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CEREBRAL HEMISPHERIC EMOTIONAL EXPERIENCE IN NORMAL AND DEPRESSED MOOD

by

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Abstract

The present study was designed to examine hemispheric differences in phenomenological aspects of emotional experience and to reference any differences to "normal" bilateral experience. A secondary purpose was to relate any hemispheric asymmetries to depressive symptomatology.

Several hypotheses were advanced, based on parallels between laterality studies of physiological, phenomenological and identificational aspects of emotion. Primary hypotheses were for stimuli presented first to the right hemisphere to be experienced as more negative than when presented first to the left hemisphere or to both hemispheres simultaneously. Secondary hypotheses were for a greater positive relationship between depression and right hemispheric negative emotional ratings than for the left hemispheric or bilateral ratings.

These predictions were tested by two experiments on 50 male and 50 female subjects. The first study was conducted to select experimental stimuli that would represent emotionally positive, negative, and neutral events. Subjects were tachistoscopically presented with 30 (verbal) nonsense words and 30 (nonverbal) geometric figures to the center of fixation. Their task was to complete a depression inventory, and rate each stimulus on two 15 point scales that reflected how they felt about it and how confident they were of their feelings. The 12 verbal and 12 nonverbal stimuli rated as most positive, negative, and neutral were then presented to subjects in the second study. Here, similar procedures were used, with the major exception that each stimulus was presented three times: to the left visual field; right visual field; and center of fixation.

As predicted, stimuli presented first to the right hemisphere were experienced as more negative than either stimuli presented first to the left hemisphere or stimuli presented bilaterally. However, left hemisphere and bilateral presentations typically failed to differ. Contrary to prediction, a relationship was not found between depression and any emotional ratings.

These results support a conception of a "negatively biased" right hemisphere relative to left hemisphere or normal bilateral emotional experience. A variety of implications for understanding "normal" emotional experience were discussed, including the possibility that left hemispheric experience may be similar to conscious "normal" experience. Implications for understanding "abnormal" behavior included an explanation of dramatic emotional changes following left hemispheric injury, and greater support for lateralized theories of "repression" and stress than for theories of depression.

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Cerebral Hemispheric Emotional Experience in Normal and Depressed Mood

It is a curious irony of research on hemispheric asymmetries that one of the most central components of emotion -- phenomenological report -- has been studied the least. While this experiential or subjective aspect of emotion has been investigated by only a few studies outlined below, the majority of studies have focussed on two other components of emotion, categorized here as the identification of emotion and the physiology of emotion.

Identificational dependent measures are defined as those concerned with skill in emotional identification or recognition. They have included accuracy and/or response time in emotional tone (e.g., Carmon & Nachson, 1973; Haggard & Parkinson, 1971; Ley & Bryden, 1982; Megibow & deJamaer, 1979; Safer & Leventhal, 1977) and emotional expression (Landis, Assal & Perret, 1979; Ley & Bryden, 1979; McKeever & Dixon, 1981; Suberi & McKeever, 1977). Physiological dependent measures can be defined as being concerned with nervous system activity, and have included electroencephalography (e.g., Davidson & Schwartz, 1976; Davidson, Schwartz, Saron, Bennett & Goleman, 1979; Gill & Martin, 1983; Harmon & Ray, 1977; Tucker, Stenslie, Roth & Shearer, 1981), lateral eye movement observation (Ley, 1979;

Schwartz, Davidson & Maer, 1975; Tucker, Roth, Arneson & Buckingham, 1977), facial electromyography (Schwartz, Ahern & Brown, 1979), and heart rate monitoring (Dimond & Farrington, 1977).

Whereas the majority of studies using identificational and physiological measures have made claims concerning the right hemisphere's "specialization" for emotion (see reviews by Bryden, 1982; Bryden & Ley, 1983; Campbell, 1982; Ley & Bryden, 1981; Moscovitch, 1983; and Tucker, 1981) the studies using phenomenological measures have suggested that each hemisphere has a unique emotional perspective, outlook, or "bias". There is, however, disagreement as to which hemisphere is more negatively/positively "biased" than the other and what the "bias" refers to.

This experiment explored these phenomenological differences between the hemispheres with four goals: (1) attempting to resolve the controversy over which hemisphere is more negatively biased than the other, (2) comparing, within the same experiment, initially unilateral emotional experience with that of the individual's "normal" emotional experience, (3) relating this emotional comparison to the subject's present mood (ranging from normal to depressed), (4) performing these goals using a number of methodological improvements designed to eliminate identificational or accuracy aspects of the subject's task, making it a basically phenomenological one.

Collectively, these goals will focus upon the cortical aspects of lateralized emotional experience. Although anterior-posterior brain differences appear to interact with left-right brain differences in the study of emotion (e.g., Davidson & Fox, 1982; Kinsbourne & Bemporad, 1984; Tucker, 1984), they are dealt with at an empirical level in this paper, rather than a theoretical one. And, although the primary importance of subcortical regions to emotional behavior is acknowledged in hemispheric studies (e.g., Ladavas, Nicoletti, Umilta & Rizzolatti, 1984), their examination is not within the scope of this study.

A review of what are termed here "phenomenological" studies is outlined below. These studies share an interest in subjects' subjective emotional experience of stimuli, typically expressed on a pleasant-unpleasant or positive-negative scale. This is followed by a discussion of the hypotheses of the study.

Differential Hemispheric Phenomenological Experience in Normals

Dimond, Farrington, & Johnson (1976) appear to have been the first investigators to specifically examine hemispheric differences in the phenomenological aspects of emotion in normals. Subjects were fitted with specially designed contact lenses to channel light into a single visual field, corresponding to either the right or left hemisphere. (See Dimond, Bures, Farrington and Brouwers, 1975, for details.) The stimuli were three silent films depicting surgery (emotionally negative), travel (neutral) or a cartoon (positive). They found that subjects whose lenses projected input (first) to the right hemisphere rated all films as more unpleasant (and all but the "neutral" travel films as more horrific) than the left hemisphere group. Dimond et al concluded that the right hemisphere "aligns itself more with the characteristic perception of the depressive patient than with that of the normal individual" (p. 691). Unfortunately, this statement may be premature. While it can be claimed that the right hemisphere was emotionally more negative than the left hemisphere, it cannot be claimed with as much certainty that the right hemisphere was more negative than subjects' normal mood. Although some subjects did view the films bilaterally ("free vision"), they were part of the pilot study, and hence were not exposed to the same procedures (such as being fitted with special lenses) or the same number of films (watching four more than experimental subjects). This lack of comparability should make direct comparisons more tentative.

In contrast to Dimond et al (1976), Beaton (1979) found that the right hemisphere was emotionally biased in the opposite direction. Using a dichotic listening paradigm, he presented subjects with selections of poetry and nonvocal classical music. These were rated as more "pleasant" when presented to the left ear (predominantly right hemisphere) than the right ear, while the music was also rated as more "soothing" when presented to the left ear. Hence, although he agreed with Dimond et al (1976) that each half of the brain has a different emotional experience, Beaton concluded "that the right cerebral hemisphere is more disposed towards seeing the bright side of life than is the left hemisphere" (p. 108).

In an attempt to resolve this controversy, Gill (1982) used both visual and auditory stimuli to examine the effect of sensory mode. A pretest first assigned one of five initial emotional values to the stimuli: very positive, mildly positive, neutral, mildly negative, or very negative. They were then presented to experimental subjects in the context of a simulated driving experience, with auditory stimuli representing traffic sounds (presented dichotically) and visual stimuli representing traffic lights and signs (presented unilaterally). Subjects were to evaluate how positive or negative each stimulus was. Across sex and sensory mode, subjects receiving the stimuli to the left ear and visual field (right hemisphere) rated the stimuli as more negative than the left hemisphere group, for all types of emotion. Hence, Dimond et al's (1976) model of a negatively biased right hemisphere was supported. However, it was also recognized that the converse could be concluded: that the left hemisphere was positively biased in relation to the right hemisphere.

Further evidence of a left hemisphere positive bias was found by Davidson and Moss (cited in Kinsbourne and Bemporad, 1984). Subjects were unilaterally presented with emotional and neutral faces. Their task was to rate the degree of emotion expressed by the stimulus, and the degree of emotional response they felt towards it. Across expressions, subjects felt more happiness for right visual field (left hemisphere) presentations than left visual field presentations. A trend was also found for more sadness for left visual field (right hemisphere) presentations than for right visual field presentations. This pattern was replicated by Davidson, Schaffer, and Saron (cited in Kinsbourne and Bemporad, 1984).

An interest in differentiating between a left hemisphere positive bias or a right hemisphere negative bias was expressed by Natale, Gur and Gur (1983). After a series of three experiments, they concluded that while the left hemisphere reflected a positive bias, the right hemisphere was not seen to have any emotional bias. Hence, while previous studies had always referred to emotional differences as between the hemispheres, Natale et al referred to emotionality within each hemisphere. Details of the two relevant experiments are outlined below, followed by criticisms of their approach. (Experiment II is omitted since its concern was with "accuracy".)

In Experiment I, subjects were tachistoscopically presented with facial pictures depicting four emotionally negative expressions, one positive expression, and one expression of surprise. Subjects were asked to rate the faces on a seven point emotional scale. Left visual field (right hemisphere) presentations to right handers were judged more negatively for all negative expressions. This suggested either a right hemispheric negative bias or a left hemispheric positive bias consistent with Dimond et al (1976) and Gill (1982). In Experiment III, subjects were presented with facial composites, in which half of a face was happy, and the other half was sad. Their task was to judge whether the face suggested a more positive or more negative mood. (Trials were presented at a speed at which each subject failed to reach a 75% correct criterion in judging whether one or two emotions were presented in a single composite photograph.) It was found that right visual field (left hemisphere) stimuli received more positive judgements than left visual field stimuli. Once again, these results were consistent with Dimond et al (1976) and Gill (1982).

A "bias index" was then calculated as the proportion of positive judgements compared to negative judgements. Hence, a score of zero would be found when an equal number of positive and negative judgements were made, indicating no emotional bias. Using this index, Natale et al (1983) reported that the right hemisphere did not show emotional bias, while the left hemisphere was biased towards positive judgements.

Unfortunately, this bias index is problematic. At least two criticisms can be directed toward this procedure. First, it can be argued that Natale et al were not measuring just phenomenological bias, but also accuracy in recognition of facial expression. This can be seen in several aspects of the experimental paradigm. (a) The stimuli used were facial expressions, for which Natale et al found a right hemispheric superiority in recognition of emotion (Experiment II). Although not mentioned by the authors, this is consistent with the findings of other studies (e.g. Ley & Bryden, 1979; Safer, 1981, Experiment II). Unfortunately, at least one study has concluded that emotional recognition and facial recognition are not independent (Hansch & Pirozzolo, 1980). Hence, it is difficult to say whether the superiority relates to emotion per se, or to facial identification accuracy, or to some combination of the two. (b) The experimental task emphasized logic and/or accuracy in emotion, rather than subjective experience. The initial procedure of determining, on an individual basis, a 75% correct criterion recognizing that a face expressed two emotions clearly communicated a search for accuracy to the subject. Moreover, the experimental trials that followed echoed this accuracy in merely asking the subject to make a dichotomous choice as to whether the face was more positive or more negative. A continuous ten point scale, for example, would have communicated a more subjective aspect of the task to the subject. (c) The bias index itself is based on accuracy. It assumed that each hemisphere has an equal probability of making a positive or negative judgement. Hence, a left hemisphere positive bias meant that the left hemisphere saw more positive faces than it should have, had it been accurate.

In light of these elements of accuracy in the experimental paradigm, the failure to find an emotional bias for the right hemisphere can be alternately interpreted here as right hemispheric accuracy at emotional recognition. Unfortunately, then, phenomenological and logical tasks have been confounded.

Second, the significance of this positive left hemisphere bias is unclear. The interpretation is that the left hemisphere is more positive than it is negative, and not that it is more positive than the right hemisphere. Since the left hemisphere is discussed in isolation from the right hemisphere, the effect of this bias upon interhemispheric relations is left unanswered. Without basing hemispheric biases in relation to one another, their influence upon behavior may not be meaningful at this stage.

In summary, then, at least three studies have found evidence that the right hemisphere has an emotionally more negative experience of stimuli than the left, one study has found the opposite pattern, and one study has reported a left hemispheric positive bias with no bias assigned to the right hemisphere. Two questions arise from this literature: what is the emotional experience of each hemisphere relative to the other; and what is the meaning of these differences to behavior?

Possibly the simplest method of trying to answer these questions would be to compare the emotional experience of each individual hemisphere with the experience of the hemispheres operating together. In effect, this would compare the left and right hemispheres' experience with that of the individual in a normal "waking" state. Operationally, this would involve unilateral presentation of stimuli (where one hemisphere receives input before the other) being compared with bilateral presentation of stimuli (where both hemispheres technically can receive input simultaneously). Using this paradigm, the meaning of emotional "biases" becomes startlingly clear. An investigator can claim, for example, that one hemisphere is more negatively biased than the other hemisphere, but also that one hemisphere is more negatively biased than the individual's normal subjective experience. The implications of being able to make statements of this sort are twofold. First, a better understanding of the relative contribution of each hemisphere to the individual's conscious "normal" emotional experience could be gained. Second, a better understanding of "abnormal" emotional experience could also arise, since there are a variety of theories of psychopathology based on disturbed relations between the hemispheres (e.g., Gruzelier, 1981). Despite these implications, no previous studies appear to have used or proposed this type of experimental paradigm.

Experimental Purpose and Hypotheses

In light of the problems discussed with current understandings of emotional "biases", the advantages of a more meaningful conception of hemispheric differences in emotion, and the lack of a test of this paradigm, the primary purpose of the study was to compare subjects' emotional experience of stimuli presented first to the left hemisphere, right hemisphere, and both hemispheres simultaneously.

It was predicted that the right hemisphere would be found to be more emotionally negative than the left, and that the individual's bilateral or "normal" experience would be between the emotional extremes of the two hemispheres. Operationally, this was to be reflected in left visual field stimuli presentations (to the left side of a viewing screen) being rated more negatively than central (or bilateral) stimuli presentations, which in turn were expected to be more negative than right visual field presentations (to the right side of a viewing screen).

A secondary purpose of the study was to take into consideration the individual's present mood, immediately prior to his or her experience of the experimental stimuli. Although intuitively it would seem that an individual's mood would be related to how he or she makes emotional judgements, no previous phenomenological studies of hemispheric differences have examined this factor. It was assessed in this study using the CES-Depression Scale (Radloff, 1977), which has been used extensively with nonclinical populations.

Two predictions were made about depressed mood. First, it was predicted that the level of depressed mood that an individual experienced would be positively related to the degree of negative emotion experienced in right hemisphere presentations. Hence, as depression increased, so would right hemispheric "negativity". Second, the relationship between mood and hemispheric ratings was expected to be strongest for the right hemisphere. Hence, depressed mood was expected to be more related to right hemispheric experience. Operationally, these two hypotheses were reflected as a greater positive relationship between Depression Scale scores and left visual field stimuli presentations, than right visual field or central stimuli presentations.

These experimental predictions are based on five sources of evidence in the literature on hemispheric asymmetries in emotion. First, the phenomenological studies of Dimond et al (1976), Gill (1982) and Natale et al (1983), previously discussed, all suggest that the right hemisphere has a more negative emotional experience than the left hemisphere. (Or they suggest that the left hemisphere has a more positive emotional experience than the right hemisphere.) Second, studies of neurological patients suggest that when both hemispheres are not functioning together normally due to damage or barbituation, each hemisphere has a unique emotional experience. When the left hemisphere is the intact or normal hemisphere, the individual is more euphoric or indifferent than "usual", whereas when the right hemisphere is intact, the individual is more depressed than "usual". Third, studies of emotional identification (using speed or accuracy measures) suggest a right hemispheric specialization, or superiority, for negative emotion and a left hemispheric specialization for positive emotion. Fourth, physiological studies of normals suggest that each hemisphere is specialized, or more active, with different types of emotion. The right hemisphere has been found to be physiologically more active with emotionally negative stimuli than other types of stimuli, while the left hemisphere has been found to be physiologically more active with emotionally positive stimuli. Hence, the right hemisphere is implicated with negative mood, while the left hemisphere is implicated with positive mood. Lastly, physiological studies of depressed subjects indicate that they have patterns of greater right than left hemispheric activation, suggesting a relationship between mood and hemispheric activity.

Collectively, these areas of research were seen to relate to the experimental hypotheses. Each area of research will be elaborated on in the forthcoming sections.

Differential Hemispheric Superiority with Emotion

A variety of laterality studies interested in emotional identification or recognition have concluded that the right hemisphere is superior, or specialized, in dealing with most or all types of emotion (e.g. Bryden, 1982; Ley & Bryden, 1981; Newlin & Golden, 1980). Conversely, the left hemisphere has been regarded as inhibiting emotional arousal (Tucker, 1981). There are, however, several studies that have found hemispheric superiority to be related to the type of emotion being presented. While the right hemisphere may be superior with emotionally negative stimuli, the left hemisphere has been seen to be superior with emotionally positive stimuli. This interaction is seen as supporting the experimental hypotheses, since it parallels the phenomenological pattern of an emotionally negative right hemisphere (relative to the left) and/or an emotionally positive left hemisphere (relative to the right).

Visual Stimuli

At least three laterality studies of emotion using visual stimuli have found an interaction between hemispheric superiority and type of emotion. Reuter-Lorenz and Davidson (1981) bilaterally presented subjects with two photographed faces: a nonemotional one; and an emotional one displaying a positive or negative emotion. Subjects were instructed to indicate which side the emotional face was on by pressing an appropriate button as quickly as possible. They found that while the right hemisphere was superior in response time to sad faces, the left hemisphere was superior with happy faces. In a second experiment, Reuter-Lorenz, Givis and Moscovitch (1983) added closed mouth happy faces to the open mouthed faces used previously, and bilaterally presented pairs of emotional and nonemotional faces to three groups of subjects: right-handed, left-handed, and "inverted" left-handed. They found that both right-handed and inverted left-handed subjects showed a right hemisphere advantage in speed for sad faces and a left hemisphere advantage for both open and closed mouth happy faces. Interestingly, the "non-inverted" left-handed subjects showed exactly the opposite pattern. Reuter-Lorenz et al argue that since subjects were simply detecting emotion, their measure was "less confounded by cognitive factors" (p. 688) than matching or categorizing measures. Together, these two studies strongly suggest that the hemisphere that is dominant for language (left hemisphere in right handers) is superior in response time in dealing with positive emotion, while the hemisphere dominant for visuospatial processes is superior with negative emotion.

Correspondingly, studies that report a right hemisphere superiority overall have nonetheless found this effect to be strongest with negative emotions. Campbell (1982) reported a study by Buchtel, Campari, Derisio and Rota (1978) appearing in an Italian journal that a right hemispheric superiority in recognizing facial emotions was least for happy faces and greatest for sad ones. Similarly, Ley and Bryden (1979) reported that the right hemispheric superiority they discovered for emotional expression was greatest for the extremely negative facial expression.

In attempting to reconcile studies finding an exclusive right hemispheric superiority for emotion with those that do not, one possibility is that many of the former studies found this effect because they favored the use of more negative stimuli than positive ones (e.g. Graves, Landis & Goodglass, 1981; Safer, 1981; Suberi & McKeever, 1981) with some investigators not even using an emotionally positive condition (e.g. McKeever & Dixon, 1981). It is also possible that more cognitive abilities are being examined, such as holistic judgements (e.g., Nebes, 1978) or facial identification (e.g., Hansch & Pirozzolo, 1980).

Apart from these differences in accuracy, studies concerned with hemispheric superiority in emotion have also made some interesting phenomenological observations. Natale and Gur (1981), for example, had subjects assign emotional ratings to faces with various expressions. They found that the faces classified as neutral presented to the right hemisphere were experienced as being more negative than when presented to the left hemisphere. Sackeim and Gur (1978) presented subjects with a set of facial photographs called "composites" (in which one side of the face is the mirror image of the other). The photos had been selected to represent a neutral expression and six emotional expressions (happiness, surprise, fear, anger, sadness and disgust). They found that the intensity ratings for anger and disgust were significantly higher for left side composites (associated with the right hemisphere) and tended to be higher for sadness and anger, while intensity ratings for happiness tended to be higher for right side composites (associated with the left hemisphere). Analyzed slightly differently, the left side composites (right hemisphere) were judged more intense than right side composites significantly more often for negative emotions (disgust, anger, fear, sadness) than for positive emotions (happiness and surprise). Essentially, this data supports a right hemispheric involvement with negative emotion and a left hemispheric involvement with positive emotion. Sackheim and Gur suggest, then, that "as in the case of the processing of emotional information, the direction of hemispheric control over emotional expression may be determined by the type of emotion being expressed" (p. 479).

Auditory Stimuli

In addition to these visual studies, at least one study using auditory stimuli has found a similar pattern of results. Bryden, Ley & Sugarman (1982) explored emotional reaction to musical tones. Based on assumptions from psychological research on music (Davies, 1978; Hevner, 1935) and their own pretest, the authors classified major keys as emotionally positive, minor keys as negative, and a random sequence of tones as neutral. Four tones for each emotion were dichotically presented to the subjects, whose task was to classify each tone as positive, negative or neutral, and to rate it on a seven point positive-negative scale. Overall, a left ear/right hemisphere superiority in accuracy was found. However, they also found a significant interaction between ear of presentation and the emotional value that they had previously assigned to each musical stimulus. Music that was classified as neutral and negative tended to be rated as more positive when presented to the right ear/left hemisphere. Moreover, when target and competing emotions were the same, right hemisphere superiority was greatest with emotionally negative tones and least with positive tones.

