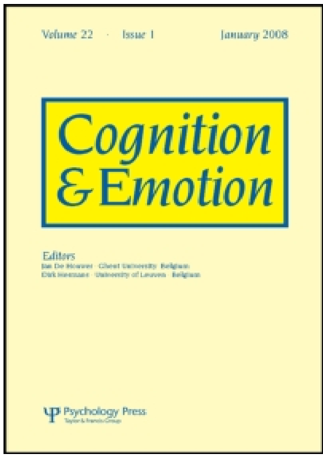

Cognition & Emotion
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713682755

Individual differences in perceptual sensitivity and response bias in anxiety: Evidence from emotional faces

Tahl I. Frenkel [a]; Dominique Lamy [a]; Daniel Algom [a]; Yair Bar-Haim [a]
[a] Tel Aviv University, Tel Aviv, Israel

First Published on: 19 May 2008

To link to this article: DOI: 10.1080/02699930802076893
URL: http://dx.doi.org/10.1080/02699930802076893

COGNITION AND EMOTION
0000, 00 (00), 1–13

Psychology Press
Taylor & Francis Group

Individual differences in perceptual sensitivity and response bias in anxiety: Evidence from emotional faces

Tahl I. Frenkel, Dominique Lamy, Daniel Algom, and Yair Bar-Haim

Tel Aviv University, Tel Aviv, Israel

We investigated the perception of emotional stimuli in anxious individuals and non-anxious cohorts. Signal detection theory analysis was applied to the discrimination of emotionally charged faces at several points along a continuum of emotional intensity. This design permitted the derivation of multiple measures of sensitivity and response bias for fearful and for happy faces. Anxious individuals lacked a conservative bias in judging fearful stimuli and a liberal bias in judging positive stimuli compared with non-anxious individuals. In addition, anxious participants had lower perceptual sensitivity (d') than non-anxious participants for mildly threatening stimuli, as well as a trend towards lower perceptual sensitivity for moderately positive stimuli. These results suggest that the processing of threat information in anxiety is affected by sensitivity and bias differently at different levels of affective intensity.

INTRODUCTION

Anxious individuals have been shown to display a variety of biases when processing threat-related information (see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJendoorn, 2007; Beck & Clark, 1997; Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1997, for reviews). However, the exact nature of the mechanisms underlying these biases is still largely unknown. Broadly construed, threat-related processing biases in anxiety may stem from perturbed perceptual sensitivity to threat-related features, from a tendency to interpret stimuli as threatening, or from both. The objective of the present study was to formally assess the distinct roles of perceptual sensitivity and interpretation bias (or response criterion)

Correspondence should be addressed to: Yair Bar-Haim, Department of Psychology, Tel Aviv University, Tel Aviv 69978, Israel. E-mail: yair1@post.tau.ac.il

This study was supported by the Helene and Woolf Marmot Research Fund for Neurophysiology and by grants from the Israeli Science Foundation (989/03) and the National Institute for Psychobiology in Israel to Yair Bar-Haim.

www.psypress.com/cogemotion DOI: 10.1080/02699930802076893

in the processing of threat in anxious and non-anxious individuals. To that end, we applied the conceptual framework of signal detection theory (SDT).

To our knowledge, only three studies have employed SDT paradigms to assess anxiety-related differences in perceptual sensitivity and response criterion (Becker & Rinck, 2004; Manguno-Mire, Constansa, & Geer, 2005; Winton, Clark, & Edelmann, 1995). These studies required participants to discriminate between threat and non-threat stimuli that were briefly presented and then masked. Despite variation in the types of anxiety studied (spider phobia, self-reported trait-anxiety, and social anxiety), and the type of stimuli employed (lexical, pictorial), these studies all yielded similar results: significant between-groups differences in response criterion, but not in perceptual sensitivity. Specifically, relative to non-anxious participants, anxious participants had a more liberal criterion in judging stimuli as threatening but did not show higher perceptual sensitivity in detecting threat cues.

