase in the tendency to behaviorally engage (to approach) in stressful situations was correlated with stronger *right* (or weaker left-) hemispace biases.

Changes in Levels of Depression and Anxiety and Perceptual Asymmetries

Prediction #4 was that changes in depression and/or anxiety over time would be related to changes in hemispace biases (in a direction consistent with the model). The prediction was not supported: changes in levels of depression and in state anxiety across time were not related to CFT scores.

Handedness and Mood

Prediction #5 was that any differences between left- and right-handers would be in the direction of higher rates for left-handers than for right-handers on measures of negative emotional states (e.g., depression and anxiety). Prediction # 5 was not supported. Left-handers did not differ from right-handers in mean levels of state-anxiety, trait-anxiety, or depression.

Handedness, Mood, and Perceptual Asymmetries

Prediction #6 was in three parts. Prediction #6a was that right-handers would be more clearly lateralized than left-handers on the CFT. This prediction was confirmed. Consistent with prior studies, left-handers' perceptual asymmetry scores were more heterogeneous than right-handers. At the group level, for some but not all statistical comparisons, left-handers had weaker left-hemispace biases than right-handers. At the individual subject level, proportionately more left-handers than right-handers were classified as right-hemispace biased.

Prediction #6b was that at comparable levels of depression, right-handers would show a greater reduction in magnitude of left-hemispace biases, whereas at comparable levels of anxiety, they would show a greater increase in magnitude of left-hemispace biases. As already noted, left- and right-handers differed in the direction and strength of hemispace biases but did not differ (per prediction #5) in the mean levels of depression and anxiety. Similarly, there were no significant interactions between handedness, levels of depression and anxiety, and strength of hemispace biases. Thus prediction #6b was not supported.

Prediction #6c was that left-handers with right-hemispace biases would show changes in strength of right-hemispace biases in accordance with Heller's predictions for anxiety and depression. Prediction #6c was not supported. When a group of left-handers showing right-hemispace biases was examined separately, there was no relation between their levels of depression and anxiety and the strength of their right-hemispace biases. Recall from Levy et al. (1983) that this subgroup of left-handers should show characteristically higher left- than right-hemisphere arousal. If we assume that arousal levels are influenced by depression and anxiety, then left-handers with right-hemispace biases should also show changes in the magnitude of their CFT scores with changes in depression and anxiety.

Lastly, although not predicted, when left-handers were examined alone, there was a relation between increases in levels of depression and increases in left-hemispace biases. Furthermore, this effect appeared only for consistent left-handers, not inconsistent left-handers.

Summary, Conclusions, and Future Directions

A general summary will first be provided for the results for right-handers followed by a separate discussion of the results for left-handers.

Right-Handers

For right-handers, the main results are complex and, for the most part, do not support Heller's model. For trait anxiety, the model predicts that subjects with high depression and low trait anxiety would show weaker left hemispace biases on the CFT compared to the controls (low depression/low anxious). This prediction was not supported. The only subjects whose CFT scores were in this direction were those with high depression and high trait anxiety. This latter finding is also inconsistent with Heller's model because the model predicts that there should be no differences in CFT scores for this subgroup compared to controls; that is, the competing arousal patterns for depression and anxiety should cancel each other out and produce a left-hemispace bias similar to that of controls. It should be noted, however, that this finding was of uncertain reliability, occurring only at Time 2.

Although Heller's model deals only with trait anxiety, similar predictions presumably would follow for state anxiety. Here again, though, the results were in the reverse direction, with increases in levels of state anxiety related to decreases, rather than increases, in left-hemispace biases. Additionally, when levels of trait anxiety were examined in relation to levels of state anxiety, among subjects reporting high levels on both dimensions a greater proportion had right-hemispace biases compared to controls. This finding was reliable, occurring at both Time 1 and 2. Recall that it was predicted that concomitant high levels of state- and trait-anxiety would result in a greater overall left-hemispace bias than either form of anxiety in isolation. These results, therefore, were in the reverse direction from what was predicted and are suggestive of decreased right-hemisphere arousal and possible left-hemisphere hyperarousal in subjects who are currently in states of anxiety.

The current study also found that changes in levels of depression and in state anxiety across time were not related to CFT scores, much less in the direction that would be predicted by Heller's (1993) model. One possible way to reconcile this finding with the prediction derived from the model is that variations in patterns of perceptual asymmetries in depression and anxiety are more trait-like or stable and, therefore, are relatively uninfluenced by variations in levels of depression or state-anxiety across the two testing periods. Although this interpretation appears to contradict the findings for state-anxiety, the possibility will be raised in the next section that "state anxiety," as measured by the STAI, may be measuring more than just state anxiety.

Subtypes of Anxiety: Re-consideration of the Model. The current results are in obvious conflict with Heller's (1993) model and the predictions it makes for depression and anxiety. Is there any way that they can be reconciled? Heller et al. (1995) themselves recently have suggested one approach. They posited that it may be necessary to consider the type of anxiety being measured when making inferences about neocortical activity.

Worry vs. Panic. As one possibility, Heller et al. (1995) make a distinction between panic, characterized by a number of somatic concerns and physiological changes, and worry, characterized by uncontrollable, often intrusive, and ruminative thoughts. They also note that in reports of higher levels of right hemisphere activity in association with anxiety, the kind of anxiety studied is more often panic, whereas in studies that found either no asymmetries or higher left hemisphere arousal in association with anxiety, the kind of anxiety studied is more often worry. What this pattern of results suggests for the current study is that the STAI State-Anxiety Scale may be measuring dimensions of anxiety more closely related to worry, or rumination, than panic. Closer examination of this scale supports this possibility. On the STAI State-Anxiety Scale (see Appendix D) there are many items that might be classified as worry rather than panic (e.g., "I am presently worrying over possible misfortunes," I feel indecisive," "I am worried," and "I feel confused"). The same kind of items can be found in the STAI Trait-Anxiety Scale (e.g., "I feel that difficulties are piling up so that I cannot overcome them," I worry too much over something that doesn't matter," "I have disturbing thoughts," I make decisions easily," and "I take disappointments so keenly that I can't put them out of my mind").

Given that state anxiety showed an inverse, rather than a positive, relation to CFT scores and that the state anxiety measure used in the current study might contain a mixture of anxiety subtypes, the data were re-examined to better understand this relation. First, on the possibility that "state anxiety" itself contains a mixture of subtypes, a principle components analysis was performed on the STAI State Anxiety Scale. This analysis revealed four factors. Next, a hierarchical regression was performed to compare the four factors' relation to CFT scores. The results indicated that two factors, best described as "cognitive worry" and "free-floating anxiety," were the only factors related to hemispace bias, with higher levels of both being related to weaker left-hemispace bias. Taken together, the results suggest than in state-anxious persons, it is only the cognitive worry and free-floating anxiety subtypes that are associated with decreased right- (or increased left-) hemisphere arousal. Also, in hindsight, it appears that the STAI contains a mixture of anxiety subtypes beyond that of "state" vs. "trait" and that certain subtypes, but not others, are intimately related to hemispace bias. This would explain why state anxiety was inversely related to CFT scores and why high state- and trait-anxiety (using the same measure of trait-anxiety used by Heller et al., 1995) were related to weaker left-hemispace biases. This might also explain why Heller et al. (1995) failed to find stronger left-hemispace biases in subjects with high trait-anxiety in the absence of depression. That is, to the extent that the anxiety measures tapped into more than one subtype of anxiety and to the extent that certain subtypes of anxiety are related to anxiety in opposing ways, then interpretation of the results is obscured by these possible confoundings.

Anxious Arousal (panic) vs. Anxious Apprehension (worry). Recently, Heller and colleagues have elaborated more fully on the panic-worry distinction and its utility in studies of the role of arousal in perceptual asymmetries. They draw on Watson et al.'s (1995) distinction among subtypes of anxiety: anxious arousal and anxious apprehension. Heller and Nitschke (1997) propose that their terms *worry* and *panic* exemplify these two kinds of anxiety, respectively. They then propose that brain activity might be different for anxious arousal and anxious apprehension. They make this suggestion on their view that these kinds of anxiety differ significantly in both psychological and physiological characteristics. Anxious arousal is characterized by physiological hyperarousal and somatic tension (including fear, tachycardia, dyspnea, sweating, and choking) and would include disorders of anxiety such as panic, post-traumatic stress disorder, and phobias. Anxious apprehension, on the other hand, is characterized by worry and verbal rumination and includes such disorders of anxiety as generalized anxiety disorder and obsessive-compulsive disorder. Just as there is high comorbidity between anxiety and depression, anxious apprehension and anxious arousal can also co-occur in the same population of individuals. For example, being worried about future events (anxious apprehension) may prompt one to experience somatic tension (anxious arousal). Given left-hemisphere dominance for language in most right-handers, Heller and colleagues have also hypothesized that anxious apprehension should be associated with more left- than right-hemisphere activity because of the strong verbal component inherent in worry and cognitive anxiety. Conversely, they suggest that the literature linking somatic arousal to posterior right-hemisphere regions of the brain (see Introduction) should be associated with more right posterior activity and with anxious arousal. Nitschke, Palmieri, Miller, and Heller (Nitschke, personal communication, February 9, 1998) found support for their proposed divisions in a study of EEG activity in undergraduate subjects with high scores either on a measure of anxious apprehension (Penn State Worry Questionnaire; Molina & Borkevec, 1994) or on a measure of anxious arousal (Anxious Arousal scale of the Mood and Anxiety Symptom Questionnaire; Watson et al., 1995). The two groups showed different patterns of hemispheric asymmetry, with the anxious apprehension group showing more left-sided activity and the anxious arousal group showing more right-sided activity in parietotemporal regions.

Approach vs. Withdrawal. Heller and Nitschke (1997) have also begun to speculate about the possible interactions between their arousal-apprehension dimension and both of the typologies of emotion discussed in the Introduction, namely, Davidson's (1992) approach-withdrawal distinction and the positive-negative valence distinction. Heller and Nitschke suggest that anxious apprehension that leads to approach or withdrawal tendencies might also favor the left or right anterior regions, respectively. With regard to valence, they predict that anxious apprehension characterized by approach tendencies would be accompanied by relatively pleasant affect. In contrast, anxious apprehension characterized by withdrawal tendencies would be accompanied by relatively unpleasant affect.

It is possible that the distinction, still based on an approach-withdrawal dimension, is simpler than Heller and Nitschke have supposed. Let us assume that anxious apprehension and anxious arousal are related to increases in left or right parietal activity, respectively. If so, it may be that anxious arousal is related to withdrawal behavior, whereas anxious apprehension is related to the absence of approach or withdrawal. To elaborate, anxious arousal and its association with fear (Watson et al., 1995) implies a fight or flight type response or an *instrumental* response to or away from an object (here termed *instrumental anxiety*). Anxious apprehension, on the other hand, and its association with verbal rumination, suggests little in terms of movement toward or away from an object or goal (here termed *non-instrumental anxiety*). Rather, the apprehensive person does not move, but instead describes feelings of being "stuck," "indecisive," or "frozen." Because the current study did not distinguish between anxious apprehension and anxious arousal, it was not possible to test the prediction that anxious arousal would be related to withdrawal behavior. However, the current study did measure state- and trait-anxiety as well as styles of coping in stressful situations (Carver et al., 1989). Among the COPE's many subscales, there are at least four that assess approach and withdrawal coping tendencies in response to stressful situations (i.e., make instrumental vs. non-instrumental behavioral responses). The question is whether anxious persons' hemispace biases differ in relation to their tendency to approach or to avoid stressful situations. That is, a group of anxious subjects with concomitant high levels of the tendency to disengage, or withdraw, should be most like Heller and Nitchske's "anxious arousal" group and, thus, should show greater right- than left-hemisphere arousal. The current study confirmed that there is a difference. Among trait-anxious subjects, an increase in the tendency to behaviorally disengage (withdraw) from situations was correlated with an increase in *left* hemispace bias (indicating greater right hemisphere arousal). This suggests that anxious persons who engage in instrumental behavior (i.e., withdrawal) have greater right- relative to left-hemisphere activity. If we are to assume that this group is most like Heller and Nitschke's "anxious arousal" subgroup, then it also supports their proposed distinction. Likewise, in a group of non-anxious subjects, increases in tendencies to behaviorally engage (approach) in situations were correlated with increases in *right* hemispace biases.