Collectively, these visual and auditory studies suggest that while the right hemisphere is superior in the identification or recognition of emotionally negative stimuli, the left hemisphere may be superior with emotionally positive stimuli. Moreover, dependent measures of emotional identification are consistent with phenomenological observations in indicating greater right hemispheric involvement with negative emotion, relative to the left, and greater left hemispheric involvement with positive emotion, relative to the right.

Differential Hemispheric Phenomenological Experience in Neurological Patients

In contrast to the sparsity of studies commenting on phenomenological aspects of emotion in normals, there is an impressive array of studies of emotional behavior in neurological patients. Also impressive is the consistency with which the majority of the reports implicate the right hemisphere with negative emotion and the left hemisphere with positive emotion. This evidence comes from studies of a variety of effects discussed below, including unilateral lesions, seizures, carotid barbiturate injection, ECT, and commissurotomies. The interpretation that is given in this paper to these reports is that the abnormal state of one hemisphere has disrupted or silenced its emotional experience, such that the emotional state of the patients corresponds with that of the contralateral, intact hemisphere. (Although Tucker, 1981, 1984, argues for an ipsilateral interpretation of lesion and barbituation studies).

Since many of these studies allow a comparison of unilateral with bilateral or 'normal' emotional experience, they are directly relevant to the primary experimental hypothesis. Hence, evidence will be offered that the right hemisphere is negatively emotionally biased relative to normal bilateral function, while the left hemsphere is positively biased relative to normal bilateral function.

Prior to outlining these studies, a cautionary note may be appropriate. It is recognized that there is a possibility that an intact hemisphere may compensate, to a degree, for damage to the other hemisphere (Kinsbourne, 1974; Moscovitch, 1976), and that extrapolations from clinical populations may carry certain risks. However, these concerns are reduced when this data is not examined in seclusion, but in relation to the wide variety of other subject populations and dependent measures that this study considers.

Commissurotomies

Anecdotal evidence for the involvement of both hemispheres in emotion can be found in studies of commissurotomized patients. First, Gazzaniga (1967), Sperry (1968), and Sperry, Gazzaniga and Bogen (1969) found that each hemisphere had an emotionally reactive nature -- a point that is questioned (e.g. Schwartz et al, 1975). As an example, a picture of a nude female presented to a particular hemisphere will produce an embarrassed response, whether or not it is the left or the right hemisphere. Sperry (1968) reported negative right hemisphere reactions to aversive odors (such as wincing or complaining). He also reported the right hemisphere to cause a commissurotommized individual to frown, wince or shake the head when it "hears" the other hemisphere make a verbal error, (since it is unable to vocalize its own annoyance). Second, split-brain research has also reported instances of the left hemisphere having an emotionally positive bias and the right hemisphere having a negative one. Dimond (1979), for example, notes that the speech of commissurotimized patients is often euphoric. He attributes this positive mood to the left hemisphere, claiming that it "certainly possesses its own mechanisms for laughter and humor as expressed through speech" (p. 37). Indeed, Harman and Ray (1977) use Levy (cited in Harman & Ray, 1977) as a reference for commissurotomized patients even displaying the catastrophic or indifferent reactions similar to individuals with left and right hemisphere damage, respectively (outlined below).

Unilateral Lesions

Observations of patients with unilateral brain damage may have been the first suggestions that each hemisphere has a different emotional experience. Babinski (1914) noted that a patient with right hemisphere damage would be either unaware of a left-sided hemiparesis, or accepted it with a positive attitude. Goldstein (1939, 1948) reported that patients with lesions in the left hemisphere (intact right hemisphere) shared a similar emotional state of anxiety and depression which he called a "catastrophic reaction". Symptoms included depressive behavior such as crying spells and anxiety reactions, and aggressive behavior such as swearing. Although this may be explained as simply frustration in response to loss of normal language, reports of opposite behavior in patients with right hemisphere damage apart from Babinski (1914) make this less likely. For example, Hecaen, Ajuriaguerra and Massonet (1951) reported that patients with right parieto-occipital damage showed a relaxed and nonaggressive mood called an "indifference reaction". Denny-Brown, Meyer, and Horenstein (1952) reported similar behavior in patients with right parietal lesions.

In a comparison of left and right hemisphere damaged groups, Hecaen (1962) supported the previous studies. Indifferent reactions were found more in patients with right hemisphere than left hemisphere damage, while catastrophic behavior was found more in left hemisphere damaged patients than right hemisphere damaged patients. Gainotti (1969) also compared the incidence of indifferent and catastrophic reactions, and found similar results. He later further investigated these phenomena by specifically comparing left and right hemisphere damaged patients on several behaviors or symptoms (Gainotti, 1972). Patients with lesions in the right half of the brain were characterized as indifferent, often making jokes and frequently minimizing or tending to deny their deficits. Correspondingly, patients with lesions in the left half of the brain appeared acutely aware of their deficits, displaying anxiety attacks, crying, swearing and pessimism over their abilities. More recently, Tucker (1981) reported the work of Dobrokhotova and Braghina (1974) (in a Russian journal) which again found right hemisphere damaged patients to be indifferent or euphoric and left hemisphere damaged patients to be in a depressed state.

Collectively, these studies indicate that when the left side is the only intact hemisphere, an emotionally positive or euphoric mood predominates. When the right hemisphere is the only intact area, an emotionally negative or depressed mood predominates. This interpretation is consistent with at least one study of hemispherectomy patients. Sackeim, Greenberg, Weiman, Gur, Hungerbuhler and Geschwind (1982, Study 2) found that almost all right hemispherectomy patients they retrospectively examined had symptoms of euphoria. Hence, whether the right hemisphere is damaged or removed, patients tend to have emotionally "positive" reactions.

The possibility that these emotional reactions are due to cognitive defects or other factors has been argued against by at least two investigators. Sackeim et al, 1982 (Study 1) examined cases of pathological crying or laughing after cerebral lesions. Laughing was at least three times as common in right hemisphere as compared to left hemisphere damage, while crying was at least twice as common in left hemisphere as right hemisphere damage. They concluded that these symptoms were not secondary reactions to cognitive or sensorimotor defects. Kinsbourne and Bemporad (1984), reviewing several reports of depression after left hemisphere damage stated that left anterior brain injuries were associated with depression. They concluded that the depression was not related to degree of cognitive impairmment, or performance in daily tasks, psychiatric history, or length of time after injury.

Unilateral Barbituation

A lateralized emotional response has also been observed in patients administered an intracarotid barbiturate injection (or the "Wada technique"). This procedure effectively sedates a cerebral hemisphere, allowing an observer to attribute a patient's emotional state largely to the hemisphere remaining "awake". Terzian and Cecotto, in 1959, were possibly the first to make note of the emotional reactions to this technique (Terzian, 1964). Following sedation of the hemisphere dominant for language (typically the left in right handed individuals) they found patients exhibited a "depressive-catastrophic" reaction, while those whose nondominant hemisphere was sedated demonstrated a "euphoric-maniacal" reaction. Hence, the emotional effects of temporary sedation and longer term damage to a particular hemisphere were found to be similar. (While Perria, Rosadini and Rossi, 1961, generally replicated these effects in surgical patients, Alema, Rosadini, and Rossi, 1961, did not find these reactions in patients with diffuse brain damage.) Rossi and Rosadini (1967) replicated these reactions in a large sample of neurological patients. They reported that over half the patients had an emotional reaction to the sedation: of these, left hemisphere barbituration produced depression in most individuals, while right hemisphere barbituration led to euphoria in most individuals. Depressive reactions were characterized by sadness, frequent crying, and pessimism, in which "the patient complains of almost everything: his health and the health of his family, his financial conditions, his work, and so on; he is convinced he will soon die and his family will go to ruin" (p. 171). Euphoric reactions seemed to be characterized by a progressively more intense experience, going from relaxation, to optimism, to joking and eventual laughter.

A few investigators have questioned this evidence. First, Milner (1967) has failed to find any hemispheric differences in emotional states, and, indeed, argues against a lateralization of emotion (Milner, 1971, 1974). However, Campbell (1982) speculates that this failure may be related to different subject populations (European vs. his North American) or methodology. (For example, Milner tested hemispheric differences in a within-subjects design, while the other studies used a between-subjects design). Second, Tucker (1981) refers to the finding of Rossi and Rosadini (1967) that emotional effects occur only after the sedative effects have worn off, possibly making contralateral interpretations less likely. Nonetheless, the emotional function of the affected hemisphere would certainly have been disrupted. Moreover, since the emotional reactions have been reported by several investigators, and since they parallel the findings of lesion and hemispherectomy studies, this literature is seen as largely supportive of different hemispheric emotional experiences.

Unilateral Seizures

Studies on seizures elicited by electroconvulsive therapy (ECT) offer additional support for a pattern of differential hemispheric response. Galin (1974) reviewed six ECT studies and found some indications that right hemisphere ECT was more effective than left hemisphere ECT in alleviating depression, while D'Elia and Raotma (1975) concluded from twenty-nine studies that right (nondominant) hemisphere ECT was as effective as ECT applied to both hemispheres. Hence, right hemispheric seizures were associated with a more positive mood.

Conversely, the ECT studies show negative mood to be associated with left hemisphere seizures. Deglin (1973) found that while right hemisphere ECT resulted in patients exhibiting generally positive facial expression, left hemisphere ECT led to more negative expressions. Deglin and Nikolaenko (1975) found even more behavioral differences, suggestive of the indifferent-catastrophic reactions of right and left hemisphere damaged patients respectively. Hence, while the right hemisphere seizures lead to more positive or euphoric responses, those in the left hemisphere lead to an increase in anxiety and depressed mood. That these results are due to disruptions within the hemisphere being treated is suggested by Stromgren and Juul-Jensen's (1975) report that with unilateral ECT, same-sided EEG changes are predominant, while opposite sided EEG changes were few. (In light of this association between right hemispheric seizures and improved mood, unilateral right hemisphere ECT is the most popular form of ECT in England, while its use in the United States is increasing, Usdin & Lewis, 1979).

A different pattern of results has been reported with epileptic seizures. Sackeim et al (1982, Study 3) examined case reports of laughing during epileptic auras or seizures. Laughing was found in twice as many left as right hemisphere disturbances (which the authors attributed to disinhibition, rather than the disruption that this study uses to explain other seizure results). However, overall, Sackeim et al concluded that the left "subserves" certain positive emotions more than the right hemisphere, while the right "subserves" certain negative emotions more that the left hemisphere. This is in agreement with the view proposed throughout this study.

Psychological Assessment

Apart from clinical observations of emotional reactions, objective personality tests have also been used in hemispheric studies of emotion. Although Dikmen and Reitan (1974a, 1974b, 1977) have found the degree of a patient's impairment to be more related to their emotional state than the site of damage, and have found no hemispheric differences on "relevant" MMPI scales, at least five other studies have. (Moreover, Dikmen and Reitan did acknowledge that the MMPI may not be the most suitable instrument for use in this situation.) Meier and French (1965) administered MMPI's to "psychomotor epileptics" with EEG abnormalities in either the left or right temporal lobe. They found a trend for greater depression on scale 2 (D) in patients with left hemisphere abnormalities, compared to those with right hemisphere abnormalities. Bear and Fedio (1977) also administered right and left temporal epileptics the MMPI. In addition, they had observers evaluate the personality traits of the patients. The two groups of epileptics were found to differ on two factors derived from a factor analysis of MMPI and observers' ratings. On a normal-severe disturbance factor, observers rated right temporal epileptics as more severe than left temporal epileptics. Yet, the patients themselves evidenced the reverse: left temporal epileptics (pessimistically) saw themselves as more severe than the (indifferent-euphoric) right temporal patients. On a second, emotive-ideative factor, observers rated the (depressed) right temporal group as more emotionally demonstrative than the (indifferent) left temporal group. Thus, the right temporal epileptics in both studies had some symptoms of the catastrophic reaction of right hemisphere damaged patients, while Bear and Fedio's left temporal epileptics exhibited the indifference and denial of left hemisphere damaged patients.

MMPI's administered to patients with other brain disorders are reflective of these hemispheric differences. Black (1975) found that the profiles of patients with left hemisphere damage had greater depression that those with right hemisphere damage. In general, left hemisphere patients' profiles were consistent with a negative or catastrophic personality, while right hemisphere patients' profiles were consistent with an unemotional or indifferent personality. However, since the right hemisphere group's depression may have been related to their greater overall cognitive deficits, Gasparrini, Satz, Heilman and Coolidge (1978) administered the MMPI to left and right hemisphere damaged groups that failed to differ on several neuropsychological tests measuring cognitive and/or expressive difficulties. (These tests included the WAIS, a finger-tapping test and a form-board test.)

Left hemisphere patients were found to be more depressed than right hemisphere patients. (Indeed, no right hemisphere damaged patients had elevated "depression" scale (2) scores.) Moreover, the mean profile of left hemisphere patients was a 2-8-7 pattern, which was seen as "compatible with a major affective disorder" (p. 472). This data thus supports a "catastrophic" reaction being associated with left hemisphere damage.

Other than MMPI's, at least one study has used specific depression inventories. Robinson and Benson (1981) administered patients with left hemisphere damage four measures of depression: the Zung Self Rating Depression Scale (Zung, 1965); Hamilton Depression Scale (Hamilton, 1960); Nurses' Rating Scale for Depression (Robinson & Szetela, 1981); and the Visual Analogue Mood Scale (Folstein & Luria, 1973). Scores from each test were then combined to form an "overall" depression score. Indications of moderate to severe depression were found in approximately 45% of their sample.

In light of the number of studies on neurological patients reviewed, and the variety of reports (clinical observations and MMPI'S on patients with seizures, other organic disorders, and commissurotomies), it is apparent that a different emotional reaction ensues from damage/sedation to the right or left hemisphere. While the intracarotid barbiturate and commissurotomy studies confirm that each hemisphere is emotionally responsive, the clinical observations and MMPI profiles of brain damaged subjects consistently indicate that when the left hemisphere is intact, an inappropriately positive reaction ensues, and when the right hemisphere is intact, an inappropriately negative reaction ensues. Given that these are examples of the characteristic emotional expression of each hemisphere (when the emotional control of the other hemisphere is damaged) this suggests that the right hemisphere has an emotionally negative bias towards events, relative to normal bilateral experience, while the left hemisphere conversely has a more positive "outlook". This is in direct support of the proposed study's hypothesis that bilateral experience will be represented between the emotional 'extremes' of each hemisphere.

Differential Hemispheric Activation with Emotion

A variety of physiological procedures have been used in the search for hemispheric differences in emotion, including heart rate monitoring, electroencephalography (EEG), electromyography (EMG), and lateral eye movement observation. As each physiological procedure is discussed below, the view that will be advanced is that hemispheric activation is, indeed, a function of the type of emotion, with greater right hemispheric activation with negative emotion and greater left hemispheric activation with positive emotion. This interaction is seen as supporting the experimental hypotheses, since it parallels the phenomenological pattern of greater right hemispheric involvement with negative emotion, and greater left hemispheric involvement with positive emotion.

EEG

Some of the most impressive evidence for differential hemispheric activation as a function of emotion comes from the EEG studies, since they provide possibly the most relevant index of cortical activity. Davidson and Schwartz (1976) recorded bilateral parietal lobe alpha activity (8-13 Hz) of subjects asked to self-induce either emotional or nonemotional states using verbal or visual imagery. Emotional recollections were from either angry or relaxed experiences. Overall, they found less alpha activity in the right hemisphere than in the left. Since alpha activity is an inverse index of hemispheric activation (e.g. Thompson, 1975), with low alpha associated with high activity, the authors interpreted the results as evidence of greater right hemispheric activation during emotion. Of possibly equal interest is that 100% of the females showed greater relative right hemispheric activation during anger compared to "prefeedback", while an apparently smaller percentage showed this effect for "relaxation". This may suggest that right hemispheric activation is greatest for negative affect.

Harmon and Ray (1977) also used emotional recollections as stimuli, but arrived at conclusions opposite to Davidson and

Schwartz (1976). Subjects first recalled past events in which they felt happy, sad, angry or fearful. Out of the three negative memories, one was chosen by the experimenter as having the most "meaningfulness, concern, and anxiety". This memory and the happy memory were then acted out to the subject for thirty-five seconds on the pretext of coaching them on how to self-generate the two emotions, while EEG activity between 3 and 30 Hz was recorded. They found that the left hemisphere reflected increased power over time for the happy memory and decreased power for the negative memory. Although the right hemisphere displayed a similar trend, it was not significant. The authors concluded not only that the left hemisphere is more reflective of emotional changes per se, but also that it becomes more activated with negative emotion and less activated with positive emotion. However, Harmon and Ray's emphasis on charting the power for each hemisphere over the thirty-five seconds of time is not explained, and to this author is of unknown importance, especially since "power" is itself a function of amplitude and time. An opposite interpretation can be derived simply by looking at their data slightly differently. Toward the end of the recording time (when the emotional impact would likely be at its maximum), the left hemisphere appeared to display greater activation to positive emotion than the right. At the same time, the right hemisphere appeared to display greater activation to negative emotion than the left (Fig 1, p. 458). Such an interpretation of the data supports the model of hemispheric involvement advanced by this paper.

More conclusive evidence of this pattern of involvement is offered by Davidson et al (1979) and Tucker et al (1981). Davidson et al (Experiment 1) recorded alpha activity from the left and right frontal and parietal areas while subjects viewed tapes of television programs varying in emotional content. The subjects' task was to use a pressure-sensitive device to indicate how much they liked (or disliked) the presentations. Davidson et al then analyzed the EEG activity that corresponded with each subjects' most positively and negatively rated segments. While parietal lobe alpha activity did not show significant hemispheric differences, frontal lobe activity did. The left frontal lobe was more activated (or displayed less alpha) than the right during the most positive segments, and the right frontal lobe was more activated than the left during the most negative segments. A second experiment recorded left and right frontal and parietal lobe alpha activity while subjects "self-generated" emotionally negative and positive imagery. The pattern of hemispheric involvement found in the frontal lobe replicated the pattern found in their first experiment.

Tucker et al (1981, Experiment 2) also found greater right frontal lobe activation in response to negative emotion, using a self-generated emotion. Subjects were presented with fifteen minutes of "relaxation instructions", followed by a five minute recording of "direct suggestions" of inducing either a manic or a depressed mood. After this, subjects reflected upon relevant personal experiences to enhance their mood for one minute. (The other mood condition was induced after a debriefing.) For each mood state, subjects also performed an arithmetic and an imagery task, representing left or right hemisphere-specific tasks, respectively. Alpha recording at the left and right frontal, central, parietal and occipital regions indicated greater right frontal activation during the (negative) depressed mood than the (positive) manic mood. (However, Tucker and Dawson, 1984, failed to replicate these results with actors generating depressed mood. Tucker, 1984, attributes this to differences in cognitive tasks and contrasting emotions between the studies.)

Davidson (1984) has attempted to define more specifically which positive or negative emotions reflect asymmetrical EEG patterns. This was done by recording EEG while subjects displayed facial expressions of various "discrete" emotions. Consistent with his previous work, he found that facial expressions of disgust had greater relative right frontal lobe activation than expressions of happiness.

Apart from adults, these asymmetrical patterns have also been found in infants ranging from 2-3 days to 10 months.

Infants of 2-3 days had bilateral EEG recorded while being given a sucrose solution (eliciting expressions of interest) or a citric acid solution (eliciting expressions of disgust) by Fox and Davidson (cited in Fox and Davidson, 1984a). They found that the sucrose (seen here as a positive stimulus) elicited greater relative left frontal lobe activation than the citric acid (seen as a more negative stimulus). Davidson and Fox (1982) presented 10 month old infants with videotapes of an actress portraying a happy or sad facial expression (seen here as positive or negative stimuli, respectively). In two studies, they consistently found greater relative left frontal lobe activation in response to the happy expression than to the sad expression. Similar results were found by Fox and Davidson (1984b). Infants had the largest left frontal lobe activation when their mothers were reaching for them (an emotionally positive stimulus). Correspondingly, the infants had the greatest right frontal lobe activation when they were separated from their mothers (an emotionally negative stimulus).

Thus, these EEG studies are consistent with a model of differential hemispheric activation as a function of type of emotion, with the right hemisphere more activated than the left with emotionally negative stimulation (and vice versa).

Lateral Eye Movements

A second measure of physiological involvement is lateral eye movements (LEMs). Several reports have implicated LEMs to the right with left hemispheric activation, and left LEMs with right hemispheric activations (e.g. Galin & Ornstein, 1974; Gur, 1975; Gur, Gur & Harris, 1975; Kinsbourne, 1972; Weiten & Etaugh, 1974). Although Ehrlichman and Weinberger (1978) have criticized this interpretation, Gur and Reivich (1980) subsequently found LEMs and alpha activity to correspond with regional cerebral blood flow (using the 133Xe inhalation method) in a verbal and spatial task, and Shevrin, Smokler and Kooi (1980) have found LEMs to correspond with lateralized event-related brain potentials.