Careful review of these previous SDT studies raises three issues that warrant further consideration. First, all of these studies examined sensitivity and criterion for the detection of threat. However, naturalistic situations often require subtle discrimination between small nuances in threat intensity rather than between the presence and the absence of threat. For instance, small changes in threat-related facial expressions may convey gradual information about potential threat in the environment thus allowing for adaptive preparation. Second, and related to the preceding point, previous SDT studies did not consider variation in threat intensity. However, previous research and theory suggest that threat-related biases in anxiety may vary as a function of stimulus threat intensity (e.g., Mogg & Bradley, 1998; Mogg et al., 2000; Wilson & MacLeod, 2003). Finally, an important prerequisite for SDT analysis is an experimental setup that yields imperfect detection. Previous anxiety-related SDT studies created this condition by presenting masked stimuli, thereby examining sensitivity and criterion for liminal processing. However, naturalistic stimuli are typically supra-liminal. Possibly, these factors conspired to conceal anxiety-related individual differences in perceptual sensitivity.

In the present study, by using morphing techniques, we created face stimuli showing finely graded continua of fear expression ranging from neutral (no threat) to fearful (high threat). We then selected pairs of facial stimuli differing in fear intensity by 5%, around three fear intensity levels (mild – 20% fear, moderate – 50% fear, and high – 80% fear). This novel approach allowed us (1) to perform SDT analyses at various points along the continuum of threat intensity, and (2) to generate the imperfect detection performance necessary for SDT analysis, with long exposures that allowed conscious perception of the stimuli.

In addition, because data from a number of recent studies suggest that processing biases in anxiety may be associated not only with threat-related facial expressions but also with positive facial expressions (e.g., Bradley, Mogg, White, Groom, & de Bono, 1999; Fox, Russo, & Dutton, 2002; Silvia, Allan, Beauchamp, Maschauer, & Workman, 2006), we tested sensitivity and criterion in the processing of positive stimuli (happy faces) as well.

Based on the extant literature, we expected that relative to anxious participants, non-anxious participants would show a more conservative criterion in judging fearful faces as more fearful. We also expected the opposite pattern to emerge for happy faces, such that anxious participants would show a more conservative criterion in judging happy faces as more happy. Finally, we expected the more sensitive measurement tools introduced in the present study to reveal anxiety-related differences in perceptual sensitivity if such differences indeed existed.

METHOD

Participants

A group of non-anxious participants and a group of anxious participants were selected from a pool of 240 undergraduate psychology students. Selection was based on response to Spielberger's State-Trait Anxiety Inventory (STAI) Trait scale (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Participants who scored in the top 5% of the distribution ($n =$ 12, 10 females, Mean STAI-Trait score $= 54.6$, $SD = 5.0$) were allocated to the anxious group, whereas participants who scored in the bottom 5% of the distribution ($n = 11$, 7 females, Mean STAI-Trait score $= 23$, $SD = 1.8$) were allocated to the non-anxious group, $t(21) = 19.17$, $p < .0001$. Participants whose score on the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) exceeded the recommended clinical cut-off score of 10 were not included in the selected groups. However, despite this exclusion procedure depression level was still higher in the anxious relative to the non-anxious group, $t(21) = 3.36$, $p < .01$. Finally, the two groups did not differ in age, $F < 1$, $M_{\text{Age}} = 22.78$, $SD = 1.05$, and gender distribution, Fisher's Exact Test $= .37$ (two-sided).

Apparatus

The experiments were programmed using E-Prime software (Psychology Software Tools, Inc., Pittsburgh, PA). Displays were generated by an Intel Pentium 4 computer attached to a 17″ CRT monitor, using 640×480 resolution graphics mode. Responses were collected via the computer keyboard. A chin rest was used to set viewing distance at 50 cm from the monitor. The experiments were conducted in a dark room.

Stimuli

Examples of the experimental stimuli are presented in Figure 1. For the sake of parsimony, the following sections describe only the fearful expression condition. The same procedures were applied for the happy expression condition.

