Facial affect perception in anxious and nonanxious men without depression

D. ERIK EVERHART

SUNY at Buffalo School of Medicine, Buffalo, New York

and

DAVID W. HARRISON

Virginia Polytechnic Institute and State University, Blacksburg, Virginia

In two experiments a tachistoscopic paradigm was used to examine hemispheric differences in facial affect perception among anxious and nonanxious men without depression. In Experiment 1, hemispheric processing of Ekman and Friesen's (1978) happy, angry, and neutral emotional faces was tachistoscopically examined, with reaction time as the dependent variable. The following results were obtained: (1) a right-hemisphere (LVF) advantage for the perception of facial affect, consistent with previous reports of the right hemisphere's relative specialization for facial affect perception and (2) slower reaction time to facial affect stimuli for anxious men, regardless of valence and visual field. Similar procedures were used in Experiment 2, but with accuracy rather than reaction time as the dependent measure. Analyses yielded a three-way interaction, with anxious men identifying angry affects in the left versus right visual field more accurately, whereas nonanxious men demonstrated symmetry for the processing of angry affects. Implications for hemispheric asymmetry (i.e., relative right posterior activation) among anxious individuals without depression are discussed.

The neuropsychological investigation of anxiety among humans has recently received increased attention within the literature. In one of the most noted human neuropsychological theories of anxiety, Heller (1993) proposed that anxious individuals without depression demonstrate relatively greater *right anterior* and *right posterior* functional activation, whereas individuals without anxiety do not. Heller's theory reflects an integration of the work of multiple investigators involved in research on emotion, psychology, neuropathology, neurophysiology, neuropsychology, and behavioral neurology. Historically, there has been strong support of hypotheses regarding relatively greater right anterior activation for individuals experiencing negative affective states (particularly fear and anxiety), reflecting numerous electrophysiological (EEG) experiments and tremendous consistency across findings (Davidson, 1993, 1995; Davidson & Fox, 1988). Right anterior activation during negative affective states (i.e., anxiety and hostility) has also been demonstrated in our laboratory through the use of quantitative electroencephalography (Everhart & Harrison, 1996) and has been inferred via anxious individuals' performance on neurobehavioral measures that are reflective of anterior functioning (Everhart, Shenal, & Harrison, 1998). In contrast, few studies have explored the function of the right posterior region as it may

relate to anxiety without depression. This is partially due to previous failures of EEG studies to find "emotion-related" activity in this region (Heller, 1993), and to the relatively few studies that have adequately controlled for depressive symptoms (e.g., psychomotor retardation), which are known to be highly correlated with anxiety, and thus may account for discrepant results within the literature.

Although previous EEG studies have not adequately demonstrated a relationship between emotion and the right posterior cerebral region, there is support for relatively greater right posterior activation among anxious individuals. Support for this theory is derived from mounting evidence of the right posterior region's role in the regulation of the autonomic nervous system (Herridge, Harrison, & Demaree, 1997; Wittling, 1995) and from well-documented evidence of autonomic hyperarousal found among anxious individuals (Barlow, 1988; Heller, 1993; Heller, Etienne, & Miller, 1995; Heller, Nitschke, Etienne, & Miller, 1997).

Facial Affect Perception and the Right Hemisphere

Although research associated with the autonomic nervous system, hemispheric asymmetry, and anxiety is currently proliferating, there are relatively few published experiments in which right posterior functioning in anxious individuals without depression has been examined via the use of neurobehavioral measures. One way in which right posterior functioning is examined neurobehaviorally is to use tasks that assess emotion processing (e.g., facial affect processing). Studies of the perception of facial affective

Correspondence should be addressed to D. E. Everhart, Division of Developmental and Behavioral Neurosciences, Department of Neurology, SUNY at Buffalo School of Medicine, 100 High Street (D6), Buffalo, NY 14203 (e-mail: evmeverhart@juno.com).