Schwartz et al (1975) measured LEMs in subjects asked four categories of questions: verbal-emotional, spatial-emotional, verbal-nonemotional and spatial-nonemotional. They found fewer right LEMs on emotional compared with nonemotional questions, and a greater number of left LEMs on emotional compared with nonemotional questions. Schwartz et al concluded that this provided "new support for the hypothesis of a special role for the right hemisphere in regulation of emotional processes" (p. 288). However, from the brief description of their questions, Schwartz et al (like other studies criticized) appear to have used largely negative emotional stimuli. Hence, whether this is evidence for right hemispheric activation for emotion per se or merely for negative emotion is arguable. This criticism is similarly applicable to Tucker et al's (1977) use of only negative emotion. Their subjects were asked the same questions as Schwartz et al (1975) in either a neutral or a stressful emotional condition. The neutral condition required the subjects to simply answer the questions to supposedly calibrate an EEG, while in the emotional or "stressful" condition, subjects were told that their responses to questions were reflective of the quality of their intellect and personality. Tucker et al reported that across the verbal-spatial dimension, the stressful condition elicited a greater number of left LEMs in response to questions than the nonemotional condition. Although they concluded that this demonstrated the "importance of the right half of the brain in affective experience" (p. 699) their use of negative emotion (stress) should qualify this statement (as for the questions themselves, the amount of emotionally positive queries is again unknown). Thus, possibly all that was demonstrated was greater right hemispheric activation with negative emotion -- which is consistent with this paper's model of differential hemispheric involvement in emotion.

Emotionally positive stimuli were included in two subsequent studies. Ley (1979) asked subjects to describe an extremely positive and negative experience, and to recall its date, intensity, imagery, and ease of producing an image. As each question was asked, LEMs were observed. Although Ley found more left LEMs to the questions on emotional experiences, he failed to find any differences for positive and negative recollections, or for intensity, imagery and ease of recreating an image. However, in light of Tucker et al's (1977) findings on the effect of stress, Ley speculates that the anxiety involved in describing the emotional experiences may have "superceded" the effect of a separate positive and negative mood. If so, then the findings would support a greater right hemispheric activation in response to negative emotion.

More conclusive support comes from Ahern and Schwartz (1979). They added a verbal-spatial dimension to the emotionally positive (happiness or excitement) and negative questions (sadness or fear) they asked subjects while observing LEMs. They found that positive questions evoked more right LEMs than left (indicating greater relative left hemisphere activation), while negative questions evoked more left LEMs than right (indicating greater relative right hemisphere activation). Indeed, they found that hemispheric differences for emotion were greater than those for the verbal-spatial dimension. They therefore suggested "that lateralization for positive and negative emotion may be a more fundamental aspect of neural organization than lateralization for verbal/spatial processing" (p. 696). Considering the literature on verbal-spatial differences, this is a strong endorsement for the lateralization of emotion.

EMG

A third physiological measure that has been used is facial electromyography (EMG). Schwartz et al (1979) presented the emotional and verbal/spatial questions given to subjects used by Ahern and Schwartz (1979), after which bilateral zygomatic and corrigator muscle EMG was recorded (termed the "involuntary" response condition). Subjects were then asked to generate happy, excited, sad and fearful facial expressions, while EMG was similarly recorded (termed the "voluntary" response condition). The relatively complex results of this study support a lateralization of emotion in at least two ways. First, in the involuntary condition, greater right zygomatic muscle activity than left was found for positive questions (indicating greater left hemispheric involvement) while negative questions evoked the opposite effect, with greater left zygomatic muscle activity than right (indicating greater right hemispheric involvement). Moreover, this effect was greater for the more intense questions (happiness and fear) than less intense ones (excitement and sadness). Second, greater overall left muscle activity than right (greater right hemispheric activation) was found in emotionally neutral situations: the resting baseline in the voluntary condition, and the neutral questions in the involuntary condition. Schwartz et al (1979) interpret this as consistent with Tucker et al's (1977) finding of greater right hemispheric activation in response to stress (or negative emotion) -- in this case, the various stresses of Schwartz et al's experiment.

Heart Rate

A fourth and possibly most indirect physiological measure to be discussed is heart rate, used by Dimond and Farrington (1977). Subjects were fitted with special contact lenses restricting input to one visual field (Dimond et al, 1975) and presented with a "neutral" travel film, "negative" surgery film and "positive" cartoon (used in Dimond et al, 1976). Heart rate was recorded throughout the films. Mean heart rate was greater when the positive film was presented to the left hemisphere than the right hemisphere, while for the negative film, mean heart rate was greater when presented to the right hemisphere than the left hemisphere. No hemispheric differences were elicited by the neutral film. It would thus appear that autonomic nervous system activity may be greater for a particular emotion when mediated (first) by the hemisphere hypothesized to be specialized for that affect -- further support for a physiological lateralization of emotion.

Inferential Observations

Apart from these various physiological measures, hemispheric activation has been inferred from nonphysiological paradigms. In pursuing Tucker et al's finding of greater right hemispheric activation in response to stress, Tucker, Antes, Stenslie and Barnhandt (1978) compared subjects' performance at tachistoscopic verbal and spatial tasks under nonstressful and stressful experimental conditions. The stressful condition differed from the nonstressful in the greater number of experimenters, use of white lab coats and technical jargon, displaying of electronic equipment and attachment of (nonfunctional) electrodes to the subject. The verbal task was a judgement as to whether two consecutively presented words were antonyms, with the first word presented in the center of the screen and the second presented to either visual field. A similar spatial judgement task required the subject to decide whether two consecutively presented shapes were identical. Tucker et al found that subjects scoring high on a state anxiety questionnaire had greater right visual field (left hemisphere) errors across verbal and spatial tasks. This was interpreted as a possible "processing load" upon the left hemisphere, and hypothesized that this load may "prime" the left hemisphere to greater activity. An alternative and opposite interpretation is offered here -- that decreased left hemispheric performance would be associated with a decrease in activation. This is also consistent with a corresponding increase in right hemispheric activation in response to stress, found by Tucker et al (1977). A second expriment tested whether an increase in left hemisphere errors was associated with changes in activation.

High and low trait anxiety subjects were administered two tasks: a judgement as to whether two simultaneously bilateral tones were of equal loudness; and a series of verbal-spatial questions (from Schwartz et al, 1975) presented while LEMs were observed. They found high-anxiety subjects judged more auditory trials louder in the right ear (left hemisphere) than in the left ear, which they refer to as a "right-ear attentional bias" (p. 382). They interpret this as increased left hemisphere activation or more probably decreased right hemispheric activation (although this can be interpreted alternately as simply an increase in left hemisphere errors), and hence, decrease in left hemispheric activation. A second finding of Tucker et al was that trait anxiety was associated with fewer left LEMs (lesser right hemispheric activation), but unrelated to right LEMs. Although Tucker et al (1978) regard this as a "suppression" or decrease in right hemispheric activation (contrary to Tucker et al, 1977) the lack of a corresponding change in right LEMs makes this difficult to interpret.

Shearer and Tucker (1981) further investigated hemispheric "activation" by nonphysiological means. Subjects viewed sexual slides (e.g. nudity) and aversive slides (e.g. corpses), and were asked to either facilitate or inhibit emotional arousal by whatever means they chose. (They found that subjects tended to use imaginal or global ideation cognitive strategies to facilitate arousal, and analytic and verbal strategies to inhibit arousal.) The attentional bias "probe" used in Tucker et al (1978) in which subjects judged which tone was louder, was employed at timed intervals during slide viewing as the index of hemispheric activation. Analysis of this data found significant differences only for the aversive-facilitation condition, indicating greater relative right hemispheric activation. Since the sexual materials failed to show a similar effect, Shearer and Tucker admit that the "discrepancy in the attentional bias data between the sexual and aversive conditions could be taken as support for the notion that the right hemisphere is specifically involved in negative emotion" (p. 90).

Having reviewed four different physiological measures and one nonphysiological measure of relative hemispheric activation, it is apparent that they all reflect substantial support for a lateralization of activity as a function of type of emotion. Moreover, the pattern that can be interpreted from the majority of studies, and that is consistent with the literature on phenomenology and emotional identification, is that negative affect evokes greater right hemispheric involvement than left hemispheric involvement. There is also support for the corresponding pattern of greater left than right hemispheric involvement in response to positive affect.

In light of the role that emotion plays in human life, this model of hemispheric involvement has significant implications not only in a better understanding of normal behavior, but of "abnormal" as well.

Differential Hemispheric Activation with Depressed Mood

It is important to examine patterns of hemispheric activation in depressed individuals, since emotionally negative stimulation, negative mood, and clinical depression are seen as related. For example, if temporary negative mood increases right hemispheric activity in normals, is a longer lasting depressed mood correspondingly associated with high levels of right hemispheric activity? In general, it will be seen that the right hemisphere has a unique physiological involvement with depression. Based on this research, it was predicted that the right hemisphere would also have a unique phenomenological involvement with depression . This was expressed in the specific experimental hypotheses that (a) depressed mood would be positively related to right hemispheric negativity and (b) depressed mood would be more related to right hemispheric experience than to left hemispheric or bilateral experiences.

In studying depressed populations, two primary indices of activation have been used: electrodermal activity (EDA) and electroencephalographic (EEG) activity. Subjects have ranged from mildly depressed college students to severely depressed, institutionalized patients. Not surprisingly, the results of these studies are complex and at times contradictory, both because of the variety of subjects and the variety of dependent variables (e.g. amplitude, power, response latency, variance, synchrony, etc.). Nonetheless, in examining those aspects of the experimental reports that are relevant to differential hemispheric activation, it is apparent that there is, indeed, support for a relative increase in the right hemispheric activation of depressed individuals.

It should be noted that studies using measures that cannot be interpreted as relevant to "activation" have not been included (e.g. Rochford, Weinapple & Goldstein, 1981). For example, Wiet (1981a, 1981b) has found right hemispheric "variability" in unsuccessful university students, reporting only amplitude variance and non/Gaussian amplitude distributions. Unfortunately, the significance of these measures to previously reported literature is unknown. However, studies in which the amplitude itself is given (e.g.,D'Elia & Perris, 1973; Perris, 1975) have been included.

EDA

At least two studies of EDA in depressives have found lateralized responses. Gruzelier and Venables (1974) presented depressed patients (along with schizophrenics and "personality disorders") with a tone habituation sequence and tone discrimination task, in which they discriminated 1000 Hz from

2000 Hz tones by pushing a button. The mean response amplitudes of the skin conductance recordings (taken throughout the experiment) were found to be lower in the right hand than the left hand, across time and task. In an effort to interpret these results within a framework of hemispheric activation, Myslobodsky and Horesh (1978) repeated the tone habituation sequence and added verbal and visual-imagery tasks, each containing nonemotional and emotional material. The tasks were presented to normals and endogenous and reactive depressives, while EDA (and lateral eye movements) were recorded. While reactive depressives failed to shown lateralized responses, the other groups did show these respnses. Endogenous depressives had greater EDA on the left hand than on the right hand for the emotional verbal tasks, while the normals reflected the opposite asymmetry. In the visual tasks and the tone sequence, the endogenous depressives again reflected greater left-sided EDA. These results replicated Gruzelier and Venables (1974) for the endogenous depressives. Since the results of Myslobodsky and Rattok (1975) suggested that EDA was contralaterally controlled (finding greater right-sided EDA during a verbal task and vice-versa for a visual task) Myslobodsky and Horesh interpreted both studies as suggesting "a higher excitability in the right half of the brain" (p. 117) in depression. (Myslobodsky and Horesh also measured LEMs throughout the study. Across spatial-analytic and neutral-emotional questions, reactive and endogenous depressives had more left LEMs than right LEMs, while normals failed to show significant differences. Hence, once again, greater relative right hemispheric activity was found in depression.)

EEG

Several EEG studies have also found asymmetrical activation in depressives. D'Elia and Perris (1973) recorded centro-occipital EEG's at two time intervals from depressives having either an endogenous or a "mixed" etiology. The first recording was 1-2 days prior to a series of either bilateral ECT or Indoklon therapy, and four days after the final treatment. Examining the mean integrated amplitude for each hemisphere, the right hemisphere was found to be more activated than the left prior to treatment, while the hemispheres were approximately equal in activation after treatment. This is consistent with the hypothesized greater right hemispheric activation with negative emotion. Based on several statistics, the equalization of the hemispheres appears to be largely the result of an increase in left hemispheric activation, rather than a right hemispheric decrease. This, too, is consistent with previous results, in that left hemispheric activation parallels an increase or improvement in positive mood. Hence, although D'Elia and Perris interpret this as indicating "a deeper involvement of the dominant (left) than the nondominant hemisphere (right) during depression" (p. 195), this appears to be more accurately stated as left hemispheric involvement in improvement from depression, rather than the depression itself.

Perris (1975) attempted to extend his previous study by recording EEG's of "psychotic depressives" who had not received any treatment for their current depressive episode. Recording was done for a ten minute period in which the patient was resting with eyes closed. While Perris' interest was largely in average evoked responses and the within patient amplitude variance, the statistic of most relevance to activation hypotheses was the mean integrated amplitude. Consistent with his previous study, Perris again found greater mean amplitude in the right hemisphere than in the left (the means, however, failed to reach significance). Thus a trend was found for nontreated depressives to have greater right than left activation.

Flor-Henry, Koles, Bo-Lassen and Yeudall (1975) further investigated depression by comparing unmedicated "psychotic depressives" and other psychiatric patients with normals. All groups were presented with verbal and visuospatial tasks. Bilateral EEG recording on several frequencies was conducted throughout the tasks, as well as in a resting, eyes open state. Two results are of interest. First, the depressives showed an increase in the variability of the power of the right parietal lobe during the two tasks. Second, compared to normals, the depressives had increased power in the right temporal lobe for high frequencies (13-20 and 20-50 Hz) and decreased power in the right parietal lobe for lower frequencies (alpha band) during the resting condition. Flor-Henry and Koles (1980) again compared normals and depressives on a number of EEG variables during resting and verbal-spatial tasks. They concluded that changes "in depression involved increased right temporal power" (p. 40). Together, these studies suggest greater right hemispheric activation in depressives, compared to normals, in the temporoparietal area.

Normals were also compared with depressed subjects by Schaffer, Davidson and Saron (1983). Measuring alpha activity, they found that depressed subjects at rest had greater right than left frontal lobe activation. Normals were found to have either greater left than right frontal lobe activation, or else a pattern of only small differences between left and right recording sites.

Emotionally arousing stimuli were presented to normal and depressed subjects during EEG recording by Gill and Martin (1983). They failed to find the positive association between right hemisphere activity and negative emotion found by many studies. Nondepressed and mildly depressed university students were administered the CES-Depression Scale (Radloff, 1977), and then stereophonically presented with emotionally negative, positive and neutral instrumentals and sound effects, with type of emotion randomized over trials. Bilateral alpha activity was monitored from frontal, temporal and parietal locations for five seconds following stimulus onset. While no significant interactions were found between hemisphere and type of emotion, right hemispheric activation was found to be negatively associated with depression. Hence, in contrast to the positive relationship between depression and right hemisphere activity that other studies report, they found an inverse relationship.

Recently, EEG studies have expanded investigation of the concept of depression from a syndrome approach to a symptom approach. Thus, rather than assuming that depression is a single entity, EEG recordings are related to a variety of symptoms. Advocating this approach, Perris and Monakhov (1979) obtained ratings on a number of clinical symptoms of psychotic and nonpsychotic depressed patients. EEG was bilaterally recorded from precentral, parietal and occipital sites while the subject sat quietly with eyes closed for five minutes. They found an increase in right hemispheric activity (but not left hemispheric activity) to be associated with suicidal tendencies in all three recording areas, and with depressed mood, psychomotor retardation and "experience of conative and intellectual inhibition" (p. 225) in the precentral area.

Gill, Martin and Fernando (1984) administered mildly-moderately depressed and nondepressed university students several mood surveys. These included the CES-Depression Scale (Radloff, 1977), the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, and Erbaugh, 1961) and an adaptation of the State-Trait Personality Inventory or STPI (anger, anxiety and curiosity subtests, Spielberger, 1979). Subjects were then stereophonically presented with emotionally positive, negative and neutral instrumentals and sound effects of approximately seven seconds duration. Bilateral recording of EEG was performed at parietal, temporal and frontal locations for five seconds after stimulus onset. They found a positive association between depression (on both depression inventories), anxiety, and anger and the proportion of right frontal lobe activation. Similarly, depression, anxiety and curiosity were found to be associated with right parietal lobe activation. (Interestingly, depression, anxiety and anger were negatively associated with right hemispheric activation in the temporal lobe.) Thus, while this data generally supports the association between right hemipheric activation and negative emotion, it also indicates the importance of the effect of recording site and symptoms upon patterns of lateralization.

Inferential Observations

At least one nonphysiological paradigm has been used as evidence of greater relative right hemispheric activation in depression. Kinsbourne and Bemporad (1984) reviewed three dichotic listening studies that failed to find the right ear/left hemisphere advantage in performance found in "normals". They interpreted this as evidence of right hemisphere overactivation (or left hemisphere underactivation). The relationship between performance and mood was indicated by the finding that the amount of right hemisphere performance deficit was related to severity of symptoms (Bruder & Yozawitz, 1979). Consistent with this, the "normal" dichotic asymmetry returned after depressive symptoms were reduced (Wexler and Heninger, 1979) and after right hemisphere ECT (Moscovitch, Strauss, and Olds, 1981).

In light of these studies of depressed individuals, at least three conclusions can be tentatively advanced. First, in severely depressed people, greater right hemispheric than left hemispheric activity can be found. This is supportive of a model of increased right hemispheric activation being associated with negative emotion. Second, comparisons of depressives with normals and depressives after treatment indicates the possibility of increased left hemispheric activity during improvement of mood. This is consistent with a model of increased left hemispheric activation associated with positive emotion. Third, these patterns of laterality may not be as evident in less depressed individuals. Reactive hospitalized patients displayed no lateralization, while mildly depressed nonhospitalized individuals were found to have the degree of right as compared to left hemispheric activation depend upon the electrode location and whether the type of emotion was presented randomly (Gill & Martin, 1983) or in a consecutive series (Gill et al, 1984). This suggests that there may be some type of association between the severity of a depression and the degree of greater right than left hemispheric activation, if any.

It is evident, then, that the physiological studies of depressives have supported and extended the model postulated in normals of greater right hemispheric activity in negative mood, relative to the left hemisphere. This unique physiological relationship is seen as supporting the hypothesized phenomenological relationship between depressed mood and the right hemisphere.

Summary

The experimental hypotheses have been seen to be suggested by five areas of research. First, phenomenological studies of normals have indicated that the right hemisphere experiences stimuli as emotionally more negative than the left hemisphere. Second, phenomenological reports by, and observations of, neurological patients have indicated that the nondamaged right hemisphere experiences stimuli as emotionally more negative than when both hemispheres are working normally in unison.

Conversely, the nondamaged left hemisphere experiences stimuli as emotionally more positive than when both hemispheres are working normally in unison. Third, studies of emotional identification, using speed or accuracy measures, have indicated that the right hemisphere is superior to the left in dealing with negative emotion, while the left hemisphere can be superior to the right in dealing with positive emotion. Hence, these measures parallel phenomenological measures of emotion in that the right hemisphere appears to be more implicated with negative emotion than the left hemisphere, while the left hemisphere is more implicated with positive emotion than the right hemisphere. Fourth, this differential hemispheric involvement with emotion is also reflected in physiological measures in normals. The right hemisphere is more activated than the left with emotionally negative stimuli, while the left hemisphere is more activated than the right with emotionally positive stimuli. Fifth, consistent with normals' reactions to negative stimuli, evidence from depressed subjects indicates that the right hemisphere has a unique physiological relationship with depressed mood.

Collectively, then, identificational, physiological, and phenomenological sources of research all suggest that the right hemisphere is more implicated with negative emotion than the left, while the left hemisphere is more implicated with positive emotion than the right. Normal hemispheric unity, or bilateral experience, appears to occur in between these two emotional extremes.

Methodological Rationale

Sex of Subjects

Sex differences have been found to be of major interest to laterality studies of various cognitive functions (e.g., Bryden, 1982; Fairweather, 1982; McGlone, 1979). It is interesting, then, that sex has not proved to be a significant variable in previous phenomenological studies. No sex effects were reported by Dimond et al (1976), Beaton (1979) or Gill (1982), with only Natale et al (1983) finding a main effect for sex. In Experiment I (previously described) they found that females evaluated stimuli more negatively than males. However, a significant interaction between sex and type of emotion indicated that lower ratings were only for negative emotions (sadness, anger, fear and disgust), with no differences in ratings found between the sexes for happiness or surprise.

In contrast to phenomenological studies, sex differences have been found in studies using physiological dependent measures related to emotion. Tucker et al (1977) studied the effect of neutral and stressful (or negative) question periods upon conjugate lateral eye movements. They found that only males had increased left eye movements (right hemispheric involvement) in the stressful condition. Schwartz et al (1979) studied the effect of emotional questions and voluntary face mimicking on facial EMG. They found that in the question condition, "females accounted for most of the right-side superiority in excitement" which "supports the prediction that females would show greater degrees of lateralization than males" (p. 570). Consistent with this, in the facial expression condition, only females had increased left muscle output (right hemispheric involvement) over right muscle output, and "any significant emotion-related lability" (p. 570). Borod and Caron (1980) studied the relationship between facial asymmetry ("facedness") and type of emotion. While females were found to be more lateralized (left-faced) for emotionally pleasant/positive facial expressions, males were more lateralized for negative expressions. Collectively, these studies suggest that sex differences interact with type of emotion. Females may show greater lateralization with positive emotion and/or excitement, while males may show greater lateralization with negative emotion.

