

Sex differences and cerebral asymmetry in facial affect perception as a function of depressed mood

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Twenty-four right-handed subjects (12 men and 12 women), half within each sex classified as with depressed mood and the other half as nondepressed, participated in a tachistoscopic study of the influence of depressive symptomatology on the hemispheric processing of emotional faces (happy, angry, and neutral). Slower emotional processing was found in women with depressed mood than was found in nondepressed women, whereas diametrically opposite effects were seen in men. Cerebral asymmetry was also found as a function of affective valence, with a right-hemisphere advantage for the identification of angry faces. Symmetry was found in the identification of happy faces. Additionally, women with depressed mood more often identified neutral faces as angry, whereas depressive symptomatology reduced the strong negative response bias in men, with increased ambivalence or uncertainty in neutral affect perception. These results are discussed in light of hypothesized differences in cerebral asymmetry with depression and according to sex.

A diversity of previous research has focused on the neuropsychology of depression. Evidence from clinical lesion studies has shown that left-hemisphere lesions tend to be associated with a catastrophic reaction syndrome exhibited by sadness, crying, and depressive mood, whereas right hemispheric lesions are characterized by indifference, apathy, and pathological laughing (Gainotti, 1969; Gainotti, 1972). Likewise, electroencephalogram studies have reported that depression is associated with increased right-hemispheric activation relative to that of the left hemisphere (Davidson & Fox, 1988; Schaffer, Davidson, & Saron, 1983; Tucker, Stenslie, Roth, & Shearer, 1981). Otto, Yeo, and Dougher (1987) suggest that this may occur as a result of either an increase in the activity of the right hemisphere or a decrease in left-hemisphere activity. Additionally, in studies using neuropsychological test batteries, depressives have demonstrated impaired performances consistent with right-hemispheric dysfunction (Kronfol, Hamsher, Digre, & Waziri, 1978; Silverstein, McDonald, & Meltzer, 1988).

Neuropsychological research has also revealed sex differences in hemispheric asymmetry. Right-handed women generally show more diffuse and bilateral representation of language and spatial abilities compared with men, who typically show greater lateralization of language abilities in the left hemisphere and of spatial abilities in the right hemisphere (Bradshaw & Nettleton, 1983; McGlone, 1980). Further, in a series of tachistoscopic studies, men

were shown to be significantly faster than women in processing affective facial stimuli presented to their left visual field (LVF; right hemisphere) (Harrison & Gorelczenko, 1990; Harrison, Gorelczenko, & Cook, 1990).

Studies of the hemispheric perception of emotion have consistently revealed an LVF superiority for identifying facial affective stimuli, providing evidence for greater right-hemisphere involvement in the processing of affect (McKeever & Dixon, 1981; McLaren & Bryson, 1987). Other research has indicated a differential hemispheric superiority of the right hemisphere for processing negative emotion and of the left hemisphere for processing positive emotion (Reuter-Lorenz & Davidson, 1981; Reuter-Lorenz, Givis, & Moscovitch, 1983).

The purpose of the present experiment was to provide preliminary data on depressed men and women (i.e., those who reported significant depressive symptomatology) versus nondepressed men and women in the hemispheric processing of affective facial stimuli. Since prior research has indicated a right-hemisphere superiority for processing negative emotion, it was hypothesized that the subjects would display improved reaction times for negative affect with presentation to the right hemisphere (LVF). Since women appear less strongly lateralized, it was predicted that women would show reduced cerebral asymmetry for negative affect. Further, if depression results from a relative decline in left-hemisphere activation, it was hypothesized that depressed mood would impact cerebral asymmetry in affect perception, with heightened right cerebral advantages for both sexes. This effect was predicted to be more pronounced in men, who generally display less diffuse processing of negative emotion. Also, if women rely on left-hemispheric processing of emotion, and depression

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impairs left cerebral systems, then women with depressed mood may show increased cerebral asymmetry and an overall reduction in emotional processing speed. For the affectively neutral stimuli, a negative affective, response bias was predicted. Based on previous findings of right-hemispheric activation in depression and of increased right cerebral asymmetry for emotion in men, males with depressive symptomatology were expected to show a greater negative response bias to neutral stimuli than were women with depressed mood and nondepressed men.