Face photographs from 8 Caucasian actors were selected from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE; Matsumoto & Ekman, 1988). Two prototypical photographs of each actor were selected, one displaying a fearful expression and another displaying a neutral expression. Interpolated (or "morphed") face stimuli were created using Morpheus Photo Compressor software (Morpheus Software, LLC, Santa Barbara, CA) by combining the prototypical fearful expression with the neutral expression of the same actor. In the low-fear-intensity experiment, morphed faces included 17.5% or 22.5% of the prototypical fearful face. In the moderate- and high-fear-intensity experiments, percentages of the prototypical fearful face were 47.5% and 52.5%, and 77.5% and 82.5%, respectively. Within each experiment, one level of fear (17.5%, 47.5%, or 77.5%) was labelled as displaying less of the fearful expression and the other level (22.5%, 52.5%, or 82.5%) was labelled as displaying more of the fearful expression. Thus, for each of the three emotion intensity levels (20%, 50%, and 80%) there were 8 different stimuli depicting 4 different individuals (2 females, 2 males) with two sublevels of emotion differing by 5% (less emotion or more emotion). Each morphed face subtended 431 × 300 pixels and appeared against a grey background.

To test the degree of linearity of the morphing technique, image similarity metrics were extracted for the fearful and happy pairs at the three different intensity levels along the morph continuums. Specifically, the red, green, and

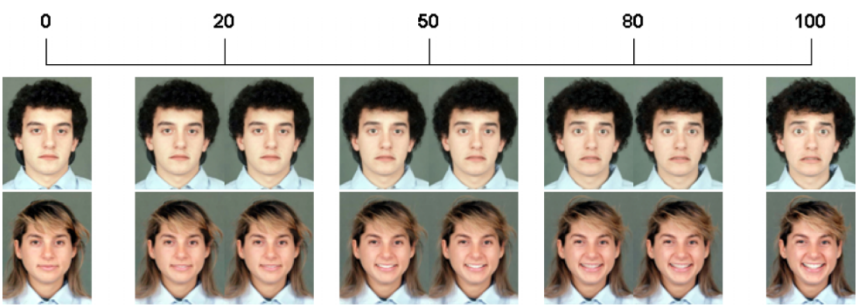

Figure 1. Example of the faces used in the signal detection experiments.

blue luminance values were averaged in each pixel of each of the pictures followed by the computation of pixel-by-pixel correlations between pairs of stimuli in each condition of stimulus emotion intensity (see Thierry, Martin, Downing, & Pegna, 2007, for similar methodology). These correlations provide a quantitative measure of similarity among images in each condition at the pixel-by-pixel level. The correlations between each of the 24 picture pairs were all greater than .997, suggesting large overlap between the pictures in each pair. Fisher's r-to-Z comparisons between the pictures in the different emotion intensity levels revealed no differences in the magnitude of picture pair similarity.

Procedure and design

Participants were tested in a series of six separate experiments. In each experiment, discrimination of one emotion type (fearful or happy), around one emotion intensity (20%, 50%, or 80%) was tested. Each experiment consisted of four blocks, each including two morphed faces of the same individual, differing in emotion level by 5%. On each trial, one of two possible morphed face stimuli, differing in fear intensity by 5%, appeared until response. Participants were required to label the level of fear of the morphed face as less fearful or more fearful, by pressing a designated key ("1" or "2", respectively) on the numerical keypad. In line with classical SDT discrimination procedures, each experimental block began with a definition of the two signals to be discriminated. Each of the two morphed faces was presented for 2000 ms with a label describing its intensity level status (i.e., "less fearful" or "more fearful"). The less fearful face was always presented first. Blocks were presented in random order and consisted of 70 trials each. Within each emotion condition, order of emotion intensity experiments was counterbalanced. The three experiments for each emotion type were completed within ten days. Testing of the two emotion conditions (fearful and happy) was separated by one month on average. To summarise, each participant completed 6 experiments, each experiment consisted of 280 trials divided into 4 equal blocks of 70 trials each.

Dependent measures

For each of the six experiments two variables were extracted for statistical analysis using signal detection techniques (Macmillan & Creelman, 1991): a measure of the response criterion (c), and a measure of perceptual sensitivity (d'). Both measures were computed based on hit rates (proportion of trials in which a face was correctly judged to be more fearful) and false alarm rates (proportion of trials in which a face was incorrectly judged to be more fearful). High d' scores reflect high perceptual sensitivity. With regard to response criterion c, positive values of c reflect a bias towards judging the face as less fearful, whereas negative values indicate a bias towards judging the face as more fearful. A *c* score of 0 indicates the absence of a response bias.