Thus, while sex differences in the present phenomenological study were not specifically predicted, previous evidence suggested the potential of an interaction between sex and other relevant variables. For this reason, both males and females were used as subjects.

Handedness and English as First Language

In general, all of the studies reviewed have used right-handed subjects. The rationale for their use is based upon the knowledge that an extremely high proportion of right-handers have speech abilities localized to the left hemisphere (e.g., Young, 1982). This high degree of predictability is critical to studies of laterality, especially cognitive studies, which relate most hemispheric differences to a verbal/nonverbal dichotomy between the left and right hemispheres (e.g. Bradshaw & Nettleton, 1981). With left-handers, however, this relationship is not consistently reversed. For example, Springer and Deutsch (1981) report on a study by Rasmussen & Milner which found approximately 15% of left-handers with speech localized to the right hemisphere, 15% with speech represented in each hemisphere, and 70% with speech localized to the left hemisphere. Not surprisingly, tachistoscopic and dichotic paradigms have not found the same degree of hemispheric lateralization in left-handers as in right-handers (e.g. Bryden, 1965).

In light of these factors, one of the criteria for subjects' participation in the study was right-handedness, as indicated by a handedness questionnaire.

A related criterion is English as first language. While the above-mentioned verbal-nonverbal dichotomy applies to subjects whose first language is English, it is not known what effect other languages have upon this relationship. This is of particular concern with pictorial or nonphonetic (logographic) languages such as Chinese dialects, which have been associated with different hemispheric patterns (Tsao, Su, & Feustel, 1981.)

Apparatus in Laterality Studies

Most studies of hemispheric asymmetries in normals attempt to selectively present information to a particular hemisphere. Since this information will quickly transfer over from one hemisphere to the other, the purpose of experimental apparatus is to allow one half of the brain some time to process stimuli before the information transfer occurs. The two most common apparatus are dichotic listening equipment (for presenting auditory stimuli) and the tachistoscope (for presenting visual information) (e.g. Young, 1982).

A dichotic procedure was not used in this study because it is not adaptable to comparing unilaterally with bilaterally presented stimuli, which is one of the purposes of this study.

The other apparatus, the tachistoscope, is an optical instrument used to present stereoscopic visual information to one hemisphere before the other. Since stimuli presented to a visual field is transmitted to the contralateral hemisphere (e.g. Clark, 1975; Young, 1982) a tachistoscope presents stimuli for very short periods of time to a location off to the side of a central fixation point. As a result, only the visual hemifield closest to the stimulus will have time to transmit the image (to the opposite hemisphere). The presentation time used in this study (in both the pretest and experiment proper) is 100 milliseconds, which is less than the fastest saccadic latencies for any experimental conditions (Young, 1982, p. 15).

Whereas unilateral presentations have been made to the left or right side of a viewing screen, a bilateral presentation would simply involve a presentation to the center of fixation. If a subject has been focusing upon a centrally presented dot just prior to the experimental trial, then both visual hemifields should encompass the experimental stimuli when it is presented. Clearly, then, the tachistoscope is suited to this study's comparison of unilaterally with bilaterally presented stimuli, since only the stimulus location, and not the stimulus itself, changes.

Type of Stimuli

The choice of stimuli for the proposed study was dictated by three requirements. First, the stimuli had to reflect the basic verbal-nonverbal differentiation between the left and right hemispheres (e.g. Bradshaw & Nettleton, 1981). Since the exclusive use of either type of stimuli may confound the findings with hemispheric specialization or accuracy, both types of stimuli were used in the experiment, and compared in the data analysis. Previous laterality studies of emotion have rarely considered the influence of these differences.

A second requirement of the experimental stimuli was that they minimize the effect of other hemispheric specializations.

Facial expressions were therefore not used because of a right hemisphere superiority for accuracy in facial recognition (e.g., Benton, 1980) and the finding that emotional recognition is not independent of facial recognition (Hansch & Pirozollo, 1980). Similarly, meaningful language was not used because of a left hemisphere superiority with linguistic tasks (e.g. Bradshaw & Nettleton, 1981; Bryden, 1982).

A third requirement of stimuli was that they encourage subjects to regard them as subjectively as possible, since phenomenological experience is of interest and not accuracy in emotional recognition. The best method of meeting this requirement is seen as through the use of relatively unfamiliar stimuli, which may minimize the possibility of subjects responding according to "logical" customs or teachings.

In light of these requirements, the verbal stimuli chosen were nonsense words (reducing both the meaningfulness and the familiarity of the stimuli). The nonverbal stimuli chosen were irregular geometric shapes (avoiding faces and familiar spatial objects or relationships).

In order to maximize the emotional range of stimuli presented to the experimental subjects (from positive to negative) a pretest was used to evaluate subjects' emotional experience of a variety of stimuli chosen by the experimenter. The stimuli at the positive and negative extremes, and at a "neutral" midpoint, were then selected for the experiment proper.

Method

Subjects

The study used 50 male and 50 female students enrolled in Introductory Psychology at the University of Manitoba. Of these, 20 subjects participated in the pretest, using an equal number of males and females. Participation in the study satisfied part of their course's experimental requirements.

There were three criteria for participation on experimental sign-up booklets: normal visual acuity, English as a first language, and right-handedness. Subjects were checked for these criteria using a questionnaire completed at the beginning of the experiment (presented in Appendix A). Right-handedness was assessed using a handedness survey by Raczkowski, Kalet and Nebes (1974). To meet the criteria, subjects must have used their right side for at least 12 of 14 activities, with the constraint that writing, kicking, and throwing must be right-sided.

Subjects ranged in age from 17 to 34, with a mean age of 20 for both sexes.

Apparatus

There were two subject rooms. An experimental chamber was used for administering the handedness survey, and the CES-Depression Scale (Radloff, 1977). A sound-proofed chamber was then used for tachistoscopic presentation of stimuli, with a Scientific Prototype 3 channel tachistoscope (model GB). Viewing distance was 114.3 cm.

Stimuli

Two categories of visual stimuli were used: verbal and nonverbal. The pretest used 30 verbal and 30 nonverbal stimuli (selected by the experimenter), while the experiment proper used 12 verbal and 12 nonverbal stimuli (selected by the pretest procedure). All stimuli measured approximately 3.5 to 4.5 cm in width, mounted on a 13 x 18 cm white card. Only 1 stimulus was placed on a card.

Verbal stimuli were "nonsense" words of five letters each. They were selected by the experimenter using the following procedure. The first six letter word from each of the 26 alphabetical categories (such as "a", "b", "c", etc.) occurring in the Winston Canadian Dictionary for Schools (1965) was selected. To obtain four more words, the second six letter word occurring under the sixth category ("f"), and the twelfth ("l"), eighteenth ("r"), and twenty-fifth ("x") categories were also selected. Then, for each word, the first letter was kept in place, the first vowel encountered thereafter was removed, and all following letters were rearranged in reverse order. For example, the word "abacus" was selected, and transformed into "asucb". (The exception to deleting the vowel was the "x" category. Since no six letter words beginning with "x" were found, the word "xebec" was selected, and all letters following "x" reversed, transforming it to "xcebe".) The list of verbal pretest stimuli is given in Appendix B.

Nonverbal stimuli consisted of 20 geometric shapes ranging from familiar forms, such as circles or rectangles, to uncommon forms . These were drawn or traced from other pictoral representations, and given a grey shading. The other 10 forms were the "inkblots" from the Rorschach Psychodiagnostics Schemablock sheet, photoreduced to 65% of their original size on a black-and-white format. All 30 stimuli were symmetrical, and colored a dark grey/black (making them more comparable to the black lettering of the verbal stimuli). The list of nonverbal stimuli is given in Appendix C.

Subjects in the pretest received 60 stimuli mounted only at the center of fixation, for a total of 60 presentations. Experimental subjects received 24 stimuli mounted at 3 different positions, for a total of 72 presentations. The 3 positions were at the center of fixation, to the right of center (right visual field), and to the left of center (left visual field). The inside edge of left and right visual field stimuli measured 4.0 cm from the center of fixation, using a 2 degree angle from the card's midpoint (at a viewing distance of 114.3 cm).

Procedure

The pretest was initially conducted to select the stimuli for the experiment proper. Pretest subjects were presented with a wide variety (60) of stimuli at the center of fixation, from which the 4 most emotionally positive and 4 most negative stimuli were selected for each category of stimuli: verbal and nonverbal. In addition, four stimuli for each category were selected that had the most "neutral" emotional value. This group of 24 stimuli were then presented to experimental subjects to the left side, right side, and center of the viewing screen. Both the pretest and experimental studies tested subjects on an individual basis. Details are outlined below.

Pretest. All pretest subjects first completed the handedness questionnaire, which asked them about any visual problems, the languages they spoke, and the age(s) at which they were learned. Subjects who met the experimental criteria were then given the CES-Depression Scale (presented in Appendix D).

Upon completion of the questionnaires, subjects were taken to the experimental chamber and given a standard instruction sheet (presented in Appendix E). Descriptive words used in the instructions as reference points for "positive" and "negative" ratings were taken from mood surveys such as the Depression Adjective Checklist (Lubin, 1965). The experiment was described as a study of emotional reactions to unfamiliar stimuli, such as nonsense words and geometric figures. Subjects' task was to: (1) concentrate on a black dot in the center of the viewing screen, (2) reflect upon how positive or negative they felt about each stimulus, (3) rate this feeling after each presentation, using a 15 point positively ascending Lickert-type scale -- the dependent measure (presented in Appendix F), and (4) rate their confidence in their feelings, again using a 15 point scale (presented in Appendix F). This was designed as a covariate for each emotional rating, with at least three purposes. First, since a "don't know" category was not provided, it reflected any uncertainties subjects had about how they felt. Second, it could reflect uncertainties about subjects' understanding of their task, especially in the early trials. Lastly, it could reflect subjects' uncertainty about whether they actually saw a stimulus on the screen and/or what it represented. This is important in light of the possibility that central presentations are visually easier to deal with than peripheral presentations.

Prior to viewing the stimuli, it was emphasized to subjects that there were no "right" or "wrong" answers to their task. Subjects were also told that they would be given as much time as desired to perform their ratings.

Each stimulus presentation began with a white background for a 1 second duration, followed by a black dot at the center of fixation for 500 msec, and then the stimulus at the center of fixation for 100 msec. Subjects were randomly assigned one of two randomized orderings of stimuli.

After each trial, the experimenter ensured that the subjects had not lost their place on the emotional rating sheet, by having them call out the number of the next trial when they were ready. Once all trials had been completed, the subject was asked to guess the experimental hypothesis, followed by a debriefing.

After all subjects were tested, the means and standard deviations of the emotional ratings were computed for each of the 60 stimuli. The verbal stimuli were then separately ordered (from most negative to most positive) for males and females. For each sex, the four most negative, four most positive, and four neutral (orders 13, 14, 15, and 16) were then selected. When agreement was found between the sexes as to the stimuli in each emotional category, these stimuli were chosen for the experiment proper. For categories not in agreement, the next highest or lowest rated stimulus was selected, until agreement was reached. Where more than four stimuli per emotional category were possible, stimuli were chosen with the lowest standard deviations. The same procedure was then followed for the nonverbal stimuli.

Verbal and nonverbal stimuli selected for the experiment proper are given in Appendix G.

Analyses were then conducted on the emotional ratings for the stimuli selected to test for significant differences between the emotional categories (discussed in the Results).

Experiment Proper. Procedures used with subjects in the experiment proper were similar to the above, with the following exceptions: (1) they were informed that the location of stimuli on the viewing screen may vary, and that fixating at the screen's center would allow them the best view of all stimuli, (2) presentations were made to the left and right visual fields, as well as to the center of fixation, (3) subjects were randomly assigned to one of three randomized orderings of stimuli.

Experimental design Under a mixed design analysis of variance there were 2 within-subjects variables: (1) type of stimulus (verbal or nonverbal) and, (2) location of stimulus (left or right visual field, or center of screen). There were also 2 between-subjects variables: (1) sex (male or female) and (2) depression score.

The dependent measure was 'emotional rating', which was reflected on the 15-point rating scale. 'Confidence ratings' were designed as covariates for each emotional rating, to statistically control for various methodological artifacts.

Hypotheses and Statistical Analyses

(1) Stimuli presented to the left visual field (right hemisphere) were hypothesized to be experienced as more negative than stimuli presented to the center of fixation (both hemispheres simultaneously) when confidence was controlled for. Correspondingly, stimuli presented to the right visual field (left hemisphere) were hypothesized to be experienced as more

positive than stimuli presented to the center of fixation (both hemispheres simultaneously).

This was to be tested using a mixed model repeated measures analysis of covariance. The effect of 3 independent variables was to be tested: visual field (left, right, or central), which was of most interest; type of stimulus; and sex. A significant main effect for visual field was predicted. Differences in emotional experience between the left and right visual fields and the center of fixation were to be examined using orthogonal contrasts.

(2) It was hypothesized that as depression increased, the emotional experience of stimuli presented to the left visual field (right hemisphere) would be more negative.

This was to be tested using a multiple regression analysis. Depression scores were to be predicted on the basis of 7 variables. One variable was to be sex, which was to be "dummy coded" since it is a nominal-scale variable. The other variables were emotional ratings from the 6 combinations of type of stimulus (2 levels) and visual field (3 levels). These variables were labelled left visual field verbal ratings, left visual field nonverbal ratings, right visual field verbal ratings, right visual field nonverbal ratings, central verbal ratings, and central nonverbal ratings. It was predicted that significant main effects would be found for left visual field verbal and left visual field nonverbal ratings. In addition, it was predicted that the relationship between these 2 variables and depression score would be negative, (based on negative "beta weights" or standardized regression coefficients), indicating that as depression increases, positive emotional ratings decrease (and/or negative ratings increase).

(3) Since it may be expected that all ratings would become more negative as depression increased, the third hypothesis would examine the importance of this relation between left visual field presentations and depression. It was hypothesized that depression would be more related to left visual field (right hemisphere) emotional experience than to right visual field (left hemisphere) or central/bilateral emotional experience. This was to be examined using a t-test formula outlined by Cohen and Cohen (1975) for testing the significance of the differences between dependent correlations. It was predicted that these tests would show the relationship between depression and (verbal & nonverbal) left visual field (right hemisphere) ratings to be significantly larger than between depression and central ratings or depression and right visual field (left hemisphere) ratings.

Results

Pretest

After the pretest procedure had selected the stimuli to be used in the experiment proper, a "validity check" was performed upon the data for the chosen stimuli. The purpose of the analysis was twofold: to test for significant differences in emotional rating between the stimuli classified as negative, neutral, and positive; and to test for the effect of the order of stimuli presentation upon the emotional ratings.

The data was examined with a 2 (Sex) x 2 (Order) x 3 (Emotional Category) mixed design analysis of variance. A separate analysis was computed for each type of stimulus (verbal and nonverbal) consistent with their separate stimuli selection procedures used in the pretest.

The results of the analysis for nonverbal stimuli are presented in Table 1. A significant main effect was found for Emotional Category, F (2,32) = 20.65, $p < .0001$. Since a sphericity test indicated that the assumption of compound symmetry was violated for Emotional Category and its interactions ($p < .0033$), the Greenhouse-Geisser correction (Geisser and Greenhouse, 1958) was used to make the analysis more conservative. All other main effects and interactions were not found to be significant ($p > .1310$).

Insert Table 1 about here

The main effect for Emotional Category is presented in Figure 1. A priori contrasts (using the Bonferroni technique to divide alpha) indicated that the stimuli categorized as positive were rated as significantly more positive than stimuli categorized as neutral, F (2,32) = 4.35, p < .025, while the neutral stimuli were rated as significantly more positive than stimuli categorized as negative, F (2,32) = 18.30, p < .001.

Insert Figure 1 about here

A similar pattern of results were found for the analysis on the verbal stimuli, presented in Table 2. A significant main effect was found for Emotional Category, F (2,32) = 9.04, p < .0008. (Since the sphericity test failed to indicate a violation of the assumption of compound symmetry, no correction to the p value was applied.) All other main effects and interactions were not found to be significant (p > .1881).

Insert Table 2 about here

Table 1

2 (Sex) x 2 (Order) x 3 (Emotional Category)

Repeated Measures Analysis of Variance for Emotional

Ratings of Nonverbal Stimuli

Source	*df*	*MS*	*F*	*p*	*p*(adj)[a]
S	1	6.97324	0.58	0.4569	
O	1	2.68889	0.22	0.6423	
S x O	1	3.04943	0.25	0.6210	
Error	16	11.99392			
E	2	69.43398	20.65	0.0000	0.0001
E x S	2	4.51986	1.34	0.2750	0.2704
E x O	2	5.06434	1.51	0.2370	0.2402
E x O x S	2	8.04478	2.39	0.1075	0.1310
Error	32	3.36170			

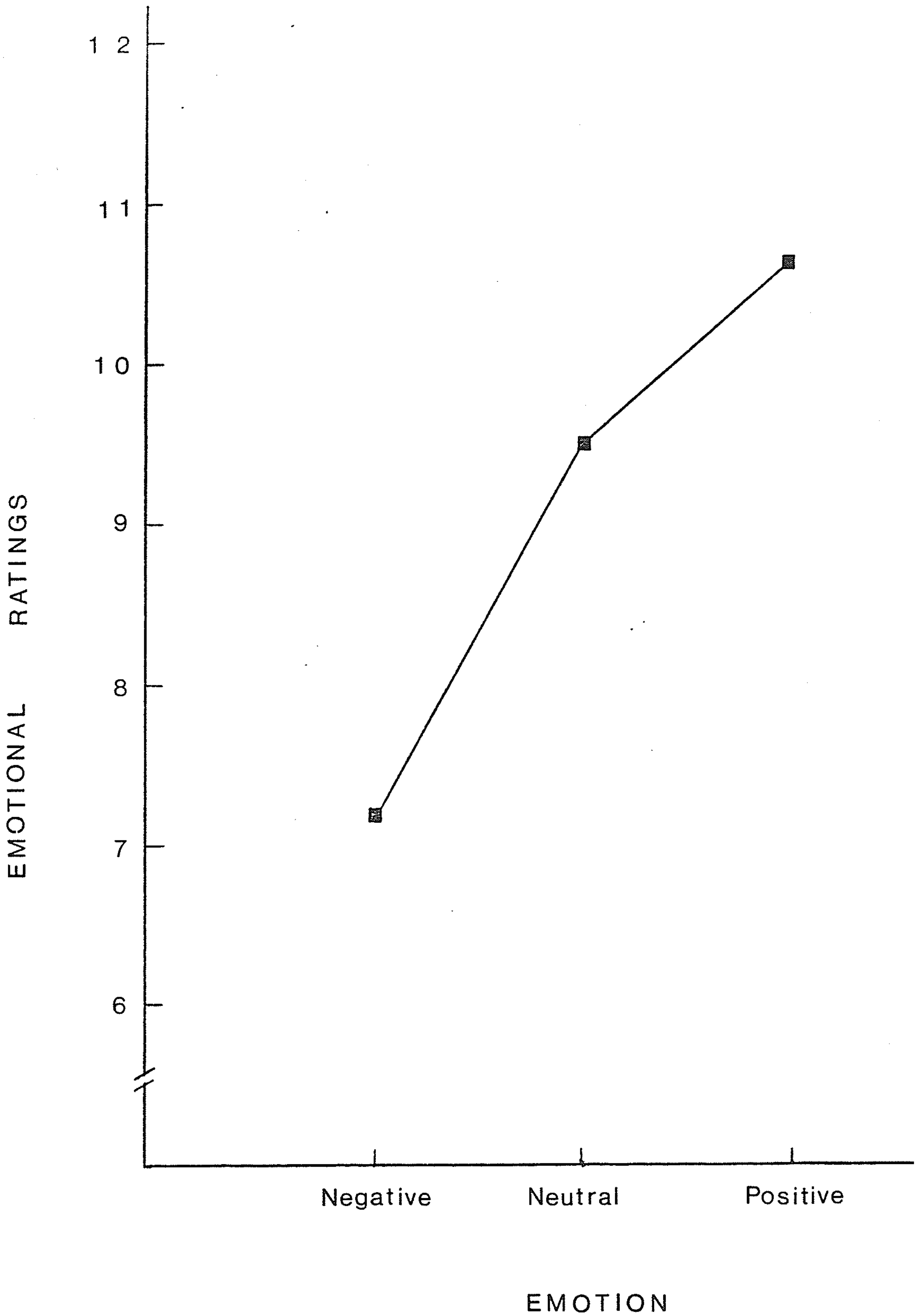
Note. S: Sex. O: Order of Stimuli Presentation.
E: Emotional Category.

[a]Greenhouse-Geisser adjusted probability for effects having significantly violated the assumption of compound symmetry.

Figure 1

Mean emotional ratings of nonverbal stimuli

as a function of emotional category.



1 2
1 1
1 0
9
8
7
6
EMOTIONAL RATINGS
Negative
Neutral
Positive
EMOTION

Table 2

2 (Sex) x 2 (Order) x 3 (Emotional Category)

Repeated Measures Analysis of Variance for

Emotional Ratings of Verbal Stimuli

Source	*df*	*MS*	*F*	*p*	*p*(adj)[a]
S	1	0.34610	0.07	0.8012	
O	1	9.98419	1.89	0.1881	
S x O	1	2.87535	0.54	0.4713	
Error	16	5.28136			
E	2	14.84065	9.04	0.0008	
E x S	2	0.36701	0.22	0.8009	
E x O	2	0.47246	0.29	0.7518	
E x S x O	2	0.39678	0.24	0.7867	
Error	32	1.64151			

Note. S: Sex. O: Order of Stimuli Presentation.
E: Emotional Category.