stimuli have consistently demonstrated right-hemisphere superiority (or LVF advantage) for the identification of facial affective stimuli (McKeever & Dixon 1981; McLaren & Bryson, 1987). Moreover, the perception of facial affect is dissociable from facial identification (also strongly associated with right-hemisphere processing), as some prosopagnosics can identify facial emotions even though they cannot recognize faces (Bauer, 1984; Sergent, 1994; Tranel, Damasio, & Damasio, 1988). Lesion studies have implicated subcortical structures (e.g., the amygdala) in the perception of facial affect (e.g., Adolphs, Tranel, Damasio, & Damasio, 1994, 1995). However, in subjects with focal brain damage, Adolphs, Damasio, Tranel, and Damasio (1996) found cortical surface regions associated with processing of facial affect (right inferior parietal cortex and the right mesial anterior intracalcarine cortex). Impaired recognition of facial affect following lesion to right posterior regions has also been described by other groups (e.g., Bowers, Bauer, Coslett, & Heilman, 1985; Rapcsak, Comer, & Rubens, 1993; Sergent, 1994).

Thus, in assuming that facial affect processing requires utilization of the right posterior cortex, Heller et al. (1995) administered a chimeric face-processing task (which typically elicits a left hemispatial bias) to four groups of subjects; high-anxious/low-depressed, high-depressed/low-anxious, high-anxious/high-depressed, and low-anxious/low-depressed. The normal left hemispatial bias observed on this task was greater for individuals with elevated levels of anxiety. The authors interpreted this finding as evidence of relatively greater right posterior functional activation among individuals with elevated levels of anxiety.

The Present Experiments

Our purpose in the present two tachistoscopic experiments was to further explore right posterior functioning in anxious men without depression via their perception of positive, negative, and neutral facial stimuli, in comparison with that in men who do not report elevated levels of anxiety. Prior research has suggested relatively greater right-hemisphere activation in anxious individuals without depression, although there is little research that tachistoscopically examines the relationship between anxiety without depression and perception of positive, negative, and neutral emotional faces. The use of a divided field tachistoscope paradigm allows for the examination of hemispheric asymmetry with respect to the perception of affect as a function of anxious mood. This has not been previously examined. In the first experiment, Ekman and Friesen's (1978) pictures of happy, angry, and neutral faces were tachistoscopically presented within the left and right visual half fields to anxious and nonanxious men without depression. The dependent measure for the first experiment was reaction time. There are four important distinctions between the first and second experiments. First, time demands for Experiment 2 were eliminated, because the dependent measure was accuracy rather than re-

action time. Second, exposure time of facial affective stimuli was significantly decreased from 250 to 50 msec (thereby making the identification of facial affect more difficult). Third, the number of total trials per subject was doubled (from 20 to 40). Fourth, a "middle anxiety" group was added in order to provide more information regarding emotional processing among men who report "mid" levels of anxiety.

In a similar previous experiment (using only reaction time as a dependent variable) that utilized *depressed* and *nondepressed* men and women and similar emotional stimuli, Crews and Harrison (1994) found the following: (1) right hemispheric superiority (faster reaction time when stimuli were presented to the LVF) for the processing of emotional faces, (2) faster emotional processing (e.g., reaction time) for facial affect among depressed as opposed to nondepressed men, and (3) slower emotional processing for facial affect among depressed as opposed to nondepressed women. Given the well-documented association between anxiety and depression, it may be assumed that many of the subjects also experienced elevated levels of anxiety. However, Crews and Harrison did not report Beck Depression Inventory Scores or Trait Anxiety Scores, making such statements, as they apply to this experiment, speculative.

Based on previous findings that anxious individuals without depression have larger left hemispatial biases than do nonanxious individuals, that negative affect is processed faster in the left visual field (right hemisphere), and that depressed men who were likely anxious processed emotional stimuli faster than nondepressed men (Crews & Harrison, 1994), it was predicted that anxious men would have faster reaction times than would nonanxious men for affective stimuli.

EXPERIMENT 1

Method

Subjects. Group screening was conducted to identify right-handed men with elevated levels of anxiety who did not endorse having depressive symptomatology and right-handed men with low levels of anxiety ($n = 60$). Thirty of the men were classified as having elevated anxiety levels without depression and the other 30 as having low anxiety levels without depression. Women were excluded from the study because of previous findings of increased lateralization for emotion with the right hemisphere in men compared with women (Harrison & Gorelczenko, 1990; Harrison, Gorelczenko, & Cook, 1990).