Data analysis

To assess anxiety-related differences in response criterion (*c*) and perceptual sensitivity (*d′*), two separate ANOVAs were first conducted. Emotion (fear, happy) and Intensity (20%, 50%, 80%) served as within-subject factors, and Group (anxious, non-anxious) served as between-subjects factor. These ANOVAs were followed by linear pre-planed contrast for each of the variables in each of the six experiments. Two types of contrasts were applied: (a) between-groups two-tailed contrasts were used to determine anxiety-related differences; and (b) one-sample *t*-tests against zero within each anxiety group were used to determine whether a bias that was significantly different than zero in fact existed.

RESULTS

In Figure 2 we present the means and standard errors for response criterion (*c*) and perceptual sensitivity (*d′*) for the faces at around 20%, 50%, and 80% intensity separately for the two groups.

Criterion (*c*)

The ANOVA results revealed a significant Emotion by Group interaction, $F(1, 22) = 15.21$, $p < .001$, which was subsumed under an Emotion by Intensity by Group three-way interaction, $F(2, 21) = 4.63$, $p < .05$. None of the other effects reached statistical significance.

Between-groups contrasts for each intensity level of fearful faces revealed that non-anxious participants tended to judge the faces to be "less fearful" than did anxious participants around the 20% and the 50% fear intensities, ts(21) = 2.43 and 1.99, ps < .05 and .06, Cohen's ds = 1.06 and 0.87, respectively (Figure 2a). No between-groups difference was found around 80% fear intensity. One sample *t*-tests against zero indicate that non-anxious participants were biased to judge fearful faces of mild (20% fear) and moderate (50% fear) intensities as "less fearful", ts(10) = 3.47 and 2.60, $ps <$ .01 and .05, respectively. A similar, but non-significant, numerical trend was also observed in non-anxious participants for the high fear intensity (80% fear). By contrast, one-sample *t*-tests against zero show that anxious participants had no criterion bias at any of the stimulus fear intensities, all ps > .40.

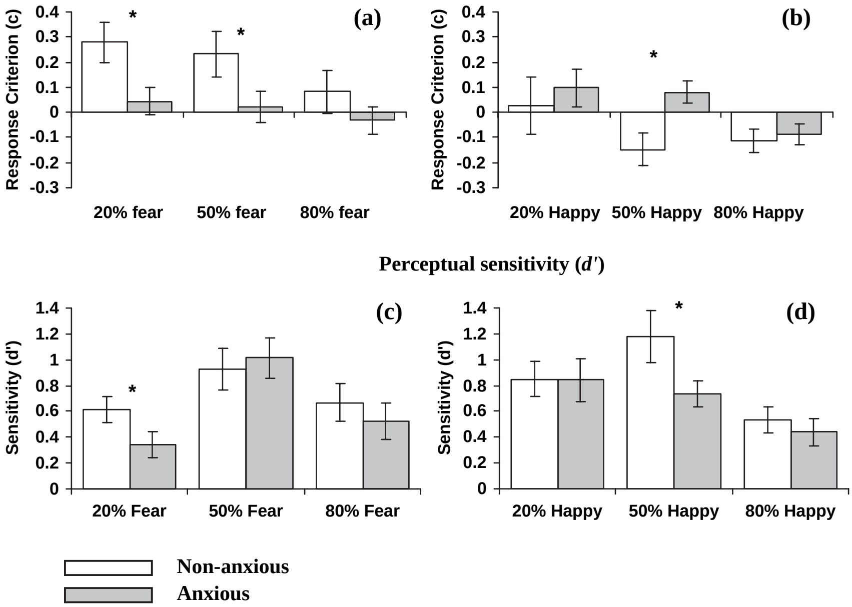

Figure 2. Response criterion (c) and perceptual sensitivity (d') for fearful and happy facial expressions of emotion in anxious and non-anxious participants. Statistically significant contrasts are denoted with asterisks.