[a]Greenhouse-Geisser correction: not warranted.

The main effect of Emotional Category is presented in Figure 2. A priori contrasts indicated that the stimuli categorized as positive were rated as significantly more positive than stimuli categorized as neutral, F (2,32) = 4.65, $p < .025$, while neutral stimuli were rated as significantly more positive than stimuli categorized as negative, F (2,32) = 4.40, $p < .025$.

Insert Figure 2 about here

Collectively, these analyses indicated that the stimuli classified by the pretest as negative, neutral, and positive did indeed differ from each other in emotional ratings. This suggests that the stimuli had a range of emotional values and that their classifications have some face validity, relative to each other. The lack of a significant order effect indicated that these emotional ratings are not dependent upon particular presentation orderings. Further, the failure to find significant sex differrences indicates that the same sets of stimuli may be used for both sexes in the experiment proper.

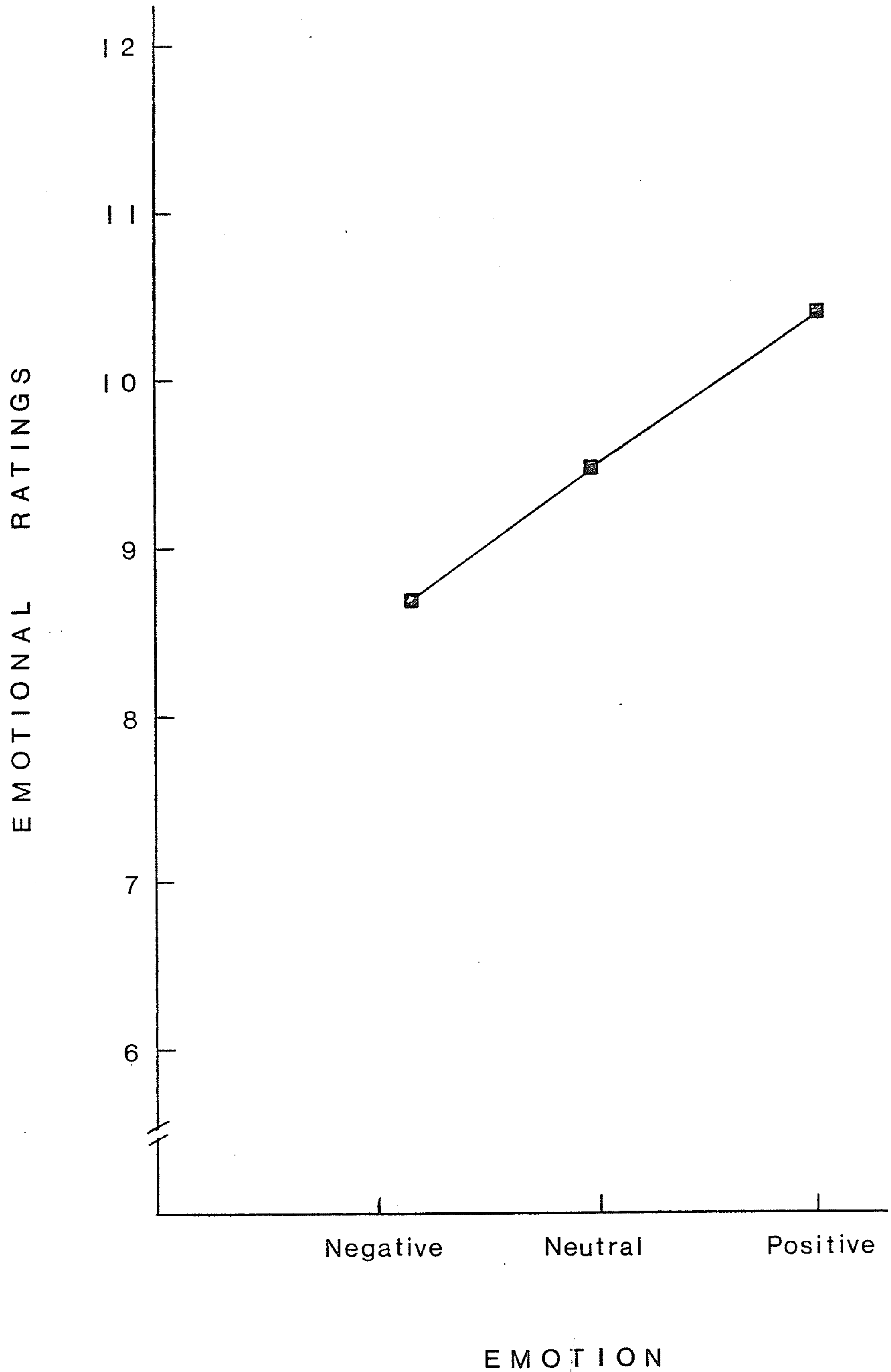
Experiment Proper

Consistent with the "validity checks" performed in the pretest, the effect of order of stimulus presentation upon emotional rating was initially examined, using a 2 (Order) x 2 (Sex) x 2 (Type of Stimulus) x 3 (Visual Field) x 3 (Emotional

Figure 2

Mean emotional ratings of verbal stimuli

as a function of emotional category.



12
11
10
9
8
7
6
EMOTIONAL RATINGS
Negative
Neutral
Positive
EMOTION

Category) mixed design analysis of variance. The main effect of Order failed to be found significant, F (2,74) = .43, p > .6517. Similarly, all interactions involving Order were not found to be significant (all F's < 2.26 and p's > .1124). This indicated that subjects' responses were not dependent upon a particular stimulus order (similar to the pretest results).

Emotional Ratings

The prediction that right visual field stimuli presentations would be rated more positively than left visual field presentations was tested with a 2 (Sex) x 2 (Type of Stimulus) x 3 (Visual Field) mixed design analysis of covariance. (Since an analysis of subjects' confidence in emotional ratings revealed systematic differences, confidence was used as a covariate). The results of the analysis are presented in Table 3. Sphericity tests indicated that the assumption of compound symmetry was violated for both Type of Stimulus (p < .0001) and Emotional Category (p < .00001), indicating the use of more conservative p values for these effects and their interactions.

Insert Table 3 about here

Significant main effects were found for Type of Stimulus, F (1,77) = 16.61, p < .0001 and Visual Field, F (2,155) = 10.63, p < .0002). All other effects were not significant (p > .0609).

Table 3

2 (Sex) x 2 (Type of Stimulus) x 3 (Visual Field)

Repeated Measures Analysis of Covariance for

Emotional Ratings with Confidence Ratings as the Covariate

Source	*df*	*MS*	*F*	*p*	*p*(adj)[a]
S	1	25.06598	3.33	0.0720	
Error	77	7.53044			
T	1	132.74563	16.61	0.0001	
T x S	1	21.74611	2.72	0.1031	
Error	77	7.98983			
VF	2	23.05612	10.63	0.0000	0.0002
VF x S	2	1.64000	0.76	0.4712	0.4485
Error	155	2.16893			
T x VF	2	2.50440	3.06	0.0498	0.0609
T x VF x S	2	0.17909	0.22	0.8038	0.7575
Error	155	0.81874			

Note. S: Sex. T: Type of Stimulus. VF: Visual Field.

[a]Greenhouse-Geisser adjusted probability for effects having significantly violated the assumption of compound symmetry.

The main effect of Type of Stimulus is presented in Figure 3, indicating that nonverbal stimuli were rated more positively than verbal stimuli. As one method of exploring this difference, the mean minimum and maximum emotional ratings for each stimulus type were compared. The mean minimum rating for verbal stimuli was 1.5, considerably more negative than the nonverbal stimuli at 5.39. A smaller difference between the two types of stimuli was found with mean maximum ratings, with verbal stimuli at 12.03, and nonverbal stimuli at 13.72. This suggests that the differences between the two types of stimuli may be more related to lower minimum values for verbal stimuli than to higher maximum values for nonverbal stimuli.

Insert Figure 3 about here

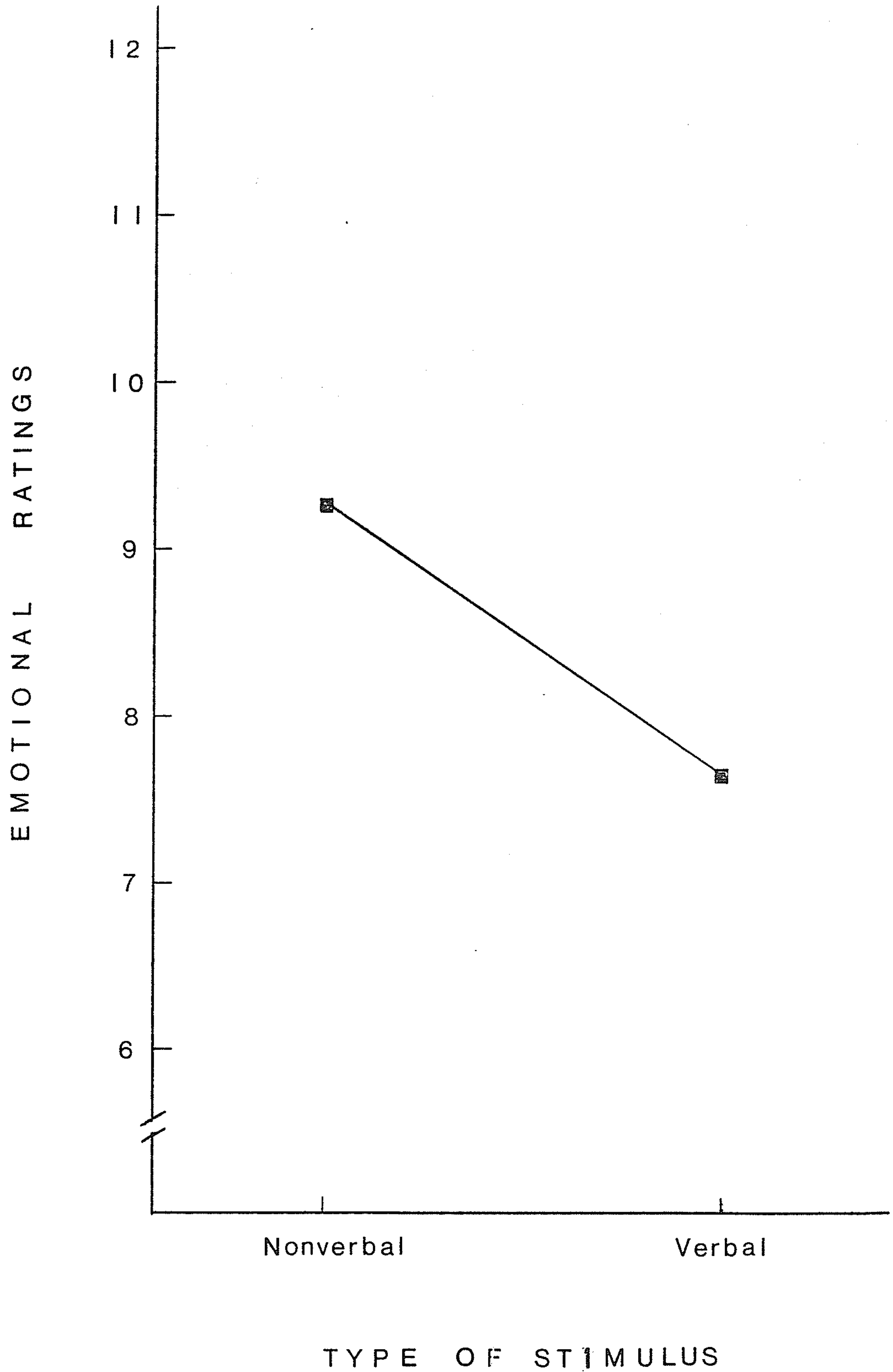
The main effect of Visual Field is presented in Figure 4. (For ease of hemispheric interpretations, the right visual field is presented on the left side of Figures 4, 5(a), 5(b), and 6, to correspond with the left hemisphere. Similarly, the left visual field is presented on the right side of the figures to correspond with the right hemisphere.)

Planned comparisons on this effect indicated that contrary to the prediction that right visual field presentations would be rated more positively than the other two locations, the central

Figure 3

Mean emotional ratings as a function of

type of stimulus.


12
11
10
9
8
7
6
EMOTIONAL RATINGS
Nonverbal
Verbal
TYPE OF STIMULUS

presentations received the most positive ratings. Central presentations were rated as more positive than both the left visual field presentations (as predicted), $F(1,155) = 28.82$, $p < .001$, and the right visual field presentations (not predicted), $F(1,155) = 4.86$, $p < .05$. However, the prediction that right visual field presentation would be rated as more positive than left visual field presentations was supported, $F(1,155) = 10.01$, $p < .005$.

Insert Figure 4 about here

Depression Scores

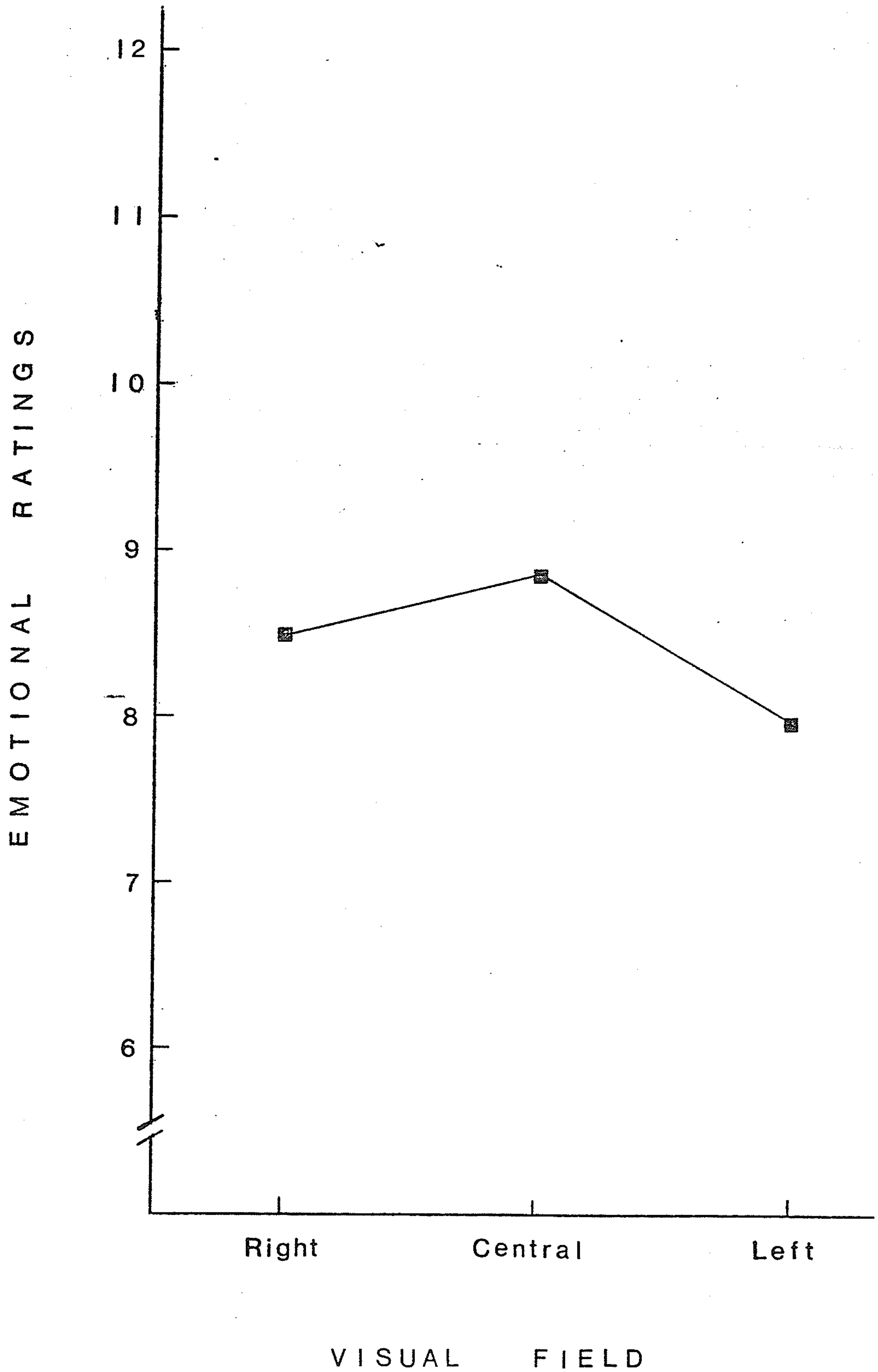
Descriptive statistics on subjects' depression scores indicated that a considerable range of depressive symptomatology was present in the sample. Scores ranged from 1 to 44, out of a possible range of 0 to 60. The mean depression score was 11.31, with a standard deviation of 7.81. Fourteen subjects had scores greater than 16, which Radloff (1977) uses as an arbitrary critical value for depression. Together with 3 subjects having a depression scores of exactly 16, the "depressed" subjects represented 21.25% of the sample. These scores of greatest depression were approximately equally distributed between the sexes: 9 males and 8 females.

The relationship between subjects' depression scores and

Figure 4

Mean emotional ratings as a function of

visual field of stimulus.


12
11
10
9
8
7
6
EMOTIONAL RATINGS
Right
Central
Left
VISUAL FIELD

their emotional ratings of the stimuli were examined with a multiple regression analysis. Depression was predicted upon the basis of sex, and emotional ratings of 6 categories of stimuli: left visual field verbal; left visual field nonverbal; right visual field verbal; right visual field nonverbal; central verbal; and central nonverbal. The analysis of variance is presented in Table 4, with the contribution of each predictor given in Table 5. Contrary to prediction, the set of variables failed to predict subjects' depression scores, F (7,72) = 1.723, $p > .1171$. Moreover, the expected negative relationship between depression and left visual field ratings, (as indicated by negative standardized regression coefficients in Table 5), was not found. Only the left visual field nonverbal stimuli showed a trend in the expected direction. Hence, subjects' level of depression was not found to be related to their emotional ratings of the stimuli or their sex.

Insert Tables 4 and 5 here

In light of these nonsignificant findings, tests were not warranted on the third hypothesis' expectation of a greater relationship between depression and emotional ratings of left visual field stimuli than central or right visual field stimuli.

Table 4

Analysis of Variance for the

Multiple Linear Regression

Source	df	MS	F	p
Regression	7	98.7918	1.723	0.1171
Residual	72	57.3276		

Table 5

Summary of Predictor Values for the

Multiple Linear Regression

Variable	Coefficient	Std. Error	Std. Reg. Coeff	*t*	*p*
Intercept	21.87682				
Sex	-2.33165	1.78937	-0.150	-1.303	0.1967
NR	-0.35877	0.94741	-0.081	-0.379	0.7060
NC	0.73038	1.07463	0.171	0.680	0.4989
NL	-0.86803	0.86806	-0.214	-1.000	0.3207
VR	-1.91537	0.84502	-0.489	-2.267	0.0264
VC	0.52161	0.53467	0.146	0.976	0.3326
VL	0.98020	0.81805	0.254	1.198	0.2348

Note. Coefficient: Unstandardized Regression Coefficient
Std. Error: Standard Error
Std. Reg. Coeff: Standardized Regression Coefficient
NR: Nonverbal Right Visual Field Emotional Ratings
NC: Nonverbal Central Visual Field
NL: Nonverbal Left Visual Field
VR: Verbal Right Visual Field
VC: Verbal Central Visual Field
VL: Verbal Left Visual Field

Ancillary Analyses

Two analyses were conducted that were not originally proposed. One analysis examined the effect of emotional category upon emotional rating, while the second further examined the relationship between depression and emotional rating.

Emotional Category

The category of emotion was examined with a dual purpose: as another "validity check", to see if emotional ratings differed between emotional categories, as they did in the pretest; and to see if the visual field effects upon emotional rating interacted with the category of emotion. These questions were tested with a 2 (Sex) x 2 (Type of Stimulus) x 3 (Visual Field) x 3 (Emotional Category) mixed design analysis of covariance. Subjects' confidence in each emotional rating served as the covariate.

The results of the analysis are presented in Table 6. Where effects violated the assumption of compound symmetry ($p < .0001$), the Greenhouse-Geisser correction was noted beside the appropriate effect in Table 6. In addition to the expected significant main effects of Type of Stimulus, $F\ (1,77) = 16.61$, $p < .0001$, and Visual Field, $F\ (2,155) = 10.63$, $p < .0002$, the effect of Emotional Category was found to be significant, $F\ (2,155) = 40.10$, $p < .00001$. An interaction between Emotional Category and Type of Stimulus was also found, $F\ (2,155) = 27.60$, $p < .00001$. However, interpretation of the main effect and two-way interaction is superceded by a three-way interaction between Emotional Category, Type of Stimulus, and Visual Field, $\underline{F}$ (4,331) = 3.79, $\underline{p} < .0051$.

Insert Table 6 about here

This interaction is presented in Figures 5(a) and 5(b) as 2 two-way interactions to improve clarity of interpretation. Each graph depicts a different type of stimulus: verbal or nonverbal.