The results of the current study suggest that attentional and perceptual biases are related to withdrawal behaviors (i.e., anxious arousal) and the "emotion surveillance system" (Nitschke, personal communication, February 9, 1998) of the right hemisphere. The right hemisphere has been shown to be primed by ambiguous and threatening stimuli and is hypothesized to play a role in orienting to such stimuli (for reviews, see Eysenck, 1992; Mathews & McLeod, 1994; MacLeod, 1990). In addition, the current results suggest that anxious arousal is related to right-hemisphere activity, suggesting that anxious arousal is associated with an augmentation of the emotional surveillance system (e.g., preparing the organism for fight or flight), even in the absence of an emotional stimulus (e.g., as assessed by the COPE). Thus, engagement of right-hemisphere regions that accompany anxious arousal can be hypothesized to produce a set of behaviors that include attentional and other cognitive responses designed to evaluate the presence of a threat and to prepare for a behavioral action.

Left-Handers

Consistent with previous studies (e.g., Levy et al., 1983), left-handers as a group had weaker perceptual asymmetries than right-handers. In addition, proportionately more left-handers than right-handers showed right-hemispace biases. Left-handers, however, were not different from right-handers in levels of depression, trait anxiety, or state anxiety. Similarly, there were no significant interactions between handedness, levels of depression and anxiety, and strength of hemispace biases — even in a subgroup of left-handers with right-hemispace bias, a group that, according to Levy et al. (1983), should have higher left- than right-hemisphere arousal. These results are difficult to interpret: If we were to consider, jointly, Heller's arousal model and its predictions for depression and anxiety, and the current results on handedness, namely that left-handers as a group have weaker asymmetries and more frequent right-hemispace bias than right-handers, then the left-handers, compared to right-handers, ought not to have had similar depression and anxiety scores. Their scores instead should have been different, namely, their depression scores should have been higher. Furthermore, the results for the inconsistent left-hander-depression-perceptual asymmetry effect should have gone in the reverse direction assuming that Peters and Servos' (1989) are correct in their suggestion that consistent left-handers, not inconsistent left-handers, are the "reverse" of right-handers (i.e., show reverse advantages for lateralized tasks). That these expectations were not borne out suggests at least two possibilities: 1) hemispheric specialization for arousal and for the perception of emotion is organized differentl in right-handers and left-handers such that, for example, the two are more consolidated in one hemisphere for right-handers but more dissociated for left-handers, and/or 2) depression and anxiety are only one way in which differences in perceptual asymmetries can be explained — a way that does not appear to contribute significantly to the differences between left- and right-handers. This is not to say that handedness differences in perceptual asymmetries are unrelated to depression and anxiety. As the current results revealed, for left-handers, there was a difference between consistent and inconsistent handedness in the interaction between depression and perceptual asymmetries. It is, rather, that we do not currently possess a model and perhaps enough meaningful subclassifications of handedness to understand or to predict how handedness and emotion interact to produce differences in perceptual asymmetries.

Limitations of Current Study

The current study has several possible limitations. To begin with, it was extremely difficult to isolate the variables of interest in an undergraduate population. Recall that only one of 435 subjects met criteria for inclusion into the low depression, high trait anxiety group. In addition, given that only 18% of the sample were left-handed (despite concerted effort to recruit left-handers), one can appreciate the difficulty of establishing an appropriate sample size for the variables of interest. Perhaps before factors of handedness can be addressed (as well as others with similarly low prevalence rates in normal populations), the model should be refined using the most accessible populations.

A second limitation of the current study relates to its choice of independent measures. As discussed earlier, the STAI may not be the most suitable measure for use in studying Heller's (1997) revised model, which distinguishes between anxious approach and anxious apprehension. To the extent that the STAI measures both kind of anxiety, it cannot distinguish between them to assess their respective influences on neuropsychological functioning.

A third possible limitation of the current study is its choice of dependent measures, namely, the Chimeric Faces Task, or CFT. That is, because the CFT is only a proxy measure of hemispheric specialization for emotion used to infer asymmetric hemispheric arousal, it may have insufficient external validity. However, this possibility is diminished by evidence supporting: 1) the proposal that the distribution of attention in space is biased in the direction contralateral to the more activated hemisphere (for review, see Reuter-Lorenz, Kinsbourne, & Moscovitch, 1990), 2) right hemisphere superiority for face recognition (for a review, see Benton, 1980), and 3) the CFT's ability to measure both hemispheric specialization for the perception of emotion and asymmetries in hemispheric arousal (e.g., Levy et al., 1983b).

Lastly, the current study is limited in its ability to generalize to or make interpretations about clinical populations. This may be especially true for considerations of state-trait congruence. The reason is that clinical populations are far more likely than non-clinical populations to be high on both dimensions.

General Conclusions and Future Directions

In summary, the main results of the current study were complex and did not support Heller's model as originally formulated. The data, however, fit better with Heller's recently revised model and provide preliminary support for the suggestion that subtypes of anxiety are characterized by different regional brain activity. However, such an interpretation must be tempered by the observation that even though the "purification" of the STAI State-Anxiety Scale revealed a significant relation only between CFT scores and "cognitive worry" and "free-floating anxiety," the correlations between these two factors and CFT scores remained relatively unchanged from the correlation between CFT scores and the entire 20-item State-Anxiety Scale. In addition, the factor "autonomic arousal," — the factor that should be related to Heller and Nitschke's (1997) anxious arousal dimension — was unrelated to CFT scores. According to Heller and Nitschke's revised model, autonomic arousal should be related to CFT scores in the opposite direction of cognitive worry and free-floating anxiety. Although these observations weaken an interpretation of the data as favoring Heller and Nitschke's revised model, they should not be interpreted as evidence for rejecting their proposed revision. That is, as mentioned earlier, the current study neither measured anxious apprehension nor anxious arousal, but rather made inferences about these constructs from measures of anxiety designed to measure other constructs, namely, trait and state anxiety. To the extent that these measures are unable to assess anxious arousal and anxious apprehension, then any conclusions about the validity of Heller and Nitschke's (1997) model are suspect.

Regardless of the viability of Heller and Nitschke's proposed revisions for anxiety subtypes, the data in the current study for state anxiety and trait anxiety suggest that when we examine regional brain asymmetries, we cannot treat anxiety as a unitary construct. To the extent that different psychological conditions affect hemispace biases in different ways, as the current study demonstrated for state anxiety and trait anxiety, we must consider their separate influences as well as their possible interactions. Just as trait-anxiety often co-occurs with depression, so, too, do state- and trait-anxiety co-occur as well as a variety of anxiety subtypes (e.g., anxious arousal and anxious apprehension; instrumental anxiety and non-instrumental anxiety). Therefore, it will be important for future studies to include better assessments of those subtypes.

If Heller and Nitschke's (1997) revised model proves unsound, it remains to be seen what new model might offer more explanatory power. Based on the data in the current study, one possible interpretation is that deviations from the normal left hemispace bias (e.g., right hemispace biases) simply reflect other deviations in the "stability" of the individual, for instance, high levels of state anxiety in the current state anxiety. This interpretation is supported by evidence for deviations in reaction times between left- and right-hemispace bias groups (Wirsen, Klinteberg, Levander, & Schaller, 1990), with the latter group showing slower reaction times and "also appear[ing] to be more cautious...and less impulsive" (Wirsen et al., 1990; p. 237). While this interpretation is tentative, it may hold additional explanatory power.

Given that anxiety appears to be related to regional brain activity, albeit in a manner that remains to be elucidated, it will also be important to examine anxiety in relation to unilateral brain damage. Typically, these clinical populations have been studied only along a positive/negative dimension. Heller's model makes specific predictions about the effects of such unilateral damage on anxiety. From the clinical studies earlier, one can expect unilateral damage to also cause changes in anxious arousal (e.g., increase or decrease in panic or fear responses), anxious apprehension (e.g., increase or decrease, perhaps indifference, in worry), or instrumental anxiety (e.g., increased tendency to approach or withdrawal from situations), depending on location of damage.

The current study also helps to shed light on the question of whether patterns of brain activity and cognitive function characteristic of anxiety are present regardless of mood state. The results suggest that when there is congruence between state- and trait-anxiety (particularly at the high end), regional brain activity is altered to a greater degree than when there is noncongruence. Thus, regional brain differences may be overlooked in persons who are not currently in anxious states. In the future, therefore, it will be important to find state and trait measures for each of the dimensions discussed earlier (i.e., approach-withdrawal, arousal-apprehension). It is possible that the relation between these dimensions and regional brain activity will be different for persons depending on the level of congruity between their state and trait for the dimension being assessed. Thus, it will also be important to study Heller's model in persons with specific psychological disorders, especially given the number of dimensions on which anxiety may vary. As already noted, it probably will be difficult to isolate such individuals in the general college population. Individuals with clinical disorders are much more likely to have congruence between 'state' and 'trait' on the dimensions being examined.

The current study also suggests that the state-trait distinction (as measured by the STAI) is not synonymous with Heller's anxious arousal-anxious apprehension dimension and that it measures more than one meaningful subtype. So far, this distinction has not been clearly made in the literature. Thus, when drawing conclusions about arousal or apprehension, one must be careful when using state-trait measures because these measures often include items that measure both anxious-arousal and anxious apprehension.[12] That is, persons in a state-anxious state are not necessarily aroused to action (i.e., approach or withdrawal from a situation) — instead, such persons in states of anxiety could be in heightened states of worry (e.g., worrying about an upcoming examination or having an increase in occurrence of intrusive thoughts). In the future, it will be important to more accurately differentiate between anxious apprehension and anxious arousal.

In sum, the results thus do not support Heller's model but suggest how an integration of her revised model with Davidson's model might have more explanatory

[12] Although Heller et al. (1995) recognize the value of the distinction, Heller continues to cite her 1995 study — a study that uses the STAI Trait-Anxiety Scale — as evidence for anxious arousal. However, as we have seen, the scale includes a number of items that are more characteristic of anxious apprehension than anxious arousal.

power. The results also suggest that any such integration calls for a clear understanding of the relation between anxiety and hemispheric arousal and will depend on making meaningful distinctions among anxiety subtypes. Just as it may be helpful to treat 'emotional valence' as an approach-withdrawal dimension, it may be helpful to treat anxiety as an approach-withdrawal dimension. The current findings, with regard to approach vs. withdrawal coping styles in anxious individuals, suggest that a clear understanding of the relation between anxiety and hemispheric arousal may depend intimately on making meaningful distinctions among its subtypes as well as on better integration of neuropsychological theories of emotion. Only then, perhaps,will we begin to "carve nature at its joints" (Davidson, 1992b, p. 243).