METHOD

Subjects

Group screening was conducted to identify right-hand dominant subjects with depressed mood (i.e., those who reported significant depressive symptomatology) and right-hand dominant nondepressed individuals (12 men and 12 women in total). These volunteer subjects were recruited via sign-up sheets from undergraduate psychology courses. The mean age of the subjects was 18.8 years ($SD = 1.5$). Half of the subjects within each gender had been classified via the Beck Depression Inventory (BDI; Beck, 1972) as with depressed mood and the other half as nondepressed. No attempt was made to determine specific DSM-III-R depression diagnoses. As more nondepressed individuals met selection criteria (see Group Classification section) than were needed, the nondepressed subjects were randomly selected from their respective pool. The subjects were all unmedicated and free from concurrent medical illnesses. Additionally, the women were not tested with regard to the phase of their menstrual cycle.

Group Classification

Handedness was determined using a validated self-report questionnaire (Coren, Porac, & Duncan, 1979) consisting of 13 items which inventoried four types of lateral preference (hand, foot, eye, and ear). Average concordance between self-report and behavioral measures for the test is stated at .90. Items were scored as +1 for "right-handed," -1 for "left-handed," and 0 for "both" responses. A score of +6 or more was the criterion for right-hand dominance and inclusion in this study.

Depressed mood was assessed using the validated self-report, BDI, (Beck, 1972). Scores on this 21-question measure may range from 0 to 63. Subject scores of 0-9 (BDI normal range) were considered nondepressed, while subjects who scored +12 or more were considered to have significant depressive symptomatology (i.e., depressed mood).

Stimuli and Apparatus

Thirty emotional faces (10 happy, 10 neutral, and 10 angry) from Ekman and Friesen's (1978) validated pictures of facial affect were randomly selected. Pictures were reproduced on slides, with the stimulus appearing in either the right visual field (RVF) or the LVF. Stimuli were mounted with the inside edge of the picture 3° from center and the outside edge 12° from center. A total of 60 slides (10 RVF happy, 10 LVF happy, 10 RVF neutral, 10 LVF neutral, 10 RVF angry, 10 LVF angry) were used.

The subjects were tested in a sound-attenuated chamber. All time-based and event recording was performed in a separate room using automated programming equipment. Subjects were monitored from this separate room and prompted via an intercom. Stimuli were presented using a Constant Illumination Tachistoscope (Lafayette Model 42011) which projected them onto a white screen which was at a distance of 2.67 m and was 1.35 m in front of the subject. The screen's center was marked with a black dot positioned 1.47 m above the floor. Luminance level was 4.5 cd/m², reduced to 2.5 cd/m² during stimuli presentation. Trial onset was signaled by a 2000-Hz,

55-dB tone located behind the subjects. Manipulanda consisted of two "soft touch" trip switches mounted flush on the midline of a right-handed student desk, 58.5 cm from the chair's back. Switches were separately labeled "happy" and "angry."

Procedures

The procedures were approved by the Institutional Review Board and Human Subjects Committee. Upon arrival for testing, subjects were seated and received a second BDI screening. Only subjects who scored within their previous groups' screening range were tachistoscopically tested. The subjects were then given the following task instructions:

In this part of the study, you will have to make decisions concerning faces which you will see on the screen. The presentation of the faces will be brief and either to the left or to the right of the black dot. The presentation of the face will be preceded by a tone (the tone is sounded). We ask that, upon hearing the tone, you focus on the black dot because the face will be presented about 3 seconds after the tone. We also ask that you use your right index finger to choose whether the face is happy or angry. Please keep your index finger raised above and between the two switches. After the presentation of the face, please make your selection by pressing the switch labeled "happy" or "angry." Please respond as quickly and as accurately as possible. To get you used to the procedure, practice trials will be provided. Also, we will inform you when the practice trials end and the study begins. There is an intercom located behind you if you need to contact us. We will remind you to fixate on the black dot during the testing. Any questions?

