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Anxiety-Related Bias in the Classification of Emotionally Ambiguous Facial Expressions

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High- and low-trait socially anxious individuals classified the emotional expressions of photographic quality continua of interpolated ("morphed") facial images that were derived from combining 6 basic prototype emotional expressions to various degrees, with the 2 adjacent emotions arranged in an emotion hexagon. When fear was 1 of the 2 component emotions, the high-trait group displayed enhanced sensitivity for fear. In a 2nd experiment where a mood manipulation was incorporated, again, the high-trait group exhibited enhanced sensitivity for fear. The low-trait group was sensitive for happiness in the control condition. The mood-manipulated group had increased sensitivity for anger expressions, and trait anxiety did not moderate these effects. Interpretations of the results related to the classification of fearful expressions are discussed.

Research into the interaction between emotional states and emotional information has produced some robust findings. It is now well established that high-anxiety individuals exhibit cognitive biases that differ from low-anxiety individuals (for reviews, see Dalgleish & Power, 1999; Eysenck, 1997; Williams, Watts, MacLeod, & Mathews, 1997). For example, at an encoding level, anxious individuals often favor the processing of anxiety-related information, and this may occur at a preattentive level (e.g., Öhman, 1996). Investigations into possible memory differences between anxious and nonanxious individuals have produced a more varied pattern of findings, with Williams et al. (1997) arguing for perceptually based implicit memory effects in anxiety, and Eysenck (1992) proposing that explicit memory biases are found. As yet, there is no consensus of opinion or data to provide a comprehensive picture of memory effects associated with anxiety.

All models of cognition and emotion predict that there should be an interpretative bias associated with anxiety, such that anxious individuals should interpret ambiguous stimuli that have a threatening interpretation in the threat-related manner (e.g., Williams et al., 1997).

Investigations into interpretative biases in anxiety have used verbal stimuli that are themselves ambiguous (e.g., threat–neutral homographs) or describe ambiguous scenarios. The standard finding from these studies is that anxious individuals opt for the threat-related interpretation of an ambiguous word/scenario. For example, Eysenck, MacLeod, and Mathews (1987) found that high-trait anxious participants were more likely than low-trait individuals to write down the threatening interpretation of a series of threat–neutral homophones. Mathews, Richards, and Eysenck (1989) replicated this basic finding with a clinically anxious sample. This paradigm was ex-

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tended by Eysenck, Mogg, May, Richards, and Mathews (1991), who presented ambiguous sentences (e.g., "*the doctor examined little Emma's growth*"). Again, it was revealed that clinically anxious individuals were more likely than controls to interpret such ambiguous sentences in the threat-related manner (i.e., that Emma was having her cancer rather than her height examined). It was also found that participants did not falsely recognize threat-related foils in the recognition task, thus adding support to the idea that the interpretation bias was not simply a response bias.

Using a semantic priming paradigm, Richards and French (1992) presented ambiguous threat–neutral homographs to high- and low-anxious participants. Each threat–neutral homograph (e.g., *arms*) was followed by either a threat-related associate (i.e., *weapons*), a neutral associate (i.e., *legs*), or an unrelated word (e.g., *plant*). When the interval between the prime (homograph) and the target (associate) was short (i.e., 500 ms), both high- and low-anxious participants showed priming, that is, faster reaction times (RTs) to related than unrelated trials for both threat and neutral trials. However, at longer stimulus onset asynchronies, the high-trait participants showed priming for threat-related meanings, and the low-trait participants showed priming for the neutral meanings.

Research into the relationship between cognition and emotion has typically used verbal stimuli when in fact it is likely to be the case that faces are more ecologically valid. Facial perception appears to be a relatively automatic and preattentive process that appears early on in development. When people are exposed to masked facial expressions, they react spontaneously with distinct facial electromyographic reactions in emotion-relevant facial muscles that tend to mimic the observed facial expression (Dimberg, Thunberg, & Elmehed, 2000). In this study, angry and happy faces were presented briefly and masked by a neutral face. Researchers have argued that both positive and negative emotions can be evoked by a nonconscious perception of a corresponding facial expression. In developmental research, infants only a couple of months old are able to discriminate among different emotional expressions such as happiness and fear, and researchers have argued that this suggests some degree of "prewiring" (Nelson, 1987, 1993). Although Nelson and de Haan (1997) argued that the neural systems that mediate the recognition of facial expressions may require a little experience to develop, it is clear that this ability is present before the capacity for language has developed. Öhman (1993) speculated that anxiety serves to sensitize the perceptual system to environmental threats, such as angry faces, and this may have an adaptive function. Gilboa-Schectman, Foa, and Amir (1999) argued that facial expressions displaying approval and disapproval are highly related to social evaluations, whereas words are only indirect representations of these social signals. In evolutionary terms, facial expressions appeared very early on, as indicated by the observation that humans share some expressions, such as appeasement and genuine enjoyment smiles, with nonhuman primates, even though the species split some 4.5–6 million years ago (Cole, 2001).

There is a body of research investigating the processing of emotional facial expressions in both unselected samples and samples selected for anxiety. From a series of experiments in which schematic angry and happy faces were presented in congruent (same face–same emotion displays) or incongruent displays (e.g., an angry face among a neutral crowd), Fox et al. (2000) concluded that an angry facial expression is detected more efficiently than a happy expression. It is interesting that Fox et al. reported that anxiety had no effect in any of their experiments. This is in contrast to the experiment conducted by Byrne and Eysenck (1995) in which high-trait anxious individuals were relatively quicker to identify an angry face in a neutral crowd compared with low-trait anxious individuals. There are several differences between the two studies that may account for the discrepancy in findings related to anxiety. Byrne and Eysenck selected high and low scorers on the trait version of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), whereas this does not appear to be the case for Fox et al. (although full details are not presented). Second, Byrne and Eysenck presented black-and-white photographs in displays of 12 faces that remained in full view until a response was made, whereas Fox et al. presented black-and-white schematic faces in displays of 4 faces for 300–800 ms. The present investigation is more similar to that of Byrne and Eysenck in that participants with extreme scores on the social anxiety continuum are selected, photographic-quality stimuli are used, and facial stimuli remain in full view until a response has been made.

