ANXIETY AND AFFECTIVE CONTEXT MODULATE AWARENESS THRESHOLDS

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Abstract

Threat awareness is central to anxiety phenomenology. Previous studies have investigated anxious observers' ability to discriminate between different emotions using liminal or subliminal stimuli. Here, we asked whether a stimulus is more likely to access conscious perception in anxious individuals when it is threatening relative to when it is not. Crucially, the stimuli emotional contents were task-irrelevant. Anxious individuals required shorter exposure times to become aware of masked stimuli, irrespective of stimulus valence. However, whereas threat-related stimuli required lower exposure times in high- than in low anxiety individuals irrespective of stimulus context, positive stimuli required lower exposures only when presented among threatening stimuli. Our findings suggest a prominent role for affective context in anxious individuals' conscious perception of visual stimuli.

Biases in automatic, preattentive processing of threat play a prominent role in etiology and maintenance of anxiety disorders. Information-processing models of fear suggest an early threat detection mechanism typically associated with the amygdala automatically assesses emotional valence of incoming information. According to these models, this mechanism is more sensitive in anxious than in non-anxious individuals, resulting in greater unconscious perception of threat, as well as enhanced attentional priority for threat in anxious individuals (see Bar-Haim et al., 2007 for review). Our objective in the present study was to investigate whether threat-related information may have privileged access to anxious subjects' awareness. As attention is often conceived as the gateway to conscious perception, enhanced attention to threat in anxiety should imply that these stimuli thrust more readily into the awareness of anxious individuals relative to non-anxious individuals. However, competing accounts such as the hypervigilance-avoidance hypothesis (e.g., Mathews, 1990) suggest that despite enhanced initial encoding of potential threat, avoidance of such stimuli aimed at reducing anxious mood states immediately follows, preventing elaborate evaluation processes typically occurring in non-anxious individuals. Thus, whether conscious awareness of threatening stimuli has privileged access to anxious individuals' awareness remains an open question.

When addressing this issue, it is important to clarify whether one refers to awareness of the stimulus emotional content or to awareness of some other properties of the emotional stimulus. In the former case, one may ask whether observers are better at discriminating fearful faces from neutral ones than happy faces from neutral ones, for instance, and emotion is therefore task relevant. In the latter case, one may ask whether observers are better at discriminating a word from a non-word when the word happens to be threatening than when it happens to be neutral or positive, and emotion is therefore task irrelevant. These are fundamentally different questions: when emotion is task relevant, one probes subjects' ability to detect the presence of a given emotion relative to other emotions. When emotion is task irrelevant, one probes whether the valence of an object makes it easier to detect or distinguish from other object categories.

Studies aimed at measuring anxiety-related individual differences in perception of emotional valence have typically relied on signal detection (SDT, Green & Swets, 1966)

methods, using masks to limit exposure to the critical stimuli. Importantly, stimulus valence was task relevant. Anxious subjects were typically found not show higher perceptual sensitivity for threat than for positive stimuli, or to differ from non-anxious subjects in sensitivity, but exhibited a more liberal criterion.

By contrast, studies in which emotion was task irrelevant compared perception of emotional stimuli only in the general population and reported higher detection rates for negative versus positive words, suggesting that preventing negative words from reaching awareness is more difficult. Similar studies focusing on anxiety-related individual differences have not been reported.

In the present study we investigate whether threat-related information is privileged in awareness of anxious relative to non-anxious individuals when emotion is task-irrelevant. We could not use SDT for two reasons. First, in order to assess false alarms separately for each emotion category, SDT requires adopting a blocked design with regard to emotional valence. In a mixed design a false alarm is not emotion-specific, precluding the separate calculation of sensitivity and criterion for each emotion category. Yet, with blocked designs, one cannot be confident that emotion is task irrelevant because emotion is necessarily confounded with response. Second, SDT requires use of fixed SOAs. However, previous studies aimed at investigating perception thresholds for emotional stimuli in the general population have revealed that emotion-related differences in perceptual sensitivity vary as a function of the SOA used (e.g., Milders, Logan & Sahraie, 2007). Thus, using a fixed exposure may mask potential differences between emotions. We therefore designed a procedure that allows *comparison* of thresholds between anxious and non-anxious individuals for different expressions of emotion, as described below.

Experiment 1

Method

Participants

Three-hundred undergraduate students at Tel Aviv University were screened using the Spielberger State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983). We randomly sampled twelve high-anxiety students (8 women; Trait Anxiety Score > 2.1) and twelve low-anxiety students (6 women; Trait Anxiety Score < 1.45) to participate.