TABLES

Table 1

Subject Demographic Information for Right- and Left-Handers

	Right-Handed		Left-Handed	
	Male	Female	Male	Female
N	82	275	36	42
Age	20.7	19.7	20.0	20.1
(SD)	(5.0)	(3.2)	(2.14)	(3.7)
Ethnicity (%)				
Caucasian	79.3	82.5	86.1	83.3
African-American	2.4	7.6	--	9.5
Native-American	2.4	1.5	--	--
Asian-American	8.5	2.5	--	2.4
Hispanic	6.1	4.0	2.8	4.8
Other	1.2	1.8	11.1	--
Year in School				
Freshman	35.4	43.1	27.8	42.9
Sophomore	24.4	28.5	30.6	14.3
Junior	17.1	15.3	25.0	23.8
Senior	23.2	13.1	16.7	14.3
Grad	--	--	--	4.8
Laterality Index				
Score	36.34	13.57	17.03	37.12
(SD)	(3.25)	(5.42)	(6.19)	(2.98)
Handedness Consistency				
Consistent	29%	18%	64%	45%
Inconsistent	71%	82%	36%	55%

Table 2

Internal Consistency (Coefficient Alphas) for Independent and Dependent Measures for First and Second Testing Sessions

	Time 1 (N = 435)	Time 2 (N = 255)
Independent Measures		
Handedness Questionnaire (8 items)	.9492	.9357
STAI (State)	.9181	.9283
STAI (Trait)	.9160	.9221
CES-D	.8844	.9137
Dependent Measure		
Chimeric Faces Task (34 items)	.9448	.9446
Post Hoc Measures		
AIM (40 items)		
Positive Affectivity (17 items)	.9223	.9173
Negative Intensity (10 items)	.7736	.6929
Serenity (7 items)	.8219	.8655
Negative Reactivity (6 items)	.7613	.8053
COPE (60 items)		
Active Coping (4 items)	.6794	--
Planning (4 items)	.8415	--
Denial (4 items)	.7750	--
Behavioral Disengagement (4 items)	.7056	--
STAI State Anxiety Scale (4 Factors)		
Serenity (9 items)	.8922	--
Free-Floating Anxiety (3 items)	.6346	--
Autonomic Anxiety (3 items)	.6404	--
Cognitive Worry (4 items)	.7637	--

Table 3

Test-Retest Reliability of Independent and Dependent Measures Across a Four Week Interval

	($\underline{N}$ = 255)
Independent Measures	
Handedness Questionnaire (8 items)	** .959
STAI (State)	** .516
STAI (Trait)	** .845
CES-D	** .548
Dependent Measure	
Chimeric Faces Task (34 items)	** .748
Post Hoc Measures	
Affect Intensity Measure (40 items)	
Positive Affectivity	** .821
Negative Intensity	** .752
Serenity	** .709
Negative Reactivity	** .839

** Correlation is significant at the 0.01 level (2-tailed)

Table 4

Frequency

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Table 4

Frequency of High- and Low-Depressed and High- and Low-Trait Anxious Subjects for Heller et al. (1995) and Current Study for both Time 1 and Time 2

a. Heller et al. (1995) (Right-Handed males and females = 830)

	Depressed	
Trait-Anxious	Low	High
Low	297	20
% of total sample	35.8	2.4
% of those meeting criteria	69.7	4.7
High	16	93
% of total sample	2.0	11.2
% of those meeting criteria	3.8	21.8

b. Current Study Time 1 (Right-Handed males and females = 357)

	Depressed	
Trait-Anxious	Low	High
Low	124	37
% of total sample	34.7	10.4
% of those meeting criteria	55.6	16.6
High	1	61
% of total sample	0.3	17.1
% of those meeting criteria	0.4	27.4

c. Current Study Time 2 (Right-Handed males and females = 224)

	Depressed	
Trait-Anxious	Low	High
Low	80	36
% of total sample	35.7	16.1
% of those meeting criteria	53.7	24.1
High	1	32
% of total sample	0.4	14.3
% of those meeting criteria	0.7	21.5

Table 5

Frequency of High- and Low- State-Anxious and High- and Low-Trait Anxious Subjects for Current Study for both Time 1 and Time 2

a. Current Study Time 1 (Right-Handed males and females = 357)

	State-Anxious	
Trait-Anxious	Low	High
Low	165	14
% of total sample	46.2	4.0
% of those meeting criteria	73.7	6.3
High	10	35
% of total sample	3.0	9.8
% of those meeting criteria	4.4	15.6

b. Current Study Time 2 (Right-Handed males and females = 224)

	State-Anxious	
Trait-Anxious	Low	High
Low	93	21
% of total sample	41.5	9.3
% of those meeting criteria	66.9	15.1
High	4	21
% of total sample	1.8	9.3
% of those meeting criteria	2.9	15.1

Table 6

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[13] Table reflects
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Table 6

Frequency of Hemispace Biases for High- and Low-Depressed and High- and Low-Anxious Right-Handed Subjects for Heller et al. (1995) and Current Study (Time 1) Using Heller's Decision Rule[13]

a. Heller et al. (1995)

Anxious	Depressed: Low	Depressed: High
Low		
Left biased	234 (78.8%)	8 (40.0%)
No asymmetry	16 (5.3%)	2 (10.0%)
Right biased	47 (15.8%)	10 (50.0%)
High		
Left biased	15 (93.8%)	75 (81.1%)
No asymmetry	0	2 (4.3%)
Right biased	47 (15.8%)	14 (15.1%)

b. Current Study using Heller et al.'s (1995) Criteria

Anxious	Depressed: Low	Depressed: High
Low		
Left biased	99 (79.8%)	26 (70.3%)
No asymmetry	2 (1.6%)	0
Right biased	23 (18.5%)	11 (29.7%)
High		
Left biased	1 (100%)	75 (81.1%)
No asymmetry	0	2 (4.3%)
Right biased	0	14 (15.1%)

[13] Table reflects data for right-handers who met cutoff criteria for inclusion (N = 426). 426 of 830 participants (51.3%) of Heller et al.'s (1995) sample met criteria for inclusion.

Table 7

Frequency of Hemispace Biases for High- and Low-Depressed and High- and Low-Anxious Right-Handed Subjects in Current Study Using the Binomial Distribution and p-value of <.05 (Time 1)

	Depressed					
Anxious	Low			High		
	N	CFT	SD	N	CFT	SD
Low						
Left biased (≥ 21)	85	-.691	(.23)	19	-.752	(.23)
No asymmetry (14-20)	23	-.003	(.10)	9	-.007	(.01)
Right biased (≤ 13)	16	.724	(.23)	9	.575	(.34)
High						
Left biased (≥ 21)	1	-1.000	(--)	36	-.628	(.22)
No asymmetry (14-20)	0			12	-.001	(.11)
Right biased (≤ 13)	0			13	.665	(.29)

Table 8

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a. Mean CF
Subjects a

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Table 8

Mean CFT Scores for High- and Low-Depressed and High- and Low-Trait-Anxious Right-Handed Subjects and Analysis of Variance of Hemispace Biases for Heller et al. (1995) and Current Study (Time 1)

a. Mean CFT Scores for High- and Low-Depressed and High- and Low-Anxious Subjects as Reported by Heller et al. (1995)

	Depressed				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.422	.48	-.117	.44	-.269
High	- .517	.45	-.386	.50	-.451
M	-.469		-.251		

b. Mean CFT Scores for High- and Low-Depressed and High- and Low-Anxious Subjects in Current Study

	Depressed				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.385	.54	-.262	.60	-.357
High	-1.000	--	-.230	.57	-.230
M	-.390		-.242		

c. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Sex (S)	1	.63	.43	.12
Depression (D)	1	1.57	.21	.24
Trait Anxiety (TA)	1	.29	.59	.08
S x D	1	.78	.38	.14
S x TA	1	1.46	.23	.23
D x TA	1	1.07	.30	.18
S x TA x D	0	.	.	.
S within-group error	216	(90.79)		

Note. Value enclosed in parentheses represents mean square errors.

Table 9

Correlations Between Sex, Handedness, Independent, and Dependent Variables for Time 1 and 2

	SEX	HAND	CESD #1	STAI-S #1	STAI-T #1	CFT #1	CESD #2	STAI-S #2	STAI-T #2	CFT #2

Table 9

Correlations Between Sex, Handedness, Independent, and Dependent Variables for Time 1 and 2

	SEX	HAND	CESD #1	STAI-S #1	STAI-T #1	CFT #1	CESD #2	STAI-S #2	STAI-T #2	CFT #2
SEX		.000	.352	.335	.823	.898	.292	.407	.998	.399
HAND	** .200		.671	.751	.448	.061	.538	.789	.667	.056
CESD #1	.045	.020		.000	.000	.620	.000	.000	.000	.523
STAI-S #1	.046	.015	** -.576		.000	.028	.000	.000	.000	.050
STAI-T #1	-.011	.037	** .745	** .664		.526	.000	.000	.000	.361
CFT #1	-.006	.090	-.024	* -.106	-.031		.597	.619	.639	.000
CESD #2	.066	-.038	** .548	** .419	** .557	.033		.000	.000	.783
STAI-S #2	.052	.017	** .363	** .516	** .456	-.031	** .612		.000	.797
STAI-T #2	.000	-.027	** .661	** .577	** .845	-.029	** .673	** .549		.228
CFT #2	-.053	.119	- .040	* -.122	-.057	** .748	-.017	-.016	-.075	

CESD #1 = Depression at Time 1; STAI-S #1 = STAI State-Anxiety Scale at Time 1; STAI-T #1 = STAI Trait-Anxiety Scale at Time 1; CFT #1 = Chimeric Faces Task at Time 1; CESD #2 = Depression at Time 2; STAI-S #2 = STAI State-Anxiety Scale at Time 2; STAI-T #2 = STAI Trait-Anxiety Scale at Time 2; CFT #2 = Chimeric Faces Task at Time 2

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

Table 10

Summary (

Prediction (

Variable
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Note: R^2 = .01

* p < .05.

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Table 10

Summary of Hierarchical Regression Analysis for Depression and Trait Anxiety on the Prediction of CFT Scores at Time 1 (N= 428)

Variable	B	SE B	ß
Step 1			
Handedness	-.259	.112	*-.125
Sex	.073	.100	.040
Step 2			
Handedness	.070	.113	*-.125
Sex	.007	.101	.038
Depression	.006	.007	.067
Trait Anxiety	-.002	.007	-.025
Step 3			
Handedness	-.259	.113	*-.125
Sex	.070	.101	.038
Depression	.004	.020	.046
Trait Anxiety	-.003	.010	-.034
Depression x Trait Anxiety	.000	.000	.029

Note: R^2 = .015 for Step 1; Δ R^2 = .003 for Step 2 (ps = .634;); Δ R^2 = .000 for Step 3 (ps = .919;)
* $p < .05$.

Excluded Variables in Model 1

	Beta In	t	Sig.	Partial Correlation
Depression (D)	.048	.906	.366	.049
Trait Anxiety (TA)	.026	.478	.633	.026
D x TA	.044	.831	.407	.045

Table 11

Mean CFT Scores for High- and Low-State-Anxious and High- and Low-Trait-Anxious Right-Handed Subjects and Analysis of Variance of Hemispace Biases for Current Study (Time 1)

a. Mean CFT Scores for High- and Low-State-Anxious and High- and Low-Trait-Anxious Subjects in Current Study

	State-Anxious				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.393	.56	-.298	.42	-.386
High	-.410	.31	-.143	.63	-.201
M	-.394		-.187		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Sex (S)	1	.37	.55	.09
State Anxiety (SA)	1	.81	.37	.15
Trait Anxiety (TA)	1	.00	.97	.05
S x SA	1	.03	.87	.05
S x TA	1	.38	.54	.09
SA x TA	1	.01	.92	.05
S x SA x TA	1	.73	.39	.14
S within-group error	216	(88.31)		

Note. Value enclosed in parentheses represents mean square errors.