The current experiment investigated a possible interpretation bias associated with anxiety by using ecologically valid facial stimuli. Computer-interpolated ("morphed") facial images were used with participants selected for nonclinical anxiety. These morphed facial images were produced to photographic quality by interpolating prototypes from Ekman and Friesen's (1976) series (see below). This technique allows a range of ambiguous facial expressions to be presented in a measured manner. These faces were derived from combining six prototype emotional expressions to various degrees, with the two adjacent emotions arranged in the following emotion hexagon: happiness, surprise, fear, sadness, disgust, and anger (see Figure 1). So, for example, one continuum combined fear and sadness in the following proportions: 90% fear: 10% sadness, 70% fear:30% sadness, 50% fear:50% sadness, 30% fear:70% sadness, 10% fear:90% sadness.

Of particular interest in the present research is the identification of fear and anger by high-anxiety individuals. Anger is the emotion that has been the focus of most of the research using visual pop-out methodology, and it is possible that anxious individuals are more likely to detect anger in an ambiguous face because it is directly threatening to them personally. However, fear is the emotion most readily associated with anxiety, and it could be the case that anxious people are hypervigilant for fearful expressions.

In evolutionary terms, an animal that is sensitive to detecting fear in other animals will have an advantage in terms of deciding whether to fight or flee. There is evidence that an evolved neural substrate may be implicated in the recognition of fear, and that the amygdala plays a crucial role. Adolphs, Tranel, Damasio, and Damasio (1995) proposed that bilateral damage to the amygdala resulted in impaired recognition of fearful expressions, and subsequent case studies of individuals with amygdala damage have confirmed this suggestion (Adolphs et al., 1999; Broks et al., 1998; Calder et al., 1996; Sprengelmeyer et al., 1999). LeDoux (1996) cited neurophysiological studies to support the view of the amygdala being involved in the recognition of danger and the emotion of fear, and recent functional imaging studies have also lent strong support to this suggestion (Breiter et al., 1996; Morris et al., 1998, 1996; Phillips et al., 1998).

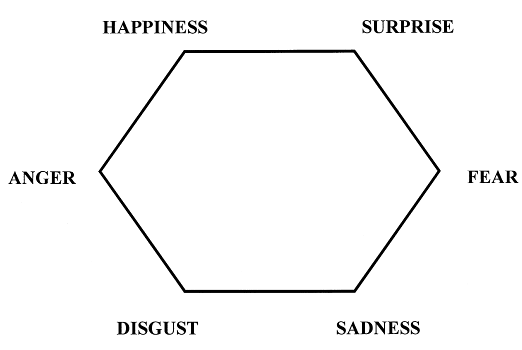

Figure 1. Emotion hexagon showing the six emotion continua.

Although many cognitive psychologists do not make a clear distinction between fear and anxiety, psychobiologists and other emotion theorists typically argue that there is a qualitative distinction between the two. There is a debate on the role of the amygdala in anxiety and fear. From work on animals, Davis, Walker, and Lee (1997) suggested that the bed nucleus of the *stria terminalis* may be a system that is more responsive to signals more similar to anxiety than to fear, whereas the converse is the case for the amygdala. In addition, the basolateral nucleus of the amygdala may be involved in both anxiety and fear (see Gray & McNaughton, 2000, for an alternative view). Davidson (2002) reviewed the evidence for the involvement of the prefrontal cortex and amygdala in emotion and proposed that there are individual differences in anxiety-related affective styles that are on a continuum. He argued that this continuum implies that the boundary between normal and pathological variations in prefrontal and amygdala processing is arbitrary.

Eysenck (1992) argued that the biological significance of anxiety is likely to be concerned with the detection of threat. The rapid detection of the early warning signs of danger has real survival value. For example, it could be fatal if the smell of something burning or gas were ignored. He goes on to point out that some people have overdeveloped threat-detection systems and they become hypervigilant and clinically anxious. There is evidence that hyperexcitability in the amygdala and extended amygdala may produce both exaggerated fear behavior and states of hypervigilance (Rosen & Schulkin, 1998). Rosen and Schulkin proposed that these fear circuits may be sensitized by psychosocial stressors, such as social defeat, and that overstimulation may produce a lowered activation threshold that causes increases in fearful behavior and worry.

There has been some preliminary evidence from Sprengelmeyer et al. (1997) suggesting that clinically anxious individuals have enhanced recognition compared with controls for both fear and anger and have a borderline advantage for the recognition of sadness. However, Sprengelmeyer et al.'s study was focused on obsessive–compulsive disorder and the processing of the disgust emotion. The finding of enhanced processing of fear stimuli was incidental to the study and was also not examined in terms of the locus of the bias along the emotion continuum.

The present experiment is primarily concerned with the emotions of fear and anger, and the main hypotheses concern these two emotions. It is predicted that high-socially anxious individuals will detect the presence of fear in emotionally ambiguous faces, where fear is one of the two component emotions, at an earlier percentage level than low-socially anxious individuals. It is expected that when the face contains 90% fear, then both high- and low-anxious participants will classify the face as being fearful. It is also predicted that the high-anxious individuals will make their classification as "fear" more quickly than the low-anxious individuals. When fear contributes 70% and 50% to the face, then the high-anxious group should classify more of the faces as expressing fear than the low-anxious group. A comparable set of hypotheses is proposed for the anger emotion.

In addition, it is predicted that the low-social anxiety group compared with the high-anxious group will classify faces expressing happiness as "happy" at an earlier percentage level than the high-anxious group, and that they will make happy classifications to faces containing expressions of happiness more quickly. These predictions were made on the basis of mood congruency research that has demonstrated both positive and negative mood congruency effects such that there may be enhanced recall of material that is congruent with mood state (e.g., Bower, 1981; Clore, Schwarz, & Conway, 1994). This mood congruency effect is also apparent for social judgments (Forgas & Bower, 1987; Johnson & Tversky, 1983) and for attributions (Seligman, Abramson, Semmel, & Von Bayer, 1979). Fiedler, Nickel, Muehlfriedel, and Unkelbach (2001) demonstrated that the mood congruency effect in their memory studies was due to an increase in sensitivity for mood congruent information rather than to a response bias. In the present experiment, it was expected that the high-socially anxious individuals would be less happy than the low-socially anxious individuals, and therefore we are expecting the low-social anxiety group to identify more faces as happy relative to the high-trait group and to make their classifications more quickly.

Including the full hexagon enables us to examine the issue of response bias versus sensitivity by, for example, determining whether the high-trait group makes, say, a "fear" response for faces along the continua where no fear is presented (i.e., along the anger–happiness, sadness–disgust, and anger–disgust continua). A stronger test would be to examine the number of fear responses made along the continuum where fear is not actually present but where one emotion is easily confused with fear (i.e., along the surprise–happiness continuum). If there is no evidence that the high-anxious group classifies faces as expressing fear when there is no fear present, then this would suggest that any enhanced classification of faces as expressing fear along the surprise–fear and fear–sadness continua is a reflection of increased sensitivity to fear rather than an expression of a response bias for fear. The presentation of the full emotion hexagon is therefore essential to enable these questions to be addressed.