Differences in Emotional Categories. Verbal and nonverbal stimuli appear to be affected differently by emotional categories. Nonverbal stimuli, presented in Figure 5 (a), will be discussed first.

Visual inspection of the nonverbal stimuli suggests that across visual fields, emotional ratings are appropriately most positive for positive stimuli, less positive for neutral stimuli, and least positive for negative stimuli. This is supported by post hoc Scheffe multiple comparisons, which found that each category of emotion differed from the other, for each level of visual field.

Specific results were as follows: for the right visual field, emotional ratings were significantly different between the negative and neutral stimuli, $\underline{F}$ (4,311) = 87.47, $\underline{p} < .001$; the neutral and positive stimuli, $\underline{F}$ (4,311) = 31.11, $\underline{p} < .001$; and

Table 6

2 (Sex) x 2 (Type of Stimulus) x 3 (Visual Field) x 3 (Emotional Category)

Repeated Measures Analysis of Covariance for Emotional

Ratings with Confidence Ratings as the Covariate

Source	df	MS	F	p	p (adj)[a]
S	1	75.19792	3.33	0.0720	
Error	77	22.59131			
T	1	398.23690	16.61	0.0001	
T x S	1	65.23832	2.72	0.1031	
Error	77	23.96948			
VF	2	69.16836	10.63	0.0000	0.0002
VF x S	2	4.91999	0.76	0.4712	0.4485
Error	155	6.50680			
T x VF	2	7.51321	3.06	0.0498	0.0609
T x VF x S	2	0.53726	0.22	0.8038	0.7575
Error	155	2.45623			
E	2	285.30027	40.10	0.0	0.0
E x S	2	4.66303	0.66	0.5207	0.4676
Error	155	7.11556			
T x E	2	173.82460	27.60	0.0	0.0
T x E x S	2	5.69238	0.90	0.4071	0.3741
Error	155	6.29798			
VF x E	4	1.77861	1.22	0.3006	
VF x E x S	4	3.09755	2.13	0.0768	
Error	311	1.45331			
T x VF x E	4	5.25208	3.79	0.0051	
T x VF x E x S	4	1.07350	0.77	0.5428	
Error	311	1.38712			

Note. S: Sex. T: Type of Stimulus. VF: Visual Field. E: Emotional Category

[a]Greenhouse-Geisser adjusted probability for effects having significantly violated the assumption of compound symmetry.

the negative and positive stimuli, F (4,311) = 102.65, $p < .001$. For the central presentations, emotional ratings were significantly different between the negative and neutral stimuli, F (4,311) = 121.82, $p < .001$, the neutral and positive stimuli, F (4,311) = 24.88, $p < .001$, and the negative and positive stimuli, F (4,311) = 256.80, $p < .001$. And for the left visual field presentations, emotional ratings were significantly different between the negative and neutral stimuli, F (4,311) = 102.40, $p < .001$, the neutral and positive stimuli, F (4,311) = 66.33, $p < .001$, and the negative and positive stimuli, F (4,311) = 333.56, $p < .001$.

In summary, emotional ratings of nonverbal stimuli were significantly different for the negative, neutral, and positive categories, regardless of visual field.

Insert Figures 5(a) and 5(b) about here

In contrast to the clearly differentiated emotional categories for the nonverbal stimuli, the ratings of verbal stimuli presented in Figure 5 (b) show fewer differences between emotional categories. Specific results are as follows: for the right visual field, positive stimuli were rated as significantly more positive than neutral stimuli, F (4,311) = 28.73, $p < .001$. However, differences were not found between the negative and

Figure 5(a)

Mean emotional ratings of nonverbal stimuli

as a function of emotional category

and visual field.

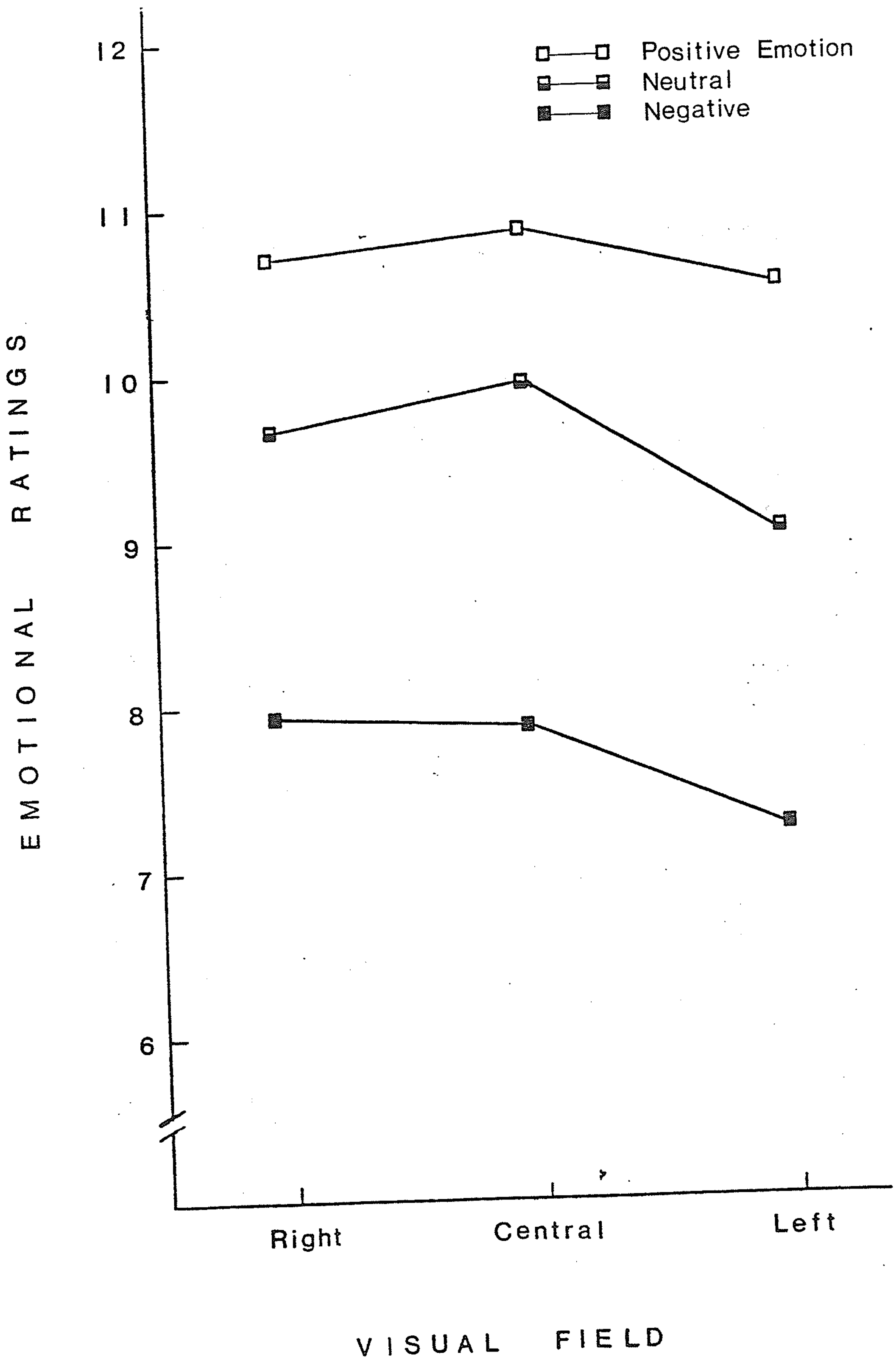
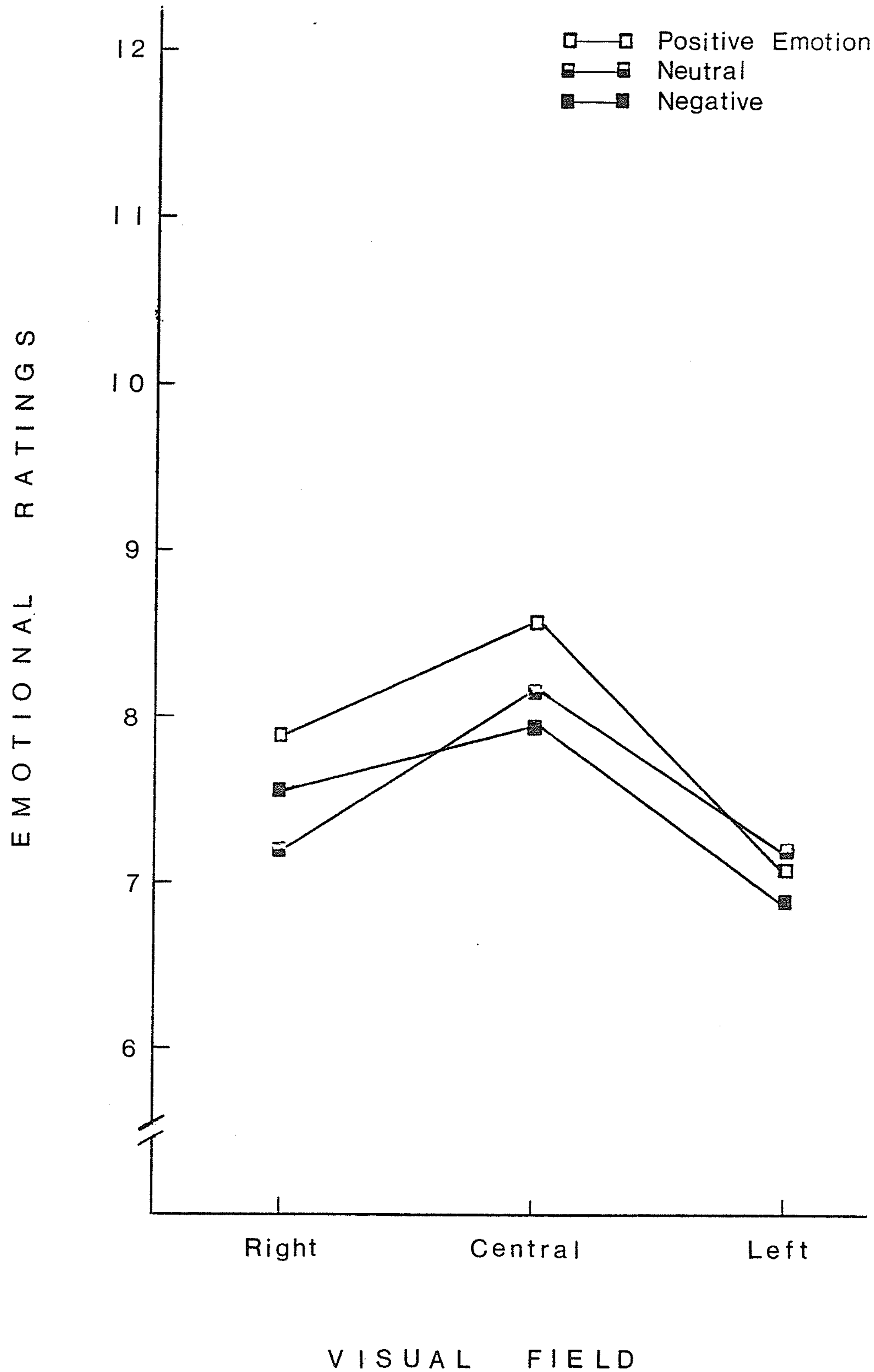

Positive Emotion
Neutral
Negative
12
11
10
9
8
7
6
EMOTIONAL RATINGS
Right
Central
Left
VISUAL FIELD

Figure 5(b)

Mean emotional ratings of verbal stimuli

as a function of emotional category

and visual field.


Positive Emotion
Neutral
Negative
12
11
10
9
8
7
6
EMOTIONAL RATINGS
Right
Central
Left
VISUAL FIELD

neutral categories, $F_{(4,311)} = 5.39$, $p > .10$, and the negative and positive categories, $F_{(4,311)} = 2.17$, $p > .10$. For central presentations, positive stimuli were rated as significantly more positive than negative stimuli, $F_{(4,311)} = 11.32$, $p < .025$. However, differences were not found between the neutral and negative categories, $F_{(4,311)} = 1.16$, $p > .10$, and the neutral and positive categories, $F_{(4,311)} = 5.23$, $p > .10$. For presentations to the left visual field, no significant differences were found betwen emotional categories. Thus, the negative and neutral stimuli failed to differ, $F_{(4,311)} = 2.68$, $p > .10$, as did the neutral and positive stimuli, $F_{(4,311)} = .18$, $p > .10$, and the negative and positive stimuli, $F_{(4,311)} = 1.47$, $p > .10$.

Collectively, these analyses indicate that in contrast to the pretest stimuli and to the nonverbal experimental stimuli, the emotional category of verbal stimuli was generally not found to affect their emotional ratings. Hence, the verbal stimuli cannot be said to represent a range of emotional values.

In an attempt to account for this lower distinction amongst emotional categories, the range of emotional ratings for verbal and nonverbal categories were compared. Both types of stimuli were found to be rated across the emotional scale, from 1 to 15. Unexpectedly, the verbal stimuli had a wider range between the mean minimum and maximum ratings than the nonverbal: 1.5 -

12.03, compared to 5.39 - 13.72. Hence, the verbal stimuli's smaller distinction between emotions does not correspond to a smaller range of values.

A second possibility is that verbal stimuli represent simply a relatively negative range of stimuli. This is suggested by their significantly more negative ratings (Figure 3). Moreover, as Figure 5 (b) suggests, all three emotional categories for verbal stimuli appear to fall closely around the negative category ratings for nonverbal stimuli.

Interaction between Visual Field and Emotional Category. Apart from comparisons between emotional categories, the other analysis of interest in the three-way interaction in Figures 5(a) and 5(b) was a test of differences in emotional ratings between visual fields. The nonverbal stimuli, presented in Figure 5(b), will be discussed first.

In general, post hoc Scheffe multiple comparisons of nonverbal stimuli indicated that the negative and neutral stimuli reflected a similar pattern: as predicted, right visual field and central presentations were more positive than left visual field presentations. Interestingly, the right visual field and central presentations were not found to differ.

Specific findings were as follows: for negative stimuli, the right visual field presentations were rated more positively than left visual field presentations, F (4,311) = 16.96, p <

.001, while central presentations were also rated more positively than left visual field presentations, F (4,311) = 15.21, $p <$ .001. However, right visual field presentations were not found to differ from central presentations, F (4,311) = .05, $p >$ .10. Similarly, for neutral stimuli, right visual field presentations were rated as more positive than left visual field presentations, F (4,311) = 11.23, $p <$ .025, while central presentations were also more positive than left visual field presentations, F (4,311) = 23.21, $p <$ .001. No differences were found between the right visual field presentations and central presentations, F (4,311) = 2.15, $p >$ .10. For positive stimuli, differences between visual fields were not found to be significant, although they tended to reflect the same patterns found for negative and neutral stimuli. Thus, right visual field and central presentations were not found to differ, F (4,311) = .77, $p >$ .10, nor were central and left visual field stimuli, F (4,311) = 2.76, $p >$ .10, or left and right visual field stimuli, F (4,311) = .62, $p >$ .10.

Like the nonverbal stimuli, the verbal stimuli, presented in Figure 5(b), generally reflected more positive ratings for right visual field and central presentations than for left visual field presentations. However, while all three nonverbal emotional categories failed to reflect differences between right visual field and central presentations, two of the three verbal emotional categories reflected significant differences. This pattern can be seen as each emotional category is discussed.

For the negative stimuli, the right visual field presentations were rated as more positive than the left visual field presentations, F (4,311) = 16.47, $p < .001$, while the central presentations were also rated as more positive than the left visual field presentations, F (4,311) = 32.32, $p < .001$. However, similar to the pattern presented in all three nonverbal emotional categories, the right visual field and central presentations were not found to differ, F (4,311) = 2.65, $p > .10$. For the neutral stimuli, the central presentations were rated more positively than both the right visual field presentations, F (4,311) = 25.28, $p < .001$, and the left visual field presentations, F (4,311) = 26.30, $p < .001$. The left and right visual field presentations were not found to differ, F (4,311) = .01, $p > .10$. For the positive stimuli, the central presentations were again rated more positively than both the right visual field presentations, F (4,311) = 12.39, $p < .025$, and the left visual field presentations, F (4,311) = 61.46, $p < .001$. And, as expected, the right visual field presentations were rated as more positive than the left visual field presentations, F (4,311) = 18.66, $p < .001$.

In light of the complexity of the results obtained from analyzing the interaction displayed in Figures 5(a) and 5(b), three summary statements can be made. First, both the nonverbal and the verbal stimuli indicated that right visual field presentations are rated as more positive than left visual field presentations. Second, nonverbal stimuli represent a range of emotional categories, while verbal stimuli generally do not represent a range of emotional values. (Since verbal stimuli received more negative ratings than nonverbal stimuli, as indicated in Figures 3, 5(a) and 5(b), they may represent a relatively negative emotional range). Third, while nonverbal stimuli do not reflect a difference between right visual field and central presentations, certain verbal stimuli are rated more positively in central presentations than in right visual field presentations.

Depression

In light of the greater number of nondepressed compared to depressed subjects in this study, an effort was made to analyze the emotional ratings of subjects that were at opposing ends of a depression spectrum. A "depressed" group was selected from the 14 subjects that met Radloff's (1977) arbitrary criterion of depression, together with 3 subjects whose scores fell at the critical depression value. Fourteen of these subjects were also more than one standard deviation above the mean depression score. A "nondepressed" group of 16 subjects were selected whose depression scores were 4 or less. (This was the critical value that came closest to giving the two groups relatively equal numbers of subjects.) Ten of these subjects' scores were also more than one standard deviation below the mean depression score.

These subjects were then used in a 2 (Depression) x 2 (Type of Stimulus) x 3 (Visual Field) mixed design analysis of variance, with the purpose of examining any effects involving depression. The results of the analysis are presented in Table 7. Since sphericity tests of compound symmetry were significant ($p < .0003$), for both repeated measures, the Greenhouse-Geisser correction was applied to their effects. The main effect of depression was not found to be significant, $F\ (1,31) = .30$, $p > .59$, nor were any interactions involving depression (p's $> .50$). As in the three-way and four-way analyses of covariance performed on the full sample size, the effects of Type of Stimulus, Visual Field (Tables 3 and 6) and Type of Stimulus x Visual Field (Table 6) were found to be significant, with respective values of $F\ (1,31) = 30.87$, $p < .00001$, $F\ (2,62) = 14.94$, $p < .0001$, and $F\ (2,62) = 8.29$, $p < .0026$.

Insert Table 7 about here

Interpretation of these two main effects was mitigated by their interaction, presented in Figure 6. Despite the use of a more restricted sample, the interaction comforms to the patterns

Table 7

2 (Depression Group) x 2 (Type of Stimulus) x 3 (Visual Field)

Analysis of Variance for Emotional Ratings

Source	*df*	*MS*	*F*	*p*	*p*(adj)[a]
D	1	2.71662	0.30	0.5908	
Error	31	9.20392			
T	1	354.13221	30.87	0.0000	
T x D	1	2.46695	0.22	0.6461	
Error	31	11.47070			
VF	2	38.16155	14.94	0.0000	0.0001
VF x D	2	0.29890	0.12	0.8898	0.7975
Error	62	2.55454			
T x VF	2	8.61740	8.29	0.0006	0.0026
T x VF x D	2	0.60786	0.59	0.5601	0.5046
Error	62	1.03900			

Note. D: Depression Group (Depressed or Nondepressed)
T: Type of Stimulus
VF: Visual Field

indicated in the previous analyses: nonverbal stimuli appear to be rated more positively than verbal stimuli (as in Figure 3); and differences between the right visual field and central presentations are more pronounced with verbal than nonverbal stimuli [as in Figures 5(a) and 5(b)]. In light of these similarities, together with the fact that the sample was not representative of the general population, and the fact that depression was not involved in the effect, further investigations of the interaction were not warranted.