Table 12

Frequency of Hemispace Biases for High- and Low-State-Anxious and High- and Low-Anxious Right-Handed Subjects in Current Study Using the Binomial Distribution and p-value of <.05 (Time 1)

	State Anxious					
Trait Anxious	Low			High		
	N	Mean	SD	N	CFT	SD
Low						
Left biased (≥ 21)	108	-.738	(.22)	27	-.734	(.20)
No asymmetry (14-20)	33	.000	(.14)	4	.001	(.10)
Right biased (≤ 13)	11	.674	(.18)	5	.788	(.24)
High						
Left biased (≥ 21)	6	-.618	(.20)	19	-.632	(.25)
No asymmetry (14-20)	4	-.009	(.00)	6	.001	(.12)
Right biased (≤ 13)	0			10	.694	(.27)

Table 13

Summary of Hierarchical Regression Analysis for State Anxiety and Trait Anxiety on the Prediction of CFT Scores at Time 1 (N = 428)

Variable	B	SE B	ß
Step 1			
Handedness	-.258	.113	*-.125
Sex	.075	.100	.041
Step 2			
Handedness	-.255	.113	-.124
Sex	.065	.101	.035
State Anxiety	.010	.006	.120
Trait Anxiety	-.005	.006	-.055
Step 3			
Handedness	-.263	.112	*-.127
Sex	.072	.100	.039
State Anxiety	-.017	.017	-.205
Trait Anxiety	-.029	.016	-.335
State Anxiety x Trait Anxiety	.000	.000	.561

Note: R^2 = .015 for Step 1; ΔR^2 = .009 for Step 2 (ps = .222); ΔR^2 = .008 for Step 3 (ps = .101).
* $p < .05$.

Excluded Variables in Model 1

	Beta In	t	Sig.	Partial Correlation
State Anxiety (SA)	.083	1.563	.119	.084
Trait Anxiety (TA)	.026	.485	.628	.026
SA x TA	.075	1.405	.161	.075

Table 14

Mean CFT Scores for High- and Low-Depressed and High- and Low-Anxious Right-Handed Subjects and Analysis of Variance of Hemispace Biases for Current Study (Time 2)

a. Average CFT Scores for High- and Low-Depressed and High- and Low-Anxious Subjects in Present Study

	Depressed				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.381	.53	-.440	.59	-.400
High	- .530	--	-.213	.49	-.223
M	-.383		-.333		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Sex (S)	1	.11	.74	.06
Depression (D)	1	.50	.48	.11
Trait Anxiety (TA)	1	.03	.87	.05
S x D	1	.91	.34	.16
S x TA	1	.01	.91	.05
D x TA	1	.54	.46	.11
S x TA x D	0	.	.	.
S within-group error	142	(83.08)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right-handed males and females)

Table 15

Frequency of Hemispace Biases for High- and Low-Depression and High- and Low-Anxious Right-Handed Subjects in Current Study Using the Binomial Distribution and p-value of <.05 (Time 2)

	Depressed					
Anxious	Low			High		
	N	CFT	SD	N	CFT	SD
Low						
Left biased (≥ 21)	57	-.665	(.22)	27	-.734	(.20)
No asymmetry (14-20)	12	.000	(.14)	4	.001	(.10)
Right biased (≤ 13)	11	.183	(.18)	5	.241	(.59)
High						
Left biased (≥ 21)	1	-.529	(--)	15	-.663	(.21)
No asymmetry (14-20)	0			9	-.002	(.15)
Right biased (≤ 13)	0			8	.412	(.49)

Table 16

Summary of Hierarchical Regression Analysis for Depression and Trait Anxiety on the Prediction of CFT Scores at Time 2 (N = 257)

Variable	B	SE B	ß
Step 1			
Handedness	-.403	.145	*-.192
Sex	.224	.122	.127
Step 2			
Handedness	-.404	.145	*-.193
Sex	.236	.123	.134
Depression	-.006	.007	-.078
Trait Anxiety	.007	.007	.090
Step 3			
Handedness	-.403	.146	*-.192
Sex	.230	.123	.130
Depression	-.021	.018	-.301
Depression x Trait Anxiety	.000	.000	.303

Note: R^2 = .046 for Step 1; ΔR^2 = .005 for Step 2 (ps = .605); ΔR^2 = .004 for Step 3 (ps = .344).
* $p < .05$.

Excluded Variables in Model 1

	Beta In	t	Sig.	Partial Correlation
Depression (D)	-.018	-.263	.793	-.018
Trait Anxiety (TA)	.037	.542	.589	.038
D x TA	.012	.182	.856	.013

Table 17

Mean CFT Scores for High- and Low-State-Anxious and High- and Low-Trait-Anxious Right-Handed Subjects and Analysis of Variance of Hemispace Biases for Current Study (Time 2)

a. Average CFT Scores for High- and Low-State-Anxious and High- and Low-Trait-Anxious Subjects in Current Study

	State-Anxious				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.405	.54	-.297	.57	-.385
High	-.235	.42	-.221	.57	-.148
M	-.380		-.259		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Sex (S)	1	1.37	.24	.21
State Anxiety (SA)	1	1.20	.28	.19
Trait Anxiety (TA)	1	4.26	.04	.54
S x SA	1	.27	.61	.08
S x TA	1	.41	.52	.10
SA x TA	1	2.60	.11	.36
S x SA x TA	1	.36	.55	.09
S within-group error				

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right-handed males and females)

Table 18

Frequency of Hemispace Biases for High- and Low-State-Anxious and High- and Low-Anxious Right-Handed Subjects in Current Study Using the Binomial Distribution and p-value of <.05 (Time 2)

Trait Anxious	State Anxious: Low N	Low Mean	Low SD	High N	High CFT	High SD
Low						
Left biased (≥ 21)	66	-.709	(.20)	14	-.655	(.20)
No asymmetry (14-20)	14	.003	(.14)	2	.003	(.00)
Right biased (≤ 13)	13	.670	(.20)	5	.576	(.26)
High						
Left biased (≥ 21)	0			11	-.690	(.17)
No asymmetry (14-20)	3	.004	(.19)	4	-.004	(.16)
Right biased (≤ 13)	1	.824	(--)	6	.520	(.21)

Table 19

Summary of Hierarchical Regression Analysis for State Anxiety and Trait Anxiety on the Prediction of CFT Scores at Time 2 (N = 257)

Variable	B	SE B	ß
Step 1			
Handedness	-.401	.145	*-.191
Sex	.226	.122	.128
Step 2			
Handedness	-.399	.146	*-.190
Sex	.226	.123	.128
State Anxiety	.000	.005	.000
Trait Anxiety	.003	.007	.036
Step 3			
Handedness	-.395	.146	*-.188
Sex	.225	.123	.127
State Anxiety	-.014	.016	-.221
Trait Anxiety	-.011	.017	-.137
State Anxiety x Trait Anxiety	.000	.000	.353

Note: R^2 = .046 for Step 1; ΔR^2 = .001 for Step 2 (ps = .874); ΔR^2 = .004 for Step 3 (ps = .369).
* $p < .05$.

Excluded Variables in Model 1

	Beta In	t	Sig.	Partial Correlation
State Anxiety (SA)	.020	.288	.773	.020
Trait Anxiety (TA)	.036	.521	.603	.037
SA x TA	.041	.594	.553	.042

Table 20

<u>Correlations Between Sex, Independent Measures, CFT Scores, and COPE Factors for Trait-Anxious-Only Group (N = 72)</u>

	SEX	CESD #1	STAI-S #1	STAI-T #1	CFT #1	COPE-AC	COPE-PL	COPE-D	COPE-BD
SEX		.327	.811	.232	.658	.300	.157	.227	.422
CESD #1	.115		.028	.000	.568	.098	.429	.334	.156
STAI-S #1	.028	* .256		.001	.019	.304	.975	.773	.507
STAI-T #1	-.141	** .629	** .377		.575	.321	.837	.469	.188
CFT #1	.053	-.068	* -.276	-.067		.972	.903	.360	.047
COPE-AC	-.124	-.196	-.123	-.119	-.004		.000	.482	.618
COPE-PL	-1.67	-.094	-.004	-.024	-.015	** .699		.108	.301
COPE-D	-.143	.115	.034	.086	-.110	-.084	-.190		.000
COPE-BD	-.095	.168	.079	.156	* .235	-.060	-.123	** .486	

CESD #1 = Depression at Time 1; STAI-S #1 = STAI State-Anxiety Scale at Time 1, STAI-T #1= Trait-Anxiety Scale at Time 1;
COPE-AC = COPE Active Coping; COPE-PL = COPE Planning; COPE-D = COPE Denial; COPE-BD = COPE Behavioral Disengagement

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

Table 21

Summary of Hierarchical Regression Analysis for COPE Subscales on the Prediction of CFT Scores at Time 1 in Trait Anxious-Only Group (N =71)

Variable	B	SE B	ß
Step 1			
Sex	1.584	2.565	.074
Step 2			
Sex	1.252	2.579	.059
Active Coping	.096	.724	.022
Planning	-.111	.614	-.031
Denial	-.963	.453	* -.289
Behavioral Disengagement	1.398	.548	* .340

Note: R^2 = .005 for Step 1; ΔR^2 = .105 for Step 2 (ps = .118).
* $p < .05$.

Excluded Variables in Model 1

	Beta In	t	Sig.	Partial Correlation
Active Coping	.005	.039	.969	.005
Planning	.004	.034	.973	.004
Denial	-.124	-1.027	.308	-.124
Behavioral Disengagement	.206	1.737	.087	.206

Table 22

Correlations Between Sex, Independent Measures, CFT Scores, and COPE Factors for Low-Trait-Anxious Group (N = 230)

	SEX	CESD #1	STAI-S #1	STAI-T #1	CFT #1	COPE-AC	COPE-PL	COPE-D	COPE-BD
SEX		.933	.254	.410	.250	.392	.931	.139	.024
CESD #1	.006		.000	.000	.478	.075	.170	.068	.040
STAI-S #1	.076	** .323		.000	.387	.001	.137	.811	.075
STAI-T #1	-.055	** .415	** .506		.434	.001	.002	.047	.000
CFT #1	-.076	-.047	-.057	.052		.055	.060	.601	.516
COPE-AC	-.057	-.119	** -.224	** -.222	-.128		.000	.224	.027
COPE-PL	.006	-.091	-.098	** -.208	-.125	** .725		.043	.006
COPE-D	-.098	.121	.016	* .131	.035	-.081	* -.133		.000
COPE-BD	* -.148	* .136	.118	** .271	-.043	* -.146	** -.181	** .439	

CESD #1 = Depression at Time 1; STAI-S #1 = STAI State-Anxiety Scale at Time 1, STAI-T #1= Trait-Anxiety Scale at Time 1; COPE-AC = COPE Active Coping; COPE-PL = COPE Planning; COPE-D = COPE Denial; COPE-BD = COPE Behavioral Disengagement

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

Table 23

Summary of Hierarchical Regression Analysis for COPE Subscales on the Prediction of CFT Scores at Time 1 in Low Trait-Anxious Group (N = 230)

Variable	B	SE B	ß
Step 1			
Sex	-1.685	1.462	.250
Step 2			
Sex	-2.014	1.477	-.092
Active Coping	-.300	.385	-.075
Planning	-.362	.366	-.096
Denial	.314	.382	.061
Behavioral Disengagement	-.710	.453	-.118

Note: R^2 = .006 for Step 1; ΔR^2 = .037 for Step 2 (ps = .131).
* $p < .05$.