Finally, there are no explicit predictions concerning the classifications made for the two continua for disgust (i.e., sadness–disgust and disgust–anger), for sadness (i.e., fear–sadness and sadness–disgust), and for surprise (i.e., happiness–surprise and surprise–fear) because each involves other anxiety-provoking emotions. However, it is of interest to examine both speed of response to these emotions and whether there are differences between the anxiety groups in terms of their classification of these emotions.

EXPERIMENT 1

Method

Stimuli

The same stimuli were used as those in previous work by Young and colleagues (e.g., Young et al., 1997). Six photographs of prototype emotional expressions (happiness, surprise, fear, sadness, disgust, and anger) were selected from Ekman and Friesen's (1976) series. They were ordered so that each of the six expressions of the same face (JJ's face) were placed adjacent to the facial expression it was most likely to be confused with. A confusion matrix for the different emotions was created and then ordered in a series based on their maximum confusabilities (i.e., placing each emotion adjacent to the one it was most likely to be confused with). The resulting order was happiness, surprise, fear, sadness, disgust, and anger, with mean percentage of confusabilities for each pair of expressions in this sequence being happiness and surprise: 0.8%; surprise and fear: 5.8%; fear and sadness: 2.4%; sadness and disgust: 2.7%; disgust and anger: 6.4%. The ends of the sequence (anger and happiness) were then joined to create a hexagonal representation. The perimeter of the hexagon is made up of the following six continua: happiness–surprise, surprise–fear, fear–sadness, sadness–disgust, disgust–anger, anger–happiness.

For each continuum, five computer-manipulated (morphed) images were constructed by blending the two prototypes in various proportions. Further details of the construction of these images may be found in Young et al. (1997). In the current experiment, each continuum comprised 5 faces with the following proportions of the two emotions: 90%:10%, 70%:30%, 50%:50%, 30%:70%, 10%:90%.

As there were six continua, each with 5 blends of emotions, there was a total of 30 faces. Only morphed images were presented; the prototype was never shown as our primary interest is in the interpretation of ambiguity. The stimuli were presented on a 14-in. (35.6-cm) color monitor, using MEL Professional (Schneider, 1990). The stimuli were 145 mm in height × 95 mm in length and subtended a vertical visual angle of 14.5° and a horizontal visual angle of 9.5°.

Procedure

Each trial began with a fixation cross presented on the screen for 1 s. The cross was replaced by a morphed facial expression that remained in full view until a verbal response had been made. The six emotions were presented on the bottom of the screen during the trials, with the position of each response category changing position randomly on each trial. There were 7 blocks of trials with each of the 30 morphed faces presented in each block. The first block was discounted as a practice block. There were short breaks between each block.

The emotion-identification task lasted approximately 30 min. At the end of the session, participants completed the State and Trait versions of the STAI (Spielberger et al., 1983), the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), and the Social Phobia and Anxiety Inventory (SPAI; Turner, Beidel, Dancu, & Stanley, 1989).

Participants

Sixty participants took part in the experiment, with a mean age of 29.68 years (SD = 13.60). Scores on the SPAI were ranked, and the top and bottom 25% of scorers were allocated to the high- and low-trait social anxiety groups, respectively. (Note that, as a matter of convenience, from this point onward in this report, the terms *high trait* and *low trait* will refer to social anxiety, not general trait anxiety as measured by the STAI.) The characteristics of the selected groups are presented in Table 1.

Results

Participant Characteristics

The high-trait social anxiety group scored higher than the low-trait social anxiety group on SPAI, $t(28) = 17.62$, $p < .001$, state anxiety, $t(28) = 3.73$, $p < .001$, general trait anxiety, $t(28) = 5.26$, $p < .001$, and BDI, $t(28) = 3.91$, $p < .001$; but did not differ in terms of age, $t(28) = 0.84$, or ratio of males to females, $\chi^2 = 2.4$, $N = 30$, *ns*.

Classification of Emotions

As the focus of the present research is on the interpretation of ambiguous facial expressions and anxiety, only significant effects involving anxiety are discussed. Responses to the faces in the hexagon are not independent, such that if a fear response is given to a face then, this precludes any of the other emotion responses being given. It is for this reason that specific continua of the hexagon are analyzed separately for each emotion, and only one emotion response is examined in any particular analysis. The RT analyses were restricted to 90% for all continua because of missing data in some of the continua at lower percentage levels. At the lower percentage levels, many participants gave responses other than "fear" for some of the faces. Basing RT estimates on so few data points per participant would be at best unreliable. Indeed, in some cases, no fear responses were given at lower percentage levels by some participants. The same occurred for other continua. Therefore, to ensure that all participants contributed data to the analysis, all RT analyses were restricted to 90%.

Table 1
Participant Characteristics for Experiment 1

Anxiety group	SPAI[a]	STAI-Trait[a]	STAI-State[a]	BDI[a]	Age	n
Low-trait social anxiety	19.31	33.20	31.20	3.53	27.07	15
	(7.71)	(7.11)	(6.96)	(3.20)	(8.08)	
High-trait social anxiety	84.09	50.27	44.20	12.60	25.07	15
	(11.93)	(10.47)	(11.55)	(8.37)	(4.51)	

Note. Standard deviations are enclosed in parentheses. SPAI = Social Phobia Anxiety Inventory (Turner, Beidel, Dancu, & Stanley, 1989); STAI = State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983); BDI = Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961).
[a] Significant difference between two groups at $p < .01$.

Fear Emotion

To examine the prediction that high-trait individuals will detect the presence of fear at an earlier percentage level compared with the low-trait individuals, we calculated the number of fear classifications made along the surprise–fear and fear–sadness continua and subjected them to a 2 (social anxiety group: high vs. low trait) × 2 (continua: surprise–fear vs. fear–sadness) × 5 (percentage of fear: 10 vs. 30 vs. 50 vs. 70 vs. 90) analysis of variance (ANOVA). This analysis revealed that, relative to the low-trait group, the high-trait group classified significantly more of the faces along these continua as expressing fear (*M* totals of 21.21 and 25.67, respectively), $F(1, 28) = 7.57, p < .01$.

A series of planned comparisons were performed where the number of fear responses produced by the two trait social anxiety groups was compared at each of the five percentage levels (see Figure 2).