Apparatus & Stimuli

Displays were generated by an Intel Pentium 4 computer attached to a 15" CRT monitor, using 1024x768 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.

Face stimuli were photographs of 4 different Caucasian individuals (2 males and 2 females) selected from MacArthur's battery of facial expressions stimuli (NimStim stimulus set: http://www.macbrain.org/faces/index.htm). Each individual presented four emotions– angry, fearful, happy, or neutral. Non-face stimuli were pictures of four objects. Masks consisted of scrambled faces and houses. All pictures were gray-scaled, matched for average luminance, and inserted behind a gray overlay with an oval central aperture subtending 102 pixels horizontally and 120 pixels vertically to ensure identical stimulus contour for stimuli.

Procedure

An initial 500-ms white fixation cross centered on a gray background was followed by the target (face or object) for a variable duration, sandwiched between two 200-ms mask displays. The backward mask was followed by a blank screen for 1500 ms or until the participant's response. Participants received no feedback on accuracy, and a new trial began after 500 ms.

Participants pressed the "F" key when seeing a face, and did not to respond when seeing a non-face or if they were uncertain about what they saw. They were not informed of the emotion manipulation. Stimulus exposure duration varied using a staircase procedure, such that exposure duration decremented by one frame (12 ms) on trials in which a face was correctly reported, and incremented by one frame on trials in which the participant failed to report the face. Separate staircase procedures for each emotion were interleaved. Exposure duration for each non-face stimulus trial was set at the average of the immediately preceding four face-stimulus trials, with duration on the first trial set at one frame. Each participant viewed four expressions of only one individual, with identity counterbalanced between subjects. The four non-face objects were identical for all participants. Each of the 8 possible stimuli (four faces and four non-face objects) appeared exactly once within each sequence of 8 trials, in random order. Each experimental session included 50 such 8-trial sequences.

Results and Discussion

Average trait anxiety scores were higher in the high-anxiety group relative to the low-anxiety group, $M=2.58$, $SD=0.45$ vs. $M=1.25$, $SD=0.15$, $t(22)=9.66$, $p<0.0001$, Cohen's $d=3.96$.

We determined the exposure duration at which the face stimulus was correctly detected on 50% of the trials, that is, the duration that corresponded to the median of the distribution of hit rates, which was assumed to belong to the normal distribution cumulative functions family. Under this assumption, the intercept of normalized data was estimated using regression analysis and was used as the threshold estimate.

An Analysis of Variance (ANOVA) with Group (low vs. high anxiety) as a between-subjects variable, and Emotion (angry, fearful, happy and neutral) as a within-subject variable was conducted on the mean thresholds (Table 1). The main effect of Emotion was significant, $F(3,66)=5.08$, $p<0.005$. Planned comparisons revealed that thresholds were lower for fearful than for neutral faces, $F(1,22)=3.89$, $p<0.05$. Thresholds did not differ between the other emotions, and the Group X Emotion interaction did not approach significance. The main effect of anxiety was also significant. Thresholds were lower in the high-anxiety group than in the low-anxiety group, $F(1,22)=5.26$, $p<0.05$, Cohen's $d=0.89$. This finding is novel and consistent with the notion of hyper-vigilance in anxiety. Because exposure durations varied between trials it was not possible to conduct formal Signal Detection analyses in order to determine whether the lower thresholds in high-anxiety resulted from higher sensitivity or from differences in criterion. In the latter case, the anxiety effect would reflect higher readiness to press a key than to refrain from doing so. Yet, the groups did not differ in false-alarm responses on non-face trials ($M=6.16$, $SD=9.06$ vs. $M=5.42$, $SD=5.09$, $t<1$), suggesting that our results reflected higher perceptual sensitivity in high-anxiety subjects.

Experiment 2

We did not find a threat-related bias in anxiety but lower thresholds for anxious individuals irrespective of the emotion displayed by the target face. Note however that in Experiment 1, the target face was equally often a neutral, happy, angry or fearful face. Thus, half of the stimuli the participants were exposed to were threatening. Such repeated exposure to threat-related stimuli may have a unique influence on high-anxiety individuals. In the next two experiments we examine the possibility that threat-related affective contexts trigger an anxiety-based bias (as described by Mogg and Bradley, 1998), that consequently enhances perception of any stimulus that is confusable with or presented within the same context as the stress-inducing stimuli.