A different pattern of results emerged with the happy faces (Figure 2b). Between-groups contrasts show that anxious and non-anxious participants did not differ in the extreme happy intensity levels (i.e., 20% and 80% happy), Fs < 1. One sample t-tests revealed that both groups had no criterion bias in judging mild emotion intensity stimuli (20% happy), ps $= .30$, and tended to judge happy faces of high intensity (80% happy) as “more happy”, $t(10) = 2.36$, $p < .05$ for the non-anxious group, and $t(11) = 2.07$, $p = .063$ for the anxious group. Between-groups difference emerged around the moderate intensity level (50% happy), $t(21) = 3.00$, $p < .01$, Cohen’s $d = 1.31$. One sample t-tests revealed that while anxious participants tended to judge the faces around 50% happy as “less happy”, $t(11) = 1.81$, $p = .10$, non-anxious participants judged these faces as “more happy”, $t(10) = 2.30$, $p < .05$.

Perceptual sensitivity (d')

The ANOVA results concerning perceptual sensitivity revealed a significant main effect for stimulus intensity, $F(2, 21) = 13.61$, $p < .0001$, with better discrimination around 50% intensity relative to 20% and 80% intensity. An

Emotion by Intensity interaction was also found, $F(2, 21) = 4.76$, $p < .05$. All these effects were subsumed under an Emotion by Intensity by Group three-way interaction, $F(2, 21) = 3.48$, $p < .05$. None of the other effects reached statistical significance.

As may be observed in Figure 2c and 2d, participants in both groups were able to discriminate between different levels of fearful emotion expressions and between different levels of happy emotion expressions for each of the emotion intensity levels (i.e., 17.5% vs. 22.5%, 47.5% vs. 52.5%, 77.5% vs. 82.5%), all ps $< .01$. Two differences in perceptual sensitivity (d') emerged between anxious and non-anxious participants. Relative to non-anxious participants, anxious participants had lower perceptual sensitivity for fearful expressions around 20% emotion intensity, $t(21) = 2.09$, $p < .05$, Cohen's $d = 0.91$ (Figure 2c), and lower perceptual sensitivity for happy expressions around 50% emotion intensity, $t(21) = 2.01$, $p = .061$, Cohen's $d = 0.88$ (Figure 2d).

DISCUSSION

The aim of the present study was to assess the contributions of perceptual sensitivity and response criterion in the processing of negative and positive emotional stimuli in anxious and non-anxious individuals. To this end, we used a classical discrimination paradigm within a signal detection theory framework.

In line with previous studies (Becker & Rinck, 2004; Manguno-Mire et al., 2005; Winton et al., 1995), anxious participants in the present study did not show a criterion bias in judging threat (fearful faces), whereas non-anxious participants were biased in judging mild and moderately fearful faces as "less fearful". Importantly, these differences were not observed for the high threat intensity level. Thus, it appears that anxious individuals lack the normative tendency to report less threat in the face of mild or moderate danger cues. Such a tendency is likely to be efficient in most daily situations, as it allows the ignoring of threat that does not necessitate immediate action and thus avoids unwarranted disruptions of ongoing activity.

Previous studies of SDT in anxiety have used positively valenced stimuli as a control condition but did not provide direct analysis of criterion-related biases in the processing of positively valenced stimuli. In the present study, we found anxiety-related biases in response criterion for stimuli of positive valence (happy faces). Specifically, anxious participants judged moderately happy faces (50% happy) as "less happy", whereas non-anxious participants judged these same faces as "more happy". Because happy facial expressions serve an important social function conveying both interpersonal fondness and signs of interpersonal security, it may be more socially adaptive to have a liberal criterion in judging happy faces as "more happy" when moderate levels of emotion are encountered.

Together, these findings show that, unlike non-anxious individuals, anxious individuals lack both a bias in judging mildly and moderately fearful stimuli as less threatening, and a bias in judging positive stimuli as more positive. Such a pattern may lead anxious individuals to experience their social surroundings as more threatening on the one hand and less friendly on the other. This double setback in the processing of emotion invites a more complex view concerning the aetiology and maintenance of anxiety. To date, perceptual perturbations in anxiety have been typically explained only in terms of biased threat processing.

Concerning perceptual sensitivity (d'), we found evidence for smaller d' in anxious relative to non-anxious participants in discriminating between mildly threatening stimuli and between moderately happy faces. Anxiety-related differences in d' were not found in previous SDT studies. This finding may be attributed to the more refined methodology employed in the present study. As we mentioned, previous SDT studies in anxiety employed threat stimuli of only one emotion intensity level whereas the present study clearly demonstrates that anxiety-related variation in perceptual sensitivity is dependent on stimulus emotion intensity.