After reading the instructions, practice trials were initiated, consisting of slides showing 10 happy and 10 angry faces. A 1-sec duration tone signaled the impending presentation of an affective face. Three seconds after the tone, a stimulus slide was shown for 200 msec. Subject identification of the affective valence of stimuli was made using a two-choice reaction-time paradigm. Intertrial intervals were 15 sec. The subjects were required to identify 8 consecutive slides correctly within the first three replications of practice slides for study inclusion.

The actual test phase consisted of slides showing 20 happy, 20 neutral, and 20 angry faces. The same presentation process as described for the practice set was used. A restricted (3 affects, 2 response alternatives) forced-choice reaction-time paradigm was used. Subjects were reminded to focus on the black dot at the screen's center after every 18 slides to improve integrity of stimulus presentation within visual fields. Location of response keys (happy, angry) was counterbalanced across subjects to eliminate position effects. Three randomized orders of slide presentation were also used to control order effects.

RESULTS

A mixed-design analysis of variance (ANOVA) with the fixed factors of group (depressed mood and nondepressed) and sex and with repeated measures of visual field (right and left) and slide affect (happy and angry only) was performed using the reaction-time scores. Post hoc, pairwise comparisons of the means were performed using Tukey's Standardized Range (*HSD*) test. Data corresponding to the neutral affect stimuli were analyzed separately.

The sex \times group interaction was significant [$F(1,20) = 5.02, p < .036$; see Figure 1]. Improved emotional perception was found in men with depressed mood compared with that of nondepressed men, whereas diametrically opposite effects of depression on emotional perception were found in women. Post hoc analysis showed that men with depressed mood had significantly faster reaction times to

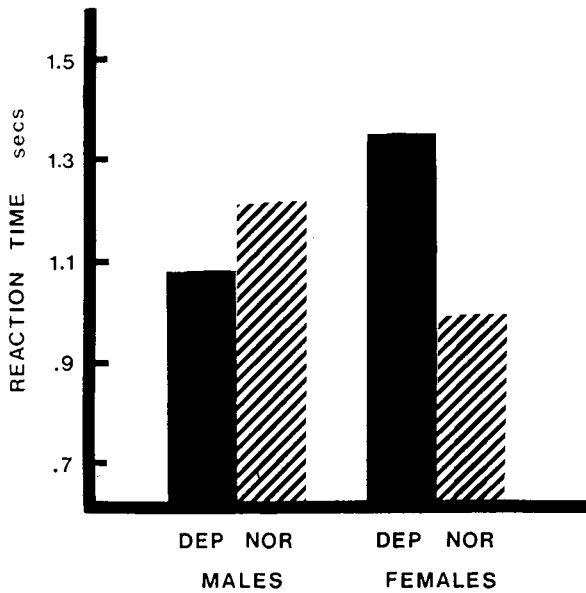


Figure 1. Reaction time as a function of sex and group (dep = depressed; nor = normal).

affective stimuli than did women with similar depressive symptomatology ($p < .05$). The women with depressed mood also displayed significantly slower reaction times ($p < .05$) than did nondepressed women.

The visual field \times slide affect interaction was significant [$F(1,20) = 5.79, p < .03$; see Figure 2]. Specifically, post hoc analysis showed that angry faces were identified faster within the LVF than they were within the RVF ($p < .05$), whereas no reliable visual field advantage was found for happy faces.

The main effect of slide affect was also significant [$F(1,20) = 14.13, p < .0012$]. Happy faces were identified more rapidly than were angry faces, irrespective of visual field. There was a marginal effect of visual field [$F(1,20) = 3.99, p < .06$]. Reaction times tended to be faster in the LVF than in the RVF, irrespective of the facial affect depicted.