These analyses showed that although the high-trait group produced more fear responses at all percentage levels, this was significant at 50%, 70%, and 90% (*F*s = 7.71, 17.35, and 4.02, respectively).

We performed two additional analyses to examine whether this bias is likely to reflect a sensitivity effect or simply an effect of response bias. The first analysis examined the continuum involving an emotion that is highly confused with fear, that is, the surprise emotion along the happiness–surprise continuum. If it is the case that the high-trait participants were simply responding to surprise with a fear response, then this suggests that in cases of high ambiguity and confusion, the high-trait participants would opt for fear even when no fear is presented. The second analysis examined the number of fear classifications along the continua where emotions were presented that were not easily confused with fear (i.e., anger–happiness, sadness–disgust, and disgust–anger). In both of these analyses, there was no hint that the high-trait group classified more of the faces as expressing fear (*F*s = 0.007 and 0.137, respectively). These two analyses are consistent with the proposal that the high-trait participants are displaying enhanced sensitivity for fearful expressions, and this is not due to a simple response bias effect.

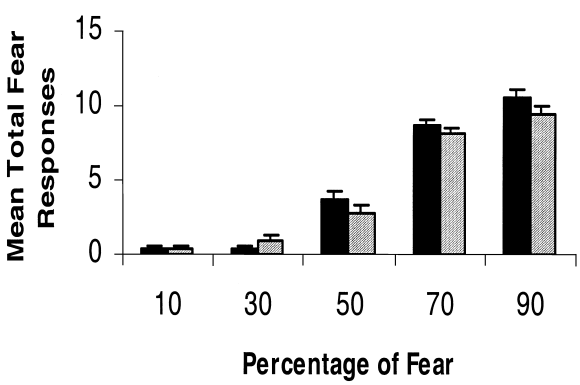

Figure 2. Number of "fear" responses of high- and low-trait social anxiety groups along the continua where fear is a component emotion (surprise–fear and fear–sadness) for Experiment 1. Darker bars represent high trait; lighter bars represent low trait.

We also predicted that the high-trait group would make their classifications of fear more quickly than the low-trait group. To test this, an analysis of the RTs for the surprise–fear and fear–sadness continua was performed. Although the high-trait group was overall quicker to respond here, this did not approach significance ($F < 1$).

We performed a standard multiple regression analysis on the entire sample ($N = 60$) to examine the relative contributions of trait social anxiety, state and general trait anxiety, and depression to the total number of fear responses along the surprise–fear and fear–sadness continua. None of the variables contributed significantly to the equation.

Anger Emotion

An analysis of the number of "anger" responses along the disgust–anger and anger–happiness continua was performed to test the hypothesis that the high-trait individuals will detect anger at an earlier percentage level. This failed to produce any significant effects. A second analysis of the RT data at the 90% level also failed to produce any support for the prediction that anxious individuals will classify faces containing some anger as "anger" more quickly than the low-trait group.

Happiness Emotion

The prediction that the low-trait individuals would detect happiness at an earlier percentage level than the high-trait individuals for the two continua containing happiness was not supported. An analysis of the RT data revealed that, as predicted, high-trait participants were slower than low-trait participants when making a happy response for faces containing a proportion of happiness (*M*s of 1,058 ms and 811 ms, respectively), $t(28) = 2.08, p < .05$.

Subsidiary Analyses: Sadness, Disgust, and Surprise Emotions

An analysis of the categorizations of each of the remaining emotions along the relevant areas of the hexagon failed to produce any significant effects. Finally, the prediction that high-trait participants would make negative responses more quickly than low-trait individuals was examined by combining the 90% RT scores for the negative responses ("fear," "anger," "disgust," and "sadness"). Although the high-trait group was faster than the low-trait group (*M*s of 1,241 ms and 1,349 ms, respectively), this failed to approach significance ($t < 1$). Therefore, there was no support for this hypothesis.

Discussion

This experiment offers support for the hypothesis that individuals high in trait social anxiety categorize more of the facial expressions as being fearful than do low-trait individuals. This effect was apparent for the specific areas of the continua where fear was one of the two component emotions (fear–sadness and surprise–fear) and is therefore consistent with Sprengelmeyer et al.'s (1997) observations in patients with generalized anxiety disorder. The present study demonstrated an interpretative bias in anxiety by using ecologically valid facial stimuli that is consistent with the research using verbal material.

The RT analysis showed that although the high-trait social anxiety group more quickly identified the faces expressing fear than the low-trait social anxiety group, this did not approach significance and therefore failed to support our predictions. There was a large amount of variability in the time taken to make a response, thereby reducing the probability of obtaining a significant effect. One reason for the RT data having great variability may be due to the way in which responses were collected. On each trial, the emotions were displayed on a monitor in a different random order. Although participants were required to make a verbal response, and therefore the position of the emotion words on the computer screen was not relevant for their response, participants may sometimes have checked the response options before making their verbal response. The changing position of the emotions on the screen may have contributed to the variability in the RT data. The multiple regression analysis, performed on the entire data set, showed that none of the variables entered (state and general trait anxiety, trait social anxiety, and BDI) significantly predicted the number of fear responses made along the surprise–fear and fear–sadness continua. This analysis contradicts the ANOVA analysis where only the top and bottom 25% of the continuum were included. It may be the case that the effects tapped by this analysis are present in the high-trait group, and including those individuals in the mid-range of social anxiety dilutes the effect. An experiment to examine this further would be useful.

Of particular interest in the present investigation is the relationship between anxiety and the emotions of fear and anger. It appears that the high-socially anxious individuals were not particularly sensitive to the anger emotion, as there were no significant effects from all of the analyses involving anger. However, it may be the case that state anxiety needs to be raised in order for there to be enhanced categorization of ambiguous faces as expressing anger. A second study was therefore undertaken to examine the influence of a mood manipulation on emotion categorization. The study also serves as a replication of the association between trait social anxiety and the categorization of fear.

EXPERIMENT 2

The procedure was identical to that for Experiment 1, but with an added anxiety-provoking mood manipulation for half the participants. The predictions for each of the emotions are the same as those outlined for Experiment 1. However, we are also interested in examining whether the inclusion of an anxiety-provoking mood manipulation procedure influences both the number of classifications made along the various emotion continua and the speed with which these are made. Models of cognition and emotion typically predict that increases in state anxiety should have the effect of enhancing cognitive biases for emotional information (e.g., Beck & Emery, 1985; Bower, 1981; Eysenck, 1992). There is also some neurobiological evidence to suggest that the amygdala would be hyperactive in clinical anxiety during an anxious episode, but not necessarily be hyperactive during other times (Rosen & Schulkin, 1998).