The finding of lower perceptual sensitivity to happy faces in anxious relative to non-anxious participants concurs with their tendency to report happy faces as less happy relative to non-anxious individuals, and could suggest impoverished processing or reduced attention to positive stimuli in anxious individuals. By contrast, the finding of a smaller d' for differences in mild threat intensity in anxious relative to non-anxious participants may seem counterintuitive. Indeed, influential cognitive theories of anxiety suggest that underlying the well-documented threat-related cognitive biases in anxiety is a greater vigilance toward threat (e.g., Eysenck, 1992; Mogg & Bradley, 1998), which should intuitively be associated with greater perceptual sensitivity to such stimuli in anxious individuals.

One can only speculate at this point as to how the gap between findings of hypervigilance towards threat in anxiety and the finding of lower perceptual sensitivity in anxious individuals reported here may be bridged. It is worth noting, however, that most of the support for theories of hypervigilance toward threat in anxiety comes from response-time studies employing attention tasks that are very different from the procedures used in the present study. Thus the present findings possibly illuminate different aspects of anxiety-related differences in threat processing. Furthermore, within-group effects of attentional bias toward threat in anxiety are typically small in magnitude (see Bar-Haim et al., 2007). By contrast, many studies of processing biases in anxiety also find a robust between-groups main effect for overall reaction time, with anxious individuals being generally slower relative to non-anxious individuals (e.g., Bar-Haim, Lamy, & Glickman, 2005; Bradley et al., 1999; Mogg & Bradley, 1999). The lower d' values in anxious relative to non-anxious participants we found with fearful as well as with happy faces may reflect such a core deficit in processing. Alternatively, hypervigilance for threat may in fact be associated with criterion-related mechanisms rather than perceptual sensitivity (d'). Additional research is needed to clarify these issues. For instance, testing for perceptual sensitivity using an ABX discrimination task might reduce the potential contingency between response biases and having to label each face as less or more expressive as was done in the present study.

It remains unclear whether the reduced perceptual sensitivity in the anxious group is restricted to emotional stimuli or generalises to non-emotional stimuli. This issue cannot be resolved based on the present findings. However, previous research on processing biases in anxiety strongly suggests that attentional biases are specific to emotional stimuli. The lion's share of this research focused on threat vs. neutral stimuli and provides convincing evidence that processing biases in anxiety are restricted to threat-related stimuli (see Bar-Haim et al., 2007; Mogg & Bradley, 1998; Williams, Mathews, & MacLeod, 1996, for reviews). Fewer studies collected data on processing biases for positive, negative, and neutral/non-emotional stimuli thereby allowing a test of the "emotionality hypothesis" in anxiety, namely, of whether anxious individuals show a bias toward emotional stimuli regardless of their valence. The results of these studies are mixed, with some indicating that biased processing in anxiety is specific to threat-related stimuli (e.g., Fox, Russo, & Georgiou, 2005; Mansell, Ehlers, Clark, & Chen, 2002), and others suggesting that processing biases in anxiety are related to emotion processing in general (e.g., Becker, Rinck, Margraf, & Roth, 2001; Chen, Ehlers, Clark, & Mansell, 2002; Fox et al., 2002; Martin, Williams, & Clark, 1991; Mogg & Marden, 1990). However, all of these studies indicated non-biased processing of neutral/non-emotional stimuli (e.g., neutral faces, scrambled faces, household objects) in anxious individuals. Therefore, it is reasonable to assume that the perceptual sensitivity findings from the present study reflect an anxiety-related bias that is specific to emotional stimuli (positive and negative) rather than a general reduction in perceptual sensitivity. Future research using the framework of our STD task with morphed-face stimuli could resolve this issue by testing discrimination sensitivity between non-emotional dimensions of faces (e.g., identity, gender, or race) in anxious versus non-anxious participants.