Group classification. Handedness was determined using a validated self-report questionnaire (Coren, Porac, & Duncan, 1979) consisting of 13 items that inventory four types of lateral preference (hand, foot, eye, and ear). The criterion for right-hand preference and inclusion in the study was a score of +6 or more, indicating a strong right-hemibody preference. Depression was assessed using the validated self-report Beck Depression Inventory (BDI; Beck, 1972). Only subjects scoring from 0 to 9 (*not depressed*, according to clinical cutoffs described by Beck) were considered for the study. Anxiety was assessed using the validated self-report State-Trait Anxiety Inventory (STAI; Spielberger, 1968). Since one goal of this study was to investigate subjects with elevated levels of anxiety "in

general," only the trait inventory of the STAI was considered. Subjects with scores of 41 or higher were classified as having elevated anxiety levels. Subjects with scores of 31 or lower were classified as having low levels of anxiety.

Stimuli and Apparatus. The stimuli and apparatus were adapted from those previously used by Harrison et al. (1990). Thirty emotional faces (10 happy, 10 neutral, and 10 angry) were selected from Ekman and Friesen's (1978) validated pictures of facial affect. The slides with the highest interrater agreement (according to Ekman & Friesen, 1978) were selected in order to optimize accuracy across subjects. These pictures were reproduced onto slides, with the stimulus face appearing in either the right or the left visual half field (RVF, LVF). The stimuli were mounted with the inside edge of the picture 3° from the center and with the outside edge 12° from the center. A total of 60 slides (10 RVF happy, 10 LVF happy, 10 RVF neutral, 10 LVF neutral, 10 RVF angry, and 10 LVF angry) were used.

The subjects were tested in a sound-attenuated experimental chamber. The automated programming equipment and the experimenter were located in a separate room. The subject was monitored through an observation window and prompted via an intercom. The stimuli were presented by a constant illumination tachistoscope (Lafayette Model 42011) onto a screen at a distance of 2.67 m. The screen was placed 1.35 m in front of the subject. The center of the screen was marked with a black dot positioned 1.47 m above the floor. The luminance level was 4.5 cd/m² reduced to 2.5 cd/m² during stimulus presentation. Stimulus onset was signaled by a 2000-Hz, 55-dB (A scale, .002 dynes/cm²) tone located behind the subjects. Manipulanda consisted of two "soft touch" trip switches flush mounted on the midline of a right-handed student desk, 58.5 cm from the back of the chair. The switches were separately labeled "happy" or "angry."

Procedure. Upon their arrival, the subjects received another pre-screening with the State-Trait Anxiety Inventory to assure relative stability of the level of anxiety. Only subjects who scored within their previous group screening ranges were tested tachistoscopically; others were debriefed and excused.

The subjects who were tested tachistoscopically were administered the following tachistoscopic 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 sec 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 the instructions were read to the subjects, practice trials consisting of 10 happy and 10 angry slides were initiated. A 1-sec tone signaled the impending presentation of an affective face. Three seconds after the tone, the stimulus slide was shown for 250 msec. The subjects identified the affective valence of the face stimuli according to a forced-choice paradigm. The intertrial intervals were 15 sec. The subjects were required to identify 8 consecutive slides correctly within the first three replications of the practice slides for inclusion in the study.

The actual test phase consisted of 20 happy, 20 angry, and 20 neutral slides. A restricted (3 affect, 2 response alternatives) forced-choice reaction time paradigm was used, in which the subjects were required to indicate whether the presented affect was "happy" or "angry." No selection for "neutral" was offered. The subjects were

instructed to focus on the fixation point at the center of the screen after every 20 slides to improve the integrity of stimulus presentation within either visual field. The location of the response keys corresponding to "positive" or to "negative" affect were counterbalanced across subjects to eliminate position effects. Three randomized orders of slide presentation were used to control for order effects.

Results

A total of 126 college-aged right-handed males were administered the Handedness Questionnaire, BDI, and State and Trait portions of the STAI. Sixty individuals (30 anxious/nondepressed, 30 nonanxious/nondepressed) were selected to participate in the tachistoscopic procedure on the basis of the criteria discussed earlier. Separate (for anxious and nonanxious subjects) group means and standard deviations are reported in Table 1 for the BDI and the STAI.