Insert Figure 6 about here

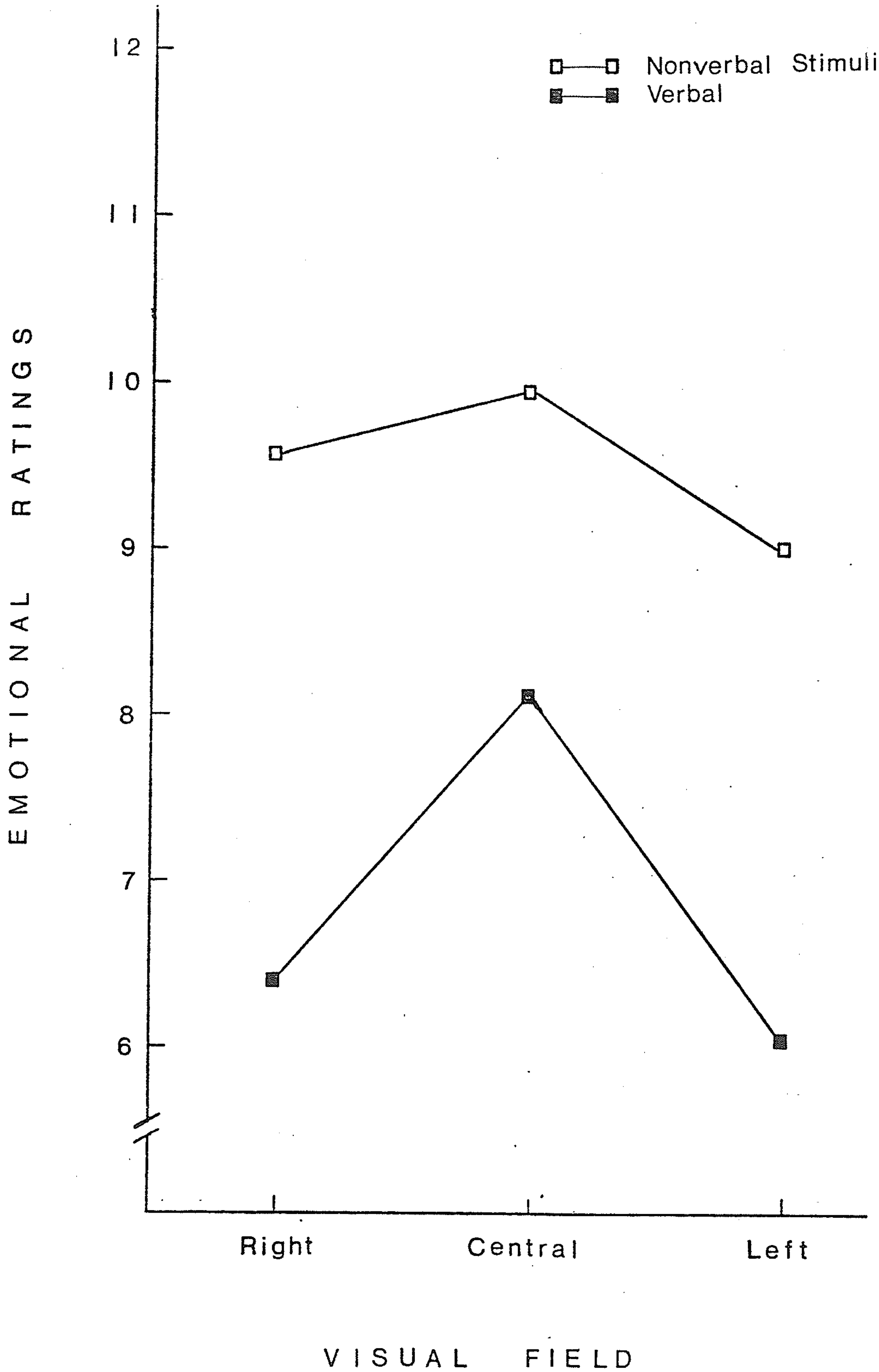
The results of this analysis parallel the multiple linear regression (Tables 4 and 5) in that subjects' level of depression was not found to be related to their emotional ratings of the stimuli.

Figure 6

Mean emotional ratings as a function of

type of stimulus and

visual field of stimulus.



Nonverbal Stimuli
Verbal
12
11
10
9
8
7
6
EMOTIONAL RATINGS
Right
Central
Left
VISUAL FIELD

Discussion

The results of this study support the primary hypothesis that right visual field presentations would receive more positive emotional ratings than left visual field presentations. This finding will be interpreted in the context of hemispheric differences in emotional experience. However, the relationship between these differences and central presentations is less clear. Contrary to prediction, central presentations were not rated between the extremes of left and right visual field presentations. Moreover, the secondary hypotheses of the study relating visual field differences to depression were not seen to be supported.

Following an interpretation of these findings, their implications for understanding normal and "abnormal" emotional experience will be discussed.

Right Hemisphere "Negativity"

Two predicted patterns were found in both the three-way analysis of covariance and the ancillary four-way analysis of covariance (Tables 3 and 4). First, stimuli presented to each hemisphere simultaneously (or bilaterally) were experienced as emotionally more positive than when presented first to the right hemisphere (left visual field). Second, and more importantly, stimuli presented first to the left hemisphere (right visual field) were experienced as emotionally more positive than when presented first to the right hemisphere (left visual field). In light of the fact that these results were obtained while subjects' confidence in their ratings was statistically controlled for, methodological explanations for this effect being related to visual acuity, illuminance, ease of stimulus identification, or related methodological factors are unlikely. Hence, a hemispheric interpretation appears to be supportable. In this context, two conclusions can be drawn. First, right hemispheric emotional experience is seen as emotionally more negative than left hemispheric emotional experience. This supports the work of Dimond et al (1976), Gill (1982), and Davidson and Moss (cited in Kinsbourne and Bemporad, 1984) and fails to support Beaton's (1979) concept of a negatively biased left hemisphere. Second, right hemispheric emotional experience is seen as emotionally more negative than bilateral emotional experience as well. This indicates that descriptions of right hemispheric experience as "negative" have some validity, since they are relative to both contralateral and bilateral functioning. While this may support Natale et al's (1983) conception of an emotionally positive left hemisphere, it does not support an "unbiased" right hemisphere.

Thus, possibly for the first time within the same study, the work of previous investigators on these hemispheric differences in emotional experience has been extended and referenced to normal emotional and/or phenomenological experience.

Additional support is given to these conclusions by several indications that the hemispheric differences are a "robust" effect. These hemispheric patterns were found for both verbal and nonverbal stimuli, suggesting that they may be generalizable to a variety of environmental events. The failure to find any stimulus order effects also supports this possibility. Consistent with the findings of Gill (1982), significant sex differences failed to be found, suggesting that the effect is generalizable to both males and females. Also consistent with Gill's (1982) study, the hemispheric differences were found across a broad range of emotional stimuli. Lastly, the failure to find any differences related to depressive symptomatology suggests that these hemispheric patterns may be present in a variety of mood states.

Bilateral Emotional Experience

Contrary to prediction, stimuli presented first to the left hemisphere (right visual field) were not felt to be more positive than stimuli presented to each hemisphere simultaneously (central presentations). Hence, the right hemisphere's emotionally more negative experience of events compared to "normal" bilateral experience does not correspond with the left hemisphere being more positive than bilateral experience.

The exact nature of the relationship between the left hemisphere and bilateral experience is dependent upon the analysis examined. Using the three-way analysis of covariance (Figure 4), the main effect of Visual Field indicates that stimuli presented to each hemisphere simultaneously are experienced as more positive than stimuli presented first to the left hemisphere. However, when the effect of Emotion is added to create an ancillary four-way analysis of covariance a different pattern appears for verbal and nonverbal stimuli [Figures 5 (a) and 5(b)]. Similar to the main effect of Visual Field, verbal stimuli classified as neutral and positive were experienced more positively in bilateral presentations than when presented first to the left hemisphere. However, verbal stimuli classified as negative, as well as all three emotional categories of nonverbal stimuli, failed to reflect differences between bilateral and left hemisphere experience.

Three issues arise from these results. The first is the question of why the verbal and nonverbal stimuli reflect different patterns of emotional experience. Second, the question can also be raised as to the significance of possible similarities between left hemisphere and "normal" bilateral experience. A third issue is what, if any, theoretical significance more positive bilateral than unilateral experience has.

Two possible interpretations can be applied to the verbal-nonverbal differences in hemispheric patterns. The most obvious interpretation is that they reflect different patterns because they differ in their discrimination between emotional categories. Hence, since the nonverbal stimuli represented three significantly different emotional categories [Figure 5(a)], they may reflect a pattern of results more representative of environmental events experienced by the general population. In contrast, the lack of differences between emotional categories in the verbal stimuli may make them less reliable and/or valid as events reflective of hemispheric patterns in the general population.

The other interpretation, compatible with the first one, is that since verbal stimuli were, in general, felt to be more negative than nonverbal stimuli, they simply reflect a range of relatively negative stimuli. In comparison, the nonverbal stimuli appear to reflect a wide spectrum of emotional categories.

A second issue to be dealt with is the theoretical significance of failing to find left hemispheric experience more positive than bilateral experience for nonverbal and negative verbal stimuli. This "failure" is seen as important since it parallels the data of Dimond et al (1976). They concluded that "the left hemisphere scores so closely resembled those for the [bilateral] free vision condition where it may be assumed that both hemispheres are stimulated, to suggest that it is usually the left hemisphere perception which predominates" (p. 692). This study's conclusions are more tentative, since nonsignificant findings do not equate the two groups. First, the left hemisphere appears to be more related to bilateral experience than the right hemisphere. Second, the assumption that our emotional experience is an "averaging" of input from the emotional extremes of each hemisphere appears to be an oversimplication.

The third issue that arises from the different patterns of emotional experience found in Figures 5(a) and 5(b) is the significance, if any, of the neutral and positive verbal stimuli being experienced more positively during bilateral presentations than unilateral presentations. The most obvious interpretation would be a methodological one: centrally presented stimuli may be more accessible for rating than peripheral presentations. However, there are two arguments against this explanation: subjects' confidence in their emotional ratings was statistically controlled for; and this finding was not found with the other types of verbal and nonverbal stimuli.

Another methodological consideration is that these stimuli represented a relatively negative range of emotional events. This may have artificially depressed left hemisphere emotional input. The difficulty with this possibility is in accounting for why bilateral presentations are not similarly affected, or why the negative nonverbal stimuli do not reflect a similar pattern.

Theoretical considerations are also troublesome. One possibility that conforms to the supported hypotheses of the study is that when more positive left hemisphere emotional experience is competing with simultaneous right hemisphere experience, a "contrast" effect occurs. Integration of the competing input would result in a more positive experience of the stimuli than if right hemispheric experience had not been simultaneously present. This is consistent with the type of stimuli being used: since the left hemisphere is superior in dealing with verbal stimuli, it may be "primed" for a specialized emotional experience, as well. However, this cannot account for why negative verbal stimuli do not reflect this pattern, nor for why the opposite contrast effect is not found with nonverbal stimuli.

In this light, the clearest statement on the more positive bilateral presentations is simply that they do not support an asssumption that conscious emotional experience is an averaged amalgam of each hemisphere's unique contribution.

Depression

Two hypotheses regarding depression data were not supported. First, depression was not found to be related to subjects' emotional ratings. Both the multiple regression analysis on all subjects and the analysis of variance on subjects at opposite ends of the depression scale failed to find differences related to visual field or type of stimulus [Tables 4, 5 (a) and 5(b), and 7]. Second, in light of these nonsignificant results, stimuli presented first to the right hemisphere would not be more related to depression than the other stimulus locations.

The failure to find significant effects does not appear to be related to methodological difficulties in measuring depression per se. Depression was measured immediately prior to the emotional rating task, providing as current a measure of depression as possible without contamination by the experimental manipulations. The test used was specifically designed to measure depressive symptomatology in the general population, presumably making it more sensitive to differences in the sample used. The range of scores, mean depression score, and standard deviation reported in the Results section indicate a relatively broad spectrum of values were sampled. Moreover, the proportion of subjects meeting Radloff's (1977) arbitary criterion for depression (17.5%) is similar to that reported by Gill and Martin (1983) (20%). (As previously described, these investigators found this measure of depression to be related to hemispheric differences in EEG activity during presentation of emotional stimuli.) Collectively, these factors argue against the possibility of sampling problems.

However, at least two methodological factors remain to be considered. First, it is possible that a stronger relationship between emotional ratings and depression may have been found if extremely negative stimuli had been used. Second, while the emotional ratings were not related to the broad spectrum of depressive symptomatology, possible relationships with distinct components of depression, such as depressed mood, were not assessed. This distinction may be of importance. Perris and Monakhov (1979), for example, found hemispheric patterns of EEG activity to depend upon whether subjects evidenced depressed mood, or anxiety and "ruminative ideation". Tucker (1981) has also argued for the need for more specific measures of psychopathology in laterality research. Hence, future studies of phenomenological differences between the hemispheres may find greater value in the use of more symptom-specific instruments.

As for the theoretical significance of the depression data, it has been previously noted that a lack of significant effects may support the generalizability of hemispheric differences in phenomenological experience to the general population. However, since this is one of the first tachistoscopic studies to include depression as a factor in emotional laterality research, it is clearly premature to disregard its use in future studies. The theoretical importance of depression to hemispheric differences is just beginnning to be evaluated.

Metholoqical Issues

Three findings of this study are seen as methodological issues, and hence are best dealt with separate from theoretically more meaningful findings.

First, it has been previously noted that verbal stimuli were rated as more negative than nonverbal stimuli. This was indicated by the main effect for Type of Stimulus (Figure 3) and by a two-way (Figure 6) and three-way interaction [Figures 5(a) and 5(b)] involving Type of Stimulus. This may be because the nonverbal stimuli were graphically more interesting than the verbal stimuli. Another factor which may have been operating is subjects' irritation at trying to read the quickly presented verbal stimuli. Despite instructions that the verbal stimuli were "nonsense words", some subjects may have made an effort to make semantic sense of them.

A second finding was the lack of differences between emotional categories in the verbal stimuli [Figure 5(b)]. Since these stimuli appear to have similar ratings to negative nonverbal stimuli, the small emotional range may be attributable to a lack of positive stimuli. Once again, this appears related to the nonverbal stimuli being more graphically interesting than verbal stimuli. Additionally, while nonverbal stimuli differed on a number of visual parameters (such as shape, shading, size, or orientation), the range of parameters for verbal stimuli were more limited. This, in turn, may have limited their emotional range.

A third and related finding is that this lack of differentiation between verbal emotional categories is in contrast to the significant differences in verbal stimuli found in the pretest. One factor related to this finding is the difference in statistical treatments used. Unlike the pretest, the ancillary analysis mean emotional ratings were adjusted to control for subjects' confidence. This suggests that some of the differentiation between pretest emotional categories may have been attributable to the effects of subjects' confidence in their ratings. Additionally, the pretest analysis used a priori contrasts to answer a specific question, allowing greater power than the ancillary analysis' post hoc Scheffe multiple comparisons testing a variety of questions. Another possible factor is the tendency for some subjects to rate stimuli toward the middle of a scale. Since the stimuli used in the pretest analysis were those rated at the emotional extremes of the scale, they may have been not as affected by this tendency as the experimental stimuli.

The question may also be asked as to why the verbal stimuli would differ between the pretest and the experiment proper, and not the nonverbal stimuli. This appears to be related to explanations already provided for the other findings. Since the verbal stimuli were less graphically interesting, and had fewer visual parameters that differed, they may have been more susceptible to any tendency to rate stimuli towards the middle of the scale.

The significance of these issues for future research is twofold. First, while a pretest procedure is certainly advocated, additional planned validity checks appear to be warranted on data from an experiment proper. Second, experimenters using both verbal and nonverbal stimuli will have to be aware of the compromise between equating the stimuli on visual parameters, and being able to obtain a range of emotional ratings. It would appear that the more similar the stimuli are, the narrower the range of emotional ratings will be. The alternative with the verbal stimuli is to use meaningful words or phrases, rather than nonsense words. While possibly increasing the emotional range, it may make verbal stimuli even less comparable to nonverbal stimuli. Extra task demands could be added by doing this, since subjects would be trying to understand and/or interpret the verbal stimuli, in addition to simply responding to their visual patterns. Thus, the compromise that experimenters make must be dependent upon their individual needs and purposes.

Implications

Right Hemispheric "Negativity"

This study has supported previous conceptions of the right hemisphere as experientially more negative than either the left hemisphere or bilateral experience. Thus, references to the right hemisphere as negatively "biased" refer to both unilateral and bilateral experience.

Implications of this model are twofold. First, it has relevance for understanding "normal" emotional and/or phenomenological experience. It suggests that our conscious experience may be an integration of separate input from the left and right hemispheres. Since the data does not indicate that bilateral experience is simply an "average" of right and left hemisphere input, the mechanisms of this integration have yet to be understood.

This model of experience stimulates questions of how each hemisphere would reflect a particular emotional range and why this would occur. One possibility of how the emotional value is imparted is through memory. Campbell (1982) refers to comments by Bower (1981) that memories of sad (or negative) events occur when individuals are in a similar sad mood. Hence, Campbell (1982) argues it is possible that "psychologically, the mood of each hemisphere may 'set' memory for emotional information" (p. 223). Work by Natale and Gur (1980) supports this possibility.

They found that leftward gazes for a "prolonged" period (associated with right hemispheric activity) increased recall of unpleasant (or negative) memories. Correspondingly, rightward gazes (left hemisphere activity) increased recall of pleasant or positive material.

The issue of why the hemispheres may impart different emotional experience invites even greater speculation. At the most basic level, the right hemisphere may deal more with the extension or preservation of life (quantity of life), while the left hemisphere deals more with the quality of life. Hence, the right hemisphere may be sensitized to internal threats (such as increased autonomic activity) as well as external threats (such as rapidly approaching stimuli). This is supported by the finding that the right hemisphere is physiologically more involved in perceiving cardiovascular changes than the left, indicated by visual evoked potentials (Walker & Sandman, 1979, 1982) and conjugate lateral eye movements (Hantas, Katkin & Reed, 1984; Montgomery & Jones, 1984). A positive relationship has also been found between accuracy in cardiovascular perception and negative reactions to noxious visual stimuli (Hantas, Katkin, & Blascovich, 1982). Additionally, Ley and Bryden (1981) cited two studies finding that the left extremities of the body were more sensitive to pain than the right (Murray & Safferstone, 1970; Murray & Hagan, 1973). Together, these studies implicate the right hemisphere in evaluating aversive and/or threatening stimuli. The value that the right hemisphere imparts to the stimuli in this study, then, may have been related to their significance as possible threats. In this light, right hemispheric input would be experienced more negatively than left hemispheric input.

Interestingly, this highly speculative model will be seen to be consistent with other findings discussed in the next section.

A second interpretation of hemispheric asymmetries in emotion has been suggested by Ahern and Schwartz (1979). They speculated that the right hemisphere's implication with negative emotion is related to a greater involvement with "avoidance" behavior (such as moving away from an object). Correspondingly, the left hemisphere's implication with positive emotion may be related to a greater involvement with "approach" behavior (such as moving toward an object).

Apart from implications for understanding "normal" experience, a right hemispheric negative bias has implications for "abnormal" emotional experience, primarily depression. Since depressed mood is, by definition, the experience of more negative thoughts and/or feelings than "normal", it is natural to speculate whether in depression there is more right hemispheric input or experience reaching consciousness than "normal". This possibility is supported by the finding of greater right hemispheric activation as a function of negative emotion (e.g., Davidson et al, 1979; Tucker et al, 1981) and of clinical depression (e.g., Flor-Henry & Koles, 1980). Thus, the right hemisphere may play a special role in the etiology of depression. (This is given additional credence by the previously mentioned possibility that left hemisphere experience more closely parallels normal bilateral experience.)

While at least two theories of depression are based on hemispheric differences, neither can completely account for the results found in this study. Tucker's (1981; Tucker et al, 1981) model of a right frontal inhibition of posterior areas is not able to account for depressed mood as well as it can for presumed functional deficits, since the role of the left hemisphere (with its more positive bias) is not considered. Flor-Henry's (1979) characterization of depressive phenomena as a loss of "control" of a dysphoric nondominant (typically right) hemisphere by a more euphoric dominant (left) hemisphere appears to fit the present study's data better. However, his references to hemispheric abnormality or "dysfunction" may be inappropriate when no consideration was given to "normal" hemispheric asymmetries in emotion.

The results of this study also support other lateralized models of psychopathology. First, a right hemispheric emotional bias lends support to recent work by Martin and his associates on "repression" (Martin, Verman & Miles, 1984; Martin, Hawryluk, Berish & Dushenko, 1984; Martin, Stambrook, Tataryn & Beihl, 1984). Martin et al have proposed that at least some "repression" is the learned inhibition of aversive information crossing from the right to the left hemisphere. They provided evidence for the selective inhibition of aversive information transfer from the right to the left hemisphere and on conditioning responses in the unattended left ear during a dichotic task. Second, a right hemispheric emotional bias also lends support to Tucker et al (1977). They have proposed that stress (or performance-related anxiety) differentially activates the right hemisphere based on lateral eye movement data. Whether stress is an element of negative effect in this situation, or vice-versa, remains to be seen.

Apart from theories of psychopathology, this study has implications for symptoms of psychopathology. Bryden (1982) listed several studies that reported a clear prevalence of left-sided compared to right-sided hysterical conversion symptoms. These included archival analyses of case studies by Ley (1980) and Axelrod, Noonan, & Atanacio (1980) and surveys of psychiatric patients by Galin, Diamond & Braff (1977) and Stern (1977). Since left-sided symptoms would implicate the right hemisphere, their greater prevalence would be consistent with this hemisphere's more negative emotional experience, and probable involvement in high anxiety and emotional distress. However, an explanation for the existence of right-sided (left hemisphere-related) conversion symptoms is more difficult. One possibility is that these symptoms may be an expression of a manic or euphoric form of denial. Since this type of denial may be seen as essentially emotionally positive, it would be consistent with a more positive left hemisphere experience.

Collectively, these implications for "normal" and "abnormal" emotional experience indicate the value of further research on phenomenological differences between the hemispheres.

Left Hemisphere and Bilateral Experience

While the significant findings on right hemisphere presentations have been seen to have important implications, a lack of significant findings may also have implications of interest. As indicated previously, the lack of differences between left hemisphere and bilateral presentations for nonverbal and negative verbal stimuli tempt the observer to speculate that normal experience may be similar to left hemispheric emotional experience. There are several implications to this possibility. Since nonsignificant findings can never equate groups, however, the following discussion must be regarded as speculative. Tests of these implications would not, of course, involve trying to prove the null hypothesis (that no differences exist). Instead, future studies could test the hypothesis that the relationship between left hemisphere and bilateral presentations is greater than the relationship between right hemisphere and bilateral presentations. Ideally, other possible covariates would also be considered, such as autonomic arousal.