Our data show that anxiety-related processing biases vary as a function of stimulus threat intensity, which is generally consistent with Mogg and Bradley's (1998) proposal that anxious and non-anxious individuals differ in their processing of threat only for moderately threatening stimuli (see also Wilson & MacLeod, 2003). Although our findings are generally consistent with this model with regard to stimuli of high- and moderate-threat intensities, they are not for stimuli of low-threat intensity. The inconsistency may be attributed to differences in experimental paradigms and theoretical frameworks (i.e., attention biases vs. SDT), or to differences inherent to the emotional intensity selected as mild. In addition, different emotion expressions may follow different increase functions of intensity as they gradually progress from neutral to the full-scale emotion prototype, as exemplified by the differences observed here between fearful faces and happy faces.

Our data also indicate increased perceptual sensitivity at 50% emotion intensity relative to the extreme ends of the continua (20% and 80% emotion intensities). The computed similarity metrics rule out the possibility that these results stem from non-linearities in the morphing procedures. However, this increased sensitivity may reflect the possibility that the face pairs around 50% emotion intensity are located around the category boundary between neutral and emotional expression and therefore entail greater d' (Calder, Young, Perrett, Etcoff, & Rowland, 1996). More programmatic research is needed to clarify these issues as well.

The results of the present study should be viewed in light of some potential limitations. First, one could argue that the sample size of the present study is rather small, thereby limiting our ability to detect the hypothesised effects. However, this criticism really should not apply, as the hypothesised effects were in fact detected for the response criterion measures (c), and for some novel anxiety-related effects of perceptual sensitivity (d'). The effects sizes of the detected between-group differences are rather large, and to the extent that such power limitations did influence our findings, they speak to the robustness of the effects already detected on statistical grounds. Second, due to our relatively small sample size we were unable to test for gender effects. Future studies may wish to assess such effects as studies showing gender differences in processing of facial expressions of emotion start to emerge (e.g., McClure et al., 2004; Montagne, Kessels, Frigerio, de Haan, & Perrett, 2005). Third, it is important to notice that although care was taken to exclude from the study participants with high self-reported depression, participants in the anxious group still reported greater depression on average than participants in the non-anxious group. High correlations between anxiety and depression are commonly reported in both clinical and normative samples, and call for caution in result interpretation (see Bar-Haim et al., 2007, for a discussion).

In conclusion, the present findings show anxiety-related differences in perceptual sensitivity and in response criterion. This pattern of results lends support to cognitive models of anxiety proposing that biased processing of threat information may occur at more than one level of processing (e.g., Bar-Haim et al., 2007; Beck & Clark, 1997). Further research is needed to first replicate the novel findings of anxiety-related differences in perceptual sensitivity; second, to determine whether these differences are specific to the processing of emotion expressions or alternatively represent a more generic anxiety-related variability in perceptual sensitivity; and third to be generalised and applied to clinically anxious populations. Finally, more refined theory and empirical data are needed in an attempt clarify potential associations between the recent findings emanating from SDT studies regarding anxiety-related individual differences in perceptual sensitivity and response criterion on the one hand, and the vast literature and theory on attentional biases in anxiety on the other hand.

Manuscript received 13 November 2007
Revised manuscript received 8 February 2008
Manuscript accepted 14 March 2008
First published online day/month/year

REFERENCES

Bar-Haim, Y., Lamy, D., & Glickman, S. (2005). Attentional bias in anxiety: A behavioral and ERP study. *Brain and Cognition*, *59*, 11–22.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJendoorn, M. H. (2007). Threat-related attentional bias in anxious and non-anxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*, 1–24.

Beck, A. T., & Clark, D. A. (1997). An information processing model of anxiety: Automatic and strategic processes. *Behaviour Research and Therapy*, *35*, 49–58.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*, 561–571.

Becker, E. S., & Rinck, M. (2004). Sensitivity and response bias in fear of spiders. *Cognition and Emotion*, *18*, 961–976.

Becker, E. S., Rinck, M., Margraf, J., & Roth, W. T. (2001). The emotional Stroop effect in anxiety disorders—General emotionality or disorder specificity? *Journal of Anxiety Disorders*, *15*, 147–159.

Bradley, B. P., Mogg, K., White, J., Groom, C., & de Bono, J. (1999). Attentional bias for emotional faces in generalized anxiety disorder. *British Journal of Clinical Psychology*, *38*, 267–278.