Method

Mood manipulation. Participants in the mood manipulation condition were led to believe that they were being observed via a video camera positioned in the corner of the room. This technique has been shown to be successful in manipulating mood (cf. Reidy, 1994).

They were informed the following:

> A PhD student, who is studying the non-verbal behaviour of individuals in different contexts, is conducting an experiment to investigate the facial expressions of subjects while performing a cognitive task. He has asked to observe the subjects participating in this experiment. He

> has a monitor set up in another cubicle and will be observing you via this video while you perform this task.

Procedure. All participants completed the state form of the STAI and a 100 mm visual analogue, with the extreme ends of the continuum labeled *not at all anxious* to *extremely anxious.* Participants were required to mark the line with a pencil to indicate their level of anxiety at that particular moment. A second Visual Analogue scale was completed after the practice block of the emotion-identification task and a final Visual Analogue scale together with the STAI, the BDI, and the SPAI at the end of the session. State anxiety was therefore measured on two occasions with the state form of the STAI (at the beginning of the experiment and at the end of the practice session) and on three occasions by the Visual Analogue scale (at the beginning of the experiment, at the end of the practice session, and at the end of the experiment).

At the end of testing, all participants were questioned about the mood manipulation. Most of the participants reported feeling anxious or nervous when they were videotaped, and they all reported that they were not aware that they were being deceived during the session.

Participants. Seventy-four participants took part in the experiment, with a mean age of 23.43 years ($SD = 6.03$). Scores on the SPAI were ranked, and the top and bottom 25% of scorers were allocated to the high- and low-trait groups, respectively. The characteristics of the selected groups are presented in Table 2.

Results

Participant characteristics. A series of separate two-way ANOVAs, each with 2 (social anxiety group: high trait vs. low trait) × 2 (mood manipulation: control vs. anxiety provoking) factors, was performed on the participant characteristics of age, general trait anxiety (STAI), BDI, and SPAI. These showed that there were no differences in terms of age, BDI scores, or ratio of males:females between the different groups. As expected, there were differences between the low- and high-trait groups for SPAI scores (*M*s of 9.60 and 66.55 for low- and high-trait participants, respectively)[1] and for general trait anxiety (*M*s of 37.17 and 46.20 for low- and high-trait participants, respectively).[2] There were no other main or interaction effects in any of the analyses.

Mood manipulation. A 2 (social anxiety group: high vs. low trait) × 2 (mood manipulation: control vs. anxiety provoking) × 2 (occasion of testing: at the beginning of the experiment vs. the end of the practice session) ANOVA was performed on the state anxiety scores. This analysis revealed, as expected, an Occasion × Mood Manipulation interaction, $F(1, 34) = 5.16$, $p < .05$. Planned t tests revealed no significant difference between the first and second occasion for the control group (*M*s of 39.39 vs. 38.33, respectively), $t(17) = 0.644$, *ns*, but there was a significant increase for the anxiety-provoking manipulation group (*M*s of 39.80 vs. 44.20, respectively), $t(17) = 2.60$, $p < .05$. There was also a main effect of group with the high-trait group having higher scores overall compared with the low-trait group (*M*s of 44.20 vs. 36.42, respectively), $F(1, 34) = 7.31$, $p < .05$.

These findings were confirmed by the analysis of the Visual Analogue scale data. These data were subjected to a 3 (occasion of testing: at the beginning of the experiment vs. after the practice session vs. at the end of the experiment) × 2 (mood manipulation: control vs. anxiety provoking) × 2 (social anxiety group: high vs. low trait) ANOVA. The analysis showed a significant main effect of group, $F(1, 34) = 9.70$, $p < .05$, with the high-trait group having higher scores than the low-trait group (*M*s of 4.05 and 2.23, respectively). There was also a Mood Manipulation × Occasion interaction, $F(1, 68) = 3.45$, $p < .05$. Further,

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[1] One of the high-trait social anxiety groups had similar general trait anxiety to the two low-trait social anxiety groups, and it is possible that the failure to find any Mood Manipulation × Trait Social Anxiety Group interactions is due to a low level of trait anxiety in the high-trait social anxiety group. We performed analyses on a subsample of participants where the high-social anxious control group was comparable to the high-trait social anxiety manipulated group. This did not change the pattern of results in any way, and more importantly, the size of the F ratio for the Anxiety Group × Manipulation interactions remained virtually unchanged. Given the very low F ratios in this new analysis, it seems unlikely that the failure to find any Mood Manipulation × Anxiety Group effects is down to the low anxiety levels of the high-anxiety control group.

[2] The high-anxious and low-anxious control groups had mean Social Phobia and Anxiety Inventory scores on either side of the clinical cut-off score (mean scores of 70.39 and 62.7, respectively). Although this difference was not statistically significant, the difference may be clinically significant. We performed analyses on subsets of participants in which the groups were more comparable. These were performed on the "anger" and "fear" responses, and in all of these analyses, the pattern of results remained the same.

Table 2
Participant Characteristics for Experiment 2

Measure	Low-trait social anxiety: Control (n = 8)	Low-trait social anxiety: Anxiety-provoking manipulation (n = 10)	High-trait social anxiety: Control (n = 10)	High-trait social anxiety: Anxiety-provoking manipulation (n = 10)
SPAI	8.92	10.14	70.39	62.71
	(9.23)	(10.91)	(12.92)	(7.90)
STAI-Trait	37.63	36.80	42.00	50.40
	(8.07)	(7.35)	(9.79)	(9.61)
STAI-State 1	38.38	33.70	40.20	45.90
	(7.33)	(9.14)	(11.31)	(12.11)
STAI-State 2	36.25	37.70	40.00	50.70
	(5.92)	(10.25)	(10.80)	(5.77)
BDI	2.13	6.10	7.40	9.20
	(2.68)	(2.40)	(2.40)	(2.40)
Age	20.63	27.10	23.30	24.30
	(2.53)	(2.26)	(2.53)	(2.26)
Visual Analogue 1	2.69	1.70	3.14	4.13
	(1.57)	(1.51)	(2.43)	(1.85)
Visual Analogue 2	2.18	2.51	3.40	5.21
	(1.80)	(2.01)	(1.83)	(2.53)
Visual Analogue 3	2.16	2.23	3.33	5.11
	(2.17)	(2.03)	(1.43)	(1.85)

Note. Standard deviations are enclosed in parentheses. SPAI = Social Phobia Anxiety Inventory (Turner, Beidel, Dancu, & Stanley, 1989); STAI = State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983); BDI = Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961).

analyses revealed no significant change in visual analogue scores for the control group, $F(2, 74) = 2.71$, *ns*, but a significant increase over time for the anxiety-provoking mood manipulation group, $F(2, 70) = 12.46$, $p < .001$. Three post hoc tests showed significant differences between the first and second occasion and between the first and third occasion, but no difference between the second and third occasion (ts = 4.20, 3.79, and 1.24, respectively).