A three-factor mixed design analysis of variance (ANOVA) with the fixed factor of group (anxious/nonanxious) and with repeated measures of visual field (left and right) and slide affect (happy and angry only) was performed. Winer (1971) recommends transformation procedures for reaction time data in order to improve homogeneity of variance for this dependent variable. Using the transformation of 1/reaction time, we found that the main effect of group was significant [$F(1,58) = 6.88, p < .05$]. Reaction times of anxious subjects were significantly slower than those of nonanxious subjects, regardless of visual field and depicted facial affect. The main effect of slide affect was also significant [$F(1,58) = 34.78, p < .001$]. Happy faces were identified more rapidly than angry faces, irrespective of visual field. A significant main effect for visual field was also demonstrated [$F(1,58) = 7.14, p < .01$]. Facial affect presented to the right hemisphere (LVF) was identified more rapidly, regardless of valence. No other reliable interactions or main effects were found with the use of this transformation. (Refer to Table 2 for means and standard deviations of significant main effects.)

In a descriptive fashion, anxious and nonanxious subjects were equivalent in accuracy rate for Experiment 1. Ninety-six percent of the presented affective slides were correctly identified by anxious subjects and nonanxious subjects. There were no significant differences between

Table 1
Means and Standard Deviations for High and Low Anxious Subjects

Measure	<i>M</i>	<i>SD</i>
High Anxiety (<i>n</i> = 30)		
BDI	7.33	2.11
State	36.73	8.42
Trait	45.80	5.90
Low Anxiety (<i>n</i> = 30)		
BDI	2.40	2.55
State	24.40	4.42
Trait	26.97	2.71

Note—BDI, Beck Depression Inventory; State, Trait, respective portions of State-Trait Anxiety Inventory.

Table 2
Means and Standard Deviations of Significant Main Effects
(Reaction Time)

Source (<i>n</i> = 60)	<i>M</i> (sec)	<i>SD</i>
Group (Happy and Angry Affects)		
Anxious	1.056	0.446
Nonanxious	0.886	0.299
Slide Affect		
Happy	0.920	0.356
Angry	1.021	0.414
Visual Field		
Left	0.959	0.391
Right	0.982	0.378
Group (Neutral Affect)		
Anxious	1.330	0.402
Nonanxious	1.075	0.270
Visual Field (Neutral Affect)		
Left	1.210	0.360
Right	1.200	0.390

groups when positive and negative affects were examined separately. Pearson product moment correlations were performed between the reaction time data and the number of errors for each condition. These correlations are listed in Table 3. As can be seen, there were multiple significant positive correlations, indicating that longer reaction times were associated with more errors. Thus, there was no speed-accuracy tradeoff.

Given the nature of this forced-choice paradigm (where a "neutral affect" selection was not offered), it was decided to analyze the reaction times to neutral affects in a separate ANOVA. The neutral affect data were considered separately because the subjects were unaware of the presence of neutral faces, and therefore, the data were qualitatively different from the data for happy and angry affects. This analysis revealed a significant group effect [$F(1,58) = 8.37, p < .001$]. As with angry and happy affects, anxious men demonstrated significantly slower reaction times to neutral affects than did nonanxious men, regardless of visual field (see Table 2). No other reliable interactions or main effects were revealed from the analyses of reaction time data for neutral affects. An ANOVA was also performed on reported affect (i.e., response bias of "happy" or "angry") as the dependent variable. No reliable interactions or main effects were revealed in this analysis. Therefore, no group differences in response bias were revealed, nor were any differences across visual fields noted.

Discussion

Analysis of the data from Experiment 1 revealed three relevant findings. First, as demonstrated in previous tachistoscope studies (Crews & Harrison, 1994; Harrison & Gorelzenko, 1990), right-hemisphere (LVF) superiority was found for the processing of facial affect stimuli, suggesting that the right hemisphere is dominant in the processing of facial affect stimuli. Second, consistent with previous reports (Crews & Harrison, 1994), happy affective stimuli were identified more quickly than angry af-

fective stimuli. Third, the hypothesis of anxious versus nonanxious men having faster reaction times to emotional stimuli presented tachistoscopically was not supported by the results of this study. That is, anxious men were significantly slower than nonanxious men in the processing of facial affective stimuli.