Excluded Variables in Model 1

	Beta In	t	Sig.	Partial Correlation
Active Coping	-.132	-1.995	.047	-.132
Planning	-.136	-2.057	.041	-.136
Denial	.029	.434	.665	.029
Behavioral Disengagement	-.061	-.905	.366	-.060

Table 24

Correlations Between Change Scores from Time 1 to Time 2 (N=225)

	CFT	CESD	STAI-S	STAI-T
CFT		.553	.859	.384
CESD	-.040		.000	.000
STAI-S	.012	** .420		.000
STAI-T	-0.59	** .354	** .276	

CFT = Chimeric Faces Task Change Score; CESD = Depression Scale; STAI-S = STAI State-Anxiety Scale; STAI-T = STAI State-Anxiety Scale

** Correlation is significant at the 0.01 level (2-tailed)

Table 25

Summary of Hierarchical Regression Analysis for Variables Predicting Changes in CFT Scores (N = 256)

Variable	B	SE B	ß
Step 1			
Handedness	3.758	1.760	.134
Sex	-1.455	1.411	-.065
Depression (Time 1)	.044	.094	.044
State Anxiety (Time 1)	-.149	.079	-.152
Trait Anxiety (Time 1)	.008	.102	.008
Step 2			
Handedness	3.754	1.766	* .134
Sex	-1.601	-.072	-1.128
Depression (Time 1)	.041	.098	.041
State Anxiety (Time 1)	-.167	.084	* -.170
Trait Anxiety (Time 1)	.088	.137	.087
Depression (Time 2)	.049	.089	.052
State Anxiety (Time 2)	.056	.072	.067
State Anxiety (Time 2)	-.150	.135	-.148

Note: R^2 = .036 for Step 1; Δ R^2 = .007 for Step 2 (ps = .587).
* $p < .05$.

Table 26

Frequency of Group Membership for Depression, Trait Anxiety, and State Anxiety Group Membership for Left-Handed Males and Females (Time 1)

a. High- and Low-Depressed and High- and Low-Trait-Anxious

	Depressed	
Trait-Anxious	Low	High
Low	24	8
% of total sample	30.8	10.3
% of those meeting criteria	54.5	18.2
High	0	12
% of total sample	0.0	15.4
% of those meeting criteria	0.0	27.3

b. High- and Low-State-Anxious and High-and Low-Trait-Anxious

	State-Anxious	
Trait-Anxious	Low	High
Low	35	1
% of total sample	44.9	1.3
% of those meeting criteria	74.5	2.1
High	3	8
% of total sample	3.8	10.3
% of those meeting criteria	6.4	17.0

Table 27

T-tests Between Left- and Right-Handers for Depression, State-Anxiety, and Trait-Anxiety

Measure	Handedness	N	Mean	SD	t	df	Sig. (2-tailed)
CFT #1	Left	78	21.00	10.4	-1.88	430	.061
	Right	354	23.23	9.2			
CES-D	Left	78	14.18	8.2	-.425	431	.671
	Right	355	14.66	9.3			
STAI-ST	Left	78	34.75	9.7	-.318	432	.751
	Right	356	35.14	9.9			
STAI-TR	Left	78	38.42	8.5	-.759	432	.448
	Right	356	39.33	9.7			

Table 28

Mean Scores for Independent and Dependent Variables for Right-and Left-Handed Males and Females

	Right-Handed		Left-Handed	
	Male	Female	Male	Female
Time 1 (N)	82	274	36	42
CESD	14.25	14.79	13.14	15.10
	(9.3)	(9.3)	(7.6)	(8.6)
STAI-State	34.56	35.32	33.81	35.57
	(9.4)	(10.1)	(8.9)	(10.5)
STAI-Trait	40.04	39.11	37.70	39.01
	(10.1)	(9.6)	(8.4)	(8.5)
CFT	23.43	23.17	21.78	20.33
	(8.7)	(9.4)	(10.5)	(10.5)
Time 2 (N)	48	178	14	20
CESD	13.67	15.13	14.21	17.20
	(8.6)	(10.5)	(7.1)	(11.6)
STAI-State	35.38	36.51	34.36	36.65
	(10.7)	(10.7)	(9.6)	(11.7)
STAI-Trait	38.46	37.83	36.71	40.10
	(9.7)	((9.3)	(7.3)	(10.2)
CFT	23.26	23.27	25.30	16.20
	(9.0)	(9.1)	(7.7)	(12.2)

Table 29

Mean Scores for Independent and Dependent Variables for Handedness and Sex

	Handedness		Sex	
	Right-Handed	Left-Handed	Male	Female
Time 1 (N)	356	78	118	316
CESD	14.66	14.18	13.91	14.83
	(9.3)	(8.2)	(8.8)	(9.2)
STAI-State	35.15	34.76	34.33	35.36
	(9.9)	(9.7)	(9.3)	(10.1)
STAI-Trait	39.33	38.42	39.33	39.10
	(9.7)	(8.5)	(9.6)	(9.5)
CFT	23.23	21.00	22.92	22.79
	(9.3)	(10.4)	(9.3)	(9.6)
Time 2 (N)	226	34	62	198
CESD	14.82	15.97	13.79	15.34
	(10.1)	(10.0)	(8.3)	(10.6)
STAI-State	36.3	35.71	35.15	36.5
	(11.5)	(10.8)	(10.4)	(11.7)
STAI-Trait	37.96	38.71	38.1	38.10
	(9.4)	(9.1)	(9.2)	(9.4)
CFT	23.26	19.94	23.72	22.55
	(9.1)	(11.4)	(8.7)	(9.7)

Table 30

Frequency of Hemispace Biases for High- and Low-Depression and High- and Low-Anxious Left-Handed Subjects in Current Study Using the Binomial Distribution and p-value of < .05 (Time 1)

	Handedness					
	Left-Handed			Right-Handed		
	N	Mean	SD	N	CFT	SD
Low						
Left biased (≥ 21)	47	-.661	(.26)	230	-.703	(.22)
No asymmetry (14-20)	10	.000	(.01)	71	.003	(.11)
Right biased (≤ 13)	21	.625	(.27)	53	.576	(.27)

Table 31

Mean CFT Scores for Left-Handers and Right-Handers and Left- or Right-Hemispace Biases and Analysis of Variance of Hemispace Biases (Time 1)

a. Mean CFT Scores for Left- and Right-Handers and Left- or Right-Hemispace Biases

	Handedness				
Direction of	Left		Right		
Perceptual Asymmetry	M	SD	M	SD	M
Left	-.661	.26	-.703	.22	-.696
Right	- .625	.27	-.647	.27	.641
M	-.651		-.576		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Handedness (H)	1	.078	.781	.059
Perceptual Asymmetry (PA)	1	1335.723	.000	1.000
H x PA	1	.810	.369	.146
S within-group error	347	(16.32)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right- and left-handed males and females)

Table 32

Mean CFT Scores for High- and Low-Depressed and High- and Low-Trait-Anxious Subjects and Analysis of Variance of Hemispace Biases (Time 1)

a. Mean CFT Scores for High- and Low-Depressed and High- and Low-Anxious Left-Handed Subjects in Current Study

	Depressed				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.005	.67	-.250	.49	-.101
High	--	--	-.250	.48	-.250
M	-.005		-.250		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Handedness (H)	1	1.64	.20	.25
Sex (S)	1	.361	.55	.09
Depression (D)	1	.502	.48	.11
Trait Anxiety (TA)	1	.48	.49	.11
H x S	1	.01	.91	.05
H x D	1	.83	.36	.15
H x TA	1	.35	.56	.09
S x D	1	.00	.94	.05
S x TA	1	.03	.87	.05
D x TA	1	1.04	.31	.17
H x D x TA	0	.	.	.
H x S x D	1	.63	.43	.12
H x S x TA	1	.01	.91	.05
S x D x TA	0	.	.	.
H x S x D x TA	0	.	.	.
S within-group error	254	(.324)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right- and left-handed males and females)

Table 33

Analysis of Variance of Hemispace Biases For High-and Low-Depressed and High- and Low-Trait-Anxious Subjects Combining Sex of Subject (Time 1)

Source	df	F	Sig	Power
	Between subjects			
Handedness (H)	1	1.71	.193	.26
Depression (D)	1	1.05	.31	.18
Trait Anxiety (TA)	1	.92	.34	.16
H x D	1	1.67	.21	.24
H x TA	1	.01	.91	.05
TA x D	1	1.25	.27	.24
H x TA x D	0	.	.	.
S within-group error	145	(92.44)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right- and left-handed males and females)

Table 34

Mean CFT Scores for High- and Low-State-Anxious and High- and Low-Anxious

Subjects and Analysis of Variance of Hemispace Biases (Time 1)

a. Mean CFT Scores for High- and Low-Depressed and High- and Low-Anxious Right- and Left-Handed Subjects

	State-Anxious				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.323	.61	-.235	--	-.320
High	-.002	.57	-.309	.46	-.219
M	-.296		-.301		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Handedness (H)	1	.50	.48	.11
Sex (S)	1	.61	.44	.12
State Anxiety (SA)	1	.03	.87	.08
Trait Anxiety (TA)	1	.26	.61	.05
H x S	1	.00	.96	.05
H x SA	1	.87	.35	.15
H x TA	1	.20	.65	.07
S x SA	1	.27	.61	.08
S x TA	1	.05	.83	.06
SA x TA	1	.11	.74	.06
H x SA x TA	1	.26	.61	.08
H x S x SA	1	.06	.81	.06
H x S x TA	1	.06	.80	.06
S x SA x TA	0	.71	.40	.13
H x S x SA x TA	0	.	.	.
S within-group error	256	(.313)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right- and left-handed males and females)

Table 35

Analysis of Variance of Hemispace Biases For High-and Low-State-Anxious and High- and Low-Trait-Anxious Left-Handed Subjects Combining Sex of Subject (Time 1)

Source	df	F	Sig	Power
	Between subjects			
Handedness (H)	1	.29	.59	.08
State Anxiety (SA)	1	.03	.87	.05
Trait Anxiety (TA)	1	.32	.57	.09
H x SA	1	.68	.41	.13
H x TA	1	.03	.86	.05
SA x TA	1	.12	.73	.06
H x SA x TA	1	.65	.42	.13
S within-group error	263	(90.22)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right- and left-handed males and females)

Table 36

Mean CFT Scores for High- and Low-Depressed and High- and Low-Anxious Left-Handed Subjects and Analysis of Variance of Hemispace Biases (Time 1)

a. Mean CFT Scores for High- and Low-Depressed and High- and Low-Anxious Left-Handed Subjects

	Depressed				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.051	.67	-.250	.49	-.101
High	--	--	-.250	.48	-.250
M	-.051		-.250		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Depression (D)	1	.664	.420	.125
Trait Anxiety (TA)	1	.000	1.000	.050
D x TA	0	.	.	.
S within-group error	41	(102.985)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Left-handed males and females)

Table 37

Frequency of Hemispace Biases for High- and Low-Depressed and High- and Low-Anxious Left-Handed Subjects in Current Study Using the Binomial Distribution and p-value of <.05 (Time 1)

	Depressed					
Anxious	Low			High		
	N	CFT	SD	N	CFT	SD
Low						
Left biased (≥ 21)	12	-.632	(.27)	5	-.494	(.33)
No asymmetry (14-20)	2	-.059	(.00)	2	-.118	(.08)
Right biased (≤ 13)	10	.647	(.28)	1	.706	(--)
High						
Left biased (≥ 21)	0			7	-.588	(.21)
No asymmetry (14-20)	0			2	-.029	(.21)
Right biased (≤ 13)	0			3	.392	(.15)

Table 38

Summary of Hierarchical Regression Analysis for Variables Predicting CFT Scores at Time 1 for Left-Handers Only (N = 78)

Variable	B	SE B	ß
Step 1			
Sex	-1.444	2.378	-.070
Step 2			
Sex	-1.670	2.371	-.080
Depression	1.010	.919	.792
State Anxiety	-.930	.748	-.870
Trait Anxiety	-.632	.508	-.513
Depression x State Anxiety	-.011	.021	-.471
State Anxiety x Trait Anxiety	-.017	.018	1.037

Note: R^2 = .005 for Step 1; Δ R^2 = .098 for Step 2 (ps = .277).