If lower thresholds in anxious relative to non-anxious participants for non-threatening expressions (e.g., happy faces) resulted from presenting them in a threatening stimulus context, the anxiety-related threshold difference for such faces should disappear when presented in a positive affective context.

Table 1. Means and standard deviations (in brackets) of awareness thresholds by anxiety group and target emotion (in ms) in Experiment 1

	Angry	**Fearful**	**Happy**	**Neutral**	
High-Anxiety	41.5 (5.1)	40.5 (8.5)	43.4 (7.3)	43.2 (9.0)	**42.2 (7.5)**
Low-Anxiety	51.2 (11.1)	48.8 (12.6)	53.9 (12.8)	51.1 (12.3)	**51.2 (12.2)**
	46.3 (9.7)	44.7 (11.3)	48.6 (11.5)	47.1 (11.3)	

Method

Participants

Fourteen high-anxiety students (11 women; Trait Anxiety score > 2.5) and fourteen low-anxiety students (9 women; Trait Anxiety score < 1.35) participated in the experiment a year after Experiment 1 was conducted, and none of them had participated in Experiment 1.

Apparatus, stimuli and procedure

Apparatus, stimuli and procedure were similar to Experiment 1 except for the following changes. The target stimuli were only two photographs of each individual: happy and fearful. Participants completed two experimental sessions; one with only happy expressions and the other with only fearful expressions. Session order was counterbalanced between subjects.

Results and Discussion

Average trait anxiety scores were higher in the high-anxiety group relative to the low-anxiety group, $M=2.97$, $SD=0.35$ vs. $M=1.21$, $SD=0.13$, $t(26)=17.74$, $p<0.0001$, Cohen's $d=6.67$.

An ANOVA with Group as a between-subjects variable, and Emotion (fearful vs. happy) as a within-subject variable was conducted on the mean thresholds (Fig. 1, right). We excluded one subject from the high-anxiety group because she did not complete both sessions.

Planned comparisons showed lower awareness thresholds for high- relative to low-anxiety individuals with fearful faces, $M=43.77$ ms, $SD=9.20$ vs. $M=59.50$ ms, $SD=16.18$, respectively, $F(1,25)=9.43$, $p<0.005$, Cohen's $d=1.2$, but no difference between the groups with happy faces, $M=53.94$ ms, $SD=12.72$ vs. $M=53.70$ ms, $SD=13.11$, respectively, $F<1$. These findings are consistent with an affective-context hypothesis: when repeatedly exposing anxious individuals to threat-related stimuli, they become hyper-sensitive also to non-threat stimuli presented among the threat stimuli.

Experiment 3

The objective of Experiment 3 was to seek converging evidence for the affective-context hypothesis by comparing awareness thresholds for the same targets under different affective contexts using a within-subject design. Happy faces were presented either among other happy

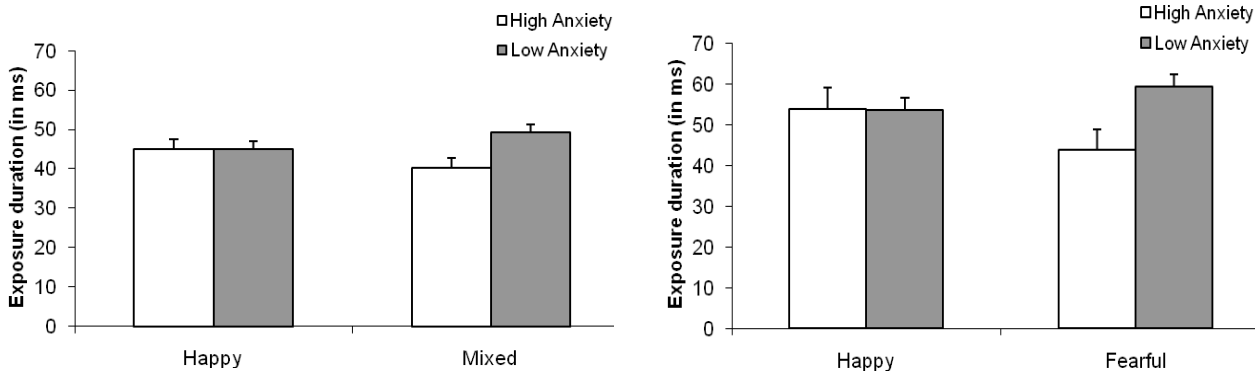

Fig. 1. Mean thresholds (in ms) by anxiety group and target presentation condition in Experiments 2 (right panel) and 3 (left panel).

faces (blocked happy condition), that is, in a threat-free emotional context or among neutral, angry and fearful faces (mixed-emotions condition), that is, in a threatening emotional context. We expected lower thresholds in high- than low-anxiety participants for all expressions of emotion in the mixed-emotions condition but no threshold difference between the two groups for the happy faces in the blocked happy condition.