The third finding is somewhat surprising, given that Crews and Harrison (1994) found depressive (and likely anxious) men to have faster reaction times to affective stimuli. However, these results do lend support to the notion that differing physiological phenomena accompany individuals with high versus low anxiety when depressive symptomatology is screened out, and the results possibly suggest neuropsychological differences between anxious men without depression and anxious men with depression.

Regarding the results of Experiment 1, several theoretical and methodological limitations must be addressed. First, the tachistoscope paradigm was complex, in that it required the subjects to visually perceive a stimulus presented in short duration, assess affective valence (happy or angry), and then motorically (with the finger) indicate the affective valence that they had perceived. The task demanded that one utilize multiple cerebral areas (grossly

Table 3
Pearson *r* Correlations Between Reaction Time and
Number of Errors Across Condition

Condition	<i>r</i>
Group	
Anxious	.26
Nonanxious	.51†
Affect	
Happy	.42†
Angry	.31*
Visual Field	
Left	.27*
Right	.29*
Group × Affect	
Anxious, happy	.29
Anxious, angry	.37*
Nonanxious, happy	.54†
Nonanxious, angry	.34*
Group × Visual Field	
Anxious, left	.32*
Anxious, right	.33*
Nonanxious, left	.28
Nonanxious, right	.50†
Affect × Visual Field	
Happy, left	.21
Happy, right	.42†
Angry, left	.33*
Angry, right	.18
Group × Visual Field × Affect	
Anxious, left, happy	.14
Anxious, right, happy	.34*
Anxious, left, angry	.41*
Anxious, right, angry	.18
Nonanxious, left, happy	.22
Nonanxious, right, happy	.51*
Nonanxious, left, angry	.36*
Nonanxious, right, angry	.24

* $p < .05$. † $p < .01$.

speaking, anterior for motor output and posterior for perception). It was possible that relative differences in anterior functioning (e.g., executive functioning, motor preparedness, perseveration, and behavioral speed) among anxious individuals contributed somewhat to their performance on the tachistoscopic task. In support of this, Davidson (1995) reported deficits associated with relative left anterior deactivation (e.g., decreased initiation and motivation) concurrent with negative emotional states (e.g., depression and anxiety). In addition, it is thought that the left frontal region is more specialized for learned, skilled, and purposeful action (Poizner et al., 1998). There is also more direct support that anxious individuals without depression demonstrate left anterior deactivation; using a hand dynamometer, Everhart et al. (1998) found failure to demonstrate superior dominant hand grip strength among 30 anxious, nondepressed college men, whereas 30 nonanxious college men demonstrated dominant hand grip strength superiority. Should anxious individuals experience relative right anterior activation (resulting in a negative affective state and decreased initiation), it is plausible that their ability to motorically respond when time demands are placed on them is somewhat diminished.

Second, in Experiment 1 we utilized a "forced-choice" tachistoscope paradigm; the subjects were not informed of the presence of neutral affects. They were provided with only two possible responses, "happy" or "angry." Thus the presence of neutral affects was a potential confound in this experiment. Third, the number of trials per subject was relatively small (60), possibly decreasing the overall sensitivity of the experimental design to detect group differences as a function of visual field.

EXPERIMENT 2

Experiment 2 was designed to remedy the limitations of Experiment 1. First, the confound of decreased behavioral speed and initiation among anxious men was resolved by eliminating reaction time as a variable via the use of an affective valence tachistoscopic task with a dependent measure of accuracy, rather than reaction time. The subjects reported their perception of facial affective stimuli orally, rather than by pressing trip switches manually. This in effect eliminated restrictive time demands on the subjects, thereby theoretically limiting frontal executive functioning and focusing on posterior cerebral processing. Second, the subjects were provided with three response alternatives—"happy," "angry," or "neutral"—thereby eliminating the forced-choice paradigm. Third, the number of trials per subject was increased from 60 to 120, thereby increasing sensitivity.