Excluded Variables in Model 1

	Beta In	t	Sig.	Partial Correlation
Depression	.194	1.703	.093	.193
State Anxiety (SA)	-.012	-.100	.921	-.012
Trait Anxiety (TA)	.052	.453	.652	.052
D x SA	.169	1.480	.143	.168
SA x TA	.036	.309	.758	.036

Table 39

Summary of Hierarchical Regression Analysis for Variables Predicting CFT Scores at Time 1 for Consistent Left -Handers (N =36) and Inconsistent Left-Handers (N = 42)

a. Consistent Left-handers (N = 36)

Variable	B	SE B	ß
Step 1			
Sex	5.095	3.929	.238
Step 2			
Sex	5.095	3.929	.238
Depression	.180	.362	.122
State Anxiety	.011	.270	.009
Trait Anxiety	.175	.346	.131

Note: R^2 = .044 for Step 1; Δ R^2 = .055 for Step 2 (ps = .600).
* $p < .05$.

b. Inconsistent Left-handers (N = 42)

Variable	B	SE B	ß
Step 1			
Sex	-5.911	3.170	-.283
Step 2			
Sex	-4.717	3.182	-.226
Depression	.901	.337	* .780
State Anxiety	-.379	.197	-.390
Trait Anxiety	-.443	.305	-.379

Note: R^2 = .080 for Step 1; Δ R^2 = .160 for Step 2 (ps = .067).
* $p < .05$.

Table 40

Mean CFT Scores for High- and Low-State-Anxious and High- and Low-Trait-Anxious Left-Handed Subjects and Analysis of Variance of Hemispace Biases (Time 1)

a. Mean CFT Scores for High- and Low-Depressed and High- and Low-Anxious Left-Handed Subjects

	State-Anxious				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.323	.61	-.235	--	-.320
High	.020	.57	-.309	.46	-.219
M	-.296		-.250		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
State Anxiety (SA)	1	.114	.74	.063
Trait Anxiety (TA)	1	.142	.71	.066
SA x TA	1	.341	.562	.088
S within-group error	43	(98.626)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Left-handed males and females)

Table 41

Frequency of Hemispace Biases for High- and Low-State-Anxious and High- and Low-Anxious Left-Handed Subjects in Current Study Using the Binomial Distribution and p-value of <.05 (Time 1)

Trait Anxious	State Anxious					
	Low			High		
	N	CFT	SD	N	CFT	SD
Low						
Left biased (≥ 21)	24	-.679	(.24)	1	-.235	(--)
No asymmetry (14-20)	2	-.059	(.00)	0		
Right biased (≤ 13)	9	.569	(.27)	0		
High						
Left biased (≥ 21)	1	-.588	(--)	5	-.588	(.26)
No asymmetry (14-20)	1	.118	(--)	1	-.177	(--)
Right biased (≤ 13)	1	.529	(--)	2	.324	(.12)

Table 42

Mean CFT Scores for Stable High- and Low-Depressed and High- and Low-Trait-Anxious Right-Handed Subjects and Analysis of Variance of Hemispace Biases for Current Study (Time 1)

a. Mean CFT Scores for Stable High- and Low-Depressed and High- and Low-Anxious Right-Handed Subjects in Present Study at Time 1

	Depressed				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.434	.52	-.554	.59	-.46
High	--	--	-.328	.51	-.51
M	-.434		-.400		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Depression (D)	1	.52	.47	.11
Trait Anxiety (TA)	1	1.54	.22	.23
D x TA	1	.	.	.
S within-group error	91	(.273)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right-handed males and females)

Table 43

Mean CFT Scores for Stable High- and Low-Depressed and High- and Low-Trait-Anxious Right-Handed Subjects and Analysis of Variance of Hemispace Biases for Current Study (Time 2)

a. Average CFT Scores for Stable High- and Low-Depressed and High- and Low-Anxious Right-Handed Subjects in Present Study at Time 2

	Depressed				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.398	.55	-.481	.64	-.412
High	--	--	-.210	.47	-.467
M	-.398		-.289		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
Depression (D)	1	.22	.64	.08
Trait Anxiety (TA)	1	2.00	.16	.29
D x TA	1	.	.	.
S within-group error	90	(.290)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right-handed males and females)

Table 44

Mean CFT Scores for Stable High- and Low-State-Anxious and High- and Low-Trait-Anxious Right-Handed Subjects and Analysis of Variance of Hemispace Biases for Current Study (Time 1)

a. Mean CFT Scores for Stable High- and Low-State-Anxious and High- and Low-Anxious Right-Handed Subjects in Current Study at Time 1

	State-Anxious				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.487	.47	-.647	--	-.489
High	-.706	--	-.177	.61	-.210
M	-.490		-.206		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
State Anxiety (SA)	1	.26	.61	.08
Trait Anxiety (TA)	1	.12	.73	.06
SA x TA	1	.93	.34	.16
S within-group error	84	(.247)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right-handed males and females)

Table 45

Mean CFT Scores for Stable High- and Low-State-Anxious and High- and Low-Trait-Anxious Right-Handed Subjects and Analysis of Variance of Hemispace Biases for Current Study (Time 2)

a. Mean CFT Scores for Stable High- and Low-State-Anxious and High- and Low-Anxious Right-Handed Subjects in Current Study at Time 2

	State-Anxious				
	Low		High		
Trait-Anxious	M	SD	M	SD	M
Low	-.435	.52	-.765	--	-.440
High	.118	--	-.102	.51	-.009
M	-.516		-.518		

b. ANOVA Table

Source	df	F	Sig	Power
	Between subjects			
State Anxiety (SA)	1	.55	.46	.11
Trait Anxiety (TA)	1	2.68	.11	.37
SA x TA	1	.02	.88	.05
S within-group error	83	(.265)		

Note. Value enclosed in parentheses represents mean square errors.
S = subjects (Right-handed males and females)

Table 46

Pattern Matrix of Principle Components Analysis using Oblimin with Kaiser

Normalization Rotation Method for STAI State-Anxiety Inventory (N = 435)

Item	Factor 1	Factor 2	Factor 3	Factor 4
I feel secure.	.593	-.023	.142	-.119
I feel at ease.	.472	-.292	.198	-.321
I feel satisfied.	.724	.109	-.237	-.161
I feel comfortable.	.796	.068	.034	.019
I feel self-confident.	.737	.348	-.038	.135
I am relaxed.	.681	-.206	.332	-.004
I feel content.	.804	.026	-.061	-.050
I feel steady.	.751	.019	.129	.055
I feel pleasant.	.720	-.070	-.065	-.181
I feel frightened.	-.005	.519	.222	-.249
I feel indecisive.	.209	.621	.170	-.064
I feel confused.	.032	.464	.073	-.459
I feel nervous.	.020	.143	.660	-.164
I am jittery.	-.044	.176	.815	.106
I am tense.	-.167	-.219	.425	-.398
I feel strained.	.078	-.135	.039	-.707
I feel upset.	-.014	.032	-.042	-.729
I am presently worried over possible misfortunes.	.059	.096	-.092	-.745
I am worried.	.019	.177	.126	-.699
I feel calm.	.423	-.292	.489	-.091

Component Correlation Matrix Between Four Factor Solution for STAI State-Anxiety and CFT Scores for Time 1 (N = 435)

	Factor 1	Factor 2	Factor 3	Factor 4	CFT
Factor 1		.000	.000	.000	.162
Factor 2	** .411		.000	.000	.004
Factor 3	** .391	** .374		.000	.073
Factor 4	** .591	** .538	** .404		.030
CFT	-.067	** -.137	-.086	* -.104	

Table 47

Summary of Hierarchical Regression Analysis for STAI State-Anxiety Four-Factor Solution Predicting CFT Scores at Time (N = 435)

Variable	B	SE B	β
Step 1			
Handedness	2.382	.097	.051
Sex	-.630	-.029	.553
Depression	.002	.002	.983
Trait Anxiety	-.036	-.036	.625
Step 2			
Handedness	2.484	.101	.041
Sex	-.917	-.043	.394
Depression	.044	.043	.568
Trait Anxiety	.051	.051	.527
Serenity	-.022	-.013	.850
Free-Floating Anxiety	-.780	-.131	* .031
Autonomic Anxiety	-.322	-.041	.456
Cognitive Worry	-.244	-.065	.329

Note: R^2 = .010 for Step 1; Δ R^2 = .036 for Step 2 (ps = .047).
* $p < .05$.

Excluded Variables in Model 1

	Beta In	t	Sig.	Partial Correlation
Serenity	-.078	-1.254	.210	-.061
Free-Floating Anxiety	-.168	-3.060	.002	-.147
Autonomic Anxiety	-.086	-1.623	.105	-.079
Cognitive Worry	-.135	-2.339	.020	-.113

Table 48

Correlations Between Sex, Handedness, CFT Scores, and AIM Factors for Time 1 (N = 435)

	SEX	HAND	CESD #1	STAI-S #1	STAI-T #1	CFT #1	AIM-PA	AIM-NI	AIM-SER	AIM-NR
SEX		.000	.352	.335	.823	.898	.000	.005	.070	.000
HAND	** .200		.671	.751	.448	.061	.806	.281	.655	.415
CESD #1	.045	.020		.000	.000	.620	.264	.000	.000	.012
STAI-S #1	.046	.015	** .576		.000	.028	.057	.000	.581	.636
STAI-T #1	-.011	.037	** .745	** .664		.526	.020	.000	.010	.035
CFT #1	-.006	.090	-.024	* -.106	-.031		.759	.278	.699	.033
AIM-PA	** .172	.012	-.055	-.094	* -.114	.015		.884	.063	.500
AIM-NI	** .139	.053	** .516	** 415	* .596	.054	** .244		.232	.000
AIM-SER	-.089	.022	** .172	.027	* .126	.019	** -.285	-.072		.000
AIM-NR	** .268	.040	* .123	.023	* .103	* -.105	** .440	** .319	.012	

CESD #1 = Depression at Time 1; STAI-S #1 = STAI State-Anxiety Scale at Time 1, STAI-T #1= Trait-Anxiety Scale at Time 1; AIM-PA #1 = AIM Positive Affectivity at Time 1; AIM-NI #1 = AIM Negative Intensity at Time 1; AIM-SER #1 = AIM Serenity at Time 1; AIM-NR #1 = AIM Negative Reactivity at Time 1

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

Table 49

<u>Correlations Between Sex, Handedness, CFT Scores, and AIM Factors for Time 2 (N = 254)</u>

	SEX	HAND	CESD #2	STAI-S #2	STAI-T #2	CFT #2	AIM-PA	AIM-NI	AIM-SER	AIM-NR
SEX		.000	.292	.407	.998	.399	.002	.015	.099	.000
HAND	** .200		.538	.789	.667	.056	.079	.168	.098	.795
CESD #2	.066	- .038		.000	.000	.783	.111	.000	.709	.013
STAI-S #2	.052	.017	** .612		.000	.797	.303	.000	.215	.336
STAI-T #2	.000	- .027	** .673	** .549		.228	.213	.000	.652	.088
CFT #2	- .053	.119	- .017	- .016	- .075		.479	.709	.909	.142
AIM-PA	** .191	.110	.100	.065	- .078	- .045		.000	.000	.000
AIM-NI	* .152	- .087	** .400	** .298	** .520	- .024	** .299		.000	.000
AIM-SER	- .103	- .104	- .023	- .078	.028	.007	** - .337	** - .226		.367
AIM-NR	.000	.016	* .155	.060	.107	- .092	** .396	** .331	.057	

CESD #2 = Depression at Time 2; STAI-S #2 = STAI State-Anxiety Scale at Time 2, STAI-T #2 = Trait-Anxiety Scale at Time 2; AIM-PA #2 = AIM Positive Affectivity at Time 2; AIM-NI #2 = AIM Negative Intensity at Time 2; AIM-SER #2 = AIM Serenity at Time 2; AIM-NR #2 = AIM Negative Reactivity at Time 2

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

APPENDICES

APPENDIX A

INFORMED CONSENT FORM

This is a study of the effects mood on the perception of emotion in normal, healthy people. It is a "normative study", which means that we don't know how normal, healthy people will respond, and we want you to help us find out. There are no right or wrong ways to respond. The study will take about twenty minutes to complete. You will receive one-half hour of research credit (1 research credit) for your participation.