Method

Participants

Twelve high-anxiety students (10 women; Trait Anxiety score > 2.5) and twelve low-anxiety students (8 women; Trait Anxiety score < 1.35) sampled from the pool used in Experiment 2.

Apparatus, stimuli and procedure

Apparatus, stimuli and procedure were similar to Experiment 2 except for the following. We used four photographs of each individual, as in Experiment 1. The blocked happy session was similar to that of Experiment 2. The mixed-emotions session was similar to Experiment 1.

Results and Discussion

Average trait anxiety scores were higher in the high-anxiety group relative to the low-anxiety group, $M=2.93$, $SD=0.32$ vs. $M=1.23$, $SD=0.15$, $t(22)=16.21$, $p<0.0001$, Cohen's $d=6.8$.

An ANOVA with Group as a between-subjects variable, and Emotion as a within-subject variable was conducted on the mean thresholds of the mixed-emotions condition (Table 2). Thresholds were lower in the high- than in the low-anxiety group, $F(1,22)=4.27$, $p<0.05$ and again, this difference was not modulated by targets' emotion, $F<1$, replicating Experiment 1. Planned comparisons showed lower thresholds for fearful than for neutral faces, $F(1,22)=2.94$, $p<0.05$ but no difference between happy vs. neutral faces, $F<1$.

Planned comparisons confirmed that happy-faces thresholds were lower for the high- than for the low-anxiety group when the happy faces were presented in a threatening context, $M=40.36$ ms, $SD=10.16$ vs. $M=49.21$ ms, $SD=12.02$, $F(1,22)=3.79$, $p<0.05$, Cohen's $d=0.8$. By contrast, thresholds did not differ between the two groups when the happy faces were presented only among other happy faces, $M=45.05$ ms, $SD=11.77$ vs. $M=45.04$ ms, $SD=6.26$, respectively, $F<1$ (Fig. 1, left). These results are in line with the affective context hypothesis.

Table 2. Means and standard deviations (in brackets) of awareness thresholds by anxiety group and target emotion (in ms) in the mixed condition of Experiment 3

	Angry	**Fearful**	**Happy**	**Neutral**	
High-Anxiety	40.5 (9.1)	38.6 (8.5)	40.3 (10.2)	40.6 (9.4)	**40.1 (9.0)**
Low-Anxiety	48.9 (9.4)	47.8 (12.7)	49.2 (12.0)	49.1 (12.7)	**48.7 (11.4)**
	44.7 (10.0)	43.2 (11.5)	44.8 (11.8)	44.8 (11.7)	

Conclusions

Consistent with other well documented threat-related cognitive biases in anxiety, the findings from the present study suggest that high-anxiety individuals are endowed with a perceptual system that is more sensitive to the mere hint of danger than that of non-anxious individuals: repeated exposure to threat-related stimuli was associated with lower awareness thresholds for stimuli presented in the same context. Whereas previous research has focused on unconscious processing and attentional priority of threat in anxiety, the present study investigated the phenomenology of threat perception, by directly evaluating the propensity of stimuli varying in emotional valence to thrust into our participants' awareness. In addition, whereas earlier studies have underscored the role of stimulus valence, the present findings revealed a striking role for affective context. Although the exact mechanism underlying the influence of context in lowering awareness thresholds in anxious individuals requires further research, our study establishes that affective context affects the contents of anxious individuals' awareness.

References

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van Ijzendoorn, M. H. (2007). Attentional Bias toward Threat in Anxious and Non-Anxious Individuals: A Meta-Analytic Study. Psychological Bulletin. 133, 1-24.

Green, D. M., & Swets, J. A. (1966). Signal detection theory and psychophysics. New York: Wiley.

Mathews, A. (1990). Why worry? The cognitive function of anxiety. Behaviour Research and Therapy, 28, 455-468.

Milders, M., Sahraie, A., & Logan, S. (2007). Minimum presentation time for masked facial expression discrimination. Cognition & Emotion, 22, 63-82.

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

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.