The following hypotheses were made for experiment two: (1) Given that overall accuracy scores were equivalent between anxious and nonanxious men in Experiment 1, it was predicted that anxious and nonanxious men would demonstrate similar accuracy scores for affective stimuli. (2) Given the notion that anxious individuals ex-

perience relative right posterior arousal, it was predicted that anxious men, as opposed to nonanxious men, would demonstrate relative right-hemisphere superiority for accuracy of processing facial affects.

Method

Subjects and group classification. The group screening and classification methods were identical to those described in Experiment 1, with one exception. In order to provide more information regarding how "normal" levels of anxiety affect facial affect perception, a middle anxiety group was added. Subjects with trait anxiety scores greater than or equal to 41 were classified as *high anxiety*, subjects with trait anxiety scores less than 41 and greater than 31 were classified as *middle anxiety*, and subjects with trait anxiety scores less than or equal to 31 were classified as *low anxiety*.

Stimuli and Apparatus. The stimuli and apparatus were almost identical to those in Experiment 1. In Experiment 2, trip switches were not used to indicate "happy" or "angry" faces. Rather, the subjects orally stated whether or not the stimuli were "happy," "angry," or "neutral."

Procedure. For Experiment 2, the subjects were administered the following tachistoscopic 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 sec after the tone. After the presentation of the face, please indicate (orally) whether the face you saw was "happy," "angry," or "neutral." 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?

A 1-sec tone signaled the impending presentation of an affective face. Three seconds after the tone, the stimulus slide was shown for 50 msec. The test phase consisted of 40 happy, 40 angry, and 40 neutral slides. Thus, a 3 (affect) $\times$ 3 (response alternatives) paradigm was used. The subjects were instructed to focus on the fixation point at the center of the screen after every 20 slides to improve the integrity of stimulus presentation within either visual field. Three randomized orders of slide presentation were used to control for order effects.

Results

A total of 135 college-aged right-handed men were administered the Handedness Questionnaire, BDI, and State

Table 4
Means and Standard Deviations for High, Middle,
and Low Anxiety Subjects

Measure	<i>M</i>	<i>SD</i>
High Anxiety (<i>n</i> = 12)		
BDI	5.00	2.86
State	44.58	7.04
Trait	46.42	5.37
Middle Anxiety (<i>n</i> = 12)		
BDI	4.50	3.09
State	33.50	6.99
Trait	36.17	5.52
Low Anxiety (<i>n</i> = 12)		
BDI	3.08	2.27
State	27.33	2.61
Trait	27.50	6.86

Note—BDI, Beck Depression Inventory; State, Trait, respective portions of State-Trait Anxiety Inventory.

and Trait portions of the STAI. Thirty-six (12 high anxious, 12 middle anxious, and 12 low anxious) subjects were selected to participate in the tachistoscopic procedure on the basis of the criteria discussed earlier. Separate (for high, middle, and low anxiety subjects) group means and standard deviations are reported in Table 4 for the BDI and the STAI.

A three-factor mixed design ANOVA with the fixed factor of group (high, middle, and low anxiety) and with the repeated measures of visual field (left and right) and slide affect (happy, angry, and neutral) was performed on mean accuracy scores. A significant, group $\times$ visual field $\times$ slide affect interaction was evidenced [$F(4, 66) = 3.41, p < .05$] (see Table 5). A significant visual field $\times$ slide affect interaction was also evidenced [$F(2, 66) = 4.85, p < .01$]. These two interactions were explored further via the use of planned, post hoc comparisons on mean accuracy scores using Duncan's multiple range test procedure. Analysis of the visual field $\times$ slide affect interaction (Table 6) revealed that angry affects were identified more accurately when presented to the LVF ($p < .05$). However, when group (high, middle, and low) differences were separately analyzed in the group $\times$ visual field $\times$ slide affect interaction, only high anxious subjects identified angry affects more accurately ($p < .05$) when these were presented to the left versus right visual field, whereas middle and low anxious subjects' accuracy scores for angry affects were similar, regardless of visual field. A graphic display of this finding can be seen in Figure 1. In contrast, group accuracy scores for happy and neutral affects were similar, regardless of visual field, therefore suggesting no asymmetry.