Your record will be kept completely confidential. To ensure this, you will be assigned a participant identification number, which will be the only way to identify you in any reports about the study. Only the experimenter will have access to files and lists that can be used to link a name with a participant number. Any publications resulting from this work will not identify you by name or in any way that would allow your identity to be discovered.

For this study, you will be asked to complete the following tasks: a subject identification form, personal information and background questionnaire, handedness questionnaire, several questionnaires assessing your current and general mood, and a questionnaire asking you to make choices between several pairs of faces.

A debriefing period will follow your participation in the experiment. Specifically, you will receive a written brief summary of the nature of the study via E-mail. This summary will include an overview of the literature, hypotheses being testing, and their predictions. You will receive one-half hour of credit (1 research point) for your participation. You have the right to discontinue your participation at any time and for any reason, and to do so without explanation or penalty. There is also an alternative method of earning extra course credit if you do not wish to participate in this or other experiments. If you wish to seek this alternative, speak with your professor for specifics. The assignment may vary from professor to professor, but it is usually to write a short paper.

If you would like further information regarding your rights as a research participant, you may contact the Office of the UCRIHS at Michigan State University by telephoning (517) 355-2180.

After the entire study is completed, if you have any questions or if you want a written summary of the general results (beyond what you will receive via E-mail), you may contact the investigators at their university offices.

Lauren Julius Harris, Ph.D.
Professor of Psychology

Travis G. Fogel, M.A.
Clinical Psychology Doctoral Candidate

I have read this consent form, I understand the conditions, and I voluntarily agree to participate in this study.

_____________________________ __________

Participant's Signature Date

PARTICIPANT IDENTIFICATION FORM

This is the only form that can identify you by name and can link you to the participant identification number that has been assigned to you. This page will be removed from the packet when you turn it in. Only the investigator will have access to this form. To ensure confidentiality, all other documents you fill out will have only your participation identification number.

Please **print** your full name.

Participant name: ____________________________ Identification number: _______

Professor of class for which
you receive research credit: ______________________________

If you would like to receive a written summary of this experiment via E-mail, please leave your E-Mail address.

E-mail address: _____________________________

At the conclusion of your participation today, we would like to provide you with the option of signing up for the experiment again — YOU WILL RECEIVE AN ADDITIONAL RESEARCH CREDIT FOR YOUR PARTICIPATION. Specifically we would like to test you again in another four weeks. We are interested in determining the test-retest reliability of the questionnaires you will complete today. Your continued participation would be greatly appreciated. For your convenience, we will have *numerous* dates and times available. These sign-up sheets will only be available at the conclusion of your participation today — they will be unavailable in class. If you wish to schedule for an additional credit, we will provide you with a written reminder. In addition, if you would like a phone call to remind you, we would be happy to do so. Simply leave your phone number below. Lastly, if you need to reschedule, please call me. I will be happy to accommodate you.

Phone Number: _____________________________

APPENDIX B

PERSONAL INFORMATION AND BACKGROUND QUESTIONNAIRE

1. What is your age? _______

2. Are you? Male: ___ Female: ___

3. What year in school are you in now? _____________

4. What is your academic major? _____________

5. Which ethnic/race category best fits you?

Caucasian:	___	Asian:	___	
African-American:	___	Hispanic:	___	
Native American:.	___	Other:	___	Define: __________

6. Mark with an 'X' the description that best applies to you:

Strongly Left-Handed	**Moderately Left-Handed**	**Ambidextrous (either-handed)**	**Moderately Right-Handed**	**Strongly Right-Handed**

APPENDIX C

For each of the tasks listed below, check the column that corresponds to the hand you would use to perform that task.

	Always Left 1	Usually Left 2	Both 3	Usually Right 4	Always Right 5
Hand Use					
1. Write a letter	___	___	___	___	___
2. Hammer a nail	___	___	___	___	___
3. Throw a ball at a target	___	___	___	___	___
4. Unscrew lid of a jar	___	___	___	___	___
5. Use knife to cut bread	___	___	___	___	___
6. Use tooth brush	___	___	___	___	___
7. Hold a match while striking it	___	___	___	___	___
8. Hold a tennis racket	___	___	___	___	___

APPENDIX D

STATE-TRAIT ANXIETY INVENTORY (STAI)

State Items

1. I feel calm.
2. I feel secure.
3. I am tense.
4. I feel strained.
5. I feel at ease.
6. I feel upset.
7. I am presently worrying over possible misfortunes.
8. I feel satisfied.
9. I feel frightened.
10. I feel comfortable.
11. I feel self-confident.
12. I feel nervous.
13. I am jittery.
14. I feel indecisive.
15. I am relaxed.
16. I feel content.
17. I am worried.
18. I feel confused.
19. I feel steady.
20. I feel pleasant.

STATE-TRAIT ANXIETY INVENTORY (STAI)
Trait Items

21. I feel pleasant.
22. I feel nervous and restless.
23. I feel satisfied with myself.
24. I wish I could be as happy as others seem to be.
25. I feel like a failure.
26. I feel rested.
27. I am “calm, cool, and collected.”
28. I feel that difficulties are piling up so that I cannot overcome them.
29. I worry too much over something that really doesn’t matter.
30. I am happy.
31. I have disturbing thoughts.
32. I lack self-confidence.
33. I feel secure.
34. I make decisions easily.
35. I feel inadequate.
36. I am content.
37. Some unimportant thought runs through my mind and bothers me.
38. I take disappointments so keenly that I can’t put them out of my mind.
39. I am a steady person.
40. I get into a state of tension or turmoil as I think over my recent concerns and interests.

APPENDIX E

Circle the number for each statement which best describes how often you felt or behaved this way — **DURING THE PAST WEEK.**					
		Rarely or None of the Time (Less than 1 Day)	Some or a Little of the Time (1-2 Days)	Occasionally or a Moderate Amount of Time (3-4 Days)	Most or All of the Time (5-7 Days)
DURING THE PAST WEEK:					
1.	I was bothered by things that usually don't bother me	0	1	2	3
2.	I did not feel like eating; my appetite was poor	0	1	2	3
3.	I felt that I could not shake off the blues even with help from my family and friends ..	0	1	2	3
4.	I felt I was just as good as other people	0	1	2	3
5.	I had trouble keeping my mind on what I was doing	0	1	2	3
6.	I felt depressed	0	1	2	3
7.	I felt that everything I did was an effort	0	1	2	3
8.	I felt hopeful about the future	0	1	2	3
9.	I thought my life had been a failure	0	1	2	3
10.	I felt fearful	0	1	2	3
11.	My sleep was restless	0	1	2	3
12.	I was happy	0	1	2	3
13.	I talked less than usual	0	1	2	3
14.	I felt lonely	0	1	2	3
15.	People were unfriendly	0	1	2	3
16.	I enjoyed life	0	1	2	3
17.	I had crying spells	0	1	2	3
18.	I felt sad	0	1	2	3
19.	I felt that people disliked me	0	1	2	3
20.	I could not get "going"	0	1	2	3

APPENDIX F

The Panic and Agoraphobia, or P & A Scale (Bandelow, 1995; Bandelow, Hajak, Holzrichter, Kunerf, & Rüther, 1995) is a self-report measure that assesses degree of severity of panic disorder and agoraphobia (Appendix F). The P & A contains 13 items with 0-4 point scales grouped in five subscales: panic attacks (frequency, severity, duration), avoidance, anticipatory anxiety, disability (family, social, employment), and worries about health. The items have high face validity. The total score is obtained by summing the item scores, while the subscale scores are obtained by averaging the item scores. Normative data are based on 235 subjects with either panic disorder, agoraphobia, or both. Reliability of the measure was calculated on the normative sample of 235 subjects with either panic disorder, agoraphobia, or both. The item-total correlations were high (between .37 and .70), and Cronbach's alpha was .88. A principle component analysis revealed a clear factor structure, with three factors explaining 65.6% of the variance: agoraphobia/disability, panic, and anticipatory anxiety/worries about health. As noted earlier, the P & A was not ultimately used in the current study due to financial constraints. Instead, the COPE (Carver, Scheier, & Weintraub, 1989) was used to assess approach and withdrawal behavioral tendencies in response to stressful situations (see Results section for a description of this measure).

APPENDIX G

We are interested in how people respond when they confront difficult or stressful events in their lives. There are lots of ways to deal with the stress. This questionnaire asks you to indicate what you generally do and feel,. when *you* experience stressful events. Obviously, different events bring out somewhat different responses, but think about what you *usually* do when you are under lots of stress.

Then respond to each of the following items by entering one answer for each statement, using the response choices listed below. Please try to respond to each item *separately in your mind from each other item*. Choose your answers thoughtfully, and make your answers as true FOR YOU as you can. Please answer *every* item. There are no "right" or "wrong" answers, so choose the most accurate answer for you -- not what you think "most people" would say or do. Indicate what YOU usually do when YOU experience a stressful event.

1 = I usually don't do this at all
2 = I usually do this a little bit
3 = I usually do this a medium amount
4 = I usually do this a lot

	1	2	3	4
I try to grow as a person as a result of the experience.				
I turn to work or other substitute activities to take my mind of things.				
I get upset and let my emotions out.				
I try to get advice from someone about what to do.				
I concentrate my efforts on doing something about it.				
I say to myself "this isn't real."				
I put my trust in God.				
I laugh about the situation.				
I admit to myself that I can't deal with it, and quit trying.				
I restrain from doing anything too quickly.				

	1	2	3	4
I discuss my feelings with someone.				
I use alcohol or drugs to make myself feel better.				
I get used to the idea that it happened.				
I talk to someone to find out more about the situation.				
I keep myself from getting distracted by other thoughts or activities.				
I daydream about things other than this.				
I get upset, and am really aware of it.				
I seek God's help.				
I make a plan of action.				
I make jokes about it.				

	1	2	3	4
I accept that this has happened and that it can't be changed.				
I hold off doing anything about it until the situation permits.				
I try to get emotional support from friends and relatives.				
I just give up trying to reach my goal.				
I take additional action to try to get rid of the problem.				
I try to lose myself for a while by drinking alcohol or taking drugs.				
I refuse to believe that it has happened.				
I let my feelings out.				
I try to see it in a different light, to make it seem more positive.				
I talk to someone who could do something concrete about the problem.				

1 = I usually <u>don't</u> do this <u>at all</u>
2 = I usually do this <u>a little bit</u>
3 = I usually do this a <u>medium amount</u>
4 = I usually do this a <u>lot</u>

	1	2	3	4
I sleep more than usual.				
I try to come up with a strategy about what to do.				
I focus on dealing with this problem, and if necessary let other things slide a little.				
I get sympathy and understanding form someone.				
I drink alcohol or take drugs, in order to think about it less.				
I kid around about it.				
I give up the attempt to get what I want.				
I look for something good in what is happening.				
I think about how I might best handle the problem.				
I pretend that it hasn't really happened.				

	1	2	3	4
I make sure not to make matters worse by acting too soon.				
I try hard to prevent other things from interfering with my efforts at dealing with this.				
I go to movies or watch TV, to think about it less.				
I accept the reality of the fact that it happened.				
I ask people who have had similar experiences what they did.				
I feel a lot of emotional distress and I find myself expressing those feelings a lot.				
I take direct action to get around the problem.				
I try to find comfort in my religion.				
I force myself to wait for the right time to do something.				
I make fun of the situation.				

	1	2	3	4
I reduce the amount of effort I'm putting into solving the problem.				
I talk to someone about how I feel.				
I used alcohol or drugs to help me get through it.				
I learn to live with it.				
I put aside other activities in order to concentrate on this.				
I think hard about what steps to take.				
I act as though it hasn't happened.				
I do what has to be done, one step at a time.				
I learn something from the experience.				
I pray more than usual.				