The ANOVA on the neutral slides, with reported affect (response bias) as the dependent variable, is depicted in Figure 3. The sex \times group interaction was significant [$F(1,20) = 5.10, p < .04$]. Post hoc analyses revealed significant differences ($p < .05$) between groups of men as well as between groups of women. Specifically, nondepressed men tended to identify neutral stimuli as angry more often than did men with depressed mood, while the opposite trend was found among the groups of women. Further, nondepressed men were found to identify neutral stimuli as angry significantly more often ($p < .05$) than were nondepressed women. The main effect of sex was also significant [$F(1,20) = 7.05, p < .02$]. Men tended to identify neutral affect as being angry more often than did women.

The reaction-time data to neutral affective stimuli also revealed significant results. The group \times visual field inter-

action was significant [$F(1,20) = 5.62, p < .03$]. Post hoc analysis revealed that the subjects with depressed mood had significantly slower reaction times ($p < .05$) to stimuli presented to their LVF than they did to those presented to their RVF. Further, both LVF and RVF reaction times in depressives were significantly slower ($p < .05$) than they were in nondepressed subjects' respective visual fields.

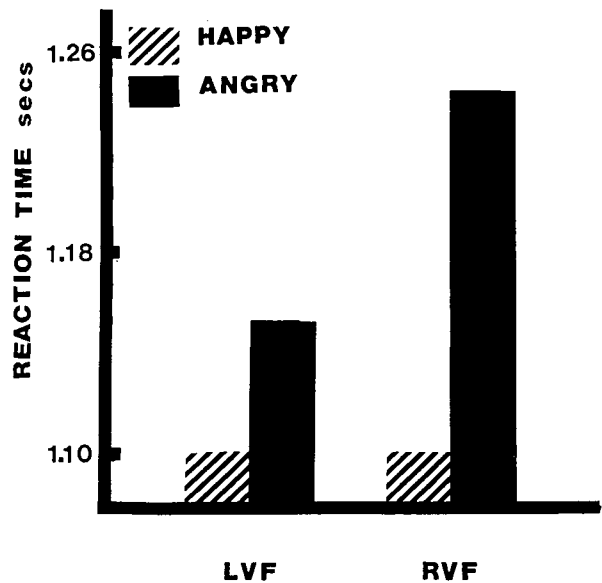


Figure 2. Reaction time as a function of positive and negative affect and visual field.

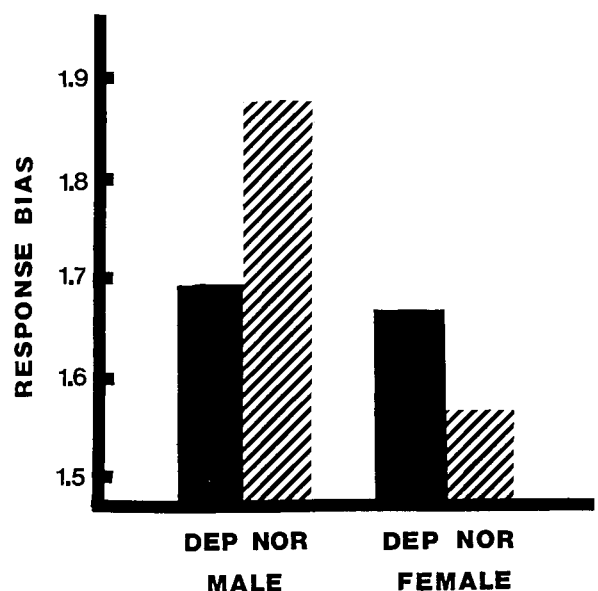


Figure 3. Mean reported affect (response bias) for the neutral faces (1 = happy; 2 = angry) as a function of group and sex.