Categorization of emotions. These data were analyzed with the same factors outlined in Experiment 1. However, there was an additional factor of Mood Manipulation (anxiety provoking vs. control). Following Experiment 1, only effects involving the between-subjects factors of either Trait Group, Mood Manipulation, or both are discussed. To be consistent with Experiment 1, RT data were analyzed only at the 90% level.

Fear emotion. The analysis of the number of fear responses along the surprise–fear and fear–sadness continua showed that, consistent with Experiment 1, there were differences between the high- and low-trait groups, as shown by the significant interaction between percentage of fear emotion and trait social anxiety group, $F(1, 136) = 2.81$, $p < .05$ (see Figure 3). Further analyses showed that the high-trait group classified a significantly higher number of the faces as expressing fear at 90% and 50%, $F(1, 148) = 8.77$ and 10.55, respectively. The high-trait group classified more faces as "fear" at 70%, but this failed to reach significance, $F(1, 148) = 3.29$, *ns.*

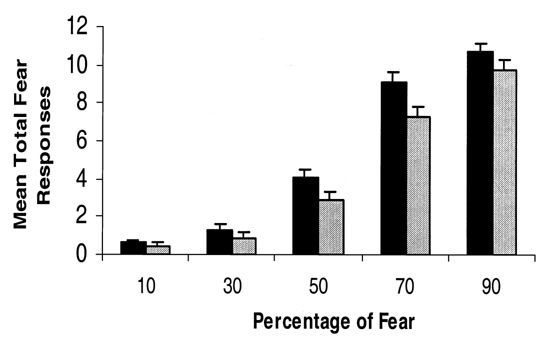

Figure 3. Number of "fear" responses of high- and low-trait social anxiety groups along the continua where fear is a component emotion (surprise–fear and fear–sadness) for Experiment 2. Darker bars represent high trait; lighter bars represent low trait.

Consistent with Experiment 1, we performed further analyses to differentiate between the possibilities of sensitivity to emotions as categories versus a response bias for those emotions showing differences between trait groups or mood manipulation conditions. An analysis of the number of fear responses along the happiness–surprise continuum (where the component emotion of surprise is easily confused with fear) revealed no significant social anxiety trait-group or manipulation effects. Likewise, an analysis of the remaining continua (anger–happiness, sadness–disgust, and disgust–anger) also failed to reveal any group effects. Therefore, the bias demonstrated for the high-trait group for fear appears to be due to an enhanced sensitivity for fear as a category.

It is noteworthy that the Mood Manipulation factor failed to have any effect on the classification of facial expressions as fearful.

We performed a standard multiple regression analysis on the whole group ($n = 74$) between the participant characteristics of trait social anxiety, the second state anxiety score, general trait anxiety and BDI, and the total number of fear categorizations along the surprise–fear and fear–sadness continua. There were no significant effects.

The analysis of the RT data showed that the high-trait group responded more quickly in making a fear response than the low-trait group (*M*s of 1,296 ms and 1,317 ms, respectively), but this did not approach significance. This does not support our prediction, although this null finding is consistent with Experiment 1.

Anger emotion. The number of anger classifications along the disgust–anger and anger–happiness continua showed that the Mood Manipulation factor played an important role in the classification of an expression as "anger." There was a main effect of manipulation, showing that the manipulated group produced a higher number of anger responses than the control group (*M* totals of 30.90 vs. 24.71, respectively), $F(1, 34) = 11.41$, $p < .01$. In addition, there was a Manipulation × Percentage of Anger Emotion interaction, $F(4, 136) = 4.20$, $p < .01$ (see Figure 4).

Further analyses revealed that the manipulated group produced a higher number of anger classifications than the control group at 90%, 70%, and 50% anger levels, $Fs(1, 151) = 23.43$, 44.37, and 66.14, respectively. Consistent with Experiment 1, trait social anxiety group had no influence on the number of anger responses made. Analyses of anger classifications along the continua where anger was not one of the component emotions revealed that there were no differences between the trait social anxiety groups or the mood manipulation conditions, indicating that there was enhanced sensitivity toward anger rather than a response bias for anger.

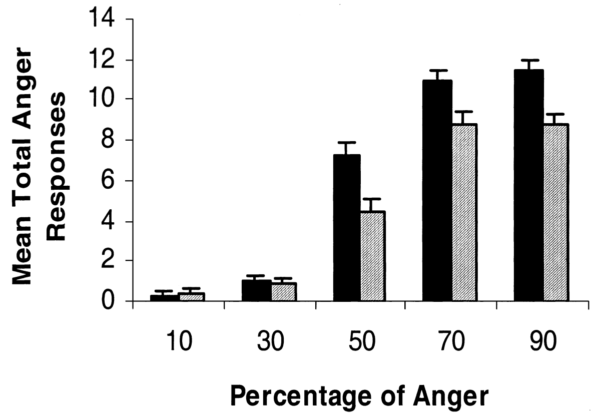

Figure 4. Number of "anger" responses in control and anxiety-provoking mood manipulation conditions along the continua where anger is a component emotion (disgust–anger and anger–happiness) for Experiment 2. Darker bars represent the manipulated group; lighter bars represent the control group.

We performed a standard multiple regression analysis on the whole group ($n = 74$) using the same independent variables as above and the total number of anger categorizations made along the disgust–anger and anger–happiness continua. This analysis produced a significant regression equation, $F(5, 68) = 4.37$, $p < .001$, accounting for 24% of the variance. Only the mood manipulation contributed significantly to the equation ($\beta = -.46$, $t[68] = 4.16$, $p < .001$). This demonstrates that it is being subjected to the mood manipulation that is important rather than the increase in the self-reported anxiety level. That is, the increase in the categorization of faces as containing anger occurs for all participants under the mood manipulation condition irrespective of the level of trait social anxiety, state or general trait anxiety, or depression.