APPENDIX H

Approach

Planning
- I try to come up with a strategy about what to do.
- I make a plan of action.
- I think hard about what steps to take.
- I think about how I might best handle the problem.

Active Coping
- I take additional action to try to get rid of the problem.
- I concentrate my efforts on doing something about it.
- I do what has to be done, one step at a time.
- I take direct action to get around the problem.

Withdrawal

Behavioral Disengagement
- I give up the attempt to get what I want.
- I just give up trying to reach my goal.
- I admit to myself that I can't deal with it, and quit trying.
- I reduce the amount of effort I'm putting into solving the problem.

Denial
- I refuse to believe that it has happened.
- I pretend that it hasn't really happened.
- I act as though it hasn't even happened.
- I say to myself "this isn't real."

APPENDIX I

A

B

APPENDIX J

Booklet (Circled) A B

FACE PERCEPTION
1997-1998 Michigan State University

<u>Instructions</u>: Turn to the packet that has been provided to you. On each of the following pages you will see 2 faces arranged one above the other. Your task will be to look at each face by focusing on the nose, and then decide which face is ***happier***, or, sometimes,, which face is **sadder**. Circle the letter on your answer sheet that corresponds to the face you choose.

****

1.	Which face, A or B, looks ***happier***?	**A** or **B**
2.	Which face, A or B, looks ***sadder***?	**A** or **B**
3.	Which face, A or B, looks ***happier***?	**A** or **B**
4.	Which face, A or B, looks ***sadder***?	**A** or **B**
5.	Which face, A or B, looks ***happier***?	**A** or **B**
6.	Which face, A or B, looks ***sadder***?	**A** or **B**
7.	Which face, A or B, looks ***happier***?	**A** or **B**
8.	Which face, A or B, looks ***happier***?	**A** or **B**
9.	Which face, A or B, looks ***happier***?	**A** or **B**
10.	Which face, A or B, looks ***sadder***?	**A** or **B**
11.	Which face, A or B, looks ***sadder***?	**A** or **B**
12.	Which face, A or B, looks ***happier***?	**A** or **B**
13.	Which face, A or B, looks ***happier***?	**A** or **B**
14.	Which face, A or B, looks ***sadder***?	**A** or **B**

15. Which face, A or B, looks ***happier***? **A** or **B**

16. Which face, A or B, looks ***happier***? **A** or **B**

17. Which face, A or B, looks ***happier***? **A** or **B**

18. Which face, A or B, looks ***happier***? **A** or **B**

19. Which face, A or B, looks ***happier***? **A** or **B**

20. Which face, A or B, looks ***happier***? **A** or **B**

21. Which face, A or B, looks ***happier***? **A** or **B**

22. Which face, A or B, looks ***happier***? **A** or **B**

23. Which face, A or B, looks ***happier***? **A** or **B**

24. Which face, A or B, looks ***happier***? **A** or **B**

25. Which face, A or B, looks ***happier***? **A** or **B**

26. Which face, A or B, looks ***happier***? **A** or **B**

27. Which face, A or B, looks ***happier***? **A** or **B**

28. Which face, A or B, looks ***happier***? **A** or **B**

29. Which face, A or B, looks ***happier***? **A** or **B**

30. Which face, A or B, looks ***happier***? **A** or **B**

31. Which face, A or B, looks ***happier***? **A** or **B**

32. Which face, A or B, looks ***happier***? **A** or **B**

33. Which face, A or B, looks ***happier***? **A** or **B**

34. Which face, A or B, looks ***happier***? **A** or **B**

35. Which face, A or B, looks ***happier***? **A** or **B**

36. Which face, A or B, looks ***happier***? **A** or **B**

37. Which face, A or B, looks ***happier***? **A** or **B**

38. Which face, A or B, looks ***happier***? **A** or **B**

39. Which face, A or B, looks ***happier***? **A** or **B**

40. Which face, A or B, looks ***happier***? **A** or **B**

APPENDIX K

AIM QUESTIONNAIRE

DIRECTIONS: The following questions refer to the emotional reactions to typical life-events. Please indicate how YOU react to these events by placing a number from the following scale in the blank space preceding each item. Please base your answers on how YOU react, *not* on how you think others react or how you think a person should react.

NEVER	ALMOST NEVER	ON OCCASION	USUALLY	ALMOST ALWAYS	ALWAYS
1	2	3	4	5	6

1. ___ When I accomplish something difficult I feel delighted or elated.
2. ___ When I feel happy it is a strong type of exuberance.
3. ___ I enjoy being with other people very much.
4. ___ I feel pretty bad when I tell a lie.
5. ___ When I solve a small personal problem, I feel euphoric.
6. ___ My emotions tend to be more intense than those of most people.
7. ___ My happy moods are so strong that I feel like I'm "in heaven."
8. ___ I get overly enthusiastic.
9. ___ If I complete a task I thought was impossible, I am ecstatic.
10. ___ My heart races at the anticipation of some exciting event.
11. ___ Sad movies deeply touch me.
12. ___ When I'm happy it's a feeling of being untroubled and content rather than being zestful and aroused.
13. ___ When I talk in front of a group for the first time my voice gets shaky and my heart races.
14. ___ When something good happens, I am usually much more jubilant than others.
15. ___ My friends might say I am emotional.
16. ___ The memories I like the most are of those of times when I felt content and peaceful rather than zestful and enthusiastic.
17. ___ The sight of someone who is hurt badly affects me strongly.
18. ___ When I'm feeling well it's easy for me to go from being in a good mood to being really joyful.

NEVER	ALMOST NEVER	ON OCCASION	USUALLY	ALMOST ALWAYS	ALWAYS
1	2	3	4	5	6

19. ___ "Calm and cool" could easily describe me.
20. ___ When I'm happy I feel like I'm bursting with joy.
21. ___ Seeing a picture of some violent car accident in a newspaper makes me feel sick to my stomach.
22. ___ When I'm happy I feel energetic.
23. ___ When I receive an award I become overjoyed.
24. ___ When I succeed at something, my reaction is calm contentment.
25. ___ When I do something wrong I have strong feelings of shame and guilt.
26. ___ I can remain calm even on the most trying days.
27. ___ When things are going good I feel "on top of the world."
28. ___ When I get angry it's easy for me to still be rational and not overreact.
29. ___ When I know I have done something very well, I feel relaxed and content rather than excited and elated.
30. ___ When I do feel anxiety it is normally very strong.
31. ___ My negative moods are mild in intensity.
32. ___ When I am excited over something I want to share my feelings with everyone.
33. ___ When I feel happiness, it is a quiet type of contentment.
34. ___ My friends would probably say I'm a tense or "high-strung" person.
35. ___ When I'm happy I bubble over with energy.
36. ___ When I feel guilty, this emotion is quite strong.
37. ___ I would characterize my happy moods as closer to contentment than to joy.
38. ___ When someone compliments me, I get so happy I could "burst."
39. ___ When I am nervous I get shaky all over.
40. ___ When I am happy the feeling is more like contentment and inner calm than one of exhilaration and excitement.

FIGURES

Figure 1. Neuropsychological Theories of Emotional Processing: The Right Hemisphere Hypothesis and the Valence Hypothesis

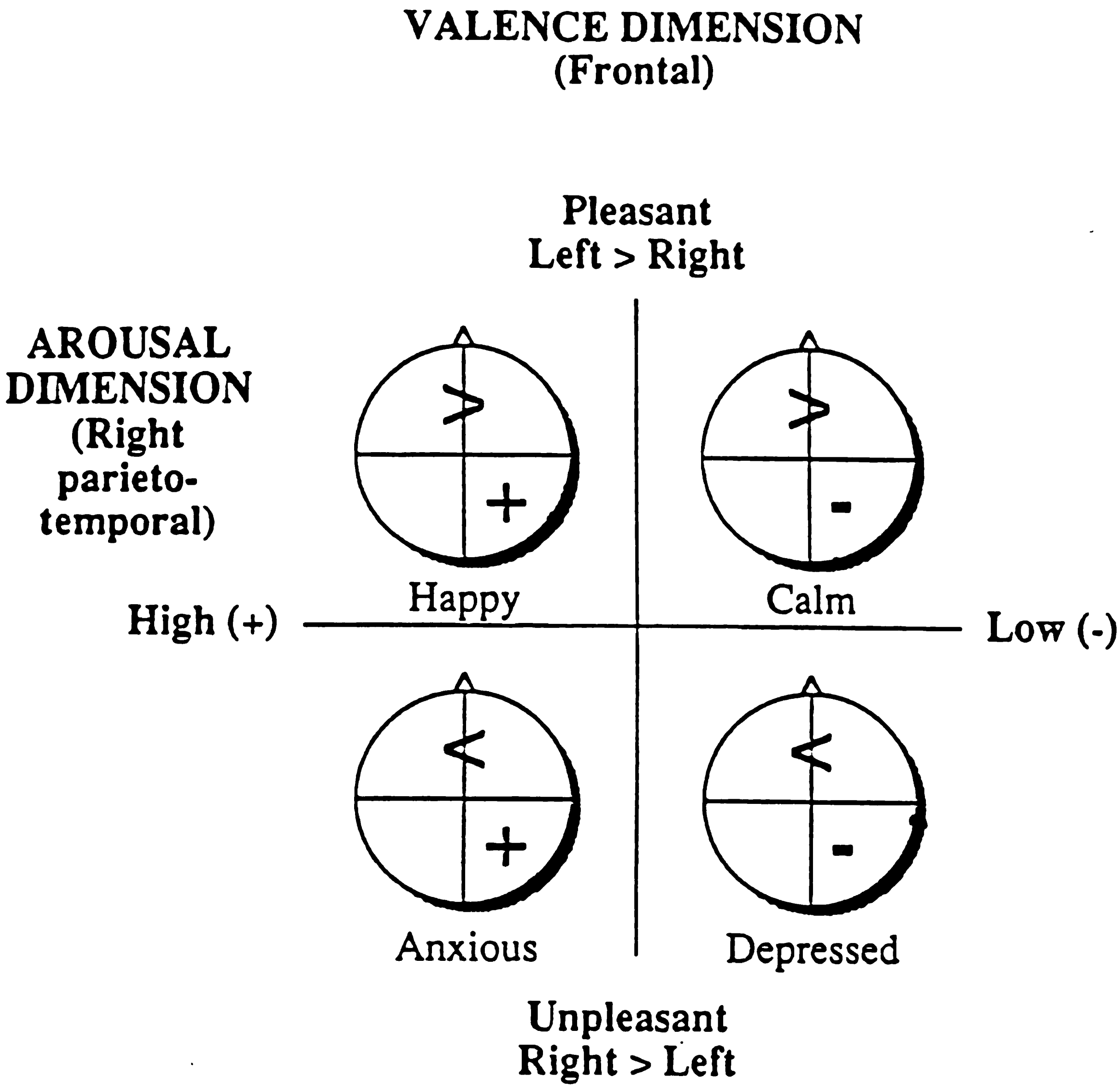
a. *The Right Hemisphere Hypothesis*

	Left Hemisphere		**Right Hemisphere**	
	Positive	Negative	Positive	Negative
Interpretation			+	+
Experience			+	+
Expression			+	+

b. *The Valence Hypothesis*

	Left Hemisphere		**Right Hemisphere**	
	Positive	Negative	Positive	Negative
Interpretation			+	+
Experience	+			+
Expression	+			+

Figure 2. Heller's Model (from Heller, 1993; Neuropsychology, 7, p. 477).


VALENCE DIMENSION
(Frontal)
Pleasant
Left > Right
AROUSAL
DIMENSION
(Right
parieto-
temporal)
>
+
>
-
Happy
Calm
High (+)
Low (-)
<
+
<
-
Anxious
Depressed
Unpleasant
Right > Left

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