First, if the left hemisphere does have more input in determining an individual's mood, this is in direct contrast to conclusions in the literature that the right hemisphere is uniquely specialized for emotion (e.g. Bryden, 1982; Campbell, 1982; Flor-Henry, 1979; Ley & Bryden, 1979, 1981; Newlin & Golden, 1980; Tucker, 1981). This implies that the measures of speed or accuracy used in most studies provide a different pattern of hemispheric involvement in emotion than more phenomenological or experiential measures. For a more complete understanding of the brain and emotion, further use of phenomenological studies is clearly warranted.

Second, the possibility of the left hemisphere being more related to an individual's mood may explain why left hemisphere damage results in more dramatic behavioral change. For example, as outlined in the Introduction, in contrast to the mild euphoria or indifference found with right hemisphere damage, left hemisphere damage results in crying, depressed mood, and other behavioral changes (e.g., reviews by Campbell, 1982; Gainotti, 1972, 1979; Kinsbourne & Bemporad, 1984; Ley & Bryden, 1981; and Tucker, 1981). If left hemisphere input more closely resembles normal experience, then its damage would naturally lead to greater apparent disturbances.

Third, and most speculative, significant left hemisphere contribution to normal experience conforms to the quality of life -- quantity of life dichotomy proposed earlier to characterize the left and right hemispheres, respectively. Since North American society makes few survival-based demands on an individual, the importance of quality of life questions are typically of more importance. This would thus involve more left hemisphere than right hemisphere contributions. (Indeed, the ability to remain emotionally positive in the face of environmental stress may, in itself, determine both the quality and quantity of life.)

In light of these implications, it is clear that phenomenological studies of the hemispheric differences can have far-reaching significance for understanding normal and abnormal emotional experience. Collectively, the conclusions of this study have demonstrated a lack of utility for the assumption that all aspects of emotion are lateralized to the right hemisphere. A more valuable conception of affect will be formulated only when phenomenological measures are considered alongside the more common physiological and identificational measures of emotion. Until then, a focus on only half the brain will provide only half the "picture".

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Verbal Stimuli as a function of Emotional Category

<u>Negative</u>	rtibb
	urtsl
	xcebe
	yworr
<u>Neutral</u>	delbb
	jrebb
	knilo
	vtnac
<u>Positive</u>	celkc
	llaib
	smehc
	yremm

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Appendix A

Survey of handedness, language(s) and visual acuity.

Sex M F Age ________

This is a survey to discover which hand you use in the following manual tasks. Circle L if you perform the task with your left hand; circle R if you perform the task with your right hand; circle B if you perform the task equally well with both hands. Assume that your hands are empty (except as indicated) before attempting each task.

With which hand do you:

1.	draw?	L	R	B
2.	write?	L	R	B
3.	remove the top card of a deck of cards (i.e. dealing)?	L	R	B
4.	use a bottle opener?	L	R	B
5.	throw a baseball to hit a target?	L	R	B
6.	use a hammer?	L	R	B
7.	use a toothbrush?	L	R	B
8.	use a screwdriver?	L	R	B
9.	use an eraser on paper?	L	R	B
10.	use a tennis racquet?	L	R	B
11.	use scissors?	L	R	B
12.	hold a match when striking it?	L	R	B
13.	stir a liquid or semi-solid?	L	R	B
14.	on which shoulder do you rest a bat before swinging?	L	R	B

* * *

15. How many of your immediate family are left-handed? ________
16. What is the first language that you learned? ________
17. At what age did you learn to speak English? ________
18. Do you have normal or corrected-to-normal vision? ________
19. Do you have any problems with your vision? ________
20. If so, what kind of problems are you experiencing? ________

____

Appendix B

Pretest verbal stimuli.

Pretest Verbal Stimuli

1. asucb
2. belbb
3. celkc
4. delbb
5. etelg
6. fcirb
7. gelbb
8. helkc
9. ielcc
10. jrebb
11. knilo
12. llaib
13. mnorc
14. nylem
15. otcjb
16. pyfic
17. qtnia
18. rtebb
19. smehc
20. ttelb
21. urtsl
22. vtnac
23. welbb
24. xcebe
25. yremm
26. ztola
27. fedac
28. lruob
29. rtibb
30. yworr

<u>Verbal Stimulus, Actual Size</u>

asucb

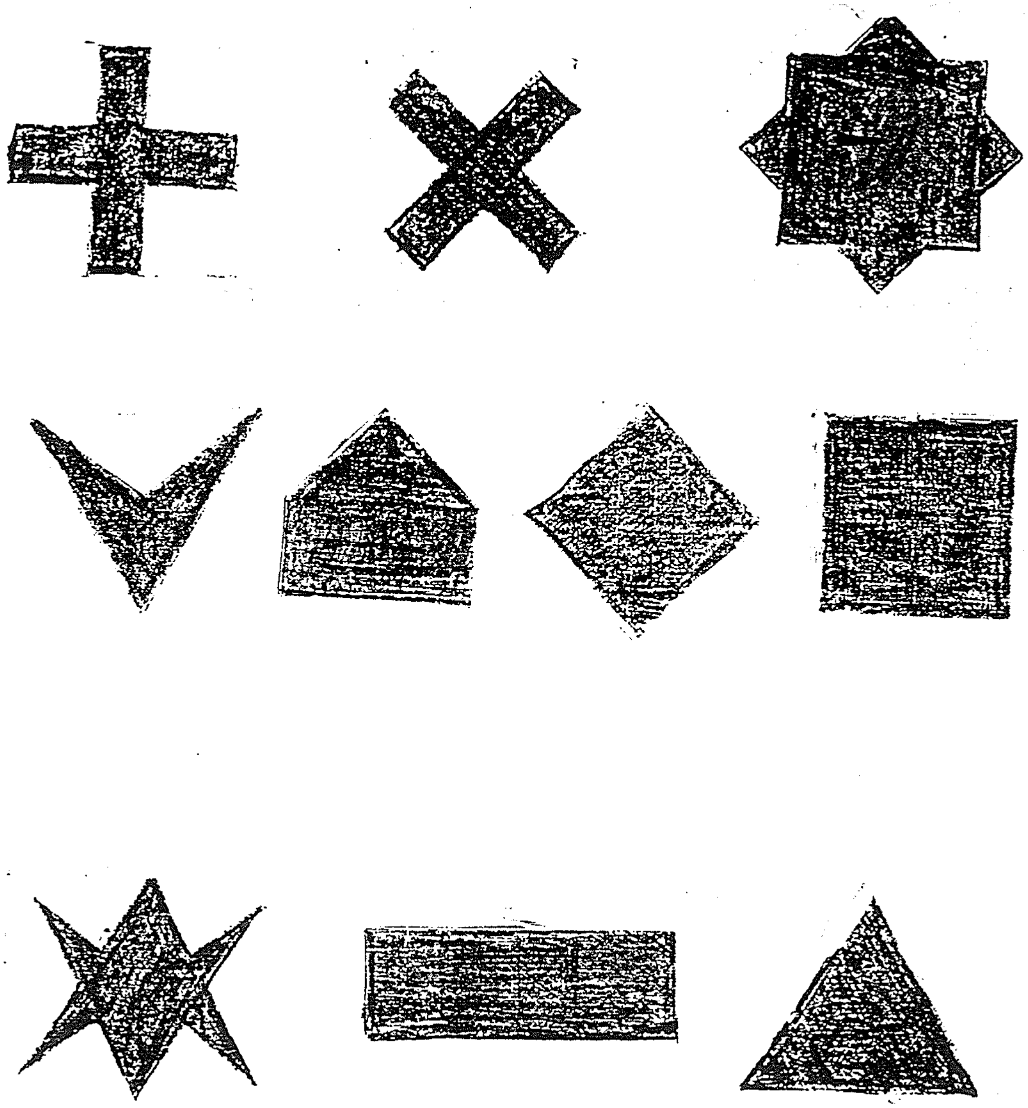
Appendix C

Pretest nonverbal stimuli, actual size:

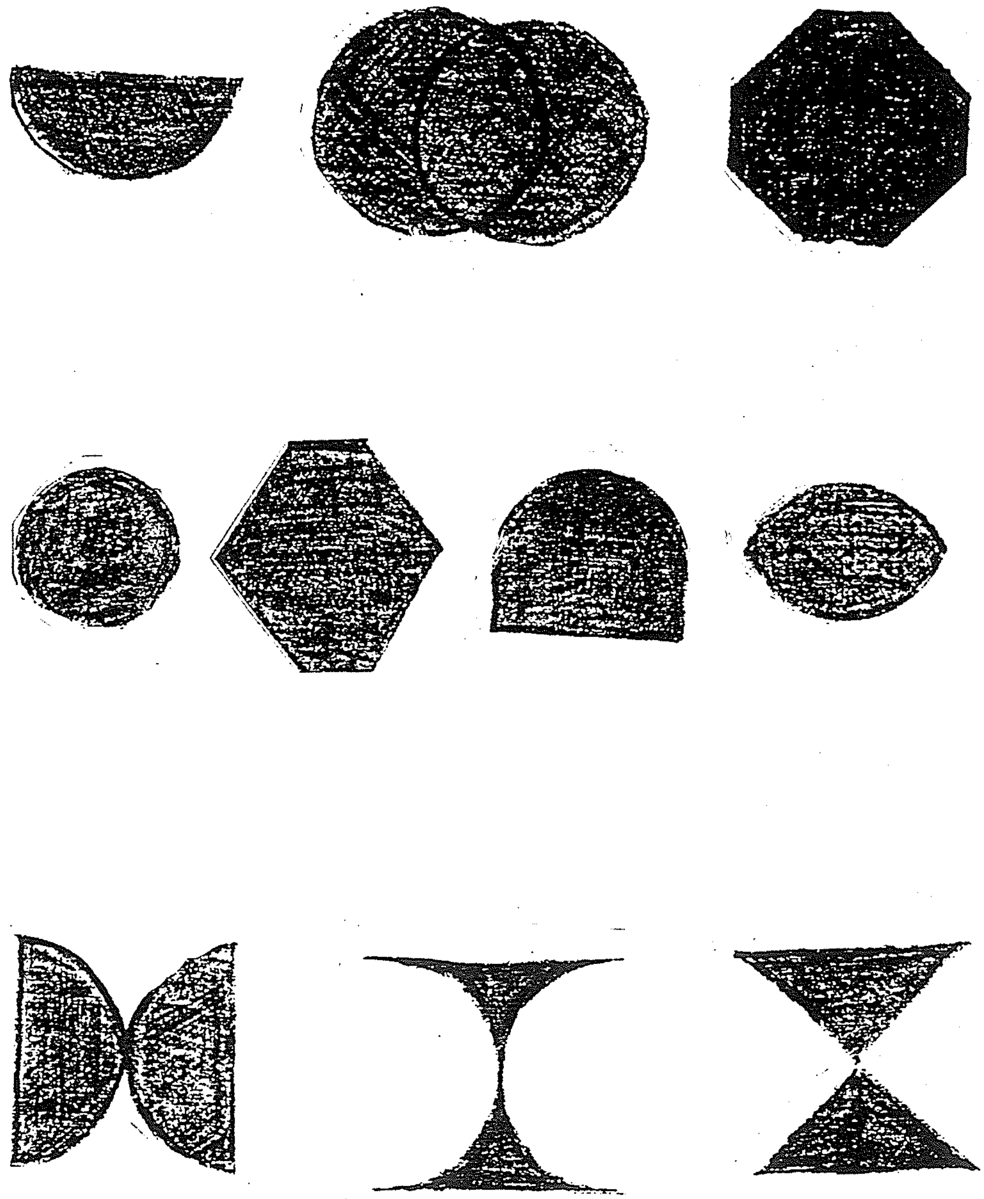
(a) Geometric figures

(b) Rorschach figures.

Geometric Figures, Page 1.

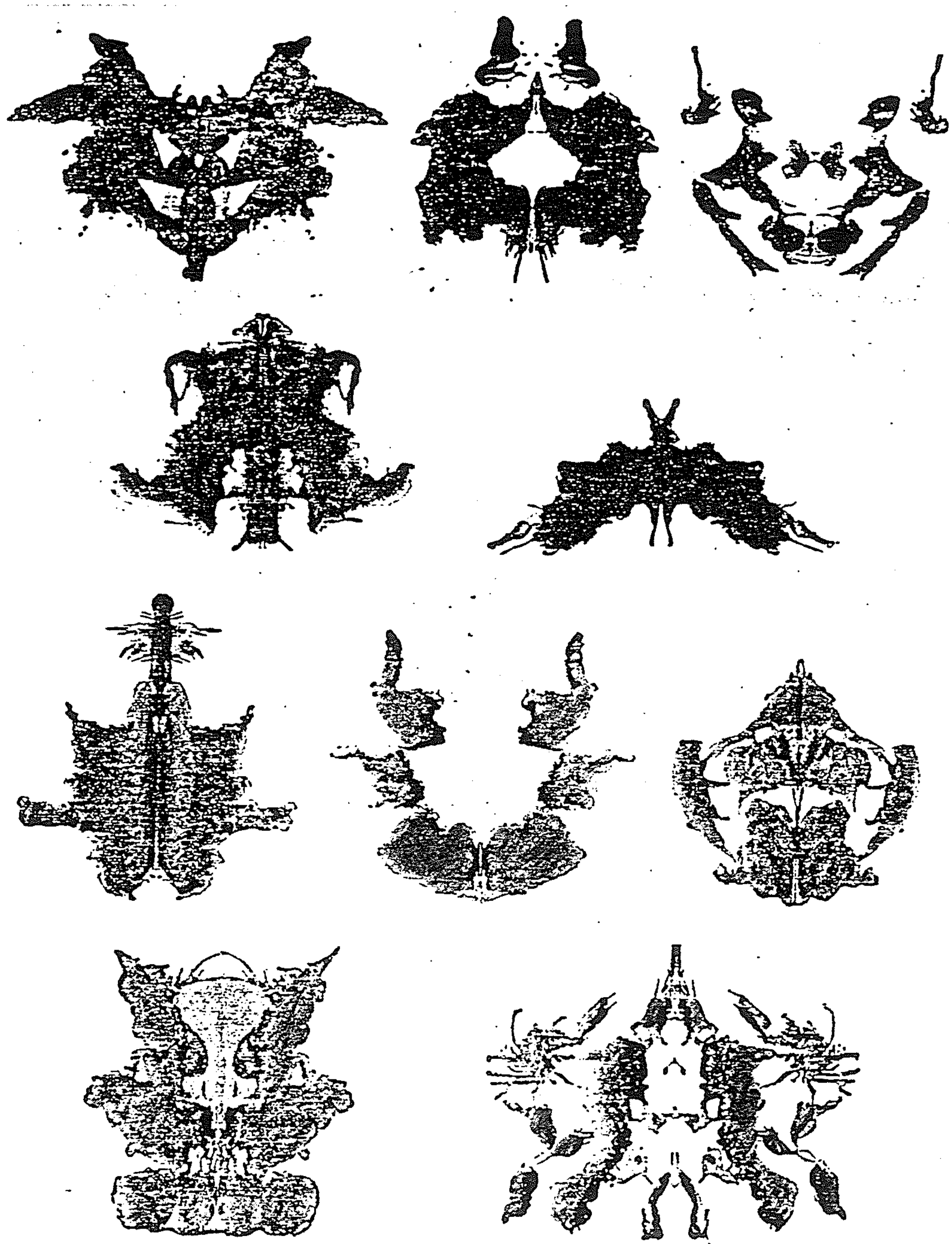


Geometric Figures, Page 2.



Stimuli From Rorschach Psychodiagnostics Schemablock

Recording Blank



Appendix D

CES Depression Scale.

INSTRUCTIONS FOR QUESTIONS: Below is a list of the ways you might have felt or behaved. Please tell me how often you have felt 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)

<u>During the past week:</u>

1. I was bothered by things that usually don't bother me.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

2. I did not feel like eating; my appetite was poor.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

3. I felt that I could not shake off the blues even with help from my family or friends.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

4. I felt that I was just as good as other people.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

5. I had trouble keeping my mind on what I was doing.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

6. I felt depressed.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

7. I felt that everything I did was an effort.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

8. I felt hopeful about the future.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

9. I thought my life had been a failure.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

10. I felt fearful.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

11. My sleep was restless.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

12. I was happy.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

13. I talked less than usual.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

14. I felt lonely.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

15. People were unfriendly.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

16. I enjoyed life.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

17. I had crying spells.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

18. I felt sad.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

19. I felt that people dislike me.

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

20. I could not get "going".

( ) Less than 1 Day
( ) 1 - 2 Days
( ) 3 - 4 Days
( ) 5 - 7 Days

Appendix E

Instructions to pretest and experimental subjects.

DIRECTIONS

The Machine. You are presently seated in front of an optical machine called a tachistoscope. This will be briefly "flashing" stimuli on the screen in front of you. The screen will remain lit throughout the experiment.

The Stimuli. Each stimulus presentation will begin with a black dot being presented in the center of the screen for half a second. Your task is to focus upon this dot. The dot will then be replaced with the experimental stimulus for approximately one tenth of a second. This will either be a "nonsense" word, or geometric shape, figure, blot, or form.

The Task. You are asked to make 2 judgements about each stimulus that you see on the screen in front of you:

1) how you felt about each stimulus (or what your emotional reaction was), on a positive to negative emotional scale. Feelings that represent the positive end of the scale might include: safe, gay, fine, enthusiastic, active, strong, sunny, light-hearted, dreamy, joyous.
   On the other hand, here are some possible feelings that would be placed at the "negative" end of the scale: miserable, gloomy, dull, sad, broken-hearted, listless, criticized, grieved, hopeless, oppressed.
   If you had little or no emotional reaction, or you neither felt positive nor negative about a stimulus, then you would place your judgement somewhere in the middle of the scale.

2) how confident you were about your emotional rating. If you are very unsure about how you felt, or if you were mainly "guessing", you would place your judgement at the "not confident" end of the scale. However, if you are very sure about how you felt, or if you did very little guessing, you would place your judgement at the "confident" end of the scale. If you just have some confidence in your emotional rating, or if you guessed somewhat, you would place your judgement somewhere in the middle of the confidence scale.

Important Points.

1) There are no "right" or "wrong" answers to this task. What is of interest is only your experience, and your perception, of each stimulus.

2) There is no time limit to your task. After each stimulus, there will be a several second delay while the next stimulus is prepared for presentation. When you have made your judgements, say "Ready", and the next stimulus will then appear.

3) Make sure that you make a judgement for all stimuli. If you did not think that you had time to react to a stimulus, simply close your eyes for a few seconds and try to recall what you felt during or immediately after its presentation.

4) As with all experiments, you may leave at any time if you have to or want to, and still receive your credit.

Appendix F

Ratings sheet.

(Page 1).

RATING SCALE

EMOTIONAL RATING — CONFIDENCE RATING

	Negative														Positive	Not confident														Confident
1.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
8.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
9.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Appendix G

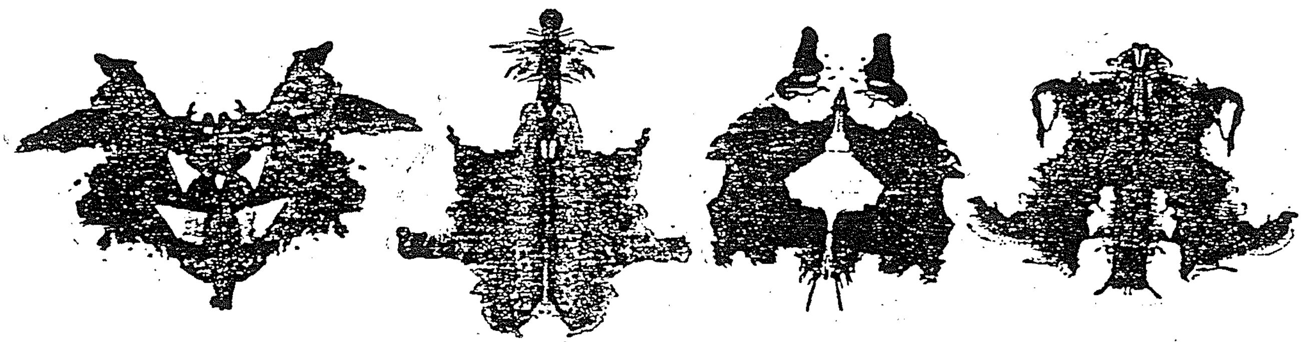
Stimuli for experiment proper:

(a) Verbal stimuli

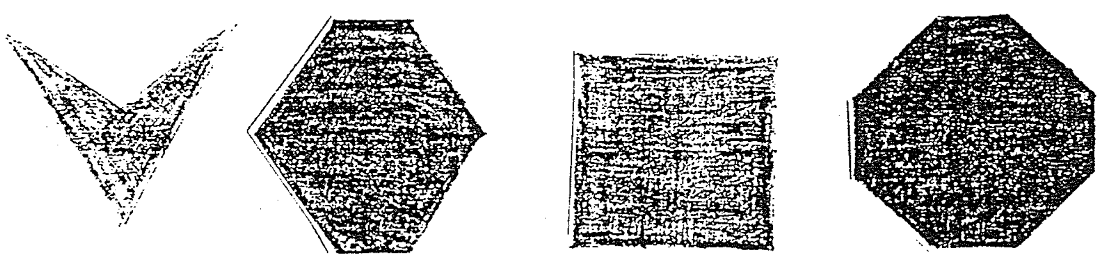
(b) Nonverbal stimuli.

Nonverbal Stimuli as a function of Emotional Category

Negative



Neutral



Positive