We performed a 2 (social anxiety group: high vs. low trait) × 2 (mood manipulation: manipulated vs. control) × 2 (continua: anger–happy and disgust–anger) ANOVA on the RT data. This revealed that, as predicted, the mood manipulated group was faster than the control group (*M*s of 1,105 ms and 1,611 ms, respectively), $F(1, 34) = 5.76$, $p < .05$, to classify faces expressing anger as "anger."

Happiness emotion. An examination of the happiness emotion showed that there was a significant interaction between mood manipulation, social anxiety group, and percentage of emotion for the analysis of the happiness continua. The high-trait group produced similar performances under the anxiety-provoking and control conditions. However, the low-trait group categorized significantly more faces as "happy" under the control compared with the anxiety-provoking condition (*M* totals of 31.70 and 26.90, respectively), $F(1, 150) = 8.65$, $p < .001$. The comparable means for the high-trait group are 28.70 and 28.50.

To examine for possible response bias effects for the happiness emotion, an analysis of the number of happiness classifications along the areas of the continua where happiness was not one of the two component emotions revealed no evidence of a response bias explanation, thereby suggesting an explanation in terms of enhanced sensitivity to happiness.

A standard multiple regression analysis was performed on the independent variables outlined above and the total number of happiness responses. The regression equation was not significant, $F(5, 68) = 1.31$, *ns*, and accounted for just 8% of the variance. Again, only the mood manipulation contributed significantly to the equation ($\beta = .24$, $t[68] = 1.99$, $p < .05$). However, this time, being subjected to the mood manipulation is associated with a reduction in the number of faces classified as expressing happiness.

Subsidiary analyses: Sadness, disgust, and surprise emotions. The analysis of the disgust continua showed that there was a significant interaction between continua, percentage, and mood manipulation for the areas of the continua expressing disgust. To investigate this further, we performed ANOVAs separately on the sadness–disgust and the disgust–anger continua. The first analysis showed that there were no effects of the between-groups factors of either Trait Group or Manipulation. However, the analysis of the disgust–anger continuum (see Figure 5) revealed a significant effect of manipulation, with the control group classifying more of the faces as expressing disgust than the mood manipulated group (*M* totals of 16.81 and 14.50, respectively), $F(1, 34) = 4.50$, $p < .05$. There was also a significant Manipulation × Percentage interaction, $F(4, 136) = 2.64$, $p < .05$, with the control group classifying more of the expressions as "disgust" at 50%, 30%, and 10% compared with the anxiety-manipulation group, $F(1, 171) = 21.80$, $p < .001$; 12.23, $p < .001$; and 6.62, $p < .05$, respectively. This reduction in the classification of expressions as "disgust" along the anger–disgust continuum is due to the manipulated group simply identifying more of these faces, particularly those at the lower

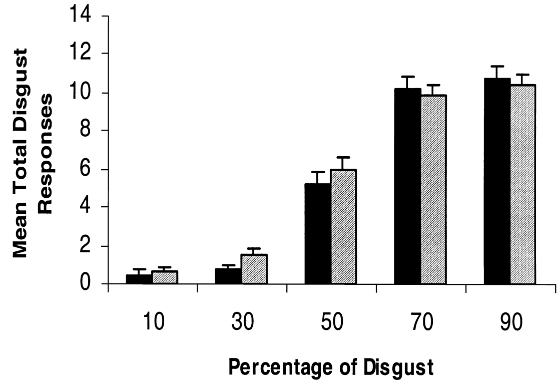

Figure 5. Number of "disgust" responses in control and anxiety-provoking mood manipulation conditions along the disgust–anger continuum for Experiment 2. Darker bars represent the manipulated group; lighter bars represent the control group.

percentage levels where the influence of the anger emotion is more pronounced, as expressing anger rather than disgust.

There were no significant findings for the surprise continua or any significant effects involving the RT data for any of the emotions.

Discussion

In Experiment 2, we successfully used a mood manipulation procedure. There was no significant decrease in state anxiety scores from the first to the second occasion for the control mood manipulation group, whereas there was an increase in scores for the participants undergoing the anxiety-provoking mood manipulation over these two occasions. These effects were unrelated to social anxiety level, showing that the manipulations had comparable effects on the high- and low-trait groups. These effects were confirmed by the analysis of the visual analogue data, which examined state anxiety levels at the beginning of the experiment, at the end of the practice session, and at the end of the experiment. This showed that the anxiety manipulation maintained its effect on state anxiety throughout the experiment.

The analysis of the number of fear responses made along the areas of the continua where fear was a component emotion replicated the effect demonstrated in Experiment 1; that is, the high-trait group overall classified a significantly larger number of faces as expressing fear than the low-trait group. However, further analysis of the interaction between trait social anxiety group and percentage level revealed that the two groups differed at both 50% and 90% but not at

70%. There is no obvious explanation for this anomalous result, particularly given the effects reported in Experiment 1. However, it is clear that the high-trait group's mean score was in the same direction as that for the low-trait group, but it failed to reach significance. The comparable analysis of the anger classifications revealed that trait social anxiety grouping was not influential, whereas being subjected to an anxiety-provoking mood manipulation as compared with no manipulation produced an increase in the number of anger classifications along those continua.

Being subjected to an anxiety-provoking manipulation was also influential in the classification of faces along the continua where happiness was one of the two component emotions. Without the mood manipulation, the low-trait participants classified a higher number of faces as "happy" compared with the high-trait group. However, this difference disappeared under mood manipulation. In all instances, these effects appear to be due to an enhanced sensitivity to the specific emotion as emotion categories rather than to a general response bias for those emotions. These findings suggest that when people (both high- and low-socially anxious) are placed in an anxiety-provoking situation, the number of facial expressions classified as "anger" increases significantly, whereas the number of "happiness" classifications decreases relative to the control mood manipulation condition. In addition to this main effect, the anxiety-provoking mood manipulation group produced a significantly higher number of anger classifications at the 50% and 70% levels. The RT data for the anger analysis offer further support for the notion that the increase in anger responses is related to the presence or absence of the mood manipulation. This analysis revealed that the anxiety-provoking mood manipulation group classified faces as expressing anger significantly more quickly than the control manipulation group.

The regression analysis performed on the total number of anger classifications made across the whole stimulus set showed that it was the presence or absence of the anxiety-provoking mood manipulation that predicted the number of anger responses made. Trait social anxiety, BDI, and state and general trait anxiety did not contribute significantly to the equation. Therefore, the enhanced classification of faces as expressing anger appears to be due to being in the ongoing situation of a mood manipulator per se rather than to a particular level of state anxiety. It appears that when in an anxiety-provoking situation, such as the one used here, both high- and low-socially anxious people behave in a similar way.