Finally, a main effect of slide affect [$F(2, 66) = 51.39, p < .001$] was revealed following statistical analysis. Post hoc comparisons revealed that happy affects were more accurately identified than neutral affects, followed by angry affects. Accuracy scores for happy, neutral, and

angry slides all differed significantly from one another. The main effect of group (high, middle, and low) was not significant, suggesting that the overall identification of faces was equivalent across groups regardless of visual field and affect. Similarly, there was no visual field main effect, suggesting that overall, the hemispheres were relatively equivalent in the identification of happy, angry, and neutral faces.

Discussion

The results of Experiment 2 yield two relevant findings. First, as was found in Experiment 1 with reaction time as a dependent measure, there was superior identification of happy versus angry affects. This finding is consistent with previous reports within the literature. Second, a three-way interaction revealed right-hemisphere superiority for the identification of angry facial stimuli among high anxious men, but not for middle and low anxious men.

There are reports within the literature of differential hemispheric superiority of the right hemisphere for the processing of negative emotion and of the left hemisphere for processing positive emotion (Reuter-Lorenz & Davidson, 1981; Reuter Lorenz, Givis, & Moscovitch, 1983). In addition, previous findings from our laboratory support right-hemisphere superiority for the processing of negative emotion (Crews & Harrison, 1994; Harrison & Gorel-czenko, 1990), although in these experiments reaction time was used as a dependent measure rather than accuracy. In Experiment 2, a right-hemisphere advantage was found for accuracy in the processing of angry faces. More specifically, angry faces were identified more accurately when presented to the LVF versus the RVF. However, when analyzed as a function of the level of anxiety (i.e., high, middle, and low), it was found that *only* high anxious men exhibited significant asymmetry (RH advantage) for the identification of angry faces. This suggests that high anxious men perceive angry affects differently than do low anxious and middle anxious men. This may also suggest increased functional activity in the right versus left parietotemporal region for high anxious individuals, which is consistent with the reports from previous studies (Heller, Etienne, & Miller, 1995).

GENERAL DISCUSSION

The present two-experiment design is novel in that this is the first study (to the authors' knowledge) in which the processing of facial affect was examined tachistoscopically in anxious individuals without depression as indicated by their self-report. In Experiment 1, the dependent measure was reaction time. In Experiment 2, the dependent measure was accuracy. The results replicate findings from previous investigations of facial affect perception. For example, the results of Experiment 1 indicate that a right-hemisphere advantage for the identification of facial affect is achieved (regardless of the subject's level of anxiety) when reaction time is used as the dependent measure. This finding is consistent with previous findings from our

Table 5
Mean Accuracy Frequencies for Group $\times$ Visual Field $\times$ Affect Interaction

Group	Happy	Angry	Neutral
Low Anxiety			
LVF	17.08	10.75	13.83
RVF	16.17	11.33	14.75
Middle Anxiety			
LVF	15.92	13.42	14.83
RVF	17.58	12.00	14.92
High Anxiety			
LVF	14.83	12.75	14.42
RVF	16.33	9.58	15.00

Note—LVF, RVF, left and right visual field, respectively.

Table 6
Mean Accuracy Frequencies for Visual Field $\times$ Affect Interaction

Visual Field	Happy	Angry	Neutral
LVF	15.94	12.31	14.36
RVF	16.69	10.97	14.89

Figure 1. Mean accuracy scores for low, middle, and high anxious subjects in left and right visual fields for angry affective slides.

laboratory (Crews & Harrison, 1994; Harrison & Gorelzenko, 1990), and it supports theories of a right-hemisphere advantage for the identification of facial affect perception discussed within the literature (Bowers, Bauer, & Heilman, 1993). A second finding from Experiment 1, which is also consistent with the literature (see Crews & Harrison, 1994; Ekman & Friesen, 1978), is that happy faces are easier to identify than angry or neutral faces.