Calder, A. J., Young, A. W., Perrett, D. I., Etcoff, N. L., & Rowland, D. (1996). Categorical perception of morphed facial expressions. *Visual Cognition*, *3*, 81–117.

Chen, Y. P., Ehlers, A., Clark, D. M., & Mansell, W. (2002). Patients with generalized social phobia direct their attention away from faces. *Behaviour Research and Therapy*, *40*, 677–687.

Eysenck, M. W. (1992). *Anxiety: The cognitive perspective*. Hove, UK: Psychology Press.

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion*, *16*, 355–379.

Fox, E., Russo, R., & Georgiou, G. A. (2005). Anxiety modulates the degree of attentive resources required to process emotional faces. *Cognitive Affective & Behavioral Neuroscience*, *5*, 396–404.

Macmillan, N. A., & Creelman, C. D. (1991). *Detection theory: A user's guide*. New York: Cambridge University Press.

Manguno-Mire, G. M., Constansa, J. I., & Geer, J. H. (2005). Anxiety-related differences in affective categorizations of lexical stimuli. *Behaviour Research and Therapy*, *43*, 197–213.

Mansell, W., Ehlers, A., Clark, D. M., & Chen, Y. P. (2002). Attention to positive and negative social-evaluative words: Investigating the effects of social anxiety, trait anxiety and social threat. *Anxiety Stress and Coping*, *15*, 19–29.

Martin, M., Williams, R. M., & Clark, D. M. (1991). Does anxiety lead to selective processing of threat-related information. *Behaviour Research and Therapy*, *29*, 147–160.

Matsumoto, D., & Ekman, P. (1988). *Japanese and Caucasian facial expressions of emotion (JACFEE) and neutral faces (JACNeuF)* [CDs]. San Francisco: Intercultural and Emotion Research Laboratory, Department of Psychology, San Francisco State University.

McClure, E. B., Monk, C. S., Nelson, E. E., Zarahn, E., Leibenluft, E., Bilder, R. M., et al. (2004). A developmental examination of gender differences in brain engagement during evaluation of threat. *Biological Psychiatry*, *55*, 1047–1055.

Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy*, *36*, 809–848.

Mogg, K., & Bradley, B. P. (1999). Orienting of attention to threatening facial expressions presented under conditions of restricted awareness. *Cognition and Emotion*, *13*, 713–740.

Mogg, K., & Marden, B. (1990). Processing of emotional information in anxious subjects. *British Journal of Clinical Psychology*, *29*, 227–229.

Mogg, K., McNamara, J., Powys, M., Rawlinson, H., Seiffer, A., & Bradley, B. P. (2000). Selective attention to threat: A test of two cognitive models of anxiety. *Cognition and Emotion*, *14*, 375–399.

Montagne, B., Kessels, R. P. C., Frigerio, E., de Haan, E. H. F., & Perrett, D. I. (2005). Sex differences in the perception of affective facial expressions: Do men really lack emotional sensitivity? *Cognitive Processing*, *6*, 136–141.

Silvia, P. J., Allan, W. D., Beauchamp, D. L., Maschauer, E. L., & Workman, J. O. (2006). Biased recognition of happy facial expressions in social anxiety. *Journal of Social and Clinical Psychology*, *25*, 588–602.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory.* Palo Alto, CA: Consulting Psychologist Press.

Thierry, G., Martin, C. D., Downing, P., & Pegna, A. J. (2007). Controlling for interstimulus perceptual variance abolishes N170 face selectivity. *Nature Neuroscience*, *10*, 505–511.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, *120*, 3–24.

Williams, J. M. G., Watts, F. N., MacLeod, C., & Mathews, A. (1997). *Cognitive psychology and emotional disorders.* Chichester, UK: Wiley.

Wilson, E., & MacLeod, C. (2003). Contrasting two accounts of anxiety-linked attentional bias: Selective attention to varying levels of stimulus threat intensity. *Journal of Abnormal Psychology*, *112*, 212–218.

Winton, E. C., Clark, D. M., & Edelmann, R. J. (1995). Social anxiety, fear of negative evaluation and the detection of negative emotion in others. *Behaviour Research and Therapy*, *33*, 193–196.