DISCUSSION

The primary finding from the data in this study was that of confirmation of the hypothesis that depressed mood may differentially impact the left hemisphere (linguistic strategies), on which women may rely to analyze affective stimuli, and so result in heightened dysfunction in depressed women as compared with depressed men. Specifically, compared with nondepressed women, the ability of women with depressed mood to process emotional faces decreased, as seen tachistoscopically in heightened response-time measures, whereas diametrically opposite effects were found in men. These data are consistent with previous studies that have found increased lateralization for emotion with the right hemisphere in men compared with women (Harrison & Gorelczenko, 1990; Harrison et al., 1990). The faster reaction times seen in men with depressed mood compared with women with similar symptomatology may be a combined result of this increased lateralization of emotion and a relative activation of the right hemisphere previously identified in depressed subjects (Davidson & Fox, 1988; Schaffer et al., 1983; Tucker et al., 1981). These results also appear to be consistent with previous literature that describes women as having a more diffuse and bilateral representation of language and spatial abilities than do men (Bradshaw & Nettleton, 1983; McGlone, 1980). The slower reaction times to affective stimuli in women with depressed mood appear to coincide with previous research. Ladavas, Nicoletti, Umiltà, and Rizzolatti (1984) found a lengthening of reaction times to visual stimuli presented to the right hemisphere of female subjects following sad mood induction. It may be that emotional processing in women requires a greater verbal component than it does in men, and the slower reaction times to affective stimuli seen in women with depressed mood in the present study may be attributable to increased processing time that results from a decrease in activation of the language areas in the left hemisphere (Davidson & Fox, 1988; Otto et al., 1987).

The findings that happy faces were identified more rapidly than were angry faces irrespective of visual field, while angry faces were identified significantly faster when presented to subjects' right hemispheres (LVF) than they were when presented to their left hemispheres (RVF) are all consistent with those previously reported by Harrison and associates (Harrison & Gorelczenko, 1990; Harrison et al., 1990). Further, these results support the prevalent finding of a right-hemisphere superiority for the processing of angry affective stimuli irrespective of the sex or depression category of the subject (McKeever & Dixon, 1981; McLaren & Bryson, 1987). Happy faces, however, were identified equally fast in both visual fields. This finding of bilateral positive, but not negative, affect processing capability supports the argument of McKeever and Dixon (1981) that the right hemisphere is specialized for the recognition of affective stimuli as well as for visuospatial processing.

As regards the neutral stimuli reaction-time findings, the subjects with depressed mood displayed significantly

slower reaction times to neutral stimuli presented their LVF than they did to those presented to their RVF. Further, in depressives both LVF and RVF reaction times to neutral stimuli were slower than they were in the respective visual fields of nondepressives. These results of subjects with depressive symptomatology may reflect overall decreases in the abilities of the hemispheres to process ambiguous stimuli, as well as increased interhemispheric transfer time of information, in depression.

As hypothesized, women with depressed mood identified neutral faces as angry more often (response bias) than did nondepressed women. This may reflect a relative increased activation of the right hemisphere in women with depressed mood and a corresponding tendency to perceive neutral stimuli as negative. In contrast, nondepressed men identified neutral stimuli as angry significantly more often than did depressive men. This may indicate a near-ceiling effect in nondepressed men for identifying neutral stimuli as negative (see Figure 3). It is hypothesized that as stimulus ambiguity increases, so does reliance on verbal/left-hemisphere strategies to assist the right hemisphere in affective processing. Inasmuch as depression is thought to result in a relative decrease in activation of the left hemisphere, this in turn causes increased uncertainty in men with depressed mood as to whether neutral faces are angry and the corresponding disrupted response bias.

The validity of the present study's findings may be questionable given the small sample size and the fact that subjects were classified according to their self-reported BDI scores without a specific DSM-III-R depressive disorder being determined. However, if one evaluates the validity of these results based on redundant measures which are consistent with earlier research, then this study may be interpreted as valid. Future research is required, however, to further validate and confirm the present findings. Specifically, studies are needed which replicate the current study using larger population samples and severely clinically depressed subjects. It seems possible that the results obtained in the current study with the subjects with depressed mood (as measured by the BDI) may be magnified in individuals with major depressive disorders.

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