The results of Experiments 1 and 2 suggest that high anxious and low anxious individuals have differing patterns of cerebral arousal. In Experiment 1, anxious men demonstrated slower processing of facial affective stimuli when reaction time was the dependent measure. This finding was contrary to our original hypotheses, based on Crews and Harrison (1994), who found that depressed men (who were likely anxious) demonstrated quicker reaction time to facial affects than did nondepressed men. This result has two important implications. First, it is possible that individuals with anxiety *and* depression process facial affect differently than do individuals with anxiety only. Though the results of this study cannot be directly compared to those reported by Crews and Harrison, there is some support for this notion within the literature (see Heller et al., 1995). Recent electrophysiological evidence also supports this hypothesis; Fong et al. (1997) reported that depressed individuals with comorbid anxiety demonstrated greater right as opposed to left posterior activation (as indicated by alpha asymmetry). In contrast, depressed individuals without anxiety show greater left as opposed to right posterior activation. Given this information, neurobehavioral differences associated with anterior functioning and various levels of anxiety and depression will be further explored in future investigations.

The second important implication derived from the findings of slower facial affect processing among anxious indi-

viduals is the possibility of deficits in motor execution/preparedness (i.e., left anterior deactivation) among anxious individuals. In Experiment 1, overall accuracy scores did not differ between anxious and nonanxious men. Similarly, in Experiment 2, when the requirement of time demands (via motoric pressing of the trip switch) was removed, and the presentation time of the stimuli was decreased, anxious individuals' accuracy scores were equivalent to those of nonanxious individuals. Taken together, this may suggest that anxious men's slower reaction times were due to relative deficits in motor execution rather than the perception of faces. This is consistent with the findings of Everhart et al. (1998), who have reported decreased grip strength and failure to demonstrate expected right-hand superior grip strength among a similar group of subjects. This is also consistent with previous investigations of anterior activation asymmetry (via EEG asymmetry) with positive and negative emotional states (i.e., Davidson, 1993).

In Experiment 2, anxious men demonstrated a right-hemisphere advantage for the identification of angry affect when accuracy was the dependent measure, whereas nonanxious men (i.e., low and middle anxious) demonstrated symmetry. There are reports that support the right hemisphere's dominance for the perception of negative affect and the left hemisphere's dominance for the perception of positive affect (see Natale, Gur, & Gur, 1983; Reuter-Lorenz & Davidson, 1981); however, replication has been difficult (see Bryson, McLaren, Wadden, & Macheen, 1991; McLaren & Bryson, 1987). In the present experiments, this effect was found for anxious men only, which suggests relative right posterior activation among anxious men and is consistent with the findings of Heller et al. (1995). It is possible that hemisphere-specific valence asymmetries for the visual perception of affect (i.e., left-hemisphere advantage for positive and right-hemisphere

advantage for negative) vary as a function of mood state (e.g., anxiety or depression), although this hypothesis has yet to be thoroughly investigated.

Taken together, the results from Experiments 1 and 2 partially support Heller's (1993) hypotheses regarding relative right-posterior activation among anxious individuals. In addition, the present results as well as the results reported by Crews and Harrison (1994) raise additional questions regarding the effects of various levels of depression and/or anxiety on the perception of facial affect and right-hemisphere (anterior and posterior) functioning. Future investigations of the performance of individuals with anxiety on facial affective tasks may permit further consideration of these issues.

The present investigation was limited to the use of a population of undergraduate men with self-reported elevated levels of anxiety. No further information is known regarding the nature of or level of these subjects' anxiety, and many of the anxious subjects may not have fallen within what is considered a "clinically anxious" range. Use of anxious subjects in the clinical range might have enhanced the present findings and might have substantiated the investigation's theoretical underpinnings better. On the other hand, the present method of identifying anxious subjects is consistent with that which has been used in other documented experiments (Heller et al., 1995; Tucker, Antes, Stenslie, & Barnhardt, 1978) designed for the examination of anxiety's effects on neuropsychological functioning.

It should be stated that there is another plausible explanation for the different findings in Experiments 1 and 2. The number of trials was doubled in Experiment 2, thereby increasing the overall sensitivity for detecting differences across conditions. It is possible that the use of more trials in Experiment 1 would have yielded results similar to those found in Experiment 2. However, the first experiment was also different from the second in several other ways (as previously described above), which may also account for differences. The potential impact of methodological differences across experiments is important, although well beyond the scope of this manuscript, and should be considered in future investigations. Nevertheless, the major purpose of the present investigation was to examine differences in the perception of affect as a function of anxious mood, which was accomplished.

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