GENERAL DISCUSSION

The present research was performed to investigate the relationship between the classification of ambiguous facial expressions and social anxiety. Of central importance were the emotions of fear and anger, as these are the two emotions most relevant to anxiety. It was predicted that socially anxious individuals would show increased classification of expressions as fear, anger, or both in comparison with low-socially anxious individuals when the emotions were present. This prediction was partially supported with high-trait socially anxious individuals classifying more ambiguous facial expressions as "fearful" than low-trait socially anxious individuals. This is a robust finding, as it was demonstrated in Experiment 1 and replicated in Experiment 2. In both experiments, this increased classification of expressions as being "fearful" was found only for those areas of the hexagon where fear was presented as one of the two component emotions. In both instances, the high-trait group did not have a general bias for producing more fear responses, as their performance on areas of the hexagon where fear was not one of the two component emotions was not different from that of the low-trait group. This enhanced sensitivity for fear was not moderated by increases in state anxiety, with the Mood Manipulation factor having no influence at all on the classification of expressions as "fearful."

Conversely, the trait social anxiety grouping factor played no role in the classification of faces containing anger, but the Mood Manipulation factor was important. Both high- and low-trait groups exhibited enhanced sensitivity for anger when in an anxiety-provoking situation (i.e., the anxiety-provoking mood manipulation condition). When state anxiety was not increased, as in Experiment 1, the high- and low-trait groups had similar performance profiles. It may be the case that in order for sensitivity-to-anger to be enhanced, there has to be some sort of external threat that is to some extent independent of self-reported anxiety. This explanation is supported by the multiple regression that showed that only the mood manipulator significantly predicted the number of anger responses made, and state anxiety per se was unimportant. Second, an examination of higher levels of trait social anxiety also failed to produce any enhanced classifications of anger. The mean numbers of anger responses made overall from Experiment 1 were combined with those from the control condition of Experiment 2. Participants scoring above 66 on the SPAI (considered to be in the area indicating clinical social phobia) were assigned to the high group ($n = 20$), participants scoring below 24 were assigned to the low group ($n = 20$). An ANOVA was then performed on the 10%–90% anger data. This revealed no significant effects, supporting the view that it is the situation rather than the level of social anxiety that is important in producing the increase in the number of anger classifications.

It appears that self-reported trait social anxiety is related to the enhanced classification of fear, whereas being in an anxiety-provoking situation is related to enhanced classification of anger. The enhanced classification of fear is not inconsistent with Eysenck's (1992, 1997) hypervigilance theory, which predicts that anxious individuals are hypervigilant for threat. However, the results from the analysis of the anger responses are inconsistent with Eysenck's theory.

The enhanced sensitivity for fear in the high-socially anxious group could be due to an increase in activity in the amygdala. If it were the case that the high-trait group perceived the faces as expressing fear as indicating a threat, then this would explain the increase in sensitivity for detection of fear. However, this explanation is problematic, as fearful faces are ambiguous indicators of threat. A fearful face gazing directly at the viewer may not be perceived as being directly threatening, as it implies that it is the viewer who is the source of threat. If the face were looking elsewhere rather than directly at the viewer, this may be interpreted as a signal that there is something in the environment of which to be afraid. It may be predicted therefore that a face with the eyes averted to one or other side would be seen as indicating some external source of danger in the environment. However, in the present study, the faces were looking directly at the viewer, indicating that the viewer is the source of threat rather than there being some external stimulus. It may appear then that the fearful faces in the present study are not threatening. Even if this is the case, the amygdala may still be activated, as, according to Whalen (1999), the amygdala is most responsive to ambiguous stimuli. The amygdala is preferentially activated in response to fearful rather than angry faces because fearful faces convey threat, but the source of the threat is ambiguous. Anger, however, conveys threat, but the source of the threat is unambiguous.

The issue of whether the amygdala is responsive to fearful faces because they are ambiguous rather than being threatening per se is as yet unresolved. One way to address this issue would be to examine the activation of the amygdala for nonthreatening ambiguous faces (e.g., along the happiness–surprise continuum). It would also be of interest to vary eye gaze in fearful faces (face gazing to the side vs. face gazing at the viewer).

Another possible explanation is that perceiving the fear emotion in the current experiments may be related to an empathic response, with socially anxious individuals being more likely than low-anxious individuals to empathize with a face expressing fear. There is a growing body of research examining empathic responses. Early emotion research examined the decoding of emotional expressions (e.g., Ekman, Friesen, & Ellsworth, 1972) and the universality of emotional expression. More recently, there has been an interest in the more interactive components of emotion such as emotional mimicry (e.g., Hatfield, Cacioppo, & Rapson, 1992) and empathy (e.g., Eisenberg & Fabes, 1990). Empathy is an affective state derived from the apprehension of another's emotional state and is congruent with that emotional state (Eisenberg & Strayer, 1987). Hess, Philippot, and Blairy (1998) described two functions of emotional displays. First, they serve to express the sender's emotional state and, second, signal a listener's understanding of the sender's feelings. In relation to facial displays, research has examined both the sender's expression and the reciprocal expression of the observer. In the present investigation, it could be the case that the high-social anxiety group is more sensitive to recognition of fear, and that this recognition of fear encourages mimicry of and empathy with the face, resulting in enhanced sensitivity. The current study does not address this issue directly, and further research is necessary. If participants were exposed to a stressful situation in which the fearful face was looking away from the viewer, there may be a similar response to that obtained for the angry face under the anxiety-provoking mood manipulation.

To conclude, the current findings support the view that self-reported social anxiety is involved in the classification of fear but not anger. The enhanced classification of faces as expressing anger was apparent for both high- and low-socially anxious individuals who were placed in a stressful situation. In evolutionary terms, it is highly adaptive for all people to identify danger and threat. It may be the case that the fearful faces were not directly threatening, whereas the angry faces were. If this were the case, then it appears that, at a minimum, the detection of threat is mediated by state anxiety. An angry face could be interpreted as being directly threatening when it is staring directly at the viewer, whereas a fearful face staring directly at the viewer may be more likely to elicit empathy.

The current research has demonstrated that the differences observed here for fear, anger, and happiness are all consistent with the notion that the emotions were being responded to as emotion-as-a-category. The effects reported appear to reflect enhanced sensitivity for the emotion and not a simple response bias that is invoked when an ambiguous facial stimulus